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Hide, Tallow and Terrapin: Gold Rush-Era Zooarchaeology at Thompson's Cove (CA-SFR-186H), San Francisco, California

Cyler Conrad[1] · **Kenneth W. Gobalet**[2] · **Kale Bruner**[3] · **Allen G. Pastron**[4]

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Abstract Zooarchaeological investigations at Thompson's Cove, San Francisco, a Gold Rush-era site located on the original shoreline of Yerba Buena Cove, provide evidence of the maritime California hide and tallow trade, consumption of abundant wild game, including seasonal hunting of migratory ducks and geese, and importation of non-native species into Alta California, specifically Galapagos tortoise (*Chelonoidis* sp.) and sea turtle (Family Cheloniidae). This abundant and diverse assemblage (NISP=8661, NTAXA=50) dating primarily to the 1840s–60s allows rigorous investigations into the economic and subsistence activity of San Francisco in a stratified context encompassing the California Gold Rush-era.

Keywords Gold rush · San Francisco · Zooarchaeology · Thompson's Cove

✉ Cyler Conrad
cylerc@unm.edu

Kenneth W. Gobalet
kgobalet@csub.edu

Kale Bruner
kmbruner@ku.edu

Allen G. Pastron
archeo-tec@archeo-tec.com

[1] Department of Anthropology, University of New Mexico, MSC01-1040, Anthropology 1, Albuquerque, NM 87131, USA

[2] Department of Biology, Emeritus, California State University, Bakersfield, CA 93311, USA

[3] Department of Anthropology, University of Kansas, 1415 Jayhawk Blvd., 622 Fraser Hall, Lawrence, KS 66045, USA

[4] Archeo-Tec, Inc., 5283 Broadway, Oakland, CA 94618, USA

Introduction

With the onset of the California Gold Rush, San Francisco was transformed from a small village hamlet on the shores of Yerba Buena Cove (known as Yerba Buena) into a booming city, with an almost over-night population influx numbering into the thousands. Such a massive movement of people into the San Francisco Bay area brought a series of dynamic changes to the bay region—many of which are documented in the historic literature by the large number of authors, writers and historians who were on hand to record this era. The breadth of documentation from this period makes archaeological research into this time extremely fruitful as it allows for the systematic and empirical testing of economic and subsistence patterns that are historically recognized. Recent excavations at Thompson's Cove (CA-SFR-186H; hereafter "TC"), an 1840–1907 archaeological site on the original shoreline of Yerba Buena Cove in downtown San Francisco, allows for detailed and rigorous investigations of these activities. Here, we focus our investigations on the following: (1) the nature and composition of the archaeofaunal assemblage (recovery technique, fragmentation and sample size relationships) (2) the depositional history of the faunal assemblage recovered from the original shoreline of Yerba Buena Cove (3) the evidence for the California hide and tallow trade present (4) the relationship between domesticate and wild game exploitation throughout the Gold Rush-era (late-1840s-53) in San Francisco and (5) the significance of exotic species at the site, specifically Galapagos tortoise (*Chelonoidis* sp.) and sea turtle (Family Cheloniidae). An abundant and diverse archaeofaunal assemblage recovered from stratified contexts at TC provides the opportunity to investigate these processes.

Background to Archaeological Investigations at Thompson's Cove

Archaeological investigations at TC were conducted within the framework of regulatory-compliance during the renovation and seismic retrofitting of the historic Musto Building in downtown San Francisco (Fig. 1). The Musto Building was constructed in 1907 and currently occupies the site. From 2006 to 2013, Archeo-Tec, Inc., Consulting Archaeologists, a cultural resource management firm based in Oakland, California, completed five phases of research in compliance with the regulations set forth by the California Environmental Quality Act: (1) archival research (2) pre-construction testing (3) archaeological monitoring (4) data recovery and (5) data analysis (Pastron and Bruner 2014).

Archival research and pre-construction testing revealed a potentially significant archaeological deposit extending into the early-nineteenth century (pre-Gold Rush 1840s) along the original shoreline of Yerba Buena Cove in downtown San Francisco. Subsequent monitoring and data recovery uncovered 25 cultural features including remnants of waterfront structures and a dense accumulation of artifacts spanning the period between the 1840s-1907 (Pastron and Bruner 2014). Over the majority of the parcel (94 %) the maximum vertical extent of excavations reached natural bay bottom sediments or bedrock situated on or beneath the original shoreline of historic Yerba Buena Cove (Fig. 2). Infilling of this portion of Yerba Buena Cove began during the Gold Rush (1853) and continued into the later-nineteenth century. The depositional

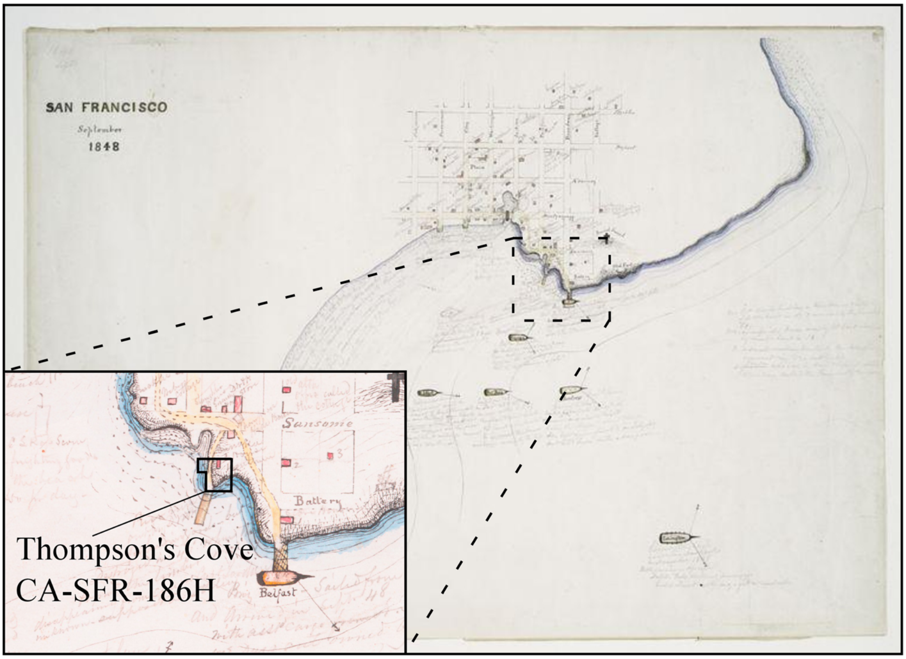

Fig. 1 Location of Thompson's Cove (CA-SFR-186H) in San Francisco, California based on Captain Augustus Harrison's 1848 map of the city. Image adapted from the New York City Library Archives (ID: 54829)

Fig. 2 The Feature 26 excavation showing the natural wave cut landing and Franciscan Bedrock underlying the original shoreline of Yerba Buena Cove at the site

record at TC documents this process of land reclamation and provides a substantial archaeofaunal assemblage (NISP=8661) from a Gold Rush-era context.

Depositional History and Cultural Context

In its natural state prior to landscape alteration and land reclamation, the project parcel straddled the shoreline at the northern extent of Yerba Buena Cove in an area known after 1847 as "Clark's Point" (Bancroft 1886, pp. 685, 784). The point is clearly depicted on contemporary maps, including the earliest of the United States Coast Geodetic Survey maps published in 1852. This promontory represents the base of what is known today as Telegraph Hill. The area around Clark's Point was a rocky shoreline rather than a broad expanse of mud flats like those that characterize the majority of the Yerba Buena Cove shoreline.

The depositional sequence at TC consists of three stratigraphic units (Table 1): indurated sandstone bedrock of the Franciscan Formation, native bay bottom littoral zone deposits, and culturally generated layers of land-fill (see Pastron and Bruner 2014 for details). Bay bottom sediments or bedrock were present across the entire parcel. Multiple facies and discontinuous lenses of littoral zone deposits composed of loamy medium to fine sands or coarse sand occurred within the near shore zone. Bay bottom deposits (Bay Mud) are composed of silty-clay to silt loam with no observable internal stratification. The high tide line was marked by water-worn bedrock that sloped steeply downward to the south and east. Below mean high water, sand or bay bottom sediments overlay bedrock. Beds of articulated valves of bent-nose macomas (*Macoma nasuta*) indicate a band of tidal flats 10–30 ft (3–9 m) from shore. Field observations of the

Table 1 Stratigraphic record and relationship of contexts at Thompson's Cove

Stratigraphic Level	Composition	Context	Date	Description
I	Bedrock	–	–	Franciscan Sandstone
II	Native Littoral and Bay Bottom Sediments	II-A	1840s–1853	Bay Mud
		II-A*	Pre-1848	Bay Mud Beneath F. 3/31/37
		II-B	1840s-1853	Sand or Loamy Sand Facies or Lenses
III	Historic Fill/Cultural Features	III-A	1840s–1853	Dredged Bay Mud
		III-B	1840s–1860s	
		III-C-I	1860s–1907	Various Landfill Deposits
		F. 25	1840s–1853	
		F. 3/31/37	1848–1849	
		F. 15	1850–1853	
		F. 7	Redeposited 1853	Secondary Fill Deposit
		F. 14	Redeposited 1853	Secondary Fill Deposit
		F. 24	1860–1870	Hollow Pit Feature
		F. 23	1907	*O. lurida* Cluster

shoreline, topographic relief, and depositional sequence within the near shore zone confirm that the site is positioned on the edge of a shallow cove opening to the south.

Historically this location has been referred to as Thompson's Cove (Davis 1967, p. 106). The name presumably derives from a connection to the merchant Alpheus B. Thompson who is reported to have operated a hide house near the head of the cove from as early as 1838 (Bancroft 1886, pp. 684–685) while engaged in the hide and tallow trade (Bancroft 1886, p. 784; Davis 1967, p. 131) and sea otter hunting (Ogden 1941, p. 123). This shallow cove with a rocky shoreline would have provided a solid landing for small boats at high tide prior to the construction of piers or wharves. Based on San Francisco City Datum (6.7 ft [20.4 m] above mean high tide) and measurements made in the field, mud flats at TC stretched 20–50 ft (6–15 m) from shore during low tide. This is a significant improvement over other stretches of the Yerba Buena Cove shoreline where mud flats stretched 200 ft (61 m) from shore at low tide. A wave-cut platform in the bedrock identified at the head of the cove formed a relatively level surface extending 10x25ft (3×8m) at high tide and would have provided a further advantage for landing small boats.

It is by virtue of its favorable topography that TC contains some of the earliest cultural deposits in the city of San Francisco. Trading and whaling vessels regularly came to anchor in the vicinity of Yerba Buena Cove to provision their ships or trade with local inhabitants (e.g., Dana 1869). The earliest sketch maps of the Yerba Buena settlement note the project area to be within a designated landing area for small boats and Davis (1967, p. 106) also notes that TC was used for landing. Archaeological findings at TC indicate that the area remained free of landfill until 1853. Thus, cultural materials within the Bay Mud reflect the use of this location beginning as early as the 1840s through the onset of the Gold Rush in 1849 and up to 1853. Much of the material items recovered from the Bay Mud reflect discard or loss during transport of goods from lighters to shore. A barrel packed with at least 11 full bottles of beer found submerged in (what would have been) approximately 2 ft (61 cm) of standing water at mid-tide exemplifies this mode of deposition.

Bay bottom deposits are overlain by a dense accumulation of cultural refuse in the tidal zone (Feature 25) reflecting the growing population of San Francisco as a result of the Gold Rush. Prior to landfilling in 1853 the open waters of TC served as dumping grounds for residents and visitors. A second tidal deposit of refuse (Feature 15) formed over an abandoned rock wharf (Feature 3/31/37) and, in contrast to Feature 25 which is the bay bottom deposits overlain by tidal zone refuse, accumulated during a restricted amount of time between the abandonment of the rock wharf c. 1849 and the filling of the parcel in 1853. These deposits of cultural materials, as well as the remnants of at least three waterfront pier supported structures, were effectively sealed beneath the primary fill layer added to the parcel as land reclamation commenced in TC. Temporally diagnostic ceramic and glass artifacts indicate that filling occurred in 1853 or later.

Culturally generated layers of land-fill in TC extend as much as 4.3 m from the natural and tidal features to the current street level and reflect differential land use in the post-Gold Rush through 1907. The primary fill deposit (Unit III-A) to be added to TC is similar in sedimentary characteristics to bay bottom sediments and indicates that the initial filling of TC was carried out with dredged Bay Mud. The deposit is homogenous across the site and was likely deposited within a relatively short amount of time, on the order of days or weeks. A second deposit of dredged Bay Mud was applied over the first (Unit III-B). This deposit has many inclusions and the top appears to form a late Gold Rush occupation surface. Additional deposits occurred throughout the nineteenth century including a prominent stratum associated with the Great Earthquake and Fire of 1906.

Discrete hollow-pit features dating to the later nineteenth century frequently occurred within the land-fill deposits representing features utilized from occupational surfaces higher in the profile. In many cases cultural material were removed from their primary place of discard and re-deposited as components of land-fill. Features 7 and 14 consist of discrete clusters of refuse incorporated into Unit III-A. Though deposited secondarily in 1853 the materials in Features 7 and 14 accumulated during the early Gold Rush with mean ceramic ages (manufacture dates) of 1848 and 1850 respectively.

The archaeology of late nineteenth-century subsistence practices in San Francisco has been reported over the past five decades in several detailed Cultural Resource Management (CRM) reports (e.g., Praetzellis and Praetzellis 2009; St. Clair and Dobkin 2005) but deposits extending into, and transitioning between, the pre-Gold Rush (1840s) to the late-Gold Rush (1853) are relatively rare, especially from discard and refuse contexts (see Kelly 1989; Pastron 1987; Pastron and Hattori 1990 for store and warehouse examples). This paper presents our analysis of the fauna from the temporally controlled stratigraphic sequence, cultural features and deposits spanning this important period during California's Gold Rush history.

Methods

Identification of the TC zooarchaeological assemblage was completed using osteological texts and comparative skeletal collections. References included Arthropods: Rehder 1995, 1996; Smith et al. 1975; Birds: Adams and Crabtree 2011; Cohen and Serjeantson 1996; Gilbert et al. 1981; Maschner et al. 2012; Mammals: Balkwill and Cumbaa 1992; Barone 1966; Boessneck 1970; Brown and Gustafson 1979; Chavez 2008; Ford 1990; France 2009; Gilbert 1980; Hillson 1986, 2005; Olsen 1960, 1964; Schmid 1972; Silver 1970; Zeder and Lapham 2010; Zeder and Pilaar 2010; Non-avian Reptiles: Bojanus 1819; Gunther 1875; Wyneken 2001. Comparative collections examined during the course of this project included specimens housed at the Museum of Vertebrate Zoology, Berkeley (birds, mammals and non-avian reptiles), the Zooarchaeological Comparative Collections at the University of California, Davis, Department of Anthropology (mammals), the California Academy of Sciences, San Francisco (non-avian reptiles and some fishes), Archeo-Tec, Inc., Oakland, (arthropods) and an author's personal comparative collection of fish skeletons (Gobalet) that is currently housed at the California Academy of Sciences, San Francisco. Arthropods, birds, mammals and non-avian reptiles were identified by Conrad and fish remains by Gobalet. Biological and taxonomic nomenclature follows Smith et al. (1975) and Turgeon et al. (1988) for arthropods, Udvardy et al. (2011) for birds, Eder (2005) for mammals, the Turtle Taxonomy Working Group (2014) for chelonians and Page et al. (2013) for fishes.

Methodology and quantification of the archaeofaunal assemblage follows Grayson (1984) and Lyman (2008). The number of identified specimens (NISP) is the primary measure of taxonomic abundance in this analysis.

Recovery Technique, Fragmentation, and Sample Size

Three different recovery methods were employed at TC. Hand collected specimens recovered during field-excavation, specimens recovered from quarter inch (6.4 mm) mesh dry sieved in the field, and specimens recovered from bulk sediment samples screened with water through eighth inch (3.2 mm) mesh in the laboratory at Archeo-Tec. Faunal materials from features 25, 3/31/37, 15 and 7 were recovered with 3.2 mm mesh. Only features 25 and 15 had faunal screened with 6.4 mm mesh and a total recovered NISP of 69 and 85 respectfully. Faunal material recovered via 3.2 mm mesh is tested (chi-squared test of independence) against hand collected and 6.4 mm mesh collected fauna to determine the effects of differential screen size recovery (Cannon 1999, 2001; Nagaoka 2005). Since both faunal groupings come from the same feature, though with different recovery techniques, significant differences between the assemblage subsets indicate that screen size is affecting the deposit. This results in smaller sized-animals being lost through larger sized mesh. A fish index is quantified by the equation Σ(1/8 in. recovered fish)/Σ(Hand collected+1/4 in. recovered fish) to investigate the differential loss of fish between contexts (see Nagaoka 2005; Quitmyer 2004).

A nestedness analysis (Jones 2004, 2013, 2015) comparing 3.2 mm mesh specimens with hand-collected and 6.4 mm mesh specimens also helps determine the degree of differential recovery between deposits based upon the species present. Nestedness is a measure that determines the degree to which one assemblage is a subset of another based off of the presence or absence of taxonomic classifications (Atmar and Patterson 1993; Lyman 2008). If recovery technique is biasing the assemblage then we hypothesize that the hand collected and 6.4 mm specimens should not be a nested subset of the 3.2 mm-recovered specimens. An open-source program NeD was used to quantify the NODF (nested overlap and decreasing fill) index and temperature (Strona et al. 2014). Nestedness values range between 0, a perfectly nested fauna, and 100, a perfectly random fauna for temperature, but opposite for NODF (100 is a perfectly nested fauna) (Almeida-Neto et al. 2008; Guimaraes and Guimaraes 2006).

Differential fragmentation due to a number of various taphonomic processes can also cause significant differences in the archaeofaunal composition per context (Lyman 1994). Cannon (2013) has recently provided a detailed synthesis of the methods applied to quantify fragmentation rates. Since NISP is the primary measure of taxonomic abundance employed at TC, the ratio between NRSP (total number of recovered specimens in the assemblage—also known as NSP) and NISP is calculated (Cannon 2013; Grayson 1991; Wolverton 2002; Wolverton et al. 2008). While this ratio is hampered by taxon-specific values, it provides a general measure of fragmentation. If ratios of NRSP to NISP are consistent across features at the site, then the rate, or degree of fragmentation, is not biasing the assemblage and is affecting all features relatively equally. Finally, to test for differences in sample size, the relationship between NISP and NTAXA (taxonomic richness) is calculated. A significantly correlated relationship between NISP and NTAXA indicates that sample size is affecting the site equally and not impacting the assemblage (Grayson and Delpech 1998; Lyman 2008).

Identifying the Deposition of Fauna, Economic and Subsistence Change

Deposits and features at TC have experienced differential periods of wetting and drying due to shifting tides. This is an important process to understand site formation, faunal depositional processes and specimen life history. Presence or absence of the mineral vivianite ($Fe^{2}+_{3}(PO_4)_2$•$8H_2O$) on archaeofaunal specimens will provide evidence of this process at TC. Vivianite is an important mineral in archaeofaunal deposits because it provides a wealth of information regarding taphonomic processes. Schumann (1993, p. 74; see also McGowan and Prangnell 2006, p. 102) reports that vivianite is known to precipitate in water on bone and teeth. If vivianite interacts with oxygen it will change from a colorless or pale green color to a dark-blue and black. We document the presence of vivianite to determine if wetting and drying is present at the site. Given the distinct depositional history of TC a spearman's-rho rank order relationship is calculated for the archaeofaunal assemblages between stratum II-A and stratum III-A. Since stratum II-A is a Bay Mud deposit, but stratum III-A is dredged Bay Mud and temporally less controlled, this analysis will determine how closely related the faunal assemblages are between these two deposits. The source of the dredged Bay Mud in III-A from within San Francisco Bay is unknown; but if these strata are significantly correlated it suggests that stratum III-A is a dredged Bay Mud deposit.

When the Spanish arrived in Alta California in 1776 they brought domesticated cattle (*Bos taurus*), sheep (*Ovis aries*), goats (*Capra hircus*), pig (*Sus scrofa*), horse (*Equus caballus*) and chicken (*Gallus gallus*) along with a variety of Mediterranean crops (Bruford et al. 2003; Chartkoff and Chartkoff 1984, pp. 259–260; Davis 1967; Duhaut-Cilly 1999, p. 169; McClellan 1872, pp. 342–344; Rouse 1978, pp. 82–85; Storey et al. 2007; Wolf 1959, p. 182). With Mexican independence in 1821 and the establishment of rancheros throughout Alta California the hide and tallow trade quickly became the dominant economic activity in California (Davis 1967). To determine if evidence of the economic hide and tallow trade is present in the earliest deposits at TC (i.e., Bay Mud II-A/B and feature 25 - 3/31/37) we undertake a comparative analysis of the relative skeletal abundance of cattle, tule elk (*Cervus elaphus nannodes*) and mule deer (*Odocoileus hemionus*), focusing on comparing the hypothesized evidence of skeletal discard due to hide and tallow trade activities with the artifactual record at the site. As Davis (1967) writes, vessels would commonly arrive in Yerba Buena Cove for supplies. Cattle tended to be brought to the shoreline and butchered for food to provision the vessel and the hide and tallow would also be collected and taken to the vessel for processing. Archaeofaunal evidence of this process should be reflected by higher abundance of complete and non-utility elements abandoned on the shoreline because vessels would commonly take high-utility elements (e.g., femora) for large soup meals (Davis 1967; Gust 1982). We expect that crania, mandibles, metapodials and phalanges (elements with low consumption value) will be present in greater frequency during maritime hide and tallow activities, along with a lower abundance of femora, humeri and scapulae (elements with high consumption value) (Gust 1982). Additionally, a spearman's-rho rank order analysis will document the relationship between pre/early (II-A/B, F. 25, F.3/31/37) and mid/late (F. 15, 7, 14) Gold Rush elemental abundances between cattle and elk/deer. A significant correlation suggests that elemental discard at the site does not change between the pre/early and late Gold Rush.

Dietary evenness, based on the abundance and richness of species is a useful measure for understanding consumption and equality of fauna within assemblages (Jones 2004; Lyman 2008; Magurran 2004). Here we calculate the reciprocal of Simpson's index (1/D) and Simpson's evenness. For 1/D, even assemblages have higher values, while uneven assemblages have lower values. More even assemblages have values approaching 1.0 for Simpson's evenness while uneven values approach 0.0. Even assemblages have faunas in which all genera/species are equally abundant, suggesting a diverse and broad diet including a variety of prey types. Uneven assemblages have faunas in which a subset of species is consumed more abundantly than others, suggesting a narrowing diet breadth focusing on a less-diverse subset of species. Simpson's evenness is sensitive to taxonomic richness like Shannon's evenness i.e., more sensitive to single-species abundance or dominance (Magurran 2004, p.116). As such, the reciprocal of Simpson's index is also recorded to understand the effect of species dominance in the assemblage.

Avian evenness within contexts at TC is also calculated to understand site seasonality and consumption of specific birds. Several migratory geese/ducks recovered at TC frequent the San Francisco Bay area following the Pacific Flyway (during fall and winter months) (Cogswell 1977; Dawson et al. 1923; Grenfell and Laudenslayer 1983; Small 1974; US Fish and Wildlife Service 1987). As such, avian distribution and abundance (evenness) may provide evidence of Gold Rush-era subsistence activity during specific seasons of the year. We hypothesize that Gold Rush features 7 and 14 (rapidly deposited and temporally controlled deposits) accumulated during the winter months due to their relative abundance of ducks and geese—a test of evenness will support or refute this hypothesis, in addition to the anatid index calculated by the equation Σ(anatids)/ Σ(anatids+Aves) (see Broughton 1994; Broughton et al. 2011).

Nestedness, based on presence or absence of fauna from temporally restricted contexts at TC (on the complete site assemblage), provides a further measure to assess subsistence activities during the Gold Rush. Whereas earlier in this paper we used nestedness to understand recovery biases, in this context nestedness will help determine domestic and wild animal exploitation at the site. We hypothesize that the presence or absence of a diverse range of animals during the pre/early (II-A/A*/B, F. 25) Gold Rush and contrastingly a less-diverse assemblage during the mid (F. 3/31/37, 15, 7, 14)/late Gold Rush and later (F. III-B-I) should be characterized by a nested assemblage and decreasing NTAXA values, indicating a narrowing diet breadth through time with increased use of domestic fauna.

To characterize the relationship between wild and domestic faunal exploitation throughout this period a domesticate abundance index is calculated using the equation ΣDomesticates(Bos taurus+Ovis aries+Capra hircus+Sus scrofa+Gallus gallus)/Σ(Domesticates+Wild Mammals+Birds+Arthropods+Fish) (see Broughton 1994; Broughton et al. 2011). This index (calculated between 0 and 1) provides a ratio of increasing (approaching 1.0) or decreasing (approaching 0.0) exploitation of domesticated animals through time at the site. If domesticates are being increasingly consumed for subsistence through time then the domesticate abundance index should approach 1.0 in later-dated contexts.

To express the relationships of changing faunal use throughout the Gold Rush-era we conclude by providing a synthesis using index measures on discrete cultural features and depositional contexts in this analysis: II-A* (pre-1848), F. 3/31/37

(1848–1849), F. 15 (1851–1853) and context III-B-I (post-1853). These deposits are in-situ and are temporally and stratigraphically controlled at the site. They experienced no significant post-depositional disturbance and were deposited sequentially on top of one another through time (Pastron and Bruner 2014).

Results

An abundant and diverse archaeofaunal assemblage was recovered at TC (Tables 2, 3, 4, and 5). Both C. Conrad and K. Gobalet attempted to identify all specimens to the finest taxon possible, resulting in 50 distinct taxonomic classifications and a total site NISP of 8661. When species identifications could not be determined, specimens were classified to a more inclusive taxon.

Recovery Technique, Fragmentation and Sample Size Biases

Use of different mesh sizes and recovery techniques at TC suggested that differential sample size biases affected faunal composition in stratigraphic contexts at the site. A chi-squared test of independence suggests this indeed is the case (Table 6). In all four features with differential recovery techniques applied (F. 25, 3/31/37, 15 and 7), significant differences ($p<0.01$) were found between the 3.2 mm mesh specimens, to hand collected and 6.4 mm mesh specimens. Each feature is not nested, based off of this analysis (comparing the presence/absence of all taxonomic groups) between differential recovery techniques within features (see Table 6). Recovery technique does seem to be influencing taxonomic abundance in the TC assemblage; in contexts where larger screen sizes were used, small animals are underrepresented. The fish index supports this conclusion, with over 70 % of the fish remains recovered only through 3.2 mm mesh. Feature 25 had 39 % of these fish specimens, feature 15 has 61 % and feature 3/31/37 and 7 each had 0 %.

Since screen size differentially affects the recovery of faunal elements between contexts at TC it is unsurprising that fragmentation also affects the TC assemblage. The ratio between NRSP/NISP is fairly consistent between features without differential recovery techniques employed (see Table 6), but vary more widely between F. 25, 3/31/37, 15 and 7, where differential recovery techniques were employed. Effects of fragmentation are expected to be lower for specimens collected by hand and screened through 6.4 mm mesh only because they are generally larger sized and more readily identifiable remains. Contrastingly, where smaller sized specimens are recovered, within the 3.2 mm mesh screen deposits, the effects of fragmentation is expected to vary more widely as a larger abundance of specimens, and identifiable specimens, are recovered.

In comparison to recovery technique and fragmentation, sample size is not driving differences in taxonomic abundance between contexts at TC. Results of a regression analysis between NISP and NTAXA indicate that a significantly correlated relationship is present at the site ($r=0.911$, $p<0.001$; Fig. 3). This test included samples which were collected by all three recovery techniques, and thus explains that while differential recovery is affecting the overall taxonomic composition of the assemblage (smaller

Table 2 Number of identified arthropod and mollusk specimens per context and date at TC

Taxon	Common name										
	Date	1840–1853	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853	1860–1870	1907	Re. 1853	1860–1907
Taxon	Stratum	Bay Mud II-A	Stratum Unit II-B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	F. 24	F. 23	Stratum III-A	Stratum Unit III-B-I
Mytilus sp.	Mussel	1 (U)		50 (F)								
Mytilus californianus	California Mussel			182 (15U/167 F)								
Mytilus edulis	Blue Mussel	1 (U)		35 (18U/17 F)	16 (7U/9 F)		128 (22U/106 F)	2 (U)			14 (1U/ 13 F)	2 (F)
Ostrea lurida	Native Pacific Oyster	7 (4U/3 F)	1 (F)	63 (57U/6 F)	6 (4U/2 F)	2 (F)	31 (7U/24 F)	6 (U)	6 (U)	149 (136U/ 13 F)	3 (U)	8 (U)
Clinocardium nuttallii	Nuttal Cockle	1 (F)										
Macoma nasuta	Bent-nose Macoma	4 (2U/2 F)									1 (F)	
Protothaca sp.	Littleneck Clam			127 (F)								
Protothaca staminea	Pacific Littleneck	2 (U)		29 (U)		8 (F)	6 (1U/5 F)	1 (U)				1 (F)
Saxidomus nutalli	Washington Clam							2 (U)			4 (2U/2 F)	
Mya arenaria	Softshell Clam										1 (U)	
Bivalve	Bivalve			100 (F)		2 (F)					1 (F)	
Haliotis sp.	Abalone						1 (F)					
Acmaea mitra	Whitecap Limpet										2 (1C/1 F)	
Cerithidea californica	California Hornsnail											1 (F)
Cypraea spadicea	Chestnut Cowrie										1 C	
Volvarina taeniolata	California Margin						1 C					

Table 2 (continued)

Taxon	Common name											
	Date	1840–1853	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853	1860–1870	1907	Re. 1853	1860–1907
	Stratum	Bay Mud II-A	Stratum Unit II-B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	F. 24	F. 23	Stratum III-A	Stratum Unit III-B-I
Gastropod	Gastropod			3 (F)		8 (F)						
Malacostraca	Crabs			14 (F)		23 (F)						
Maxillopoda	Barnacle			12 (F)								
Polyplacophora	Chiton						1 (F)					
Invertebrate, unid.	Invertebrate			1 (F)		1 (F)						
	Arthropod ∑	16	1	616	22	44	168	11	6	149	27	12

Mollusks are additionally labeled by U=Specimens with umbo/hinge present, F=Fragmented specimens only and C=Specimens which are complete. Re.=Redeposited

Table 3 Number of identified avian specimens per context and date at TC

	Common name									
	Date	1840–1853	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853	Re. 1853	1860–1907
Taxon	Stratum	Bay Mud II-A	Stratum Unit II-B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Stratum III-A	Stratum Unit III-B-I
Bubo sp.	Horned Owl					1			1	
Bubo virginianus	Great Horned Owl			1						
Larus sp.	Gulls					3				
Sterna cf. *paradisaea*	Arctic Tern					1				
Meleagris cf. *gallopavo*	Turkey			1						
Meleagris gallopavo	Turkey			1	3	1			1	2
Gallus cf. *gallus*	Chicken			1					2	
Callipepla cf. *californica*	California Quail				1					
Buteo sp.	Hawks							3		
Haliaeetus leucocephalus	Bald Eagle		1							
Anatidae	Duck/Goose			1		7	4			
Anatidae	Goose	10			1	3	24	2	1	1
Anatidae	Duck					1	4	1	1	
Anas sp.	Dabbling Ducks						2	1		
Anas americana	American Wigeon							1		
Anas discors	Blue-winged Teal							1		
Anas cf. *platyrhynchos*	Mallard			1						
Anas platyrhynchos	Mallard		1	52	4	13	1	2	1	
Melanitta deglandi	White-winged Scoter						1			
Anser sp.	Grey Geese			6			4			1

Table 3 (continued)

Taxon	Common name									
	Date	1840–1853	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853	Re. 1853	1860–1907
	Stratum	Bay Mud II-A	Stratum Unit II-B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Stratum III-A	Stratum Unit III-B-I
Chen sp.	White Geese					1				
Chen caerulescens	Snow Goose	1				11	5	1	1	2
Branta bernicla	Brant Goose						3			
Branta cf. *bernicla nirgricans*	Black Brant Goose					1				
Branta cf. *canadensis*	Canada Goose	1		1	1					
Branta canadensis	Canada Goose			6		3	9		1	1
Ardea cf. *herodias*	Great Blue Heron								2	
Ardea herodias	Great Blue Heron				2	1				
Botaurus lentiginosus	American Bittern						1			
Phalacrocorax auritus	Double-crested Cormorant								1	2
Aves, small	–		1	6	3	10	8			
Aves, medium	–			1		1	6			
Aves, unid.	–			71						
	Avian ∑	12	3	149	15	58	72	12	12	9

Re. Redeposited

Table 4 Number of identified mammalian and chelonian specimens per context and date at TC

Taxon	Common name											
	Date	1840–1853	Pre-1848	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853		Re. 1853	1860–1907
	Stratum	Bay Mud II-A	Bay Mud II-A*	Stratum Unit II-B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Concentration B	Stratum III-A	Stratum Unit III-B-I
Sylvilagus sp.	Rabbits					1						
Lepus sp.	Hares and Jackrabbits				6							
Lepus californicus	Black-tailed Jackrabbit							2			1	
Rodentia	Rodents				7	1	7	8				
Mus sp.	Mice				1							
Rattus norvegicus	Brown Rat					2	1	1				
Sciuridae	Squirrels							2				
Phoca cf. *vitulina*	Harbor Seal										1	
Canis lupus familiaris	Domestic Dog										2	
Felis cf. *catus*	Domestic Cat							1				
Felis catus	Domestic Cat				1							
Artiodactyla	Even-toed Ungulates	4						42	2		3	3
Bovidae	Sheep/Goats					4	3	78		1	21	
Bos cf. *taurus*	Domestic Cattle	19	4	13	16	15	5				6	
Bos taurus	Domestic Cattle	125	13	23	187	61	172	588	69	25	187	51
Capra cf. *hircus*	Domestic Goat				5	1					2	
Capra hircus	Domestic Goat	1			1				2		5	1
Ovis cf. *aries*	Domestic Sheep		1		2							
Ovis aries	Domestic Sheep	7	3	2	1	2	12	74	7		6	2

Table 4 (continued)

Taxon	Common name											
	Date	1840–1853	Pre-1848	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853		Re. 1853	1860–1907
	Stratum	Bay Mud II-A	Bay Mud II-A*	Stratum Unit II-B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Concentration B	Stratum III-A	Stratum Unit III-B-I
Cervus cf. *elaphus nannodes*	Tule Elk			1		4	1					
Cervus elaphus nannodes	Tule Elk	13					1					
Odocoileus cf. *hemionus*	Mule Deer/Black-tailed Deer	1			1			1				
Odocoileus hemionus	Mule Deer/Black-tailed Deer	3		1	19		1					1
Odocoileus hemionus californicus	California Mule Deer				7							
Odocoileus hemionus columbianus	Columbian Black-tailed Deer				2							
Sus cf. *scrofa*	Domestic Pig	4			17	8	7		2	2	2	2
Sus scrofa	Domestic Pig	27	1		101	6	45	164	12	2	45	8
Mammalia, small	–				75	114	5	83			2	1
Mammalia, medium	–	3		2	34	16	50	170			12	8
Mammalia, large	–	1	1	3	49	2	3		3		2	1
Mammalian, unid.	–	3			390	114	553	79			1	1
	Mammalian ∑	211	23	45	922	351	866	1293	97	30	298	79
Cheloniidae	Sea Turtle	1										
Chelonoidis sp.	Galapagos Tortoise				2							
	Chelonian ∑	1	0	0	2	0	0	0	0	0	0	0

Re. Redeposited

Table 5 Number of identified fish specimens per context and date at TC

Taxon	Common name								
	Date	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853	Re. 1853	1860–1907
	Stratum	Bay Mud II-A	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Stratum III-A	Stratum Unit III-B-I
Rajiformes	Skates and Rays (not Bat Ray)				1				
Acipenser sp.	White or Green Sturgeon	1	13			3			1
Clupeidae	Herring/Sardine		24		22	11			
	Scales		14		12	1			
Clupea pallasii	Pacific Herring		1			1			
Oncorhynchus sp.	Pacific Salmon and Steelhead		4	1	13	3			
Oncorhynchus tshawytscha	Chinook Salmon		3		17				
Cyprinidae	Minnow/Carp					2			
Ptychocheilus grandis	Sacramento Pikeminnow				6	4	1		1
Catostomus occidentalis	Sacramento Sucker					1			
Gadus sp.	Atlantic or Pacific Cod		10		2	6			
Microgadus proximus	Pacific Tomcod		26			1			
Atheriniopsidae	New World Pacific Silversides		60		214	40			
	Scales		233		830	9			
Atherinopsis californiensis	Jacksmelt		6		19	1			
Sebastes sp.	Rockfishes	3	4		2	4		6	
	Scales				5				
Ophiodon elongatus	Lingcod						1		
Sciaenidae	Drums and Croakers		1						

Table 5 (continued)

Taxon	Common name								
	Date	1840–1853	1840–1853	1848–1849	1850–1853	Re. 1853	Re. 1853	Re. 1853	1860–1907
	Stratum	Bay Mud II-A	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Stratum III-A	Stratum Unit III-B-I
Embiotocidae	Surfperches		8		3	2			
Embiotoca sp.	Black or Striped Surfperch		3						
Scomber japonicus	Pacific Chub Mackerel		2		8	4			
Actinopterygii	Ray-finned Fishes	3	148		268	33	4		
	Scales		355		538	1			
	Fish ∑	7	915	1	1960	127	6	6	2

Re. Redeposited

Table 6 Results of recovery technique (chi-squared and nestedness) and fragmentation (NRSP/NISP) analyses

Context	χ^2	Nestedness	NRSP/ NISP	Fish(1/8)/ Fish(Total)
Bay Mud II-A/A*/B	–	–	1.06	–
25	χ^2=1964.77, p<0.001, df=59	NODF=43, p>0.05 – T=29, p>0.05	1.97	0.97
3/31/37	χ^2=344.15, p<0.01, df=24	NODF=33, p>0.05 – T=31, p>0.05	2.90	1.00
15	χ^2=653.54, p<0.001, df=48	NODF=45, p>0.05 – T=16, p>0.05	1.29	0.71
7	χ^2=1070.99, p<0.001, df=47	NODF=51, p>0.05 – T=22, p>0.05	1.26	1.00
14	–	–	1.02	–
Stratum III-A	–	–	1.06	–
Stratum III-B-I	–	–	1.12	–

All taxonomic classifications and associated NISP values are examined in the chi-squared and nestedness tests. NISP for NRSP/NISP was calculated using values from the Order-Species classification. Values calculated only for contexts with NISP>100 and Taxa>1

sized fauna are recovered less often when hand collection and 6.4 mm sized mesh is used) the sample size within each context is not significantly impacting the overall taxonomic composition of the assemblage.

Faunal Deposition, Economic and Subsistence Change

Several items were quantified to understand archaeofaunal discard and site formation at TC. Vivianite mineralization is visually identifiable on several specimens at TC (Table 7).

Mineralization is also most abundant in deposits dating to the pre and early-Gold Rush period (1840–53). During this period bones and shells were discarded along the original shoreline of Yerba Buena Cove and subjected to a tidal regime resulting in distinctive taphonomic signatures.

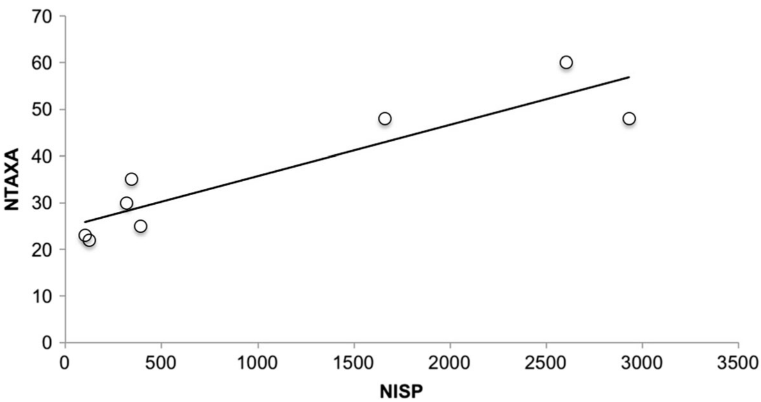

Fig. 3 Regression relationship between NISP and NTAXA (y=24.745+x0.011; r=0.911, p<0.001). Values calculated only for contexts with NISP>100 and NTAXA>1

Table 7 NISP per context with mineralization of vivianite visually identified

Feature	Arthropods	Aves	Mammals	Reptiles	Fish	Σ	%Total in context
Stratum II-A/A*/B	–	1	46	–	–	47	0.15
F. 25	–	–	3	–	–	3	0.00
F. 3/31/37	–	–	9	–	–	9	0.02
F. 15	–	4	42	–	–	46	0.02
F. 7	–	1	233	–	–	234	0.14
F. 14	–	1	11	–	–	12	0.10
Stratum III-A	–	2	35	–	–	37	0.11
Strata III-B-I	1	4	18	–	–	23	0.23
F. 1/33	–	–	1	–	–	1	0.25
Concentration B	–	–	6	–	–	6	0.19
Σ	1	13	404	0	0	418	

Percent total is from NISP totals per context

Stratum III-A was recognized as dredged and redeposited Bay Mud used as landfill at TC. To compare the composition of this archaeofaunal assemblage with the in-situ bay mud deposits (II-A/A*), a spearmans-rho rank order relationship was calculated. Results indicate that these deposits are not significantly correlated (r_s=0.19, p>0.05). An additional calculation to compare the assemblage of F. 3/31/37 and stratum II-A*, recovered from directly underneath the latter feature, indicates that these contexts are significantly correlated (r_s=0.43, p<0.05). Indicating that while the dredged and redeposited Bay Mud derives from a different location within Yerba Buena Cove, it is deposited during the same temporal period and is not intrusive material from later in the nineteenth century.

A comparison of skeletal element representation for cattle, tule elk and deer at the site reflect aspects of the California hide and tallow trade, specifically for maritime provisioning within TC (Table 8). In the earliest deposits at TC (Unit II-A/B, F. 25/29 and F. 3/31/37) the distribution of skeletal elements suggests that these species may have been discarded as complete carcasses, after hide and tallow processing occurred, as discussed earlier. Aspects of the hide and tallow trade are evidenced by the higher abundance of low-utility elements and a lower abundance of high-utility elements at the site (Gust 1982). Cattle specimens, in particular were also more complete within these contexts (i.e., less subjected to butchering; Fig. 4). Interestingly, the relative relationship between cattle elemental discard between the pre/early (Unit II-A/B, F. 25 and F. 3/31/37) and mid/late (F. 15, 7 and 14) Gold Rush does not differ significantly (r_s=0.70, p<0.05) but the relationship between tule elk and deer throughout the pre/early and mid/late-Gold Rush does differ (r_s=−0.94, p>0.05). These results suggest that during the earliest deposits at TC material evidence of the hide and tallow trade is present in the faunal assemblage, likely for maritime provisioning (see below). In addition, overall skeletal

Table 8 Skeletal element representation (NISP) for cattle (*Bos taurus*), tule elk (*Cervus elaphus nannodes*) and deer (*Odocoileus hemionus*)

Element							
Cattle	Bay Mud II-A/A*/B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Stratum III-A
Cranial	13			1	2	15	10
Mandible	16					5	1
Cervical Vertebra	1	2	1	2	23		4
Thoracic Vertebra	8	8	3	16	42	3	10
Lumbar Vertebra	5	12	2		19	1	15
Sacral Vertebra		2		2	4		3
Unidentified Vertebra	3	6	6	7	16		5
Innominate	13	15	1	9	31	2	12
Rib	81	92	35	81	217	19	92
Sternebra				8	2		
Scapula	5	9		8	69	7	15
Humerus	8	5	5	5	26	1	9
Radius	6	5	2	5	16	2	12
Ulna		4		2	9		11
Metacarpal	8				3		1
Carpal		2		5	8		2
Femur	14	4	9	15	82	13	18
Patella	1						
Tibia	8	10	7	8	14	1	14
Metatarsal	6	4	1	1	2		2
Calcaneus		5	3		2		2
Astragalus	1	2		1			
Metapodial		6			1		
Phalanx		10	1	1			1
Σ	197	203	76	177	588	69	239
Tule Elk							
Cranial							
Mandible							
Cervical Vertebra							
Thoracic Vertebra							
Lumbar Vertebra							
Sacral Vertebra							
Unidentified Vertebra							
Innominate	1						
Rib			1				

Table 8 (continued)

Element							
Cattle	Bay Mud II-A/A*/B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Stratum III-A
Sternebra							
Scapula			1				
Humerus			1				
Radius				1			
Ulna							
Metacarpal							
Carpal							
Femur	4		1				
Patella							
Tibia	8						
Metatarsal							
Calcaneus	1						
Astragalus							
Metapodial							
Phalanx				1			
Σ	14	0	4	2	0	0	0
Deer							
Cranial							
Mandible							
Cervical Vertebra	1	2					
Thoracic Vertebra							
Lumbar Vertebra		1					
Sacral Vertebra							
Unidentified Vertebra							
Innominate	1	4					
Rib		3					
Sternebra							
Scapula		2					
Humerus		1					
Radius		1					
Ulna		2					
Metacarpal							
Carpal							
Femur	1	5			1		1
Patella							
Tibia	1	5		1			

Table 8 (continued)

Element							
Cattle	Bay Mud II-A/A*/B	F. 25	F. 3/31/37	F. 15	F. 7	F. 14	Stratum III-A
Metatarsal	1	3					
Calcaneus							
Astragalus							
Metapodial							
Phalanx							
Σ	5	29	0	1	1	0	1

All NISP values include cf. taxonomic identifications, phalanges include sesamoids and ribs include costal cartilage identifications. Not including unidentified long bone elements

discard does not shift between the 1840s–53. Instead, the use of cattle primarily changes to suggest local consumption (steak cuts and market consumption) in San Francisco (non-maritime activity). Tule elk and deer distribution suggests that only during the pre/early (1840s)-Gold Rush were these species heavily consumed.

Important fluctuations in the consumption of wild and domestic species occurred throughout the Gold Rush at TC. Simpson's E and 1/D dietary evenness were calculated between contexts at the site (Table 9). To limit the effect of aggregation biases during calculation, different contexts were grouped to examine temporal patterns. Here, we subdivided contexts based upon depositional history

Fig. 4 Cattle (*Bos taurus*) specimens from Bay Mud II-A. Notice transverse disarticulation cuts across the proximal ends of both femora

Table 9 Dietary evenness between contexts at TC

Context	Simpson's E	1/D
Bay mud II-A/A*/B	0.12	3.19
25	0.23	10.62
3/31/37	0.23	4.38
15	0.13	4.70
7	0.10	3.92
14	0.14	2.81
Stratum III-A-I	0.08	2.86
Bay Mud II-A/A*/B, F. 25	0.17	9.27
F. 3/31/37, F. 15	0.13	5.31
F. 7, F. 14	0.08	3.92
Bay Mud II-A/A*/B, F. 25, F. 15	0.14	8.90
F. 3/31/37	0.23	4.38
F. 7, F. 14	0.08	3.92

Only including contexts with NISP>100, NTAXA>1 and taxonomic classifications from the Family lower, not including fish scales

in an attempt to understand subsistence activity. Generally, the faunal assemblage is less even in the earliest dated contexts (1840s), more even during the mid-contexts (~1851) and less even again in the late (1853) Gold Rush. Avian evenness tends to decrease through time while the anatid index initially decreases then increases throughout the Gold Rush, suggesting increased exploitation of a narrowing diversity of birds – focusing on ducks and geese (Table 10).

Overall an analysis of nestedness and NTAXA through time at TC suggests a fairly well nested assemblage at the site (NODF=53, $p>.05$, T=28, $p<0.05$) (Table 11). Indicating that from the 1840s–53 each subsequent context is a representative subset of previous contexts with diminishing taxonomic richness over time. Nestedness was calculated by grouping contexts Bay Mud II-A/A*/B and F. 25, F. 3/31/37 and F. 15, F. 7 and F. 14 and Stratum III-B-I. Results of the domesticate abundance index at the site describes an increasing use of domesticated animals over time (Table 12). These values are not significantly related to sample size ($r_s=0.04$, $p>0.05$) suggesting that consumption activity, rather than sample size, is driving the results.

Analysis of the faunal assemblage from stratum II-A*, F. 3/31/37, F. 15 and Stratum III-B-I shows a pattern of transitioning faunal exploitation and consumption throughout

Table 10 Avian evenness and the anatid index

Context	Anatid index	Simpson's E	1/D
F. 25	0.94	0.80	7.98
F. 15	0.85	0.69	9.02
F. 7, F.14	0.94	0.57	7.93

Values calculated by including all contexts with avian NISP>20 and NTAXA>1 (not including Aves specimens)

Table 11 Presence/absence nestedness table

Taxa	Bay Mud II-A/A*/B, F. 25	F. 3/31/ 37. F. 15	F. 7, F. 14	Stratum III-B-I
Mytilus sp.	+	−	−	−
Mytilus californianus	+	−	−	−
Mytilus edulis	+	+	+	+
Ostrea lurida	+	+	+	+
Clinocardium nuttallii	+	−	−	−
Macoma nasuta	+	−	−	−
Protothaca sp.	+	−	−	−
Protothaca staminea	+	+	+	+
Saxidomus nutalli	−	−	+	−
Haliotis sp.	−	−	+	−
Cerithidea californica	−	−	−	+
Volvarina taeniolata	−	−	+	−
Bubo sp.	−	+	−	−
Bubo virginianus	+	−	−	−
Larus sp.	−	+	−	−
Sterna cf. *paradisaea*	−	+	−	−
Meleagris gallopavo	+	+	−	+
Gallus cf. *gallus*	+	−	−	−
Callipepla cf. *californica*	−	+	−	−
Buteo sp.	−	−	+	−
Haliaeetus leucocephalus	+	−	−	−
Anas sp.	−	−	+	−
Anas americana	−	−	+	−
Anas discors	−	−	+	−
Anas platyrhynchos	+	+	+	−
Melanitta deglandi	−	−	+	−
Anser sp.	+	−	+	+
Chen sp.	−	+	−	−
Chen caerulescens	+	+	+	+
Branta bernicla	−	−	+	−
Branta cf. *bernicla nirgricans*	−	+	−	−
Branta canadensis	+	+	+	+
Ardea herodias	−	+	−	−
Botaurus lentiginosus	−	−	+	−
Phalacrocorax auritus	−	−	−	+
Sylvilagus sp.	−	+	−	−
Lepus sp.	+	−	−	−
Lepus californicus	−	−	+	−
Mus sp.	+	−	−	−
Rattus norvegicus	−	+	+	−

Table 11 (continued)

Taxa	Bay Mud II-A/A*/B, F. 25	F. 3/31/ 37. F. 15	F. 7, F. 14	Stratum III-B-I
Felis catus	+	–	+	–
Bos taurus	+	+	+	+
Capra hircus	+	+	+	+
Ovis aries	+	+	+	+
Cervus elaphus nannodes	+	+	–	–
Odocoileus hemionus	+	+	+	+
Odocoileus hemionus californicus	+	–	–	–
Odocoileus hemionus columbianus	+	–	–	–
Sus scrofa	+	+	+	+
Cheloniidae	+	–	–	–
Chelonoidis sp.	+	–	–	–
Acipenser sp.	+	–	+	–
Clupea pallasii	+	–	+	+
Oncorhynchus sp.	+	+	+	–
Oncorhynchus tshawytscha	+	+	–	–
Ptychocheilus grandis	–	+	+	+
Catostomus occidentalis	–	–	+	–
Gadus sp.	+	+	+	–
Microgadus proximus	+	–	+	–
Atherinopsis californiensis	+	+	+	–
Sebastes sp.	+	+	+	–
Ophiodon elongatus	–	–	+	–
Embiotoca sp.	+	–	–	–
Scomber japonicus	+	+	+	–

Genus/Species only (merged with cf.) NODF=53, $p>0.05$ – T=28, $p<0.05$

the Gold Rush and later-nineteenth century. The domesticate index decreases through time, but stabilizes by the 1850s (1851–53) and onto the later nineteenth century (1860s–1907) (Table 13).

Taxonomic evenness initially increases from pre-1848 to 1853 then decreases slightly from the 1860s onwards. Although stratum III-B-I represents a combination of fill deposits and in-situ features from the later-nineteenth century (aggregated), its inclusion here helps to frame broad-trends in faunal resources throughout this period.

Discussion

The archaeofaunal record at TC provides one of the most extensive records of Euro-American subsistence activity form California's Gold Rush era. Our discussion summarizes the results and interpretations of: (1) recovery technique and composition of the

Table 12 Domesticate abundance index

Context	Domesticate abundance index
Bay Mud II-A/A*/B	0.87
25	0.53
3/31/37	0.75
15	0.69
7	0.91
14	0.81
Stratum III-A	0.86
Bay Mud II-A/A*/B, F. 25	0.45
F. 3/31/37, F. 15	0.64
F. 7, F. 14	0.80
Bay Mud II-A/A*/B, F. 25, F. 15	0.50
F. 3/31/37	0.75
F. 7, F. 14	0.80

Values calculated by including contexts with NISP>100 and NTAXA>1. Only Genus/Species (combined with cf.) and Bovidae. Domesticates include: cattle, sheep, goats, pigs and chickens. Turkeys are not considered domesticates as they were imported food items during this time

faunal assemblage (2) depositional history of the faunal assemblage (3) evidence of the hide and tallow trade (4) shifting wild and domestic faunal utilization and (5) significance of imported non-native species identified at the site.

Recovery and Composition of Faunal Assemblage

Recovery technique, fragmentation and sample size are integral for understanding the taphonomic condition of the faunal assemblage. Results of the chi-squared analysis indicate that differential recovery is affecting the TC assemblage. Presence and absence of fish remains appears to be the primary driver of the differences in recovery (see Table 6). Nestedness analysis also supported this determination, with each feature being relatively not nested.

Loss of fish remains through large screen size sampling can be extremely detrimental to understanding the accurate composition of an archaeofaunal assemblage (Nagaoka 2005; Quitmyer 2004). It is also important to note that aside from fish, small mammals, birds, non-avian reptiles and arthropods can also suffer detrimental impacts

Table 13 Domesticate index and evenness values for intact contexts at TC

	II-A*	F. 3/31/37	F. 15	Stratum III-B-I
Domesticate Index	0.96	0.75	0.69	0.66
Simpson's E	0.49	0.23	0.13	0.17
1/D	3.19	4.38	4.70	2.92

of incomplete sampling (Schaffer 1992; Stahl 1996). At TC, although significant differences do exist between the 3.2 mm, hand collected and 6.4 mm samples, the inclusion of 6.4 mm sampling on feature 25, 3/31/37, 15 and 7 allows for partial control of archaeofaunal sampling. Our analyses show that features without 6.4 mm sampling are lacking the full suite of smaller sized animals. This is consistent with an in-field faunal recovery program focused on collecting large diagnostic material due to lack of time and the difficulty of excavation. Employing a fine-mesh size screening strategy helped to offset these biases at TC, and expresses the importance of fine-mesh screening at archaeological sites. The use of these techniques at TC now provides one of the most extensive, based on abundance and diversity, Gold Rush-era assemblages in San Francisco (Table 14). Cultural resource legislation and contractual agreements will ultimately determine sampling protocols in CRM projects, but any attempt to include small-size mesh sampling in archaeological deposits will greatly increase the ability to provide an accurate representation of all fauna, and other artifact classes, within a site.

In features without differential sampling the fragmentation ratio (NRSP/NISP) is almost equal, but the fragmentation ratio is highly variable in features with 3.2 mm recovery technique employed. The variation in NRSP/NISP for feature 25, 3/31/37, 15 and 7 suggests that fragmentation is affecting these contexts more intensely—which is expected given the higher degree of smaller and less-identifiable specimens. As previously explained, we did not include analyses of MNI, bone density and bone size at TC. In the future, it may be possible to further identify fragmentation biases if these analyses are employed, but here we argue that fragmentation does not impact the archaeofaunal assemblage highly enough to discount NISP as an ordinal scale measure for accurate quantification purposes; especially given the significant relationship between NISP and NTAXA (see Fig. 3). Sample size results indicate that even with differential recovery employed, the overall sample size per context is correlated.

Investigations of recovery technique, fragmentation and sample size are important to TC because they allow for a broad understanding of the composition of the faunal assemblage. In features 25, 3/31/37, 15 and 7 the inclusion of 3.2 mm sampling provides a higher resolution of the archaeofaunal composition. Fragmentation occurs differentially across the site, which is identified because of differential recovery technique, and sample size results indicate that even in contexts where 3.2 mm sampling did not occur, sample size influences are limited. In CRM contexts, employing a fine-mesh recovery technique will thus greatly enhance our understanding of the complete site assemblage and faunal dynamics. Multiple context fine-mesh sampling at TC allows for a robust identification of several species (fish and mollusks in particular) that may have been lost to the archaeological record if only hand collection techniques were used. Quantifying these measures provides a greater resolution and interpretative value of the TC assemblage.

Depositional History

Prior to the onset of the California Gold Rush during the late-1840s, the shallow (6–18 ft [1.8–5.5 m] deep) and relatively large (336 ac [136 ha]) Yerba Buena Cove would have been a busy site of human activity (Delgado 2009, pp. 54–60). Merchant vessels

Table 14 Gold Rush era, and later-nineteenth century San Francisco sites with archaeofaunal assemblages

Taxon	Date Common Name	1851 343 Sansome Street[1]	1849–1852 100 First Street[2]	1850–1880 Wing Lee Laundry: Feature 5/11[3]	1840–1857 CCSF Chinatown/ North Beach Campus Project: Feature 2[4]	1852–1857 Notre Dame Plaza[5]	1880–1900 Valencia Gardens Feature 2[6]	1870-1910 CA-SFR-125H[7]
Mytilus sp.	Mussels							X
Ostrea lurida	Native Pacific Oysters							X
Protothaca sp.	Littleneck Clams							X
Haliotis sp.	Abalone							X
Invertebrate	Invertebrates							X
Meleagris gallopavo	Turkey			X				
Gallus gallus	Chicken			X			X	
Anseriforms	-	X					X	
Anatidae-Duck/Goose	Duck/Goose				X			
Anatidae-Goose	Goose			X				
Anatidae-Duck	Duck			X		X		
Anas sp.	Dabbling Ducks		X					
Anser sp.	Grey Geese	X						
Anser albifrons	Greater White-fronted Goose	X						
Anser albifrons/*Chen caerulescens*	Greater/Snow Goose	X						
Chen sp.	White Geese		X					
Chen caerulescens	Snow Goose	X						
Gruiformes	Cranes						X	
Turdus cf. *migratorius*	American Robin					X		

Table 14 (continued)

Taxon	Date / Common Name	1851 / 343 Sansome Street[1]	1849–1852 / 100 First Street[2]	1850–1880 / Wing Lee Laundry: Feature 5/11[3]	1840–1857 / CCSF Chinatown/ North Beach Campus Project: Feature 2[4]	1852–1857 / Notre Dame Plaza[5]	1880–1900 / Valencia Gardens Feature 2[6]	1870-1910 / CA-SFR-125H[7]
Aves, unidentified	-	X		X	X	X	X	X
Sylvilagus sp.	Rabbits		X			X		X
Lepus californicus	Black-tailed Jackrabbit						X	
Rodentia	Rodents			X			X	X
Rattus sp.	Rats				X			
Sciuridae	Squirrels						X	
Carnivora	Carnivores				X			
Procyon lotor	Raccoon						X	
Ursus arctos horribilis	Grizzly Bear	X						
Canis sp.	Dog	X						
Canis lupus familiaris	Domestic Dog				X			
Felis catus	Domestic Cat		X	X			X	
Artiodactyla	Even-toed Ungulates	X			X	X		
Bovidae	Sheep/Goats	X				X		X
Bos cf. *taurus*	Domestic Cattle				X			
Bos taurus	Domestic Cattle	X	X	X	X	X	X	X
Ovis aries	Domestic Sheep	X	X	X				
Cervus elaphus spp.	Elk	X						
Odocoileus cf. *hemionus*	Mule Deer/Black-tailed Deer				X			
Odocoileus hemionus	Mule Deer/Black-tailed Deer	X						

Table 14 (continued)

	Date	1851	1849–1852	1850–1880	1840–1857	1852–1857	1880–1900	1870-1910
Taxon	Common Name	343 Sansome Street[1]	100 First Street[2]	Wing Lee Laundry: Feature 5/11[3]	CCSF Chinatown/ North Beach Campus Project: Feature 2[4]	Notre Dame Plaza[5]	Valencia Gardens Feature 2[6]	CA-SFR-125H[7]
Sus cf. *scrofa*	Domestic Pig				X			
Sus scrofa	Domestic Pig	X	X	X	X	X	X	X
Mammalia, small	-			X	X	X	X	
Mammalia, medium	-		X	X	X	X	X	
Mammalia, large	-		X	X	X	X		
Mammalian, unidentified	-			X	X	X	X	X
Embiotocidae	Surfperches				X	X		
Actinopterygii	Ray-finned Fishes	X		X	X	X		X

Fauna reported in gray literature reports and has not been subject to peer review. As such only presence/absence reported here

[1] Kelly (1989)

[2] Pastron (1987)

[3] Pastron and Beevers (2003)

[4] Pastron and Bruner (2012)

[5] Ambro (2003)

[6] Pastron and Robichaud (2007)

[7] Self and Miller (1996)

would arrive at the cove bringing goods to trade with Spanish Californians who provided cattle hides for the textile (i.e., leather) industry in Boston and tallow for candle and cooking around the globe. With the commencement of the Gold Rush in 1848, the cove became even busier. Hundreds of ships arrived in the cove in 1849 alone, as thousands flocked to the gold fields. Yerba Buena Cove itself was a sluggish pond of thick mud during periods of low tide (Delgado 2009, p. 54). Refuse discarded from vessels or along the shoreline of the cove would have either sunk to the bottom and become lodged in Bay Mud or, lighter items would have become incorporated in the tidal flow. Prior to the Gold Rush, Yerba Buena Cove was considered the primary location of discard for refuse, including animal carcasses. At low tide, when carcasses would be in the open air, the stench was considered so foul that in 1847 a law was passed banning the killing of birds, like vultures, that would scavenge the animal carcasses in the cove and help spur removal of the rotting flesh (Richards 2009, p. 27). Utilizing the cove for refuse discard continued throughout the late-1840s until the cove was intentionally filled during land reclamation in the early-1850s. At TC, several contexts were characterized as Bay Mud, or shoreline tidal deposits, confirming this historical record of refuse discard.

Presence of the mineral vivianite on several faunal specimens at TC also supports this conclusion. At TC the largest abundance of specimens with vivianite mineralization present occurred in contexts discarded directly into the cove or along the original shoreline from 1840 to 53, prior to infilling. Furthermore, vivianite is easily identified on archaeofaunal specimens at the site because of its notable dark-blue and black coloration (Fig 5a and b). As a taphonomic marker, vivianite is important because it provides additional evidence to support the shoreline and tidal discard of the TC archaeofaunal materials. Feature 7 provided the highest abundance of specimens containing vivianite (see Table 7). This feature is categorized as a redeposited discard deposit (similar to F. 14) that became incorporated at the site in 1853 during filling of the cove, but originating from a previously unknown location—vivianite mineralization allows us to positively classify this feature as a dredged Bay Mud deposit originating within Yerba Buena Cove itself.

Interestingly, not only is vivianite present at TC but it appears at additional Gold Rush era archaeological sites situated in, or along, the original shoreline of the cove. At the storeship *Niantic* (at the corner of Clay and Sansome Streets) that beached in 1849 and burned in the May 4, 1851 fire, only to be excavated in the late-1970s and early-1980s, vivianite mineralization was documented on archaeofaunal specimens at the site using X-ray diffraction (Smith 1981, pp. 183–184). The storeship burned to the water line and subsequently became inundated in the cove, resulting in submersion of the faunal remains within the vessel. Iron fasteners and fitters from the *Niantic* were suggested as possible sources of iron for the precipitation of the mineral. A close reading of the faunal report from the warehouse site on Howison's Pier (343 Sansome Street), which also burned during the May 4, 1851 fire, suggests that vivianite mineralization may have been present at this site as well (Kelly 1989). The warehouse burned along the pier with faunal remains falling into Yerba Buena Cove, and was excavated in the late 1980s. Here the author writes, "some of the bone had a powder blue to dark blue growth on it" (Kelly 1989, p. 63). While no chemical analysis of the encrustations has been performed, our visual identification is consistent with the environmental conditions, and historical faunal deposition of Yerba Buena Cove.

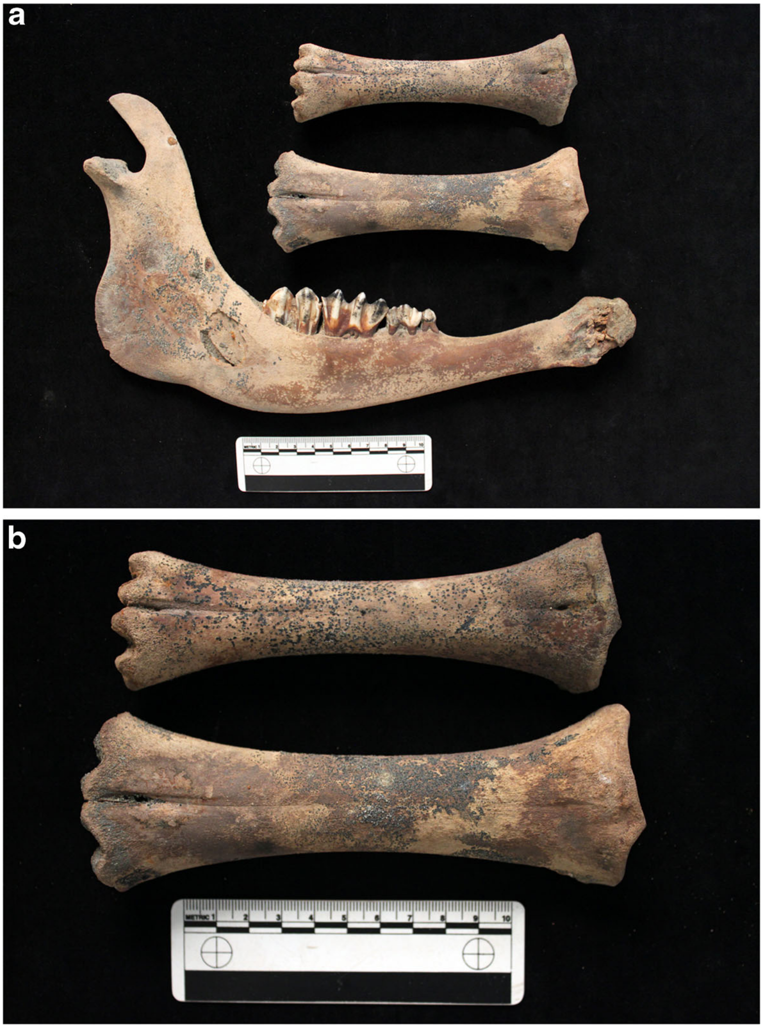

Fig. 5 **a**. Vivianite mineralization on two left cattle (*Bos taurus*) metacarpals and one left mandible from Bay Mud II-A deposits. **b**. Close up of vivianite mineralization on two left cattle (*Bos taurus*) metacarpals from Fig. 5a

Hide and Tallow Activity

When domesticated organisms were introduced to California they dramatically altered the subsistence and commercial activity of people living within the San Francisco Bay region. Spanish Californians (Californios) primarily consumed beef, but also had a diet rich in wheat, barley, corn, grapes, and citrus—all aspects of a mixed Mediterranean-Mexican derived diet (Hakel 2005). Sheep were primarily used for wool, goats were few until after the onset of the Gold Rush, and pigs were describing as being butchered primarily for lard (Davis 1967). Fruits and vegetables were not grown in large quantities, and wild game was rarely hunted for food (generally only foreign visitors would actively hunt and eat wild game). Beef was the primary component of the Californio diet (Bancroft 1888, p. 194; Davis 1967; Duhaut-Cilly 1999) as systems of ranchos were established across Alta California. As Soulé et al. (1854, p. 360) write, "[i]n 1849, the announcement of a real cabbage at dinner would have set half the population frantic with strangely stirred appetites," largely because Alta California could not cope with the massive abundances of fresh fruits and vegetables needed once the argonauts arrived.

After Mexican independence, the massive rancho and hacienda cattle populations throughout the bay area resulted in thousands of head of cattle roaming the foothills. In 1832, approximately 151,180 head of cattle were recorded in California Mission herds alone, but the decline of the Mission system resulted in private ranchos becoming the primary source of cattle in California (McLaughlin 2003). First hand observer William Heath Davis (1967) estimates that during the 1830s there were 1,200,000 cattle in California, in large part this reflects the flourishing hide and tallow trade in California during this time.

Cattle were slaughtered annually for their hide, tallow and beef (Davis 1967, pp. 30–32; Gust 1982). Rodeos were used to bring cattle together in communal slaughter grounds where they were killed, laid upon the ground on their side, skinned (in order to remove and preserve the hide) and fat removed for processing (boiling and drying) into tallow. Carcasses of cattle were abandoned at the location of slaughter. Two types of fat are taken for tallow production, the fat lying directly beneath hide (manteca) and interior fat (sebo) (Davis 1967). Californios traded the manteca for tallow but processed the sebo for private consumption (lard/cooking) as it was thought to be of a superior quality. Elk were hunted for the same purpose, but where cattle were rounded up in a rodeo, Californios enjoyed elk hunts for the chase and sport—not for food (Davis 1967). Davis (1967, p.22) writes that, capturing elk was considered a great sport, "on account of the strength, agility, fleetness and fierceness of the elk." Elk were chased, killed, and their hide and tallow removed for the market, but elk tallow was considered superior to cattle because it was whiter, firmer, and made better candles. Once elk were lassoed and killed, they were also laid upon their side, skinned for their hides, fat removed for boiling and processing into tallow, and carcasses abandoned. As an example of the Californio love for beef, even when elk were killed for hide and tallow, their meat was abandoned at the kill site along with the carcass (Duhaut-Cilly 1999, p. 137). Both Duhaut-Cilly (1999, p. 169) and Phelps (1983, pp. 19–20) note that the hide and tallow trade was the primary economic activity in California prior to the Gold Rush. Davis (1967) estimates that between 1800 and 1847 Californios exported 5,000,000 hides and 10,000,000 arrobas (1 arroba equals approximately 25lbs [11.3 kg]) of tallow.

A more precise example of hide and tallow trade activities at TC comes from a historical description of Yerba Buena Cove during the pre-Gold Rush years by Davis (1967, p. 199):

If the tide was up to the beach, then a boat would be sent ashore, or if a bullock was expected, perhaps it would be sighted, with the aid of a glass, from the vessel, and the crew coming ashore, prepared with knives, the animal was dispatched, cut up, and the meat taken aboard, together with the hide, which was stretched above the deck, or against the main rigging, to dry. Sometimes the cattle were killed in the primitive method, and cut up without hoisting, thus leaving more of the blood in the beef. They were so killed and the meat prepared at Thompson's Cove, which was a little bay south of Clark's Point, and between that and Buckalew or Watchman's Point, where Thompson had a hide house.

While cattle may have been slaughtered for there hide and tallow along the shoreline, this is primarily for sale to mariners and merchants. Presence of hide and tallow activity at TC reflects secondary butchering to provide soup cuts and salted beef for ships departing on long voyages—the hide and tallow were a primary product taken during this process. Gust's (1982) work at the Ontiveros Adobe in Southern California provides an example of what skeletal evidence should be present at archaeological sites in which hide and tallow activity took place. Her analysis indicates that when Californios killed cattle, they were discarded at the killing location as complete carcasses—after hide and tallow processing—secondary butchering of elements for beef consumption also occurred, a pattern seen at TC. Gust (1982, p. 120) writes that an, "easily identifiable attribute of this would be preservation of wholly or partially articulated carcasses." This is because butchering for beef consumption is generally limited to beef being stripped and shaved from the bones, instead of the Euro-American style of beef consumption involving steak or soup cuts (Fig. 6; also see Fig. 4) (Gust 1983). Gust's predictive model for skeletal elemental representation proved valuable for identifying these activities at TC.

Skeletal discard patterns at TC suggest that processing for the tallow occurred at the site (see Table 8). Relatively complete cattle bones, and an abundance of elements representing complete cattle skeletons (crania, mandibles, metapodials and phalanges) during the late-1840s-1848/49 provides evidence of this maritime driven hide and tallow trade. During 1849–53 skeletal element discard dramatically varies with the distribution and abundance of elements shifting to Euro-American cuts, generally steak type cuts (Gust 1983; see Fig. 6). Interestingly, the overall relationship between total

Fig. 6 Butchered femoral "steak cut" cattle (*Bos taurus*) specimens from Feature 7

skeletal discard is significantly correlated throughout this period. This indicates that during the 1840s cattle were primarily slaughtered for maritime hide, tallow and consumption activities—with the onset of the Gold Rush, cattle use shifted primarily for consumption but the preference of cattle skeletal elements or "cuts" does not alter significantly. As such, while commercial activities transition once the Gold Rush begins, general consumption activities do not.

Historically tule elk and deer were butchered for the hide and tallow trade, but to a lesser extent than cattle (Davis 1967; Duhaut-Cilly 1999). At TC, fewer tule elk and deer bones were found than cattle (based on NISP) and are not significantly correlated when ranked together (at the $p<0.05$ level) between the late-1840s to 1853. Furthermore, later tule elk remains were deposited relatively intact at the site – matching the butchery record of late-1840s-48 cattle within the context of the hide and tallow trade. In one surprising Bay Mud deposit eight complete tule elk tibiae were recovered with four femora. Multiple right-sided tibiae suggest that this was a large kill event involving multiple elk. Only the femora were incomplete, each butchered transversely through the head with a handsaw. Predominance of tule elk and deer during this period, and the elemental composition of their remains suggest that these animals were killed primarily for hide and tallow and secondarily for food before being discarded in Yerba Buena Cove.

Wild vs. Domestic Consumption

Prior to the onset of the Gold Rush, wild resources were largely ignored, except sea otters, which were heavily exploited during the early nineteenth century for their pelts (Ogden 1941). Occasionally, a foreign explorer or merchant vessel would bring Anglo-Americans that hunted throughout the foothills of the San Francisco Bay region for wild game (e.g., Osborn 1877; Phelps 1983), but Californios largely disregarded native species. In fact tule elk populations were able to rebound from a late-Holocene population decline due to the absence of indigenous native hunting and Californio exploitation (possibly as a result of indigenous extirpation) (Broughton 1994; Broughton et al. 2012; McCullough 1969, p. 25). Mule and black-tailed deer also were abundant throughout the San Francisco Bay prior to the onset of the Gold Rush (Davis 1967; Juan Batiste de Anza cited by Skinner 1962, p. 158). Furthermore, ducks and geese were so abundant prior to the Gold Rush that several records describe seeing anatids darken the sky by their flight (Davis 1967; Phelps 1983, p. 111; Skinner 1962, p. 139).

With the arrival of the argonauts, an overnight game market erupted in San Francisco and the greater bay area (Stine 1980). San Francisco's Gold Rush immigrants needed food and the limited supply of domesticates, specifically cattle, created a massive demand for fresh foodstuffs (Soulé et al. 1854, p. 360). With many miners failing to find success in the gold fields, hunting and selling wild game became immensely profitable. Already by 1851, Soulé et al. (1854, p. 360; Fig. 7) write that the markets of San Francisco were extremely rich with game of many types, "[s]almon of huge dimensions, and vast quantities of like delicious fish, whole cart loads of geese, ducks, quails, and other wild fowl, innumerable quarters of bear, elk, antelope, deer and smaller game, loaded the stalls of the dealers."

While the early years of the Gold Rush experienced a substantial wild game market, already by 1852 a decline in the market appeared (Stine 1980, p. 111). Large cattle drives from northern Mexico to California in 1852 aided this decline (Stine 1980).

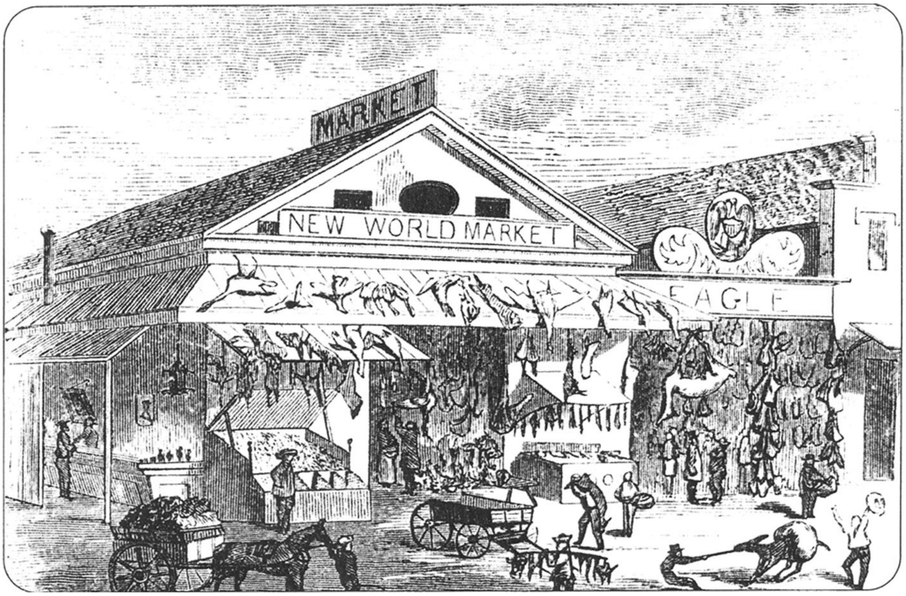

Fig. 7 New World Market at the corner of Commerical and Leidesdorff streets in San Francisco, 1851 (adapted from Soulé et al. 1854)

Upwards of 150,000 head of cattle were driven to California during this time, providing a renewed abundance of cheap domestic food. Beef became inexpensive again because of its relative abundance, and was considered much more delectable than earlier-Gold Rush cattle stocks (Stine 1980, pp. 111–112). Second, the intensive exploitation of wild game throughout the San Francisco Bay region resulted in declining numbers of all wild types. This resulted in wild game being considered a luxury food, rather than a staple dietary resource as experienced between 1849 and 51 (Stine 1980, p. 112).

The TC archaeofaunal assemblage supports this historical record. During the pre-Gold Rush, when Californio subsistence and economic activities occurred at the site, the domesticate abundance index is high, but during the early-Gold Rush (1848–49) the domesticate index lowers, and then stabilizes through time throughout the late-Gold Rush (1853) and into the later-nineteenth century (see Table 13). This quantitative measure matches the trends provided in the historical literature. During the Californio era, domesticates would have been utilized extensively for food and commercial purposes—with the arrival of the Gold Rush the wild game market became extremely robust and wild species appear in greater abundance as consumption items—with the arrival of cattle drives and decreasing local abundances of native species a subsistence shift occurs, focusing again on domesticates during the late-Gold Rush and continuing into the later-nineteenth century. Nestedness and NTAXA analyses also support this conclusion, with the complete site assemblage being relatively well nested, indicating that later-nineteenth century and late-Gold Rush faunas are subsets of early-Gold Rush faunas i.e., domesticates continue to be present but wild species are not. Finally, evenness analyses also support this conclusion (see Table 13). During the 1840s the fauna is relatively even, when focus on domesticates would have been present (high domesticate index). During 1848–51 evenness values decrease with a lowering domesticate index, suggesting increased wild game exploitation during this time. Moving into the mid/late-Gold Rush (1851–53) and later-nineteenth century (1860s–1907) evenness values initially decrease, with intensified wild game use, then slightly increase as a result of lowered wild game use and increased domesticate consumption.

Aside from these broad scale trends, several additional fine-grained patterns are identified in the TC archaeofaunal assemblage. A diverse group of migratory birds frequents the San Francisco Bay seasonally along the Pacific Flyway (Josselyn 1983, pp. 62–64). At TC, several migratory birds were evident in the rich faunal assemblage (Table 15). Given the seasonality of birds at TC, our investigation of anatid exploitation documents a prominent seasonal trend in San Francisco's Gold Rush era history. Historical records indicate that gold mining took place as a seasonal event. Miners would leave San Francisco in the spring to mine during the spring and summer months when weather was favorable, and would return in the fall and winter because the rain and snow in the Sierra Nevada's made mining conditions unpleasant (Bancroft 1888; Soulé et al. 1854). With increased population density in San Francisco during the winter months, an intensified game market including many species of fowl were destined for the restaurant tables in the city (Soulé et al. 1854, p. 214).

The increase in population, and thus need for resources during the fall and winter months is reflected in the TC avian assemblage. During the pre-Gold Rush evenness values are high, reflecting an equally represented faunal assemblage. Feature 15, an 1851–53 tidal deposit, has a lower dominance of ducks and geese and relatively high evenness suggesting that during this period a diverse abundance of birds were still

Table 15 Seasonality of TC birds based upon data from Grenfell and Laudenslayer (1983), U.S. Fish and Wildlife Service (1987), Dawson et al. (1923), Cogswell (1977) and Small (1974)

Taxon	Autumn	Winter	Spring	Summer
Bubo virginianus	X	X	X	X
Sterna cf. *paradisaea*	X			
Meleagris gallopavo	X	X	X	X
Gallus cf. *gallus*	X	X	X	X
*Callipepla*cf. *californica*	X	X	X	X
Haliaeetus leucocephalus	X	X		
Anas americana	X	X		
Anas discors	X	X		
Anas platyrhynchos	X	X	X	X
Melanitta deglandi	X	X		
Chen caerulescens	X	X		
Branta bernicla	X	X		
Branta cf. *bernicla nirgricans*	X	X		
Branta canadensis	X	X		
Ardea herodias	X	X	X	X
Botaurus lentiginosus	X	X	X	X
Phalacrocorax auritus	X	X	X	X

being utilized at the site. A transition occurs in feature 7 and 14 both of which are dominated by anatids. Decreasing evenness and a high anatid index suggests that these features have a high predominance of seasonal anatids in their assemblages. Since feature 7 and 14 were originally deposited ca. 1851–52 and redeposited at TC during the filling event of 1853, we suggest that these features were originally accumulated in the fall and winter months of 1851 to 1852. Possibly between September 1851 and February 1852, when seasonally migratory ducks and geese would have been most abundant and the population of San Francisco would have increased.

It is important to note that some of the animals from TC may have died naturally in San Francisco Bay, or in the Cove itself, and became incorporated into the faunal assemblage through natural processes. We do not deny this possibility, but several bird bones have direct evidence of butchery activity (Table 16). While butchery evidence appears on only a small portion of the overall avifaunal assemblage (11 %) this still suggests that the majority of the TC bird specimens were deposited following human consumption.

Table 16 Avifauna butchery evidence at TC

Taxon	Common name							
	Date	1840–1853	1840–1853	1848–1849	1850–1853	Redeposited 1853	Redeposited 1853	1860–1907
	Stratum	Bay Mud II-A	F. 25	F. 3/31/37	F. 15	F. 7	Stratum III-A	Stratum unit III-B-I
Bubo sp.	Horned owls						1	
Meleagris gallopavo	Turkey							1
Gallus cf. *gallus*	Chicken							1
Anatidae	Goose	1			1	2		
Anatidae	Duck		1			1	1	
Anas platyrhynchos	Mallard			1				
Anser sp.	Grey Geese		3					1
Chen sp.	White Geese				1		1	
Chen caerulescens	Snow Goose	1			4	1		1
Branta bernicla	Brant Goose					1		
Branta cf. *canadensis*	Canada Goose	1						
Branta canadensis	Canada Goose		4		2	2		1
Aves, small	–		1					
Aves, medium	–		1			1		
	Avian ∑	3	10	1	8	8	3	5

Evidence is comprised of either blade knife scores, handsaw cuts or cleaver cuts

Mollusks are an abundant component of the TC assemblage. Appearance of several native local species suggests that the Gold Rush population at the site consumed a broad range of species (imported mollusks were also present at TC and are discussed in more detail below). One intriguing species found in TC deposits is the California mussel (*Mytilus californianus*). Generally, this mussel inhabits wave blasted, rocky environments on the coastal margin—an environment that would not have been characteristic of the shallow, mud-flat Yerba Buena Cove. Appearance of these mollusks during the 1840s (see Table 2) indicates that the early inhabitants at the site obtained these mussels along the coast, Yerba Buena Island, or possibly the rocky areas around Fort Mason and transported them to the site for consumption. In the Bay Mud deposits at TC, several species could possibly be regarded as "natural" background species e.g., blue mussels (*Mytilus edulis*), native Pacific oysters (*Ostrea lurida*), nuttal cockles (*Clinocardium nuttallii*), bent-nose macomas (*Macoma nasuta*) and Pacific littlenecks (*Protothaca staminea*). Yet, historical documentation indicates that during the early-Gold Rush, mollusks were extensively consumed. Native Pacific oysters were historically impacted by over-exploitation and are still experiencing population impacts today as a result of consumption 'practices during this time (Conrad et al. 2015; Postel 1988). In feature 25 the ratio of *O. lurida* to *Mytilus* sp. is .24:1 where the ratio in feature 3/31/37 is .38:1 and in feature 7 .24:1. These values describe dominance of mussels in the Gold Rush-era diet of occupants at the site and likely the over-exploitation of native oysters in the San Francisco Bay by 1853 (Conrad et al. 2015). Aside from the exotic mollusks at the site, the arthropod assemblage is relatively typical of the localized fauna found throughout the San Francisco Bay region. Still, mollusks in general are rarely recovered and identified in Gold Rush era deposits (see Table 14) throughout San Francisco, making this assemblage a unique and important component of the local archaeofaunal record.

Fishes at TC provide an interesting record in comparison to other Gold Rush and later-nineteenth century assemblages recovered within the San Francisco Bay region (Table 17).

With the onset of the Gold Rush in 1848, dramatic changes occurred to the San Francisco Bay estuary principally as a result of pollution, over-fishing, introduction of exotic species and hydraulic mining (Cohen and Carlton 1998; Conrad et al. 2015; Nichols et al. 1986; Skinner 1962, p. 28). As with other wild species consumed at TC, fish were commonly utilized because they were locally available and abundant (Chotkowski 1999). The presence of both Sacramento pikeminnow (*Ptychocheilus grandis*) and Sacramento sucker (*Catostomus occidentalis*) suggest that these fish were imported into the site, likely from the San Joaquin and Sacramento river-delta where these fish were common and of large size. An April 5, 1851 description of the fish market on Long Wharf in San Francisco depicts these processes well (Johnston 1964, p. 133):

> The fish market that adorns Long Wharf is becoming ornamental as well as useful. In extent, and in the variety of the finny merchandise displayed, it already rivals those of the Atlantic cities. Every description of animal that inhabits our bay may be found spread out on the boards, and so active are their captors, the fishermen, that multitudes of them are yet alive and capable of taking their last look and flopping finally on the famous Long Wharf. Besides a tempting show of salmon and innumerable others of the fish species, are here to be viewed a

Table 17 Fishes identified in San Francisco Bay area sites

	Date	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900
Taxon	Common name	Vane Bente 3 Privies 2004	SFWBA BLK 10 P807 CTX 995	SFWBA BLK 10 P807 CTX 1034	Privy 2006 Additions	2280 Geary	835 Market	SF Historic Site	SFR-154/H 4th and Stillman
Elasmobranchiomorphi	Sharks, Skates, Rays						X		
Triakidae	Hound Sharks						X		X
Lamnidae	Mackerel Sharks				X				
Myliobatis californica	Bat Ray						X		X
Clupeidae	Herring/Sardine		X	X			X		X
Clupea pallasii	Pacific Herring		X	X					
Sardinops sagax	Pacific sardine		X				X		
Engraulidae	Anchovies		X						X
Cyprinidae	Minnow/Carp								X
Lavinia exlicauda	Hitch				X				
Ptychocheilus grandis	Sacramento Pikeminnow				X				
Catostomus occidentalis	Sacramento Sucker				X				
Oncorhynchus sp.	Pacific Salmons and Trout	X	X	X		*X*	*X*	X	*X*
Oncorhynchus mykiss	Steelhead					*X*			*X*
Oncorhynchus tshawytscha	Chinook Salmon				X	X	X	X	
Gadidae	Cod Family		X					X	
Gadus sp.	Atlantic or Pacific Cod	X	X	X		X			
Microgadus proximus	Pacific Tomcod		X						
Porichthys notatus	Plainfin Midshipman								X
Atherinopsidae	Pacific Silversides		X	X			X		X
Atherinopsis californiensis	Jacksmelt				X				
Fistularia sp.	Coronet Fish				X				

Table 17 (continued)

Taxon	Common name	Vane Bente 3 Privies 2004	SFWBA BLK 10 P807 CTX 995	SFWBA BLK 10 P807 CTX 1034	Privy 2006 Additions	2280 Geary	835 Market	SF Historic Site	SFR-154/H 4th and Stillman
	Date	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900	1850–1900
Sebastes sp.	Rockfishes	X	X	X					X
Scorpaenichthys marmoratus	Cabezon			X			X		
Hexagrammos sp.	Greenlings		X	X					
Ophiodon elongatus	Lingcod				X	X		X	X
Atractoscion nobilis	White Sea Bass				X				
Genyonemus lineatus	White Croaker					X		X	
Archoplites interruptus	Sacramento Perch		X						
Embiotocidae	Surfperch		X	X			X		X
Amphistichus sp.	Perch				X				
Cymatogaster aggregata	Shiner Perch					X	X		
Hysterocarpus traskii	Tule Perch						X		
Embiotoca sp.	Black or Striped Surfperch		X						X
Rhacochilus sp.	Perch								X
Rhacochilus vacca	Pile Perch		X						
Semicossyphus pulcher	Sheephead				X				
Stichaeidae	Prickleback								X
Sphyraena sp.	Barracuda				X				
Scomber japonicus	Chub Mackerel	X	X	X					X
Pleuronectiformes	Right or Lefteye Flounders		X	X		X		X	X
Platichthys stellatus	Starry Flounder		X			X		X	
Psettichthys melanostictus	Sand Sole	X				X			

All assemblages identified by Kenneth Gobalet and reported in gray literature reports without being subject to peer review. "X" indicates presence

> number of amphibious delicacies, such as turtles, lobsters, crabs, and at times also, scant representatives of the oyster and clam beds, which may assert, are all sufficiently plenty at many points along our coast, and even in the waters of San Francisco bay. This latter idea, by the way, is worthy of fathoming. If so be there are 'oysters and clams' in our bay, would it not pay to introduce our citizens to the flavor? However, the fish market on Long Wharf is worthy of examination.

Early evidence of cod (*Gadus* sp.) at TC is intriguing because cod are found in deep water off of the coast of California, and were not known historically to be fished in California waters until later in the nineteenth century once deep-water fishing became more active (Scofield 1954 cited in Skinner 1962, p. 23). Cod inhabit progressively shallower waters further north along the Pacific coast, but a maritime trade in cod based in San Francisco is not well documented until 1863 when the fishing boats ventured as far north as Alaska to make their catches (Clemens and Wilby 1961; Hart 1973; Love 2011). On the New England coast of the United States Atlantic cod (*Gadus morhua*) were fished during the Gold Rush era, and it is likely that TC cod represent an imported salted and dried food in the earliest Gold Rush deposits. Local newspapers from the Gold Rush provide evidence of this with the vessel *Carthage* arriving in San Francisco on February 19, 1850 direct from Boston with "fresh oyster . . . herrings . . . halibut . . . codfish," for sale at the foot of Sacramento Street (Anonymous 1850). Skeletal elements of cod recovered at TC lack skull bones and this matches the historical record of salted Atlantic cod being dried headless prior to transportation (Kurlansky 1997, p. 103). While the indigenous fishery of the San Francisco Bay region is more diverse than the assemblage at TC (Gobalet et al. 2004), the abundance and overall composition of the assemblage (including several hundred scales) is unmatched in Gold Rush era deposits in San Francisco.

Imported Non-native Species

The importation of non-native species into Alta California during the Gold Rush may provide one of the most remarkable aspects of the TC assemblage. Aside from turkeys (*Meleagris gallopavo*) which are exotic and were imported until wild flocks were established in the late-1870s (Caton 1877, p. 328) and cod, four additional non-native animals were recovered at the site; a chestnut cowrie shell (*Cypraea spadicea*), California margin shell (*Volvarina taeniolata*), two Galapagos tortoise humerii and a sea turtle phalanx (Figs. 8 and 9).

Traveling to California from the eastern United States during the Gold Rush involved taking one of three routes: (1) by land across the continental United States, (2) by vessel down the east coast of the US to Central America, across the Isthmus, and by sea to California, or (3) by sea from the east coast of the US, around Cape Horn in South America, and up the coast to San Francisco (Delgado 2009). The speed of ships made maritime travel to California the most popular. As a result, many maritime passengers stopped along the Pacific coasts of South America, Mexico and islands throughout the eastern Pacific, in particular the Galapagos Islands. The chestnut cowrie (recovered from stratum III-A) can be found from Monterey, California, south, to Baja California (Meyer 2003, p. 425) and the California margin shell (recovered from feature 7) is distributed from Point Conception, California, south, to Ecuador (including the Galapagos Islands) (Rehder 1996, p. 481). Maritime passengers traveling to California during the Gold

Fig. 8 A Galapagos tortoise (*Chelonoidis* sp.) humerus recovered from the 1840–53 Feature 25 at TC. Note transverse cut marks on the mid-shaft surface

Rush, or whalers arriving in Yerba Buena during the 1840s, may have stopped to collect shells during their voyage and transported them to Yerba Buena Cove prior to their loss or discard into the shallow waters of the Cove. This process was likely not for consumption but rather as gifts or adornments. In one documented account from Joseph Kendall, who stopped in the Galapagos Islands (Catham Island specifically) in 1848, traveling onboard the bark *Canton*, he wrote, "[t]he beach is literally composed of every kind and variety of shells: one might collect a wagon-load in half an hour" (Kendall 1935, p. 112). He continues to describe that, "[a]lmost every one of the Company have shells of something else to remember this place by; I myself took care to collect and beg many shells, etc., which are intended for my Lucy and Annie" (Kendall 1935, p. 122).

Fig. 9 A sea turtle (Family Cheloniidae) phalanx recovered from the 1840–53 Bay Mud II-A deposits at TC

This account suggests that the presence of exotic non-native shells from the eastern Pacific at TC is substantiated by historic documentation. Our analysis of San Francisco Bay area faunal records dating to the Gold Rush also indicate that this is the first time non-native mollusks have been identified within the city at this time.

Recovery of both Galapagos tortoise and sea turtle specimens, known historically as "terrapin" (Chambers 2006; Conrad and Pastron 2014), from Gold Rush era deposits at TC is astounding. Since maritime vessels traveled throughout the eastern Pacific and stopped at islands including the Galapagos en route to San Francisco, food items and resources were collected whenever possible—especially to limit the effects of scurvy. Tortoises and sea turtles were captured and transported on vessels because they were considered delectable, were easily caught (although their massive weight occasionally posed problems) could be stored alive for weeks (sometimes months or years at a time), and generally provided argonauts with a much needed fresh food supply (see references in Conrad and Pastron 2014). The breadth of this activity is clearly documented in the historical literature for San Francisco, Sacramento and even small gold rush mining towns throughout the Sierra Nevada. For the first time, the assemblage at TC provides zooarchaeological evidence to support this historical documentation within Alta California. As an example, on May 17, 1855, a San Francisco newspaper wrote that the schooner *WA Tarlton* arrived in the city after 45 days sailing from the Galapagos with 500 terrapin onboard (Anonymous 1855). These were undoubtedly sold, butchered and eaten in San Francisco and beyond. Regrettably, such an abundance of tortoises and sea turtles were captured and imported during this time that serious population declines were experience throughout the eastern Pacific. Galapagos tortoise and sea turtle populations are still recovering from the detrimental effects of these, and other, anthropogenic activities (Allen 2007; Chambers 2006; Conrad and Pastron 2014; Frazier 2003; Kittinger et al. 2013; Van Houtan et al. 2012).

Conclusions and Future Work

The mollusk, bird, mammal, fish, and tortoise/turtle assemblages from Thompson's Cove, San Francisco, provide one of the largest and most diverse records of commercial and consumption activity dating to the 1840s–60s in California. Presence of the hide and tallow trade for maritime activities, seasonal hunting of migratory ducks and geese, importation of exotic species including cod, mollusk shell, Galapagos tortoise and sea turtle are all identified within the original shoreline deposits of Yerba Buena Cove. Vivianite mineralization on faunal remains supports this shoreline deposition and provides evidence of post-depositional taphonomy. Our quantification of recovery technique, fragmentation and sample size suggest that differential recovery is driving differences in faunal composition. Yet, the inclusion of differential recovery sampling protocols (3.2/6.4 mm mesh) allows greater understanding of these differences. In general, the Thompson's Cove assemblage supports the historical record of faunal use and exploitation in Alta California prior to and during the Gold Rush. Results of abundance indices, dietary evenness and nestedness indicate that during the pre-Gold Rush (1840s) domesticates were primarily butchered for commercial purposes and for the food of mariners. At the onset of the Gold Rush a substantial demand for food drove a wild game market in the San Francisco Bay region—this market eventually reduced localized wild game populations to minute fractions of their original pre-Gold Rush height. This caused a return to primary consumption of domesticates throughout the later-Gold Rush and nineteenth century.

We suggest that continued study of the Thompson's Cove faunal assemblage will lead to a better understanding of Gold Rush era faunal exploitation and consumption. Abundance and diversity of animals at the site provides future researchers with the opportunity to explore several aspects of Gold Rush era faunal dynamics. Butchery analysis was not undertaken here, but the abundance of butchered domesticated and wild species at the site may allow future researchers to document the appearance and transition from cleaver/ax butchering in the pre-Gold Rush period, to hand saw and later machine-saw butchering throughout the nineteenth century (Gust 1983). Sampling of complete tule elk specimens at the site may allow for further genetic and isotopic analyses of historic period San Francisco Bay tule elk populations, something that Broughton et al. (2012) have recently explored with prehistoric samples from the Emeryville Shellmound in the east San Francisco Bay. Continued testing of mollusk specimens may also help identify the onset of contamination from hydraulic mining activities in the Sierra Nevada during the mid-to-late nineteenth century (Conrad et al. 2015).

Finally, we hope that with our identification of several previously undocumented non-native species in San Francisco dating to the Gold Rush, Galapagos tortoise and sea turtle in particular, a renewed focus on sampling protocols and archaeozoological investigations aimed at furthering our understanding of these importation processes may occur within academic and cultural resource management projects throughout the San Francisco Bay region.

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