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Spatiotemporal Distributions of *Tegula* spp. on Vandenberg Air Force Base: Ramifications for Identifying Diet Breadth Expansion

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*A database of marine shell from 70 archaeological assemblages at Vandenberg Air Force Base reveals substantial temporal and spatial variability in the distribution of turban snails (*Tegula *spp.). Consideration of both variables is crucial to identification of diet breath expansion in the context of subsistence stress and resource diversification. At Vandenberg AFB, increased use of* Tegula *during late prehistory strongly correlates with spatial proximity to prime* Tegula *habitat (Purisima Point) at sites on a landform that is less than 2,000 years old. When sites near prime habitat are excluded, increased* Tegula *use correlates very poorly with time, and long-term diet breath expansion to include a lower-ranked species is not supported. However, the evidence does point to short-term increased use of* Tegula *during the Medieval Climatic Anomaly, a time of known environmental stress.*

Studies at Vandenberg Air Force Base (Glassow 1990; Glassow and Gregory 2000; Perry 2004) and elsewhere along the south-central California coast (Raab 1992; Raab and Yatsko 1992; Raab et al. 2009) cite high proportions of turban snails (*Tegula* spp.) from sites dating to the late Holocene as evidence for resource diversification or intensification due to increased human population densities and associated dietary stress. In the context of optimal foraging theory and the diet breadth model, it was inferred that higher ranked resources must have been depleted during the late Holocene and site occupants were forced to rely more on the diminutive *Tegula.* This paper examines the spatiotemporal distribution of turban snails in archaeological assemblages from Vandenberg Air Force Base (AFB), using a much larger shellfish database than previously available, with the goal of assessing whether increased proportions of *Tegula* during the late Holocene reflect diet breadth expansion.

California mussel (*Mytilus californianus*) typically dominates shellfish assemblages on Vandenberg AFB, by both weight and counts of the minimum number of individuals (MNI) (Table 1; see also Glassow and Wilcoxon 1988). However, it has been noted that the relative importance of mussels decreased through time (Glassow 1996, 2002). Based on his seminal work on Vandenberg AFB in the 1970s, Glassow (1990:13–32) inferred that the exploitation of minor shellfish species, including turban snails, represented an expansion of diet breadth through time due to the overexploitation of mussels late in prehistory. Similarly, Glassow and Gregory (2000) infer that unusually high proportions of turban snails at CA-SBA-699 on Vandenberg AFB, dated to about the Middle-Late Transitional Period, were related to subsistence stress.

In an attempt to determine whether increased proportions of turban snails represented diet breadth expansion, Perry (2004) analyzed marine shell from different-aged deposits at a single site, CA-SBA-225, to determine whether varying proportions of shellfish could be linked to an intensified use of lower-ranked resources. CA-SBA-225 is located at Purisima Point, a prominent geographic feature on Vandenberg AFB (Fig.1). Perry found that shellfish assemblages from early Middle Period deposits were dominated by California mussel but that all subsequent deposits contained higher proportions of turban snails than California mussel. Some later assemblages contained as much as 91% turban snails. Based on her results, Perry (2004:96) indicated that "increases in fish exploitation, black turban procurement, and resource diversity after the early Middle Period represent shifts in subsistence patterning reflective of intensified exploitation of rocky intertidal and nearshore habitats." However, other than the early Middle Period subsistence shift, Perry (2004) found no evidence of resource intensification, and suggests that high proportions of turban snails at CA-SBA-225 reflect a unique microenvironment at Purisima Point that is especially well suited to the black turban.

SETTING

Located in northern Santa Barbara County, Vandenberg AFB is long and narrow, extending no more than 10 miles inland but with roughly 35 miles of west-facing

Table 1

PROPORTIONS OF CALIFORNIA MUSSEL (*MYTILUS CALIFORNIANUS*) AND TURBAN SNAILS (*TEGULA* SPP.) IN VANDENBERG AFB ARCHAEOLOGICAL ASSEMBLAGES, ARRANGED CHRONOLOGICALLY

Site (CA-SBA)	AU[1]	Mid-age (cal B.P.)	Distance From Coast (km.)	Distance From Purisima Pt. (km.)	Total Shellfish Assemblage Weight (g.)	*Mytilus* Weight %	*Mytilus* MNI %[2]	*Tegula* Weight %[2]	*Tegula* MNI %[2]	Reference
0212	6	165	0.0	18.4	2,482.8	95.1	67.8	1.3	10.2	McKim et al. (2007)
0207	1a	232	0.3	27.5	53,113.1	96.0	86.0	0.7	8.0	Lebow et al. (2008a)
0207	1b	280	0.3	27.5	9,134.4	97.0	93.0	0.8	2.3	Lebow et al. (2008a)
0207	2a	285	0.3	27.5	49,717.7	96.0	91.0	0.6	0.9	Lebow et al. (2008a)
0223	3e	314	0.0	3.2	163.7	65.0	60.3	3.9	12.1	Lebow et al. (2010a)
0694	L1	319	0.0	2.1	15,788.7	32.9	21.0	39.7	52.5	Moratto et al. (2009)
0694	L2	319	0.0	2.1	245.1	38.1	23.1	33.4	54.0	Moratto et al. (2009)
0694	L3	319	0.0	2.1	640.4	38.0	16.7	40.6	69.3	Moratto et al. (2009)
0207	2b	325	0.3	27.5	2,034.9	96.0	96.0	0.5	1.3	Lebow et al. (2008a)
0646	1	325	0.0	21.6	10,304.6	91.6	65.7	0.0	0.0	Lebow et al. (2010b)
0211	1	340	0.0	22.6	12,906.8	95.0	94.9	0.4	1.3	Lebow et al. (2008b)
1119	2	344	0.3	18.0	12,159.1	92.2	86.1	0.9	4.3	Lebow et al. (2009a)
0211	2	370	0.0	22.6	8,784.6	99.5	94.1	0.0	2.7	Lebow et al. (2008b)
0212	1	370	0.0	18.4	6,081.3	94.7	70.5	0.7	7.3	McKim et al. (2007)
0670	Upper	378	0.2	18.0	26,046.4	94.7	–	0.6	–	Glassow (1990:Tables10.11–10.13)
0650	1	390	0.0	21.8	2,060.0	96.7	84.0	0.0	0.0	Lebow et al. (1999)
1037	1	390	5.2	6.7	3,580.5	29.3	18.3	58.8	67.2	Lebow et al. (2005b)
0212	4	425	0.0	18.4	266.5	98.5	84.4	0.3	3.1	McKim et al. (2007)
0706	–	447	3.5	6.3	1,321.7	47.7	38.1	31.3	38.1	Chambers Consultants and Planners (1984)
1070/1071	8	455	2.9	6.0	686.1	35.5	–	53.6	–	Lebow et al. (2005a)
1070/1071	1	480	2.9	6.0	520.5	31.2	–	27.1	–	Lebow et al. (2005a)
1179	–	514	3.0	8.1	6,734.8	92.5	89.3	1.5	2.9	Chambers Consultants and Planners (1984)
1070/1071	6	515	2.9	6.0	1,267.4	58.9	–	16.0	–	Lebow et al. (2005a)
0530	1	519	0.0	17.8	9,622.3	89.8	84.2	0.5	0.9	Lebow et al. (2007)
0772	1a	520	1.9	15.3	7,688.6	90.6	84.8	0.2	2.0	Lebow et al. (2006)
0990	2	535	5.3	10.7	4,856.0	90.6	–	1.0	–	Lebow et al. (2005a)
0223	2b	613	0.0	3.2	5,036.4	69.3	43.0	15.0	37.6	Lebow et al. (2010a)
0212	2	650	0.0	18.4	8,667.6	94.7	64.9	0.9	5.7	McKim et al. (2007)
1070/1071	3	665	2.9	6.0	351.8	25.4	–	56.5	–	Lebow et al. (2005a)
0740	–	725	0.0	12.7	2,179.7	58.8	–	25.8	13.5	Lebow et al. (2000)
0755	1c	735	0.8	14.4	966.8	73.7	40.1	6.7	47.0	Lebow et al. (2006)
0935	3	760	7.8	12.5	1,724.7	75.0	–	22.4	–	Harro et al. (2000)
0223	2g	770	0.0	3.2	339.1	57.7	24.1	20.9	70.1	Lebow et al. (2010a)
0677	–	776	0.0	16.1	10,269.2	95.6	–	0.0	–	Lebow et al. (1998)
0699	–	798	0.0	1.1	7,021.9	36.5	–	49.6	–	Glassow and Gregory (2000:Table 2)
0212	3	800	0.0	18.4	1,775.4	94.7	67.5	1.2	3.8	McKim et al. (2007)
0215	1	815	7.6	19.2	3,182.6	96.1	48.7	2.4	45.8	Lebow et al. (2009)
0223	2a	845	0.0	3.2	3,509.9	64.3	31.5	19.3	60.2	Lebow et al. (2010a)

Table 1 (*Continued*)

PROPORTIONS OF CALIFORNIA MUSSEL (*MYTILUS CALIFORNIANUS*) AND TURBAN SNAILS (*TEGULA* SPP.) IN VANDENBERG AFB ARCHAEOLOGICAL ASSEMBLAGES, ARRANGED CHRONOLOGICALLY

Site (CA-SBA)	AU[1]	Mid-age (cal B.P.)	Distance From Coast (km.)	Distance From Purisima Pt. (km.)	Total Shellfish Assemblage Weight (g.)	*Mytilus* Weight %	*Mytilus* MNI %[2]	*Tegula* Weight %[2]	*Tegula* MNI %[2]	Reference
0223	2c	960	0.0	3.2	2,939.9	73.9	38.7	10.3	53.6	Lebow et al. (2010a)
0650	2	1,040	0.0	21.8	11,314.1	98.0	83.0	0.0	0.0	Lebow et al. (1999)
0223	2d	1,065	0.0	3.2	2,258.8	93.9	34.1	3.1	53.7	Lebow et al. (2010a)
0212	5	1,085	0.0	18.4	11,707.0	83.1	90.8	0.7	1.3	McKim et al. (2007)
1748	–	1,090	0.0	16.1	8,859.3	66.0	–	8.2	–	Lebow et al. (2010c)
1119	1	1,395	0.3	18.0	6,819.7	97.8	95.0	2.1	1.5	Lebow et al. (2009a)
1010	5	1,455	12.4	13.8	1,094.6	84.4	81.2	6.4	7.3	Lebow et al. (2005c)
2919	–	1,475	0.7	25.1	8,108.8	91.5	80.2	4.0	12.6	Lebow et al. (2010c).
1010	4	1,500	12.4	13.8	1,757.4	82.1	85.9	4.4	8.8	Lebow et al. (2005c)
1010	3	1,505	12.4	13.8	255.9	82.2	82.4	0.9	5.9	Lebow et al. (2005c)
0223	1a	1,535	0.0	3.2	4,152.0	63.1	31.4	22.6	60.8	Lebow et al. (2010a)
0223	1i	1,540	0.0	3.2	528.3	58.4	11.5	26.3	77.8	Lebow et al. (2010a)
1010	7	1,555	12.4	13.8	672.9	94.3	89.5	1.9	3.5	Lebow et al. (2005c)
0646	2	1,760	0.0	21.6	5,174.6	96.8	81.7	0.1	0.2	Lebow et al. (2010b)
1926	–	1,790	9.8	11.4	3,009.2	92.0	–	3.5	–	Harro and Ryan (1997)
0650	3	1,860	0.0	21.8	364.4	95.7	77.2	0.0	0.0	Lebow et al. (1999)
1010	2	2,015	12.4	13.8	436.0	80.0	81.5	2.1	7.4	Lebow et al. (2005c)
0539	–	2,098	0.1	18.2	66,229.2	97.4	–	0.4	–	Glassow (1990:Table 9.7)
1119	COL 1	2,390	0.3	18.0	1,075.8	97.9	86.9	0.5	3.7	Lebow et al. (2009a)
0756	3	2,515	1.1	14.7	43,025.9	96.4	78.2	1.0	15.5	Lebow et al. (2006)
1010	1	2,885	12.4	13.8	1,224.2	85.9	88.2	0.8	2.9	Lebow et al. (2005c)
1010	6	3,005	12.4	13.8	189.6	92.6	79.2	4.5	6.2	Lebow et al. (2005c)
0755	4a	3,815	0.8	14.4	4,939.1	95.3	84.4	0.2	5.9	Lebow et al. (2006)
0670	Lower	3,842	0.2	18.0	61,958.3	98.6	–	0.1	–	Glassow (1990:Tables10.14–10.16)
0757	4b	4,340	0.9	14.7	4,427.4	96.3	84.5	0.3	3.6	Lebow et al. (2006)
0530	5	4,575	0.0	17.8	658.2	98.9	87.1	0.1	1.1	Lebow et al. (2007)
0530	2	5,140	0.0	17.8	3,771.3	97.5	85.7	0.3	0.3	Lebow et al. (2007)
0757	4c	5,255	0.9	14.7	1,420.2	97.3	80.5	0.1	0.8	Lebow et al. (2006)
0530	3	5,745	0.0	17.8	31,878.9	98.0	92.3	0.1	0.2	Lebow et al. (2007)
0530	4	6,985	0.0	17.8	4,660.3	99.1	82.8	0.0	0.5	Lebow et al. (2007)
0757	5	7,345	0.9	14.7	14,479.0	94.6	88.3	0.2	2.7	Lebow et al. (2006)
0530	6	9,685	0.0	17.8	62,860.0	99.5	96.3	0.0	0.0	Lebow et al. (2007)

[1]AU = analytic unit, a spatiotemporally distinct assemblage within any given site.
[2]– = MNI not reported.

coastline (Fig. 1). Point Conception just south of the base is considered the boundary between the warm-water California biotic province to the south and the cool-temperature Oregonian biotic province to the north. As a result, it has high biotic diversity due to the overlap between species found in the two provinces as well as species endemic to the transition. Numerous stretches of the Vandenberg AFB coastline have rocky intertidal habitats. Invertebrate species associated with those habitats include California mussels (*Mytilus californianus*), acorn barnacles (*Tetraclita rubescens*, *Balanus glandula*, and *Chthamalus* sp.), goose

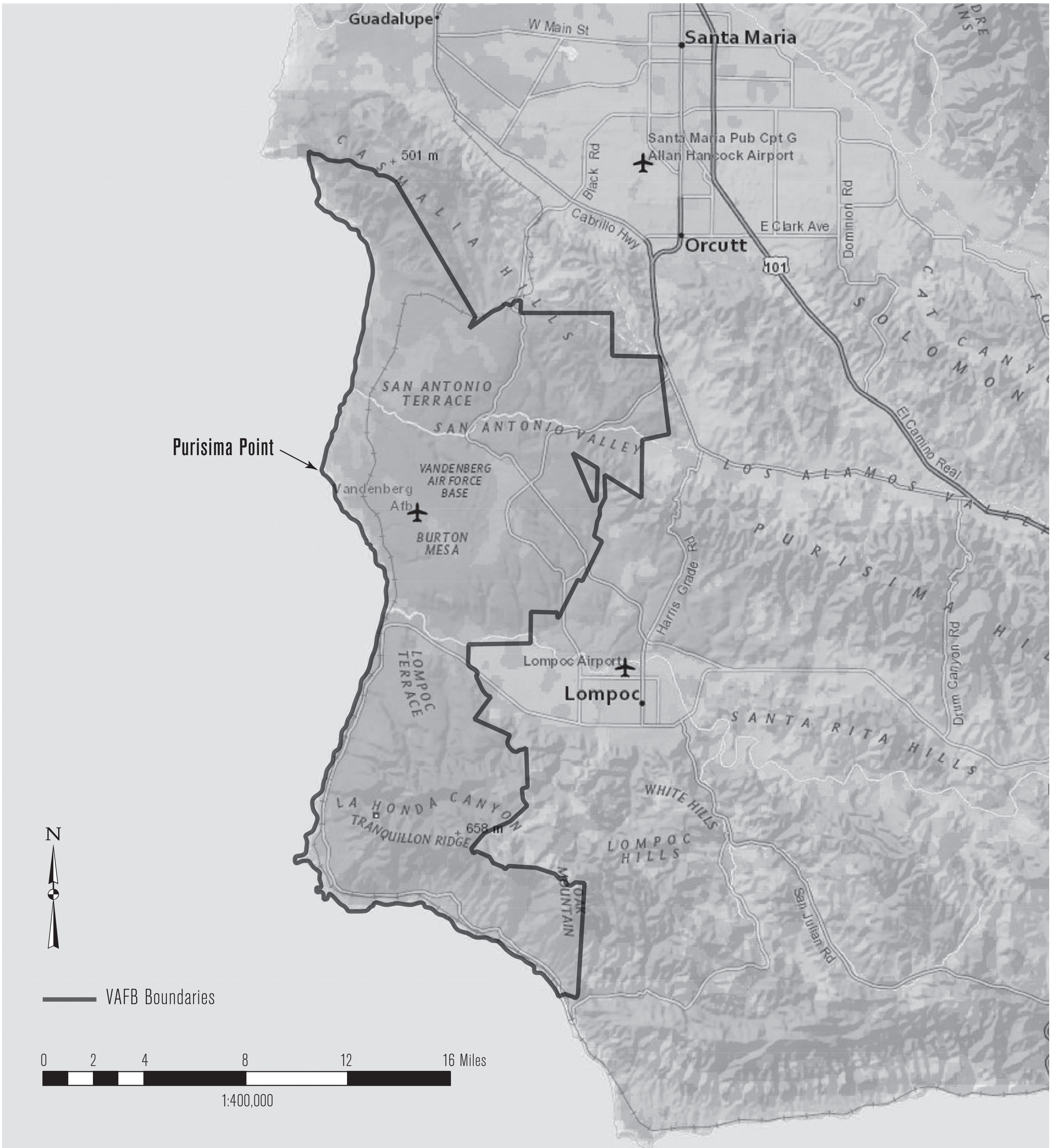

Figure 1. Location of Purisima Point at Vandenberg Air Force Base.

barnacles (*Pollicipes polymerus*), rock crabs (*Cancer* spp.), limpets (Acmaeidae), chitons (Polyplacophora), urchins (*Stronglyocentrotus* spp.), black abalone (*Haliotis cracheriodii*), red abalone (*H. rufescens*), and turban snails (*Tegula* spp.). Terrestrial habitats on the base are varied and include coastal dunes, coastal sage scrub, chaparral, oak woodlands, oak savanna, Bishop pine forest, annual grassland, wetland, marshland, and riparian woodland (Morgan et al. 1991:39–47). Plants and animals important to native people similarly varied, but terrestrial vertebrate resources in Vandenberg AFB archaeological assemblages are dominated by artiodactyls and lagomorphs (Lebow et al. 2007).

Purisima Point on Vandenberg AFB is an exposed promontory subject to heavy surf. Immediately north of the point is a long stretch of sandy beach. Immediately south is a rocky foreshore that appears to have supported a superior prehistoric fishery, as archaeological sites in the vicinity of Purisima Point have, by far, the highest proportions of marine fish bones found in Vandenberg AFB archaeological assemblages (e.g., de Barros 1994; Lebow et al. 2010a; Moratto et al. 2009). The terrestrial landscape inland from Purisima Point, an uplifted marine landform known as San Antonio Terrace, is blanketed by active to semi-stabilized dunes that are less than 2,000 years old (Johnson 1984).

The focus of this article, turban snails, are mobile, but they spend most of their time in protected areas such as crevices in the intertidal zone. They grow to a size of about 3 cm. By comparison, California mussels are filter-feeding bivalves that attach to rocks in exposed surf. They can grow to lengths of 25 cm. but tend to be less than 13 cm. long. Because both taxa live in the rocky intertidal zone, both would have been available for human collection during low tide. Analyses of shell middens on Vandenberg AFB indicate that humans were indeed consuming both (Table 1).

Erlandson (1988) found a meat-to-shell ratio of 0.298 for California mussel; Ferneau (1998:62) found that the ratio for black turban snail was similar, at 0.248. Ferneau (1998:96–97) also found that turban snails required greater processing time (1.7 times that of mussels) to recover a comparable amount of meat. Given the similar meat to shell ratios and smaller processing effort, the much larger California mussel would logically be a preferred choice and rank higher than the diminutive turban snail.

The intertidal zone at Purisima Point is a broad, relatively horizontal bench with few vertical exposures but abundant crevices and niches. California mussels are present on the few vertical faces but are otherwise absent, probably because they have difficulty remaining attached to the wave-swept horizontal surfaces. Turban snails, on the other hand, are abundant in protected shelves, crevices, and niches where they are sheltered from the waves. The author has walked most of the Vandenberg AFB coastline on different occasions and has found numerous places where turban snails are common, but except at Purisima Point they are always found in combination with abundant California mussels.

THE VANDENBERG AFB DATA

Given Glassow's (1990) seminal study and in the interest of tracking subsistence diversification and diet breadth expansion, Applied EarthWorks, Inc. has been compiling a database of shellfish proportions in archaeological assemblages from Vandenberg AFB for the past 17 years. To date, the database contains data from 70 assemblages from 29 sites (Table 1). Only site components that are tightly dated through radiocarbon analysis are included in the database. Both black (*Tegula funebralis*) and brown (*Tegula brunnea*) turban snails can be found in the Vandenberg AFB archaeological assemblages, but the black far outnumber the brown. No difference is apparent in their spatiotemporal distributions, and for this discussion the two species are lumped together. Importantly, in the context of the following discussion, most of the archaeological assemblages in the database are from sites on or very near the coast, as shown in Table 1.

Table 1 presents proportions of turban snails and California mussels in Vandenberg AFB assemblages by two measures, weight and MNI. Given that Purisima Point provides a habitat particularly well suited to turban snails but not to California mussel, the distance between each site and the Point is also provided. Figure 2 illustrates the relationship between proportions and distance to Purisima Point and reveals that turban snail proportions clearly increase with proximity to Purisima Point. The relationship between distance and percentage is stronger when measured by MNI ($r^2 = 0.5898$) than by weight ($r^2 = 0.4664$).

To examine whether basewide distributions of turban snails might have a chronological component, the percentages are plotted against age in Figure 3. Prior to 1,550 years ago, none of the 70 assemblages has more than 4.5% turban snails by weight and only a single assemblage has more than 10% by MNI. By weight, the average proportion prior to 1,550 years ago is 0.8%, and by MNI is 3.2%. Proportions vary substantially in assemblages postdating 1,550 years ago, but the average is 12.5% by weight and 22.9% by MNI. Clearly, then, the

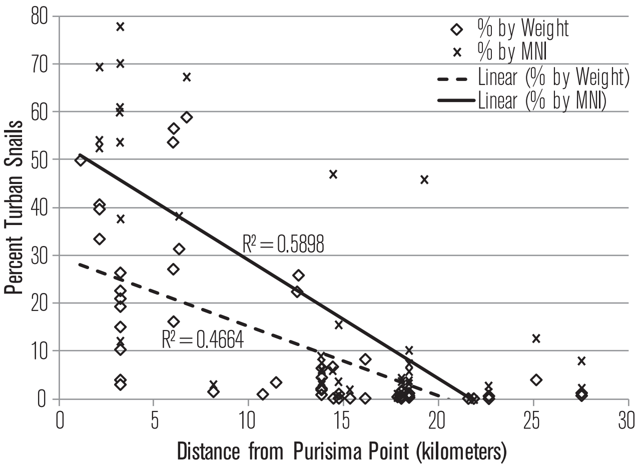

Figure 2. Relationship between proportions of *Tegula* and distance to Purisima Point.

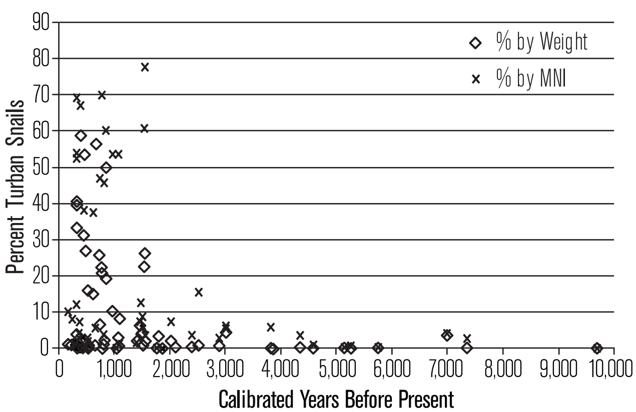

Figure 3. Relationships between proportions of *Tegula* and antiquity.

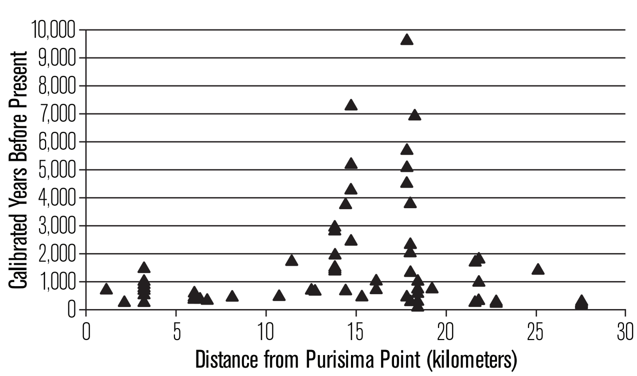

Figure 4. Relationship between assemblage age and distance to Purisima Point.

distribution of turban snails has a temporal component, with assemblages postdating 1,550 years ago much more likely to have high proportions. Hence, the pattern in Figure 3 appears to support an interpretation of expanded diet breadth after 1,550 years before present.

But the temporal distribution of turban snails is more complicated than shown in Figure 3. Figure 4 plots the antiquity of sites in the shellfish database against distance from Purisima Point, revealing that older sites are clearly at greater distances. All assemblages listed in Table 1 within 11 km. of Purisima Point (20 assemblages in eight different sites) are less than 1,550 years old. The relationship between site antiquity and Purisima Point is well documented (Chambers Consultants and Planners 1984; Lebow et al. 2005a; Tetra Tech 1990, 1991). As noted, Purisima Point lies at the western edge of the San Antonio Terrace, an uplifted marine terrace that is largely blanketed with dunes less than 2,000 years old (Johnson 1984). Given the blanket of relatively recent dune sand, sites recorded in the vicinity of Purisima Point are necessarily less than 2,000 years old.

DISCUSSION

In Vandenberg AFB archaeological assemblages, the distribution of turban snails clearly has interrelated spatial and temporal components. Turban snail proportions increase with proximity to Purisima Point and are highest after 1,550 years ago. Known sites on Purisima Point are younger than 1,550 years. Consequently, the temporal increase in turban snail proportions is directly linked to proximity to Purisima Point. Any study that examines the relative proportions of shellfish taxa on Vandenberg AFB—such as increasing proportions of turban snails late in prehistory—must be cognizant of the spatiotemporal distribution of turban snails. Braje and Erlandson's (2009:284) caution to consider local habitat when examining diet breadth expansion is well founded.

To further make this argument, Figure 5 shows the proportions of turban snails in assemblages more than 11 km. from Purisima Point. Excluding proximity to Purisima Point drops the number of assemblages from 70 to 50. Comparing Figures 5 and 3 clearly reveals a substantially different pattern after 1,550 years ago, with far fewer high proportions of turban snails. Even so, trendlines for both weight and MNI slope slightly,

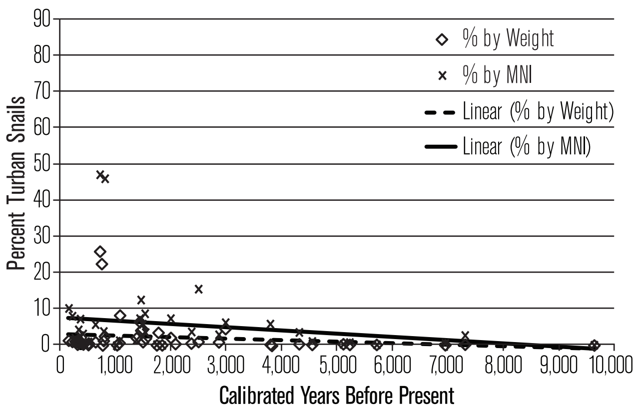

Figure 5. Relationship between assemblage age and distance to Purisima Point.

suggesting a correlation between proportions and age. However, the relationship is very weak ($r^2 = 0.0398$ by weight and 0.0361 for MNI) and might simply reflect the variability inherent in the larger sample of assemblages late in prehistory.

Figure 5 illustrates four assemblages that stand out as anomalous, with MNI percentages of 47.8 (CA-SBA-755 AU 1c) and 45.8 (CA-SBA-215 AU 1) and weight percentages of 25.8 (CA-SBA-740) and 22.4 (CA-SBA-935 AU 3). All four of these assemblages date between 735 and 815 years before present, an interval of sustained and severe drought (Larson and Michaelsen 1989; Stine 1994) corresponding to the global Medieval Climatic Anomaly (Jones et al. 1999). It undoubtedly was a time of subsistence stress.

In that context, the four anomalous assemblages shown in Figure 5 probably reflect short-term environmentally-caused subsistence stress, rather than long-term diet breadth expansion due to an intensified use of a secondary taxon caused by population pressures. It was a temporary response rather than a long-term shift in subsistence strategy.

CONCLUSIONS

Data from Vandenberg AFB support Braje and Erlandson's (2009) caution that microhabitats must be considered when examining prey rankings and diet breadth expansions. Spatiotemporal proportions of the diminutive turban snails vary strongly with distance from Purisima Point, which has excellent turban snail habitat but poor mussel habitat. Thus, on Vandenberg AFB, proximity to a unique microhabitat is the prime driver behind the increased use of turban snails late in prehistory. The Vandenberg AFB data also indicate that increased use of lower-ranking prey such as turban snails may reflect temporary subsistence stress due to environmental degradation, rather than a long-term strategy of subsistence diversification or intensification.

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