ARCHAEOLOGY OF *OSTREA LURIDA* IN DRAKES ESTERO, POINT REYES NATIONAL SEASHORE

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TABLE OF CONTENTS

FIGURES

TABLES

APPENDIX

INTRODUCTION AND STATEMENT OF PURPOSE

This study was undertaken to assist the National Park Service (NPS) with the cultural resources section of an Environmental Impact Statement (EIS) conducted to evaluate a Special Use Permit for commercial oyster operations in Drakes Estero. This study will also assist resource management planning for the waters of Drakes Estero by providing additional information on the Estero's historical ecology with regard to shellfish species.

The objectives of this study were two-fold. The first was to conduct an intensive surface inventory of archaeological sites CA-MRN-242 and CA-MRN-296 and their immediate environs (Figure 1). Particular importance was placed on gathering information on the occurrence and relative quantity of Olympia oyster (*Ostrea lurida*)[1] in relation to other shellfish species represented at these archaeological sites. The second objective was to review the archaeological and ethnographic literature relevant to the occurrence of Olympia oyster in the vicinity of Drakes Estero. In particular, this literature review focuses on the presence, origin, and age of the Olympia oyster remains at archaeological sites on the Point Reyes peninsula, as well as the Olympia oyster's relative importance as a food source for the Native Americans who occupied the area.

This report concludes with a synthesis of these data that places the current study in a comparative context and in relation to the archaeology of the Point Reyes Peninsula.

METHODS

INTRODUCTION

This study was undertaken to identify and quantify the shellfish remains present on two archaeological sites as well as to survey and update the sites' archaeological record forms. The use of standard archaeological field and analytical techniques will allow for comparison studies in the future.

Fieldwork was conducted by a team of archaeologists from the Anthropological Studies Center at Sonoma State University (ASC) and the National Park Service (NPS), marine biologists from the University of California, Davis, and a representative of The Federated Indians of Graton Rancheria (FIGR). The archaeological team consisted of Staff Archaeologist Michael Konzak, M.A.; Staff Archaeologist Sandra Massey, M.A.; Archaeological Technician Annamarie Leon Guerrero, B.A.; and NPS archaeologist Paul Engel, B.A. The marine biologists were Edwin Grosholz, Ph.D. and Chela Zabin, Ph.D. Nick Tipon was the Tribal representative from the Federated Indians of Graton Rancheria.

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[1] The oyster native to California and the west coast (*Ostera lurida*) is referred to as "Olympia oyster" in this report. Other references in the archaeological literature refer to *Ostera lurida* as just "oyster", "bay oyster", "cove oyster" (Moratto 1984) or even as "Pacific oyster" in earlier publications (Greengo 1954), likely to differentiate it from Eastern oysters (*Crassostrea virginica*). In this report, *Crassostrea gigas* will be referred to using the common name "Pacific Oyster". See Table 1 for common and scientific names for shellfish.

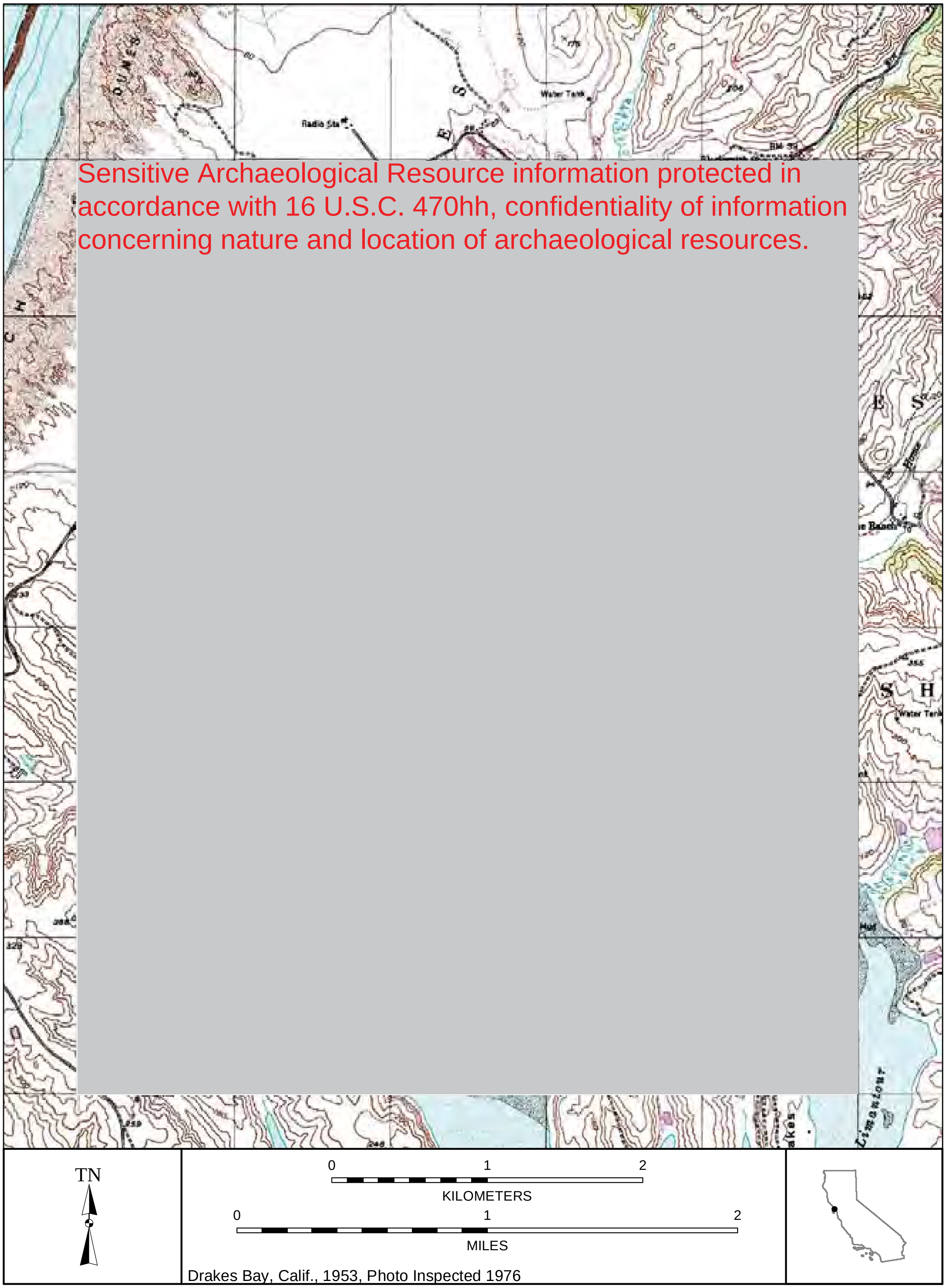

Figure 1. Location of CA-MRN-296 and CA-MRN-242

Methods

A research design (Praetzellis 2010) prepared in advance of project fieldwork specified procedures for site analysis. Created before field conditions were fully known, this document was designed for an ideal case scenario. Actual field conditions required these procedures to be modified to collect the most data possible in the time allowed.

Archaeological investigations of CA-MRN-242 and CA-MRN-296 were undertaken in three parts: identification of the sites and their constituents, identifying and recording all cultural materials and marine shells in a series of 3.3 by 3.3 ft. (1 meter square) surface sample units (SUs), and, where possible, investigating natural and human-made cut banks and eroded areas to record the sites' stratigraphy. No archaeological excavation or other ground disturbing activities took place due to the recorded presence of human remains at the sites and out of respect for the customs of the Coast Miwok. Vegetation and exposed profiles were cleared, but no excavation of any kind was carried out. The SUs were cardinally aligned and their locations recorded by GPS. The sites and adjacent features were mapped using a Trimble GeoXH, sub-foot accurate GPS receiver.

Common Name	Genus species
Olympia oyster	*Ostrea lurida*
Pacific Oyster	*Crassostrea gigas*
Eastern oyster	*Crassostrea virginica*
Common Washington clam	*Saxidomus nuttalli*
Common Pacific Littleneck clam or Rock Cockle	*Protothaca staminea*
Nuttall's cockle	*Clinocardium nuttalli*
California Mussel	*Mytilus californianus*
Bay mussel	*Mytilus trossulus*
Abalone	*Haliotis sp.*
Giant Moon Snail	*Euspria lewisii (formerly Polinices lewisii)*
Geoduck	*Panopea generosa*
Pacific gaper clam	*Tresus nuttalli*
Soft-shell clam	*Mya arenaria*

Table 1. Common and scientific names of shellfish

Within the SUs and during the process of recording the exposed profiles, all shellfish remains were examined by both archaeologists and biologists to determine taxon and, when possible, species. To determine the quantity of shells in an area, a minimum number of individuals (MNI) was calculated. This number was determined by counting non-repetitive elements, for bivalves this was done by counting whole and complete hinges, as suggested by Mason et al. (1998).

Samples of Olympia oyster shells identified at CA-MRN-296 and CA-MRN-242 were collected for radiometric dating. These shells were taken primarily from vertical cuts and SUs. Where Olympia oysters were identified in additional locations, they were collected and their location recorded using GPS. The shells collected were tentatively identified in the field as Olympia oyster by the team biologists and grouped by sampling units. These collected samples were then examined with a binocular dissecting scope by Grosholz and Zabin at the Romberg Tiburon Center of San Francisco State University and compared with literature descriptions and living samples to verify species identification. (see Appendix A: Grosholz and Zabin 2010). The largest samples of oyster shells were then sent to Beta Analytic laboratories for radiometric dating. Each date received from Beta Analytic is based on a sample of the combined shells identified from an individual unit.

Dense poison oak and coastal scrub at CA-MRN-296 made it necessary to modify the original plan of randomly placed 6.5 ft. (2 meter) square units (Praetzellis 2010). The size of the SU was reduced to 3.3 ft. (1 meter) square units and testing focused on areas of high surface visibility.

While the physical and vegetation differences, such as a vegetable garden located on the east side of CA-MRN-296, between the two sites made it necessary to vary slightly in field methods, every attempt was made to be consistent. Variations are described below.

CA-MRN-296

As this site had not been as thoroughly recorded as other prehistoric sites on Drakes Estero, the initial phase of investigations began with a surface pedestrian survey using 16 to 32 ft. (5 to 10 meter) spaced transects. Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information concerning nature and location of archaeological resources.

Clearings were examined for shell deposits and cultural materials. SUs were placed in areas where cultural deposits were identified. Care was taken to place SUs intermittently throughout the study area in order to gain an aerially representative sample of the site's content.

Vertical cuts were examined to record site stratigraphy. These areas were cleared of roots and vegetation, and eroding soil was moved to identify the layers beneath. These strata were examined for shell and cultural materials and drawn.

CA-MRN-242

This is one of the largest and most studied sites on Drakes Estero and its location is well defined. NPS volunteer and archaeological site steward Peter Van der Naillen reviews the site's condition annually. Van der Naillen assisted us to identify the location and its boundaries.

The site was initially examined by walking 16 to 32 ft. (5 to 10 meter) transects to determine areas of high surface visibility, the types of material present, and the boundaries of the deposits. A similar method was used to position SUs as had been employed at CA-MRN-296. In areas of high visibility, due to either dying vegetation or rodent back dirt, SUs were placed to record the shell and identifiable cultural materials. Since these SUs were found to cluster, two additional rows were placed near the eroding margins of the site. These locations were chosen to avoid areas in the central portion of the site where Beardsley's excavations had taken place (Beardsley 1954) and thus focus on locations where depositional integrity was greater.

CA-MRN-242 is subject to erosion on Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information concerning nature and location of archaeological resources. Safety concerns prevented archaeologists from examining the eroding deposits in cross-section.

ARCHAEOLOGICAL SITE DESCRIPTIONS

INTRODUCTION

In her National Register nomination of the Point Reyes Indigenous Archaeological District, Suzanne Stewart identified seven categories of archaeological sites on the Point Reyes Peninsula: possible major occupation sites; large, complex shell middens; small to medium sized, rich shell middens; small shell midden only; dark earth midden; lithic site only; and unclassified (Stewart 2008:12). She also defined several site clusters by geographic proximity. The Drakes Estero cluster is defined by Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information concerning nature and location of archaeological resources.

Within the Drakes Estero cluster, Sensitive ARPA information Stewart 2008:13). The remaining sites are two dark earth middens and two unclassified sites. The latter contain shell midden but have not been as intensively studied as the others.

The two sites examined in the field portion of this study were defined as a "large, complex shell midden" (CA-MRN-242) and as "unclassified" (CA-MRN-296) (Stewart 2008:13). CA-MRN-242 has been heavily studied. A large portion of the deposit has been excavated and was said to be the largest, most complex site on the Estero. Sensitive ARPA information Sensitive ARPA information CA-MRN-296 has not been as intensively examined. No archaeological excavation has taken place at this site.

Both CA-MRN-242 and CA-MRN-296 have been previously recorded by archaeologists as containing archaeological deposits of *Ostrea lurida*. The following sections contain a description of each site, the history of archaeological investigations at each, a description of the work undertaken for this study, and a summary of the results.

CA-MRN-296

Site setting/structure

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Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

Figure 2. CA-MRN-296: Archaeological Site Map

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

CA-MRN-296 is heavily overgrown with a mixture of invasive and native plants, primarily a tall and expansive quantity of dense poison oak. Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information concerning nature and location of archaeological resources.

Site history

CA-MRN-296 was first recorded by Francis "Fritz" Riddell in 1948 as a shellmound located in the lea of a small knoll, facing a tidal creek. He defined the site as 200 ft. by 200 ft. (about 60 by 60 meters) with a depth of approximately 6 ft. (2 meters). Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information Other intrusions include a garden and the "Oysterman's recently built cabin." Riddell reported that "bones" were found when the area for the house was excavated and a "beartrap" or large steel trap found at "depth" (Riddell 1948).

The site was revisited by Robert Edwards in 1967. He noted shell midden with large pockets of solid shell, bone, and obsidian flakes. Edwards provided a similar estimate of the site's extent, enlarging Riddell's estimate slightly to 195 by 245 ft. (60 by 75 meters) with a depth of 6.5 ft. (2 meters). In addition to the disturbances noted by Riddell, Edwards noted that the small knoll was being removed for fill. He remarked that the site "needs immediate salvage" (Edwards 1967a).

Michael Moratto's 1974 assessment of cultural resources in Point Reyes National Seashore includes a short note on the status of CA-MRN-296. While little additional information regarding the site's structure or constituents is provided in this report, Moratto noted that the site had been "*extensively damaged* by bulldozing relating to the oyster farm" (emphasis in the original) and the site "could be further damaged by the development of additional seafood sales facilities and interpretive devices" (Moratto 1974).

Lynn Riley's 1976 assessment of endangered archaeological sites in the Point Reyes area provided more information than any of the previous site records. In her initial introduction to the site, Riley qualified her study in the statement "the activities of the oyster farm and the present use of the site have made MRN-296 an especially difficult deposit to evaluate" and went on to say that the site "has suffered from extensive cultural modifications" (Riley 1976:56). She also noted that the oyster shells from the farm had been heaped on top of the site until, in the words of an oyster farm worker, "the truck could no longer make it up the hill" (Riley 1976:58). Riley continued: "The surface of the deposit is covered with shells from a species of oysters that I have not seen in other central California shellmounds… " and "… a visual inspection of the midden surface will not clearly differentiate between aboriginal and recent shell deposits" (Riley 1976:58). Additionally, she reported modern refuse—bedsprings, glass, nails, and composition roofing—up to 3.28 ft. (1 meter) below the surface along the northern cut. Despite (or perhaps because of) these disturbances, Riley noted occasional clam and cockle shells. In her concluding recommendations, Riley recommended limited exploratory excavation of the site to determine if intact deposits exist beneath the modern oyster shell deposits and to identify the extent of any prehistoric deposit.

During the 2010 fieldwork, a long term employee of both Johnson's Oyster Farm and the Drake's Bay Oyster Company indicated that during ground disturbance Sensitive ARPA information in the mid-1980s a human skeleton was found at a depth of approximately 4 ft. (1.2 meters) surrounded by mussel and clam shells. Kelly (2004) reports that the remains were reburied on site after analysis by Dr. Robert Jermain from San José State University.

In 1998, Sonoma State University graduate student Barbara Polansky visited and re-recorded CA-MRN-296 as part of her MA thesis research on prehistoric settlement patterns in Point Reyes (1998). Polansky noted a very dense concentration of over 2000 Olympia oyster shells in a 16.4 by 16.4 ft. (5 by 5 meter) area as well as evidence of looting, which she believed might still be taking place. Perhaps due to their fragmentary condition, Polansky appears to have misidentified the oyster species represented at this site. Polansky's thesis makes no reference to the disturbed stratigraphy, mining for fill, or dumping of oysters reported by Riley (1976).

CA-MRN-296 was visited by Michael Jablonowski in 2001. He focused only on the northern cut, with no indication that the site was explored or identified beyond that exposed cut. Jablonowski indicated the presence of a buried shell lens and suggested a likelihood of buried deposits elsewhere on the site. He also recommended dating shell samples from the deposit to determine if it is indeed prehistoric (Jablonowski 2001). No samples were taken nor any radiocarbon testing undertaken as part of that study.

Site content

During the 2010 fieldwork carried out for this project, six SUs and two exposed vertical cuts were analyzed (See Figure 2). The six SUs were placed in areas that contained shells in addition to the non-native Pacific oyster (*Crassostrea gigas*). A vertical cut adjacent to the houses and road was investigated. This cut was identified by management of the Drake's Bay Oyster Company as a location where they had seen oyster remains. The second cut analyzed was adjacent to the garden.

By visual observation non-native oyster shell was identified as the main constituent in all units and throughout the site. *The Pacific oyster shells were considered a modern intrusion and due to the extremely high differences in quantity between this species and the native species, they were not* *counted in the SUs or cuts in the interest of time*.[2] The presence of this non-native shell mixed in with a dark organic midden soil was in fact the main identifiable feature of this site, likely due to the area being used as a dumping ground for Johnson's Oyster Farm and the area being mined for fill (Riley 1976).

Of the native species identified in the SUs, clams made up the highest quantity, with the shells of the Common Washington Clam (*Saxidomas nuttalli)* being the most common. Cockles (*Clinocardium nuttallii*), Pacific Littleneck clam (*Protothaca staminea*),) and an unidentified species of clam were also identified. Clams made up approximately 74% of the overall native shellfish assemblage (See Table 2 for list of non-invasive shell quantities per SU). Examples of a non-native clam (*Mya arenaria*) were found in two units. Nine Olympia oyster shells were identified: eight in SUs 2, 4, and 5, one in Cut 1. Their proveniences were recorded by GPS and the shells collected for radiometric dating. Olympia oysters made up approximately 26% of the native shellfish assemblage. One sea mammal long bone was identified in the garden and two large artiodactyl vertebrae were noted adjacent to SU 1. Cut 1 was the more informative of the two exposures. This 30 ft. (9 meter) long cut bank was located along the north edge of the site, and had been exposed by road grading and subsequent erosion. The exposed cut was a maximum of 4.3 ft. (1.30 meters) high, ending at a 45-degree slope to the road bed (Figure 3).

The general sequence of stratigraphy in the cut began with an AO-horizon of shell midden with moderately dense grassy vegetation and weathered siltstone gravel (Layer 1, 10 cm. thick). Below this was the main layer comprised of dark sediment with a dense concentration of large shell fragments, predominately non-native Pacific oyster (Layer 2, averaging 50 cm. thick, but ranging from 10 - 60 cm. in thickness). This was followed by a layer of shell midden containing very little shell (Layer 3, 20 - 30 cm. thick). Below these cultural layers lay a dark orange-brown subsoil with weathering siltstone flecks (Layer 4, 30 cm. observed down to break in slope) ending with weathering siltstone bedrock (maximum thickness of 1 meter observed down to break in slope).

According to the team biologists, most of the oyster shell visible in Cut 1 appeared to be non-native, with one Olympia oyster specimen collected. Some non-native clam specimens were also present.

Cut 2 was adjacent to SU 4, where four Olympia oyster shells had been identified. No discernable end to the midden was identified in this exposure nor was the dense shell layer found in Layer 2 of Cut 1. Several Washington clam shells, a cockle shell, a Geoduck (*Panopea generosa*, and Pacific oyster shells were identified in the matrix. Some possible heat-affected rock fragments were also identified.

The largest samples of Olympia oyster shells collected at CA-MRN-296, from SU 4 and SU 5, were sent to Beta Analytic, Inc. for conventional radiometric analysis. Conventional radiometric analysis was performed. A Delta R value of 290 +/- 35 representing the mean average of Northern California Coast as defined by Ingram and Southon (1996) was used to

[2] An addendum to this report will examine and quantify the non-native oysters remains present at CA-MRN-296.

Table 2:
CA-MRN-296: Quantities of Native Shell per Sample Unit

SU	Olympia oyster	Pacific Littleneck clam	Washington clam	Cockle	Undiff. Clam	Total Shellfish
1		1	5		1	7
2	1				1	2
3			5		2	7
4	4	1	1			6
5	3			1	2	6
6			2		1	3
Totals	8	2	13	1	7	31

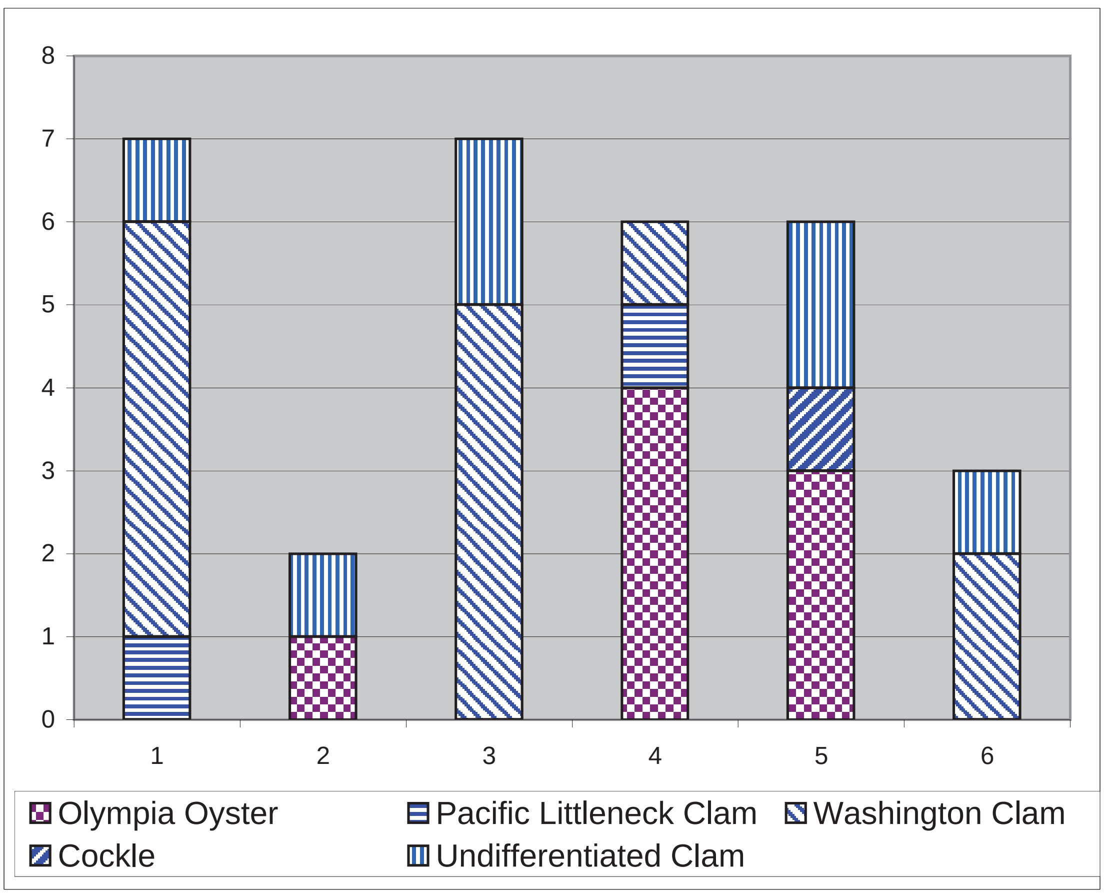

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Figure 3. CA-MRN-296: Profile of Cut 1

assist in calibrating. Sample SU 4 had a date range of 1770 to 1490 BP[3] (AD 180 to 460) while SU 5 had a date range of 1410 to 1140 BP (AD 540 to 810). (Appendix C)

Summary description

The high level of disturbance to this site documented by Riddell (1948) and Riley (1976) as well as the large quantity of relatively recent Pacific oyster shell identified both on the surface and in exposed cross-sections, make it unclear how much of the exposed content of this site is of prehistoric origin.

The absence of cultural materials commonly found at prehistoric midden sites (e.g., artifacts and faunal remains) in Cut 1 suggests that the sediments and shell visible in the exposure is the result of periods of slumping and erosion from prehistoric and modern deposits further upslope.

The relatively low proportion of shells representing aboriginal species of oyster and clam in the SUs compared to Pacific oyster shell support the notion that much of the deposit visible on the surface is of modern origin. The quantities and types of shells documented in the SUs are similar to those found in common mariculture refuse deposits, as other shellfish are often harvested inadvertently along side the targeted shellfish (Grosholz 2010, pers. comm.). However, the dates provided from radiocarbon testing indicate that the Olympia oyster shells were prehistoric in origin. This indicates that the numerous disturbances referenced in past studies have mixed the prehistoric material with the modern Pacific oyster shell dump. The shell midden recorded by archaeologists and reported by workers of the oyster farms may still be intact in portions of the site that have been buried by alluvium and the commercial oyster dump.

CA-MRN-242

Site setting/structure

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thick growth of grass covers most of the site. Concentrations of non-native thistles grow tall Sensitive ARPA information Sensitive ARPA information Erosion along the gully and the bluff has exposed the shell and dark midden soil that characterizes the site. Rodent burrow backdirt reveals the presence of shell, faunal bone, and midden throughout the site (See Figure 4).

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Richard Beardsley noted a spring approximately 600 feet (180 meters) behind the site in the 1940s. He also noted that the gully near the middle of the site was created to drain a sump

[3] All dates are calibrated BP unless noted.

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Figure 4. CA-MRN-242: Archaeological Site Map

adjacent to the site (Beardsley 1954). Sensitive ARPA information

Sensitive ARPA information

Site history

CA-MRN-242 was first recorded in 1940 by Robert Heizer, then a graduate student at the University of California, Berkeley Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information concerning nature and location of archaeological resources.

Richard Beardsley, then a graduate student of anthropology at the University of California, Berkeley, excavated the site in 1940-1941 Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information concerning nature and location of archaeological resources. The archaeological deposit was estimated to be 90 by 120 ft. (27.4 by 36.6 meters) in diameter with a depth exceeding 6 ft. (1.9 meters). Beardsley excavated 6500 cubic feet (184 cubic meters) of shell midden, estimated as approximately 1/3 of the site at that time. He noted severe site disturbances in the form of 2-foot-deep furrows Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information concerning nature and location of archaeological resources. and "exuberant rodent activity" (1954: 22). Beardsley also observed that two distinct cultural components and a dense shell layer were intact. The latter was comprised of "whole or very nearly whole clam shells thickly bedded together" and was part of the earlier (Cauley A) cultural component. Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, Confidentiality of information

B. Childers and Robert Edwards separately rerecorded the site in 1967 (Childers 1967, Edwards 1967b). Both reported the presence of looters' backdirt piles along the cliff face that were increasing erosion. Childers (1967) noted that a burial had been disturbed and the skull removed by the looter. Other notes are consistent with the artifacts and midden mentioned in previous reports but they disagree on the size: Childers recorded the site as 130 by 50 feet (39.6 by 15.2 meters) and Edwards 230 by 65 feet (70 by 20 meters).

Michael Moratto (1974) noted the site had been 40% excavated. He estimated that only 20-30% of the site remained intact and warned of continued erosion and vandalism.

Lynn Riley (1976) conducted an assessment of endangered archaeological sites including CA-MRN-242. Among a description of the artifacts visible on the surface, she provides a list of shell species present including *Ostrea lurida*, various clams, cockles, mussels, and moon snail. Riley also noted later historic-period artifacts, such as lumber and stove parts, likely from the shack that was recorded there in the 1940s. While she reported the size of the site as relatively consistent with Beardsley initial estimate, 100 by 90 ft. (30.5 by 27 meters) she indicated that Sen sitiv

Sensitive ARPA information

Ward Upson (1977) revisited the site a year later, noting that the site contained "large quantities of just about all the shells common to estero systems" as well as the presence of clams, cockles, mussels, and moon snail, but did not include oyster on his list. Upson was the first to note pilings at the end of the gully, depicted as the footings for a pier on his sketch map.

In 1998, Sonoma State University graduate student Barbara Polansky rerecorded CA-MRN-242 as part of her thesis research on prehistoric settlement patterns in Point Reyes (1998). She described it as a "tremendously rich site" with the most dense shell midden she encountered during her study and with the most variety and numbers of shellfish remains (1998:163). She also noted over 30 vertebrae from different fish species, sea lion vertebrae, hundreds of bird bones, and numerous mammal bone fragments. In a 16.4 by 16.4 foot (5 by 5 meter) sample she recorded the remains of "100+" Olympia oysters, "1000+" mussels, "200+" cockles, "1900+" clams, "50+" crab, "50+" chiton, and "20+" sea snails, noting that the deposit was "far too extensive to get counts" (1998:163).

Michael Jablonowski (2000) revisited the site and found conditions similar to previous recordings. While noting increasing erosion, he mentioned identifying obsidian flakes on the beach below the site.

Matthew Russell, a Ph.D. candidate at the University of California, Berkeley, recorded CA-MRN-242 as part of his doctoral research and mapped the site in 2009 (2010, pers. comm;. Van der Naillen 2009). Using a GPS with centimeter accuracy, he recorded the topography and extent of the site, partially to determine the extent of previous excavations. Peter Van der Naillen, a NPS volunteer accompanying Russell, noted the erosion of the site, a small amount of modern debris, and a high level of rodent disturbance that exposed midden and shell on the surface of the site.

Site content

Twenty SUs were recorded during the 2010 fieldwork. SUs 1-10 were arbitrarily placed in areas of high visibility. The high visibility areas were islands of midden and shell created by dying plants (non-native thistles) and rodent activity breaking through the thick grasses.

SUs 21-30[4] were arranged in two parallel rows oriented roughly east/west across the site. The rows were 33 ft. (10 meters) apart and a SU placed every 16.4 ft. (5 meters). The rows were placed near the cliff face and gully to avoid the center of the site that had been excavated by Beardsley in 1940-41 (see Figure 4).

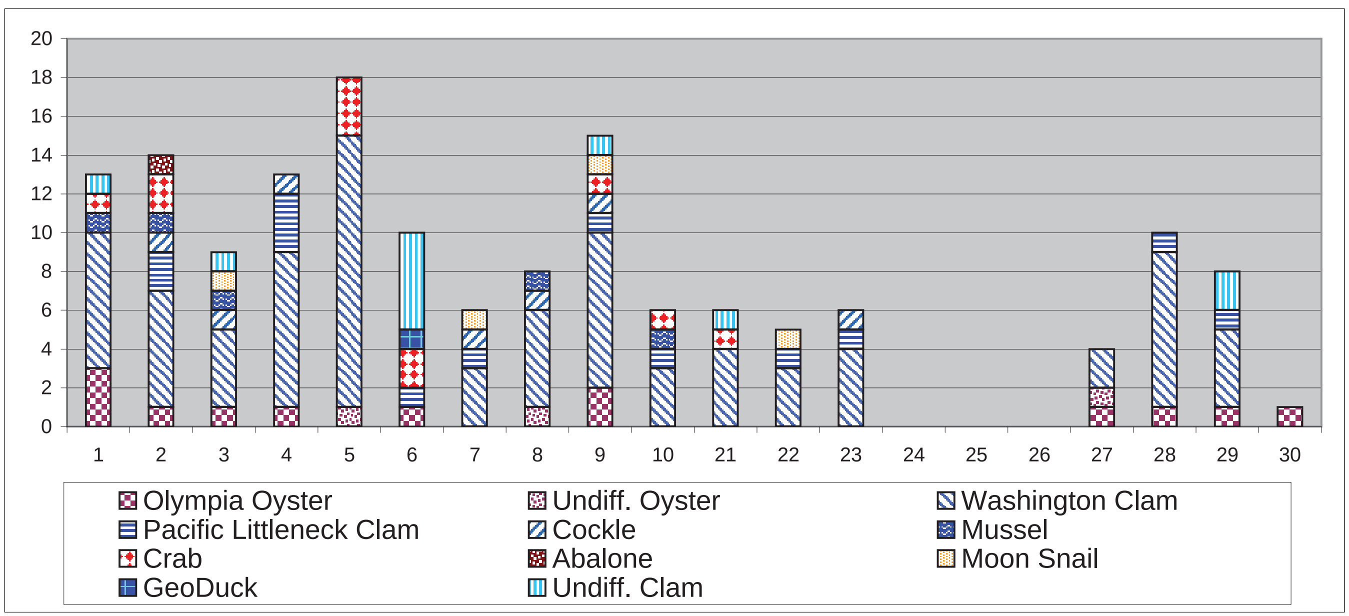
No vertical cuts were examined for stratigraphy due to unsafe conditions. Possible Olympia oyster shells were collected from one concentration along the western cliff edge (collection Point A).

Numerous species of shell were identified in the SUs including Olympia oyster, Common Washington clam, Pacific Littleneck clam, cockle, mussel (*Mytlis spp*), Geoduck clam (*Panopea generosa* also known as *P. abrupta*), abalone (*Haliotis sp.*), Moon snail (*Euspria lewisii*, previously known as *Polinices lewisii*), and crab (*Cancer* spp.). Un-speciated shell included clam and oyster

[4] Numbers 11 to 20 were not used.

Table 3.
CA-MRN-242: Quantities of Shell per Sample Unit (SU)

Unit	Olympia Oyster	Undiff. Oyster	Washington Clam	Pacific Littleneck Clam	Cockle	Mussel	Crab	Abalone	Moon Snail	GeoDuck Clam	Undiff. Clam	Total Shellfish	Percentage clam
1	3		7			1	1				1	13	61.54
2	1		6	2	1	1	2	1				14	64.29
3	1		4		1	1			1		1	9	55.56
4	1		8	3	1							13	92.31
5		1	14				3					18	77.78
6	1			1			2			1	5	10	60.00
7			3	1	1				1			6	83.33
8		1	5		1	1						8	87.50
9	2		8	1	1		1		1		1	15	66.67
10			3	1		1	1					6	66.67
21			4				1				1	6	83.33
22			3	1					1			5	80.00
23			4	1	1							6	100.00
24												0	
25												0	
26												0	
27	1	1	2									4	50.00
28	1		8	1								10	90.00
29	1		4	1							2	8	62.50
30	1											1	0.00
Total	13	3	83	13	7	5	11	1	4	1	11	152	73.03



samples. Bone from an indentified bird, a fragment from a medium sized mammal, a fragment of sea mammal bone, an elk carpal, and several Gaper clam (*Tresus nuttallii*) shell were also identified. Heat-affected rock was also observed in several areas. One piece of Chinese porcelain was collected by NPS archaeologist Paul Engel. This fragment is thought to be the same type as the Ming dynasty pieces found by Beardsley in 1940-41.

Clams and cockles made up the majority of shellfish identified in the SUs (see Table 3). An average of 69.7% of the individuals in the SUs were clam, which made up 73% of the total assemblage. On an individual level, Washington Clam constituted 54.6% with Pacific Littleneck clams and Olympia oysters the next major contributors at 8.7%. No Pacific oysters, Mya clam, or other invasive species were positively identified but some oyster and clam specimens could not be speciated.

The largest samples of Olympia oyster shells collected at CA-MRN-242, from SU 1 and Collection Point A, were sent to Beta Analytic, Inc. for conventional radiometric analysis. Conventional radiometric analysis was performed. A Delta R value of 290 +/- 35 representing the mean average of Northern California Coast as defined by Ingram and Southon (1996) was used to assist in calibrating the samples. Sample SU 1 had a date range of 2170 to 1810 BP (220 BC to AD 140) while Collection Point A had a date range of 1530 to 1310 BP (AD 420 to 640) (Appendix C).

Summary description

The wide range of shell identified on this site, as well as the presence of several types of faunal remains, indicate a substantial prehistoric deposit. This was not unexpected, as CA-MRN-242 is known to be one of the larger sites on Drakes Estero and excavations have shown it to contain a variety of resources available in the Estero as well as materials from outside the immediate area (Beardsley 1954).

Beardsley's excavation of CA-MRN-242 identified two layers on the site and a depth of cultural materials that exceeded 6 feet (1.9 meters) (1954:21). As we were not able to examine the stratigraphy of the site first hand, Beardsley's data assisted us by providing insights into the structure of the site.

The great quantity of Washington clam was not unexpected given the favorable habitat of Drakes Estero for clams (Grosholz and Zabin 2010) and that Washington clams were used by the Coast Miwok as food and as raw material for shell beads/money (Collier and Thalman 1996; Kawahara 1970). The site's inhabitants clearly made intensive use of locally available shellfish resources.

Non-local material is exemplified by abalone and mussel. These shellfish would not have grown in Drakes Estero but may have been available from other portions of the Point Reyes coast (Grosholz and Zabin 2010). Obsidian found in previous studies (Beardsley 1954, Riley 1976) is also a good indicator of traded goods, as the likely obsidian sources range from Clearlake to Annadel to Napa. This range of non-localized goods illustrate that this site was a nexus on a larger trade network during prehistory.

LITERATURE REVIEW

It is important to examine archaeological and ethnographic literature in order to assess the significance of the presence of shellfish remains at CA-MRN-296 and CA-MRN-242. Due to the proximity of Point Reyes to the San Francisco Bay Area and some of the first university anthropology departments in California, there has been a significant history of archaeological research in this region. This is particularly true at Drakes Estero because of the historic documentation and physical remains attributed to two of the earliest European explorers of California, Drake and Cermeño (Stewart 2009:14).

Information relating to the use of shellfish in prehistory and the presence of the Olympia oyster in this literature was examined and an effort was made to evaluate this information for irregularities. The wide range of skills required in the study of archaeology, the length of time archaeologists have investigated this region, and the changes in standards over time may have lead to errors, misidentifications, or inconsistencies in some of the reports examined.

This literature review focused on two different categories of documents: archaeological reports and site records, and ethnographic data. To help set these documents in a wider perspective, the current and prehistoric environmental conditions of the Estero and the natural habitat of shellfish were also examined.

Environmental Conditions at Drakes Estero

A U.S. Geological survey report on pollution studies in Drakes Bay (Anima 1991) provides descriptions and maps of the geologic makeup of Drakes Estero. Anima describes Drakes Estero as a coastal lagoon consisting of five branching bays with intertidal flats and sand flats around their margins (Anima 1991:29). Further details on the Estero are provided in a series of maps detailing the sediments and surface of the various bays. Sediments in the Estero generally range from medium grained sand to medium fine silt (42), though larger sediments (boulders cobbles and pebbles) were located in small areas adjacent to the steep cliffs that line the Estero (139-144).

Clams, such as the Common Pacific littleneck, Washington clam, or the Pacific gaper clam, are found in sand and mud flats at the low tide level down to depth of 100 feet or more (Rehder 1990:808, 802, 588). The Olympia oyster needs a hard surface to settle, but may attach to "small pieces of hard substrate" (Baker 1995:503). Baker notes that oysters can thus create loose reefs or beds in softer mud areas but also observes that "large populations also occur on rock reefs, and individuals or clusters are common on rocks…" (503). Conte indicates that natural beds are located in the sub-tidal zone for protection from seasonal temperature fluctuations; oysters often are found along rocky outcrops that provide protections from rays and other predators (Conte 1997). While conditions in Drakes Estero would support Olympia oysters, most of the Estero appears to be a more suitable habitat for species of clams.

Prehistoric Environmental Conditions at Drakes Estero

Anderson's report on the historic ecology of the Point Reyes peninsula examined sediment cores from five locations analyzing the pollen and charcoal present (2005). One of these locations was located in a bog at the head of Creamery Bay, Sensitive ARPA information

Here Anderson was able to identify three periods each dominated by a distinct vegetation community: 8000 to 5500 BP, 5500 to at least 1000 BP, and the historic period approximately 1840 to the present (2005:11).

The pollen sample from Creamery Bay contained an assemblage dating from 5500 to 1000 BP. It contained evidence of the sun flower family, grasses, sage scrub flora, and an abundance of *Ranunculus* (relatives of the buttercup family) and Quillwort spores (Anderson 2005:11). Anderson also noted small quantities of pine pollen as well as trace levels of Oak, Sequoia and Douglas fir pollen (2005:11).

These pollen data indicate that from approximately 5500 to 1000 BP the Creamery Bay area was a wet meadow with standing water at times, surrounded by grassland with coastal scrub in the uplands. A few pines may have been in the vicinity, but oak, fir, and sequoia were absent. Prior to this period, there were drier meadow conditions while the historic period was marked by an increase in introduced species and a decline of pine (Anderson 2005:11). While this analysis is on but one of the bays of Drakes Estero, conditions in the Estero in general can be inferred.

Ethnography of the Coast Miwok

Isabel Kelly was one of the few anthropologists to interview Coast Miwok elders. During fieldwork in 1931 and 1932 she interviewed Tom Smith of Bodega Bay and Maria Copa Frias from Nicasio (Kelly 1978). Of the two, Smith provided most information relevant to this study. While Kroeber (1925:272) noted that the Bodega people spoke a different dialect than those of the surrounding areas, the information provided by a Native American fisherman is clearly of significance to this study.

Smith described the great abundance of shellfish but comments that that only mussels and clams were important as a food source to the Coast Miwok (Kelly 1978:416). Collier and Thalman's organization of Kelly's original field notes (1996) contains long discussions of the various types of clams and their uses. Only two entries relate to Olympia oysters.

Tom Smith provided three pieces of information about oysters: where they were located, their relative abundance, and their proximity to Native American village sites (Collier and Thalman 1996:127). He noted only "one or two places" with oysters in the region (Collier and Thalman 1996:127) and commented that they did not exist in great numbers. The only area named by Smith was located near the mouth of Valley Ford Creek, across the creek from the village of *Awatci* (Collier and Thalman 1996:62, 127). Smith's testimony regarding the use of oysters is, in part, contradictory. At one point he indicated that oysters were not gathered but later mentions that they were "dug with a stick" (Collier and Thalman 1996:127).

Archaeology of Drakes Estero and Tomales Bay

From Heizer's initial investigations of the area in the 1940s to Matt Russell's current dissertation research, Drakes Estero has been extensively researched by local universities. Other studies, such as the present one, have been conducted in order to provide data for environmental and resource management and to comply with environmental and historic preservation legislation. This section reviews a selection of these unpublished manuscripts and technical documents of limited circulation that relate to the archaeology of Point Reyes.

Mark Rudo's (2009) summary of archaeological research in Drake's Estero provides a good background for study of prehistoric shellfish use. Rudo noted that only two of the many archaeological sites on the Estero have been recorded as containing large proportions of Olympia oyster remains, CA-MRN-296 and CA-MRN-242, though trace samples were found at three other sites, CA-MRN-216, CA-MRN-298, and CA-MRN-230. He also provided a brief, preliminary analysis of outlying areas, including Bodega Bay and Tomales Bay. In this analysis he noted that the Olympia oyster had not been recorded in any recent archaeological site records and their presence only identified in traces at two sites near Bodega Bay (Rudo 2009:5)

This research continues Rudo's comparison by examining literature about Tomales Bay by examining site records from three areas, the Point Reyes National Seashore, Sensitive ARPA information Sensitive ARPA and sites along the eastern edge of Tomales Bay.

The seven archaeological sites within the Point Reyes National Seashore examined here consist of: CA-MRN-222 (Compas and Woods 1993; Edwards 1967c), CA-MRN-225 (Edwards 1967d; Rackerby 1964a), CA-MRN-248 (Compas and Jablonowski 1993a; Edwards 1967e; Rackerby 1964b), CA-MRN-249/H (Compas and Jablonowski 1993b; Edwards 1967f; Jablonowski 1999; Rackerby 1964c), CA-MRN-250 (Edwards 1967g), CA-MRN-262/H (Bryant 1934a; Edwards 1967h), and CA-MRN-266 (Bryant 1934b; Edwards 1967i).

The nine archaeological sites in Sensitive ARPA information examined here consist of: CA-MRN-209 (Bramlette and Tibbets 1988), CA-MRN-219 (Alvarez, Jablonowski, and Tibbets 1988a), CA-MRN-221 (Alvarez et al. 1988a), CA-MRN-241 (Alvarez and Bramlette 1988), CA-MRN-251 (Alverez et al. 1988b), CA-MRN-253 (Alvarez and Jablonowski 1988), CA-MRN-361 (Bramlette and Stewart 1988a), CA-MRN-563 (Bramlette and Stewart 1988b), and CA-MRN-564 (Alvarez and Tibbets 1988).

The five archaeological sites examined here that are Sensitive ARPA information Sensitive ARPA information consist of: CA-MRN-213 (Slater and Wiberg 1984), CA-MRN-214 (Desgrandchamp and Sutton 1978; Holman and Clark 1984), CA-MRN-297 (Gerken 1967), CA-MRN-516/H (Alvarez, Jablonowski and Tibbets 1988b; Lindahl and Gruver 2002), and CA-MRN-613 (Gmoser and Dowdall 1994).

Reports examined include Compas and Praetzellis' 1994 archaeological survey of 21 sites Sensitive ARPA information, Alvarez and Bramlette's 1988 Sensitive ARPA information a surface collection report from CA-MRN-297 (Gerkin 1967), a report of Treganza's excavation of CA-MRN-222 (Treganza and King 1968), and Beardley's 1954 report that discusses his excavation at CA-MRN-266.

These reports and other technical documents evoke a picture of the prehistoric life and landscape of Tomales Bay that differs from that of Drakes Estero.

Compas stated definitively that oyster shells were found on archaeological sites in the Tomales Bay region (Compas and Jablonowski 1993a, 1993b, 1993c; Compas and Praetzellis 1994; Compas and Woods 1993). Compas and Praetzellis noted oyster shells at CA-MRN-222,

CA-MRN-224/H, CA-MRN-246, CA-MRN-248, CA-MRN-249/H, CA-MRN-268, CA-MRN-285, CA-MRN-387/H, CA-MRN-388/H, and CA-MRN-390. Ten of the 13 sites identified by Compas and Praetzellis (1994) were said to contain some oyster shell.

These records, however, identify the Pacific oyster (*Crassostrea gigas*), a species commercially grown in Tomales Bay (Rudo 2009:5). Site record forms document historic-period artifacts or deposits at 6 of these 10 sites (CA-MRN-222, CA-MRN-224/H, CA-MRN-246, CA-MRN-249/H, CA-MRN-387/H, and CA-MRN-388/H). Other sites also contain evidence of historic period occupation: At CA-MRN-268, a large eucalyptus tree was said to be located on the middle of the site (Compas and Jablonowski 1993c) while CA-MRN-248 is adjacent to wooden fence posts and an earthen dam (Compas and Jablonowski 1993a). It is clear that at least 8 of these 10 archaeological sites contain evidence of historic-era or modern occupation that may explain the presence of Pacific oyster shells. Given the similarities between the appearance of the species it is possible (and perhaps more likely) that archaeologists misidentified Olympia oyster shells as a non-native species, the Pacific Oyster.

This possible misidentification may be evident in the use of scientific names associated with the identified shellfish species and the complete absence of *Ostrea lurida* in the report. The report identifies clams present at sites using scientific names for specific species but with no differentiation of a common name. The bay mussel is identified by common and and scientific names. Oysters are identified by the scientific name for the Pacific oyster (*Crassostrea gigas*), but the common name is not provided. Common or colloquial names are used elsewhere in the report for other faunal or floral remains, not their scientific names. This inconsistency in reporting suggests that the authors did not scientifically speciate the oysters.

Alvarez and Bramlette's inventory survey in Sensitive ARPA information indicated that both oyster species were present at the prehistoric sites and that oysters were one of a large variety of shellfish harvested in the area. Alverez and Bramlette identified Olympia oyster, gaper clam, Washington clam, rock cockle (Pacific Littleneck clam), hornshells, bay mussels, and limpets as present in the shell midden sites (1988:6). They also note that at the time of the survey mussels, "native oysters", gaper clams, and rock cockle (Pacific Littleneck clam) were present in abundance on rocks near the shore (1988:2).

All records examined for Sensitive ARPA information sites identified Pacific Littleneck clam and Olympia oyster as two of the constituents of the shell middens. Some records referenced these two species exclusively (sites CA-MRN-221, CA-MRN-241, and CA-MRN-563), while the others list one to three other species. While these lists are not likely to be definitive and may represent only cursory examinations of the shellfish present at a site, they document the presence of the oysters within the prehistoric middens at Sensitive ARPA information

Three of the nine site record forms contained references to historic-period components. These components consist of light concentrations of artifacts or a few fragments of ceramic and glass at each site. CA-MRN-219was said to contain a piece of glass formed into a flake tool (Alvarez, Jablonowski, and Tibbits 1988a). Neither these individual site records nor the inventory report refer to local cultivation of Pacific Oysters or the presence of these oysters in or near the prehistoric or historic period components of the archaeological sites.

Gerkin's 1967 report examined an inter-tidal site, CA-MRN-297, located on the eastern edge of Tomales Bay (1967). Gerkin, an avocational archaeologist, was assisted and mentored in her study by many notable members of the archaeological community including Fritz Riddell, Albert Elsasser, and Tom King (1967:1). The site consisted of a shellmidden that was only completely accessible at times of extremely low tide, being mostly inundated during normal tidal conditions. The site is located in an area that was once tested as a commercial oyster farm in the 1930s but quickly failed (Gerkin 1967:4).

Gerkin surveyed the site intermittently, examining artifacts uncovered by the tides and those excavated by clam diggers searching the site for the clams that have nested amongst the midden. She noted a number of prehistoric artifacts as well as shells of the Olympia oyster, Bay mussel, geoduck, rock cockle (Pacific Littleneck clam), Horse clam (gaper clam), Abalone, and moon snail (1967:6). She also noted the presence of Pacific oyster, from the experimental oyster farm, and several historic-period artifacts, including modified, flaked bottle glass and glass beads. Gerkin also includes a quotation from Beardsley describing the nearby environment of the site as being similar to the McClure site (1967:4).

Three of the four other sites examined Sensitive ARPA information are said to contain both Olympia oysters and Pacific Littleneck clams (CA-MRN-213, CA-MRN-214, and CA-MRN-561/H).; CA-MRN-613 is described as being "dominated" by Pacific Littleneck clams; the names of no other shellfish species are provided by the recorder (Gmoser and Dowdall 1994:1). Two of the four sites on the eastern edge of Tomales Bay also contain a historic-period component. CA-MRN-516/H contains dairy-related structures and a historic refuse deposit adjacent to the prehistoric midden (Alvarez, Jablonowski, and Tibbetts 1988b). The record for CA-MRN-214 references a nearby barn and house and that the land is currently a cattle ranch (Desgrandchamp and Sutton 1978).

Treganza's excavation of CA-MRN-222 was briefly examined in Treganza and King's 1968 overview of archaeology in Point Reyes. While this excavation was conducted over a single weekend in 1964, 13 excavation units 5 by 5-ft. (1.5 by 1.5 meter) were excavated (Treganza and King 1968:10). Few artifacts were uncovered (two clam shell beads were noted under the heading "Shell") and no notes were made about the types of shell found in the matrix. Treganza indicated that this site may have been occupied during the historic period as well as during prehistory and may have been contemporary with the McClure site, CA-MRN-266 (Treganza and King 1968:13).

Beardsley excavated CA-MRN-266 (the McClure site) in 1940, 1941, and 1946 (Beardsley 1954:23). While Beardsley did not describe the species present in the site, he provided information on the surrounding environment and used the McClure site as an example when discussing food and cooking. In his description of the general setting of CA-MRN-266, he noted that the nearby bay offers "shellfish in the extensive mudflats" and that "Small mussels abound on the rocky shores to either side" (Beardsley 1954:23).

When discussing food and cooking, Beardsley noted that beds of predominately California mussel (*Mytilus californianus*) shell "burned to a red or grey color" were present at CA-MRN-266 (Beardsley 1954:30). Beardsley also believed that basin-like features in excavation Level 1 at the

McClure site were likely used to steam clams, which were identified in greater quantities in that layer (Beardsley 1954:30). Significantly, Beardsley made no mention of the presence of oyster shell in his discussion.

Archaeology of *Ostrea Lurida* in San Francisco Bay

Along the margins of San Francisco Bay are numerous shellmounds set in a wide variety of landforms. These shellmounds received scholarly attention from the early days of anthropology to today and the research into the cultures that inhabited these archaeological sites is immense. While San Francisco Bay is an area neither exclusive to the Coast Miwok nor similar in environment to Drakes Estero, it provides a useful comparative lens with which to examine the prehistoric presence of the Olympia oyster.

In his groundbreaking survey of the prehistoric shellmounds of the San Francisco Bay Area, Nels Nelson identified several sites that contained shells of the Olympia oyster (Nelson 1909:337). He noted clam and mussel were common to all mounds and usually were the majority of the constituents, but that four sites in Berkeley, Alameda, San Mateo, and Richmond contained large quantities of Olympia oysters. He also noted the "native oyster… no longer breeds in the bay, except possibly off San Mateo" being replaced by planted Eastern oysters (*Crassostrea virginica)* that "thrive fully as well as any of the native molluscs" but were threatened by pollution. In his analysis of the Ellis Landing shellmounds, Nelson identified a stratigraphic transition between clams and mussels, attributing it to a possible change in the local environment and the resulting change in the availability of resources (1910:376-378).

Gifford's slightly later examination of shellmounds noted that mussels, clam, and oyster were the most common and abundant species with "at least one of them being of importance in each of the mounds…" (1916:6). He noted that those sites containing large quantities of oyster shell, were located adjacent to areas then utilized for the production of Eastern oysters (1916:8). He attributed the distinct stratigraphic change between oyster/mussel and clam due to over harvesting (Gifford 1916:10).

Greengo's 1951 work focusing on the mollusks of the San Francisco Bay also examined the presence of oysters, clams, and mussels stratigraphically. Greengo noted that:

> Shellfish remains from mounds might be taken as a *fairly sensitive indicator* of the relative abundance of inter-tidal species… a qualification must be added involving the amount of human effort spent in procuring a meal. (emphasis in original, Greengo 1951:2).

Bennyhoff later dated these shifts to the Middle Period, with oyster giving way to mussel around 1500 BP (AD 430) and mussel to clam around 1150 BP (AD 800) (Milliken et al. 2007:109).

Explanations for the shift between shellfish species continue to be debated. In Jones and Klar's 2007 overview of California prehistory, the chapter *Punctuated Culture Change in the San Francisco Bay Area* (Milliken et al. 2007) synthesizes this discussion. Moratto (1984:259) identified parallels between coastal and bay sites that experience siltation and transition between shellfish species. Story, Usinger and Lukas (cited in Milliken et al. 2007:109) discussed sedimentation smothering oyster beds near San Mateo. Additional evidence links increases in temperatures and salinity levels with periods of Olympia oyster decline (Meyer 2003:6). Others, including such as Broughton or Jones (cited in Milliken et al. 2007:109) continue to champion the idea of overharvesting by Native Americans.

ANALYSES

INTRODUCTION

This study was conducted in two parts: fieldwork and literature review. The first section of this report documents the fieldwork, in which observations on site condition and the data gathered on shellfish are examined and placed in context. The literature review examines technical documents, unpublished reports, and other anthropological, archaeological, and ecological documents to identify the presence, origin, and age of Olympia oyster remains at archaeological sites on the Point Reyes Peninsula, as well as an assessment of the Olympia oyster's relative importance as a food source for the Native Americans who occupied the area. The present analysis synthesizes these two components and places the data in relation to the prehistory of the Point Reyes Peninsula.

PREHISTORIC SHELLFISH USE IN DRAKES ESTERO

Neither the literature review nor the field investigations conducted for this investigation indicate that oysters were used as a significant food resource by the prehistoric inhabitants of the Drakes Estero. Ethnographic research indicates that Bodega Miwok peoples used locally available resources to the extent practicable. Thus, if Drakes Estero contained a population of Olympia oysters that were suitable for collection as subsistence, it is hypothesized that the prehistoric inhabitants of the area would have taken advantage of this resource. If this were the case, the remains of these shellfish would be reflected in the content of archaeological sites on Drakes Estero in proportion to their local abundance. The archaeological fieldwork undertaken for the present study indicates that the Olympia oyster constitutes a small fraction of shellfish remains at these local sites.

The high level of disturbance recorded by Riddell (1948), the expansive disturbances discussed by Riley (1976), and the fieldwork conducted for the present study that identified vast amounts of non-native Pacific oyster shell on both the surface and in the cut banks, indicate that the shell deposits at CA-MRN-296 are a combination of materials of prehistoric origin mixed within a larger matrix of farmed Pacific oyster shells and modern trash. Though Olympia oyster shells are present, they make up a minority percentage of the native shellfish assemblage when compared to native clams.

The level of disturbance at CA-MRN-296 is highlighted when the quantities and types of shell at CA-MRN-296 are compared to those at CA-MRN-242. Though the latter has been subject to large scale excavation, the surviving variety of shellfish species shows that local resources were used and non-local resources brought to the area. Olympia oyster make up 8.5%

of the overall shell assemblage, whereas Washington clam constitutes 54.6% of the assemblage. This pattern indicates that while Olympia oysters were used at this site, they were not a major component of the residents' diet.

This conclusion is echoed in the ethnographic information available on the Coast Miwok (Collier and Thalman 1996). Kelly's interviews with Tom Smith indicate both a scarcity of oysters and a lack of a desire to utilize them. Smith also provided little information on oysters compared to other resources and other shellfish, which is taken to indicate the level importance of oysters to Coast Miwok subsistence at that time. In her later summary of Coast Miwok lifeways for the Smithsonian Institution's volume on California Indians, Kelly specifically stated that mussels and clams were the only important shellfish foodstuff to Coast Miwok (1978:416), leaving out oysters entirely. Whether this is the case for all Coast Miwok territory and for the timeline of Coast Miwok presence is not known. However, it is clear that in areas such as Coast Miwok territory near Bodega Bay where oysters were neither abundant nor easily obtained, they were not utilized by native peoples. Where oysters could be more easily harvested in areas of higher abundance, such as Tomales Bay and San Francisco Bay, Olympia oysters are often identified archaeologically.

There is evidence of Olympia oyster harvesting at many sites in Tomales Bay. However, none of the available studies indicate the quantities of oysters on archaeological sites in Tomales Bay. The archaeological studies that list oysters as constituents of archaeological sites are problematic due to the difficulty of distinguishing between various oyster species in the field. We believe that Polansky (1998) and possibly Compas and Praetzellis (1994) misidentified the species of oysters in their studies. Only one of the studies of Tomales Bay or Drakes Estero distinguished Olympic oyster and Pacific oyster (Gerkin 1967); all other studies identified one species or the other.

In Beardsley's discussion of food and cooking at the McClure site, CA-MRN-266, in Tomales Bay (1954:32), he discussed the importance of mussels and clams at different phases of the site's occupation and among the various features that exemplified cooking methods. Beardsley made no mention of oysters.

All of the Tomales Bay sites containing oyster shells also contained mussels or clams and possibly other species. Given the number of sites documented as containing oyster shells, it can be inferred that Olympia oysters were available for the Coast Miwok to harvest in Tomales Bay. However, the variety of shells present at several of the sites makes it uncertain whether oysters were a primary dietary constituent in Tomales Bay. Without more quantitative data little more can be inferred.

In San Francisco Bay, oysters appear to have been a reliable species during the Middle Period until 1500 BP (Milliken et al 2007:109). When conditions changed, either due to overharvesting or environmental shifts, a species greater in abundance and easier to obtain replaced them as the primary dietary resource. This timeline does not correspond with radiocarbon dates on oyster shells from CA-MRN-296 and CA-MRN-242 (Figure 5), but the comparison between San Francisco and Drakes Estero is also otherwise flawed. There is no evidence at CA-MRN-296 or CA-MRN-242 of a shift from oysters as a primary resource to another resource at that period or any other. While Beardsley (1954:22) noted a whole layer of clams in the stratigraphy of CA-MRN-242, he did not note a shift of resources as he does for CA-MRN-266. With the long history of academic debate regarding resource shifts in the shellmounds of San Francisco Bay, it would be surprising if a noticeable shift of resources occurred at CA-MRN-242 and Beardsley did not comment on its presence. Radiocarbon dates indicate a long range of possible oyster harvesting, from 1310 to 2170 BP (AD 640 to 220 BC) at CA-MRN-242 and from 1140 to 1770 BP (AD 810 to 180) at CA-MRN-296. It is notable that none of these date ranges extend into the historic or modern era. However, additional radiocarbon dates may further augment or refine these ranges.

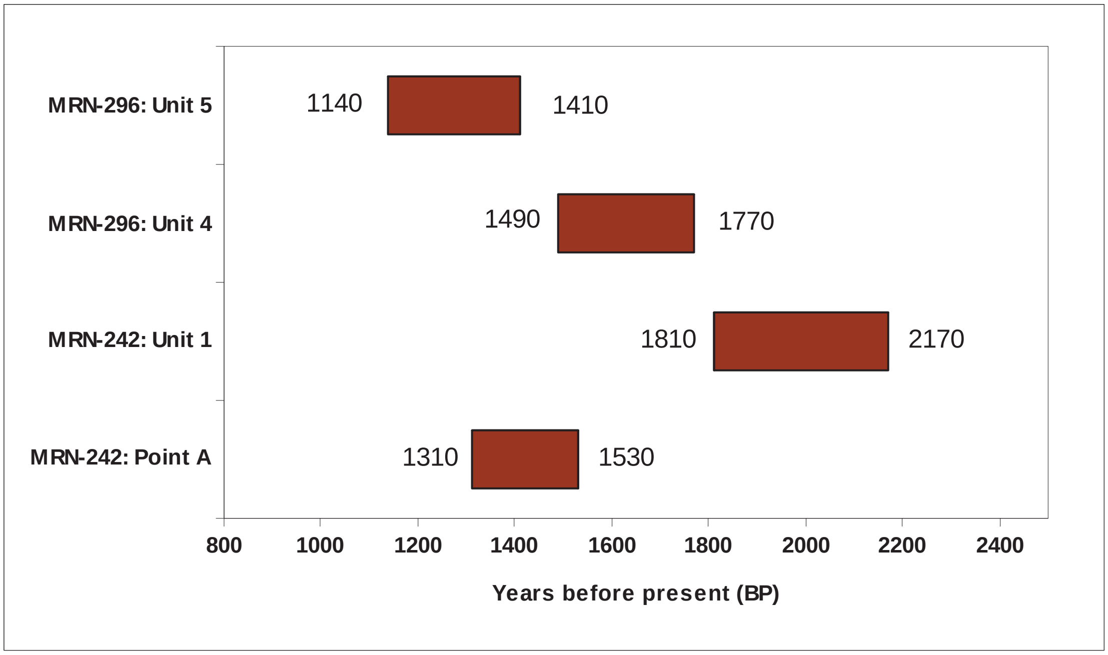


Figure 5. Radiocarbon dates from CA-MRN-296 and CA-MRN-242.

Anderson's paleoenvironmental analysis even indicates a stable landform and ecosystem from 5500 BP to the historic period. This stability likely provided for a secure and varied abundance of shellfish and other resources. The geological environment of Drakes Estero consists primarily of sand and silt flats with smaller areas of gravels and cobbles along the cliff margins. While acceptable for oysters, this habitat is more suitable for varieties of clams.

The data gathered at CA-MRN-296, CA-MRN-242, and in the literature review of Tomales Bay and San Francisco Bay indicate that Olympia oysters were known to prehistoric peoples. But noting Greengo's statement quoted above (Greengo 1951:2), these oysters were likely not utilized in abundance except in areas favorable both to the species and to their collection. The evidence for this pattern is in the high levels of Olympia oyster shell identified in archaeological sites along the San Francisco Bay and, to a lesser extent, in Tomales Bay.

Given the relative quantities of Olympia oysters identified at CA-MRN-296 and CA-MRN242, there is no archaeological evidence that a sizable population of this species inhabited Drakes Estero and was utilized as a primary dietary resource by the Coast Miwok. Non-local resources are frequently present at archaeological sites in the Point Reyes vicinity, ranging from material scavenged from Spanish shipwrecks to more mundane supplies as flaked stone. Sites in Drakes Estero that contain oysters include the site closest to Tomales Bay (CA-MRN-296) and the largest site in the vicinity of the Estero (CA-MRN-242). While small populations of Olympia oyster may have existed in the Estero and been utilized by the Coast Miwok, the relative abundance of oyster remains in Tomales Bay and their absence at all but two archaeological sites in Drakes Estero make it more likely that the oysters were brought in from Tomales Bay.

REFERENCES CITED

Alvarez S. and A. Bramlette

1988 *Archaeological Site Record for CA-MRN-241* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Alvarez, S., A. Bramlette, M. Jablonowski, and D. Tibbetts

1988a *Archaeological Site Record for CA-MRN-221* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

1988b *Archaeological Site Record for CA-MRN-561/H*. on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Alvarez, S. and M. Jablonowski

1988a *Archaeological Site Record for CA-MRN-253* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Alvarez, S., M. Jablonowski, and D. Tibbets

1988 *Archaeological Site Record for CA-MRN-219* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Alvarez, S. and D. Tibbets

1988 *Archaeological Site Record for CA-MRN-564* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Alvarez, S., M. Jablonowski, D. Tibbets, and W. Stillman

1988b *Archaeological Site Record for CA-MRN-251* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Anderson, R. Scott

2005 *Contrasting Vegetation and Fire histories on the Point Reyes Peninsula During the Pre-Settlment and Settlement Periods: 15,000 years of Change.*

Anima, Roberto

1991 *Pollution Studies of Drakes Estero, and Abbotts Lagoon, Point Reyes National Seashore, California, USA.* Open File Report 91-145. U.S. Geological Survey, Department of the Interior. Menlo Park, California.

Babalis, T.

2009 *Critical Review: A Historical Perspective on the National Research Council's Report "Shellfish Mariculture in Drakes Estero"* Unpublished report prepared for Point Reyes National Seashore. Prepared by the National Park Service, Pacific West

Region, Cultural Resources Program. On file at Point Reyes National Seashore and the National Park Service, Pacific West Region, Oakland, California.

Baker, Patrick
1995 Review of Ecology and Fishery of the Olympia Oyster, *Ostrea lurida*, with annotated bibliography. *Journal of Shellfish Research.* 14(1):501-515.

Beardsley, Richard
1946 *Archaeological Site Survey Record*, San Francisco State College, on File at Cultural Resources office, Point Reyes National Seashore, California.
1954 Temporal and Areal Relationships in Central California Archaeology, Part One. *Reports of the University of California Archaeological Survey*, 24. University of California, Berkeley, California.

Bramlette and Tibbets
1988 *Archaeological Site Record for CA-MRN-209* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Bramlette, A. and S. Stewart
1988a *Archaeological Site Record for CA-MRN-361* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.
1988b *Archaeological Site Record for CA-MRN-563* on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Bryant, S.
1934a *Archaeological Site Survey Record for CA-MRN-262/H.* on File at Cultural Resources office, Point Reyes National Seashore, California.
1934b *Archaeological Site Survey Record for CA-MRN-266.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Childers, B.
1967 *Archaeological Site Survey Record for CA-MRN-242.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Collier, Mary E.T., and Sylvia B. Thalman (compilers and editors)
1996 Interviews with Tom Smith and Maria Copa: Isabel Kelly's Ethnographic Notes on the Coast Miwok Indians of Marin and Southern Sonoma Counties, California. *Miwok Archeological Preserve of Marin, Occasional Paper* Number Six. San Rafael.

Compas, Lynn, and Adrian Praetzellis

1994 *Archaeological Site Recording and Site Record Updating of* Sensitive ARPA *Tomales Bay Archaeological Sites in Point Reyes National Seashore, Marin County, California*. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Prepared for Point Reyes National Seashore, Point Reyes Station, California.

Compas, Lynn and Michael Jablonowski

1993a *Archaeological Site Record for CA-MRN-248.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1993b *Archaeological Site Record for CA-MRN-249/H.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1993c *Archaeological Site Record for CA-MRN-268.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Compas, Lynn and Michael Woods

1993 *Archaeological Site Record for CA-MRN-222.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Conte, Fred

1997 California Oyster Culture. *California Aquaculture*. ASAQ-A07. University of California, Davis. Department of Animal Science. Davis, California.

Desgrandchamp, Cindy S. and C. I. Sutton

1978 *Archaeological Site Record for CA-MRN-214*. on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Edwards, Robert

1967a *Archaeological Site Survey Record for CA-MRN-296.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1967b *Archaeological Site Survey Record for CA-MRN-242.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1967c *Archaeological Site Survey Record for CA-MRN-222.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1967d *Archaeological Site Survey Record for CA-MRN-225.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1967e *Archaeological Site Survey Record for CA-MRN-248.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1967f *Archaeological Site Survey Record for CA-MRN-249/H.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1967h *Archaeological Site Survey Record for CA-MRN-262/H.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1967i *Archaeological Site Survey Record for CA-MRN-266.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Gerken, Agnes
1967 *MRN-S.297: An Intertidal Site on* Sensitive ARPA information *In Three Volumes and Five Apple Cartons*. on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Gifford, Edward W.
1916 Composition of California Shellmounds. *University of California Publications in American Archaeology and Ethnology* 12(1):1–29.

Greengo, R.E.
1951 Molluscan Species in California Shell Middens. *University of California Archaeological Survey Reports* 13:1–29.

Grosholz, Edwin
2010 In field personal communication at Point Reyes, 19 November 2010.

Grosholz, Edwin and Chela Zabin
2010 Identification of Oysters *(Ostreidae)* from Two Middens in Drakes Estero. Prepared for Anthropological Studies Center, Sonoma State University, Rohnert Park, California

Holman, Miley, and Matthew Clark
1984 *Archaeological Site Record for CA-MRN-214*. on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Heizer, Robert
1940 *Archaeological Site Survey Record for CA-MRN-242.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Ingram, B. Lynn and John Southon
1996 *Reservoir Ages in Eastern Pacific Coastal and Estuarine Waters*. Radiocarbon. 38(3): 573-582

Jablonowski, Michael
2000 *Archaeological Site Record for CA-MRN-242.* on File at Cultural Resources office, Point Reyes National Seashore, California.
2001 *Archaeological Site Record for CA-MRN-296.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Kawahara, Saichi
1970 A Survey of the Physical Setting of the Point Reyes Peninsula Area, Marin County, California. In Contributions to the Archaeology of Point Reyes National Seashore: A

Compendium in Honor of Adan E. Treganza, edited by Robert E. Schenk, pp.1–64. *Treganza Museum Papers* No. 6, San Francisco State College.

Kelly, Isabel
1978 Coast Miwok. In *California*, edited by Robert F. Heizer, pp. 414–425. Handbook of North American Indians, vol. 8, William C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Kelly, Roger
2004 *Native American Repatriation Program Review: Pacific West Region, National Park Service.* Prepared by the National Park Service, Pacific West Region, Cultural Resources Program. On file at the National Park Service, Pacific West Region, Oakland, California.

Kroeber, Albert L.
1925 Handbook of the Indians of California. Bureau of American Ethnology Bulletin 78. Smithsonian Institution, Washington, D.C. Reprinted 1976 by Dover, New York.

Mason, Roger D., Mark Peterson and Joseph Tiffany
1998 Weighing vs. Counting: Measurement Reliability and the California School of Midden Analysis. *American Antiquity* 63(2):303-324

Mannion, Linda and M. Curtis Mannion
1970 Abstracts from the Kelly Manuscript: Coast Miwok Material Culture. In *Contributions to the Archaeology of Point Reyes National Seashore: A Compendium in Honor of Adan E. Treganza*, edited by Robert E. Schenk, pp. 65-95. Treganza Museum Papers No. 6, San Francisco State College.

Meighen, Clement W.
1950 Excavations in Sixteenth Century Shellmounds at Drake's Bay, Marin County. *Papers on California Archaeology*: 6-9, pp. 27-32. University of California Archaeological Survey. Berkeley, California.

Meyer, Jack
2003 "An Overview of Geoarcheological Research Issues," in *Archaeological Research Issues for the Point Reyes National Seashore—Golden Gate National Recreation Area*, edited by Suzanne Stewart and Adrian Praetzellis (Rohnert Park, CA: Sonoma State University,

Morratto, Michael
1974 *An Assessment of the Cultural Resources within Point Reyes National Seashore*. Department of Anthropology, California State University, San Francisco. Prepared for Arizona Archaeological Center, National Park Service, Tucson, Arizona.

Nelson, Nels C.

1909 *Shellmounds of the San Francisco Bay Region*. University of California Publications in American Archaeology and Ethnology 7(4):309–356.

1910 *The Ellis Landing Shellmound.* University of California Publications in American Archaeology and Ethnology 7(5):357–426.

Peterson, Charles H., Barry A Costa-Pierce, Brett R Dumbauld, Carolyn Friedman, Eileen E. Hofmann, Hauke Kite-Powell, Donal T. Manahan, Francis O'Brien, Robert T. Pain, Paul Thompson, Robert Whitlatch

2009 *Shellfish Mariculture in Drakes Estero, Point Reyes National Seashore, California*. Committee on Best Practices for Shellfish Mariculture and the Effects of Commercial Activities in Drakes Estero, Point Reyes National Seashore, California. National Research Council of the National Academies. National Academies Press. Washington.

Rackerby, Frank

1964a *Archaeological Site Survey Record for CA-MRN-225.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1964b *Archaeological Site Survey Record for CA-MRN-248.* on File at Cultural Resources office, Point Reyes National Seashore, California.

1964c *Archaeological Site Survey Record for CA-MRN-249/H.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Rehder, Harald

1990 *The Audubon Society Field Guide to North American Seashells.* Alfred A. Knopf Inc. New York, New York.

Riddell, Francis A.

1948 *Archaeological Site Survey Record for CA-MRN-296.* on File at Cultural Resources office, Point Reyes National Seashore, California.

Riley, Lynn M.

1976 An Assessment of Endangered Archaeological Sites at Point Reyes National Seashore. Prepared for Western Region Office, US National Park Service.

Rudo, Mark O.

2009 *Little Archaeological Evidence of the Olympia oyster (*Ostrea lurida) *at Drakes Estero, Point Reyes Nation Seashore, California.* Unpublished report prepared for Point Reyes National Seashore. Prepared by the National Park Service, Pacific West Region, Cultural

Resources Program. On file at Point Reyes National Seashore and the National Park Service, Pacific West Region, Oakland, California.

Russell, Matt
2010 Phone conversation with Michael Konzak regarding doctoral dissertation research at University of California, Berkeley, 3 November 2010.

Polansky, Barbara
1998 *A Prehistoric Archaeological Settlement Pattern Model for the Point Reyes Peninsula*. Master's thesis in Cultural Resources Management, Anthropology Department, Sonoma State University, Rohnert Park, California.

Praetzellis, Adrian
2010 *Archaeology of Ostrea lurida in Drakes Estero: Research Design and Schedule*. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Prepared for Cultural Resources office, Point Reyes National Seashore, California.

Slater, S. E. and R. Wiberg
1984 *Archaeological Site Record for CA-MRN-213*. on File at the Northwest Information Center, Sonoma State University, Rohnert Park, California.

Stewart, Suzanne
2008 National Register of Historic Places Nomination Form for the Point Reyes Peninsula Indigenous Archaeological District. Anthropological Studies Center, Sonoma State University, Rohnert Park. Prepared for the National Park Service.

Treganza, A. E. and T. F. King
1968 *Archaeological studies in Point Reyes National Seashore, 1959-1968*. San Francisco: Report to the National Park Service.

Upson, Ward
1977 *A Description of Fifteen Archaeological Sites at Point Reyes National Seashore*. Prepared for National Park Service, Western Regional Office, Tucson, Arizona.

Van der Naillen, Peter
2009 Archaeological Site Evaluation Form for CA-MRN-242 for 28 August 2009. on File at Cultural Resources office, Point Reyes National Seashore, California.

Appendix A.

Identification of Oysters (*Ostreidea)* from Two Middens in Drakes Estero.

By Edwin Grosholz and Chela Zabin

Report to the Anthropological Studies Center

Sonoma State University

Identification of Oysters (*Ostreidae*) from Two Middens in Drakes Estero

Edwin Grosholz[1]

and

Chela Zabin[2]

[1]Department of Environmental Science and Policy, University of California, Davis, CA

[2]Smithsonian Environmental Research Center, Edgewater, MD

Project Objective

The primary objective of this project was to provide technical expertise to Dr. Adrian Praetzellis and Michael Konzak in the collection and subsequent identification of oysters (*Ostreidae*) and other bivalve mollusks encountered during surface inventories of two prehistoric middens above the shores of Drakes Estero, Inverness, CA.

Site Collection Methods

Together with ASC project staff, we collected a diversity of shell material at multiple locations (units) in each of two middens #242 and #296. Both middens were Not Responsiv

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ASC project staff conducted semi-quantitative surveys of shell samples from 1 x 1 m^2 quadrats at several units spatially distributed throughout the midden. In addition to these samples, we also identified shell samples from several arbitrary locations at each midden with the goal of increasing the diversity of species in the samples.

With these samples, we assisted ASC project staff with initial field identification of bivalve species at both midden sites. These included numerous samples of several native bivalve species typical of soft-sediment habitats in Drake's Estero including *Saxidomus nuttalli*, *Prototheca staminea, Clinocardium nuttallii,* and *Tresus nuttallii* as well as the large gastropod *Euspira lewisii*. We also identified a small number of degraded shell samples of species typical of rocky shores including *Mytilus* spp. and *Haliotis* spp. that were likely transported from sites outside the mouth of Drake's Estero.

In addition to field identification of these other mollusk species samples, we provided a preliminary identification of all oyster shell samples collected at both midden sites. These samples were bagged individually for subsequent examination and identification in the laboratory facilities at the Romberg Tiburon Center of the San Francisco State University.

Laboratory Methods for Identification of Oysters

In the laboratory, we examined cleaned and dried shell samples with a binocular dissecting scope using standard fiber-optic light source generally under 20x magnification. We used shell characteristics to distinguish Pacific oysters *Crassostrea gigas,* which were very abundant at midden #296 from native Olympia oysters *Ostrea lurida,* which were present at both middens. We checked our identifications with species descriptions and photographs in Coan et al. 2000 and Baker 1996 (references with annotated bibliography) as well as reference to living specimens collected from Tomales Bay, CA, approximately 10 km north of Drake's Estero. In order to distinguish *Ostrea lurida* from *Crassostrea gigas*, particularly in degraded specimens, we relied on the presence of chomata (small protrusions or tubercles and pits on the inside margin of the shell near the hinge) that are found only on *Ostrea lurida*. Additional cues such as size differences were also used. The Olympia oyster is no longer than 8 cm, whereas the Pacific oyster can reach 45 cm although 15-25 cm is common.

Results of Analyses

We found that most of the samples tentatively identified in the field as *Ostrea lurida* could be unambiguously confirmed in the lab. The presence of chomata (either tubercles or associated pits) could be identified on most shells (see Table 1 below). Many samples showed evidence of pits, sometimes on both sides of the hinge, which may be a function of shell degradation. The tubercles typically seen in species descriptions were less common and typically found on the right side of hinge. It was often difficult to determine whether small shell segments represented the left or right valve. The frequency of pits relative to tubercles suggests that pits may be more commonly preserved in degraded samples. The pits associated with chomata may be more commonly observed in the field than the tubercles, since the pits often contain mud or sediment that make these more visible. It may also be the case that the pits continue to deepen as the shell degrades while tubercles may flatten, break off or otherwise disappear as the shell degrades.

None of the oyster samples that could classify as *O. lurida* could be assigned to another oyster species such as *Crassostrea gigas*. All samples tentatively identified in the field were either unambiguously confirmed as *O. lurida* or determined to be 'likely' *O. lurida.*

Conclusions

The native oyster *Ostrea lurida* is unambiguously present at both midden #242 and #296. Large numbers of shells of Pacific oysters *Crassostrea gigas* were observed at #296 and were likely of modern origin. In contrast, we found no examples of *C. gigas* in #242. All of the oyster shell samples we examined at #242 were either identified as *O. lurida* or would be categorized as 'likely *O. lurida*'. For instance, there were no examples of oyster shell in excess of 8 cm at #242, whereas at #296 there were huge numbers of oyster shells in excess of 15 cm or more in length. Oyster shells well in excess of 20 cm are unambiguously *C. gigas* and not another species of *Crassostrea* such as *Crassostrea virginica*, which have also been introduced to California in the 20th century.

References

Baker, P. 1996. Review of ecology and fishery of the Olympia oyster, *Ostrea lurida* with annotated bibliography. Journal of Shellfish Research 14: 501-518.

Coan, E. V., P. V. Scott and F. R. Bernard. 2000. Bivalve Seashells of Western North America: Marine Bivalve Mollusks from Arctic Alaska to Baja California. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Table 1. Results of laboratory examination of shell samples from middens 242 and 296.

Site	Plot/Specimen ID	Notes
CA MARN 242	gully	3 shells: 1 with pits on both sides, 1 with pits on left side, 1 long, slender no pits or lines
CA MARN 242	Point A	4 full shells: 1 with pits on right side, 2 with pits on left side; one with no pits. 4 shell fragments uninformative
CA MARN 242	Unit 1	3 shells: shell 1 with chomata and worn linear structure linear running dorso-ventrally visible from sides and through layers of shell on right side;
		shell 2 with a few pits on left side; shell 3 with no pits or lines
CA MARN 242	Unit 2	chomata on left side, right side of shell missing
CA MARN 242	Unit 3	very worn and degraded, one possible chomata
CA MARN 242	Unit 4	no pits or lines
CA MARN 242	Unit 9	1 shell and 1 fragment. Full shell with chomata on the right side; fragment uninformative
CA MARN 242	Unit 27	obvious round pits on left side of hinge, right side mostly missing
CA MARN 242	Unit 28	distinct pits on right side, left side missing
CA MARN 242	Unit 29	shell with linear structures on both sides
CA MARN 242	Unit 30	linear structures on right side, obvious chomata on left
CA MARN 296	Artifact A	pits both sides of hinge
CA MARN 296	Artifact B	obvious round pits on both sides of hinge
CA MARN 296	from profile, N side	chomata on right side of hinge
CA MARN 296	Unit 2	chomata on right side of hinge
CA MARN 296	Unit 4	2 shells, each with linear structures,running dorso-ventrally visible from sides and through layers of shell, ending as chomata inside of shell
CA MARN 296	Unit 4	1 shell, both sides have chomata, linkage between chomata and linear structures as mentioned above present but very worn
CA MARN 296	Unit 5	2 shells: 1 with pits on left side; 1 with linear structures on left, and chomata on right side of shell

Appendix B.

Archaeological Site Records for CA-MRN-296 and CA-MRN-242

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION

PRIMARY RECORD

Primary #
HRI #
Trinomial CA-MRN-296
NRHP Status Code

Other Listings
Review Code Reviewer Date

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
ARCHAEOLOGICAL SITE RECORD

Primary #
Trinomial CA-MRN-296

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

State of California -- The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
LOCATION MAP

Primary #
HRI #
Trinomial CA-MRN-296

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

State of California — The Resource Agency
DEPARTMENT OF PARKS AND RECREATION

Primary #
HRI#
Trinomial CA-MRN-296

SKETCH MAP

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

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State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary #
HRI #
Trinomial CA-MRN-242
NRHP Status Code

Other Listings
Review Code Reviewer Date

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION

Primary #
Trinomial CA-MRN-242

ARCHAEOLOGICAL SITE RECORD

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

State of California -- The Resources Agency
DEPARTMENT OF PARKS AND RECREATION

LOCATION MAP

Primary #
HRI #
Trinomial CA-MRN-242

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

State of California — The Resource Agency
DEPARTMENT OF PARKS AND RECREATION

SKETCH MAP

Primary #
HRI#
Trinomial CA-MRN-242

Sensitive Archaeological Resource information protected in accordance with 16 U.S.C. 470hh, confidentiality of information concerning nature and location of archaeological resources.

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Appendix C.

Radiocarbon Dating Results from Beta Analytic

BETA

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Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

February 2, 2011

Ms. Sandra Massey
Sonoma State University
Anthropological Studies Center
1801 East Cotati Avenue
Building 29
Rohnert Park, CA 94928
USA

RE: Radiocarbon Dating Results For Samples MRN242POINTA, MRN242UNIT1S, MRN296UNIT4A, MRN296UNIT5B

Dear Ms. Massey:

Enclosed are the radiocarbon dating results for four samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Ms. Sandra Massey — Report Date: 2/2/2011

Sonoma State University — Material Received: 12/29/2010

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 290625	1770 +/- 40 BP	-0.5 o/oo	2170 +/- 40 BP
Beta - 290626	2230 +/- 60 BP	+0.1 o/oo	2650 +/- 70 BP
Beta - 290627	1940 +/- 50 BP	-0.6 o/oo	2340 +/- 50 BP
Beta - 290628	1600 +/- 70 BP	+0.4 o/oo	2020 +/- 70 BP

Beta - 290625
SAMPLE : MRN242POINTA
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 420 to 640 (Cal BP 1530 to 1310)

Beta - 290626
SAMPLE : MRN242UNIT1S
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal BC 220 to Cal AD 140 (Cal BP 2170 to 1810)

Beta - 290627
SAMPLE : MRN296UNIT4A
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 180 to 460 (Cal BP 1770 to 1490)

Beta - 290628
SAMPLE : MRN296UNIT5B
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal AD 540 to 810 (Cal BP 1410 to 1140)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-0.5:Delta-R=290±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-290625**

Conventional radiocarbon age: **2170±40 BP**

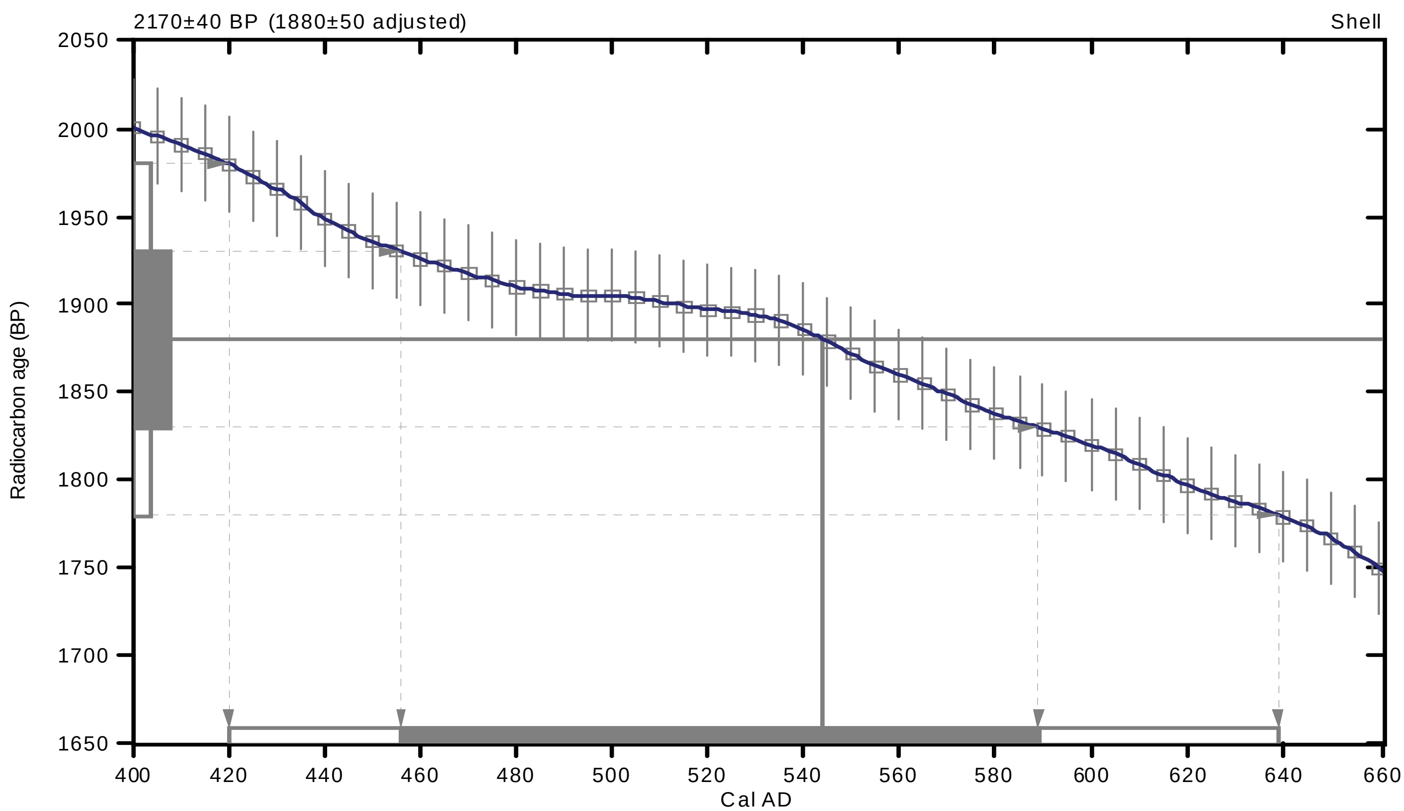
(1880±50 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal AD 420 to 640 (Cal BP 1530 to 1310)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 540 (Cal BP 1410)

1 Sigma calibrated result: Cal AD 460 to 590 (Cal BP 1490 to 1360)
(68% probability)



References:

Database used
MARINE04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.1:Delta-R=290±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-290626**

Conventional radiocarbon age: **2650±70 BP**

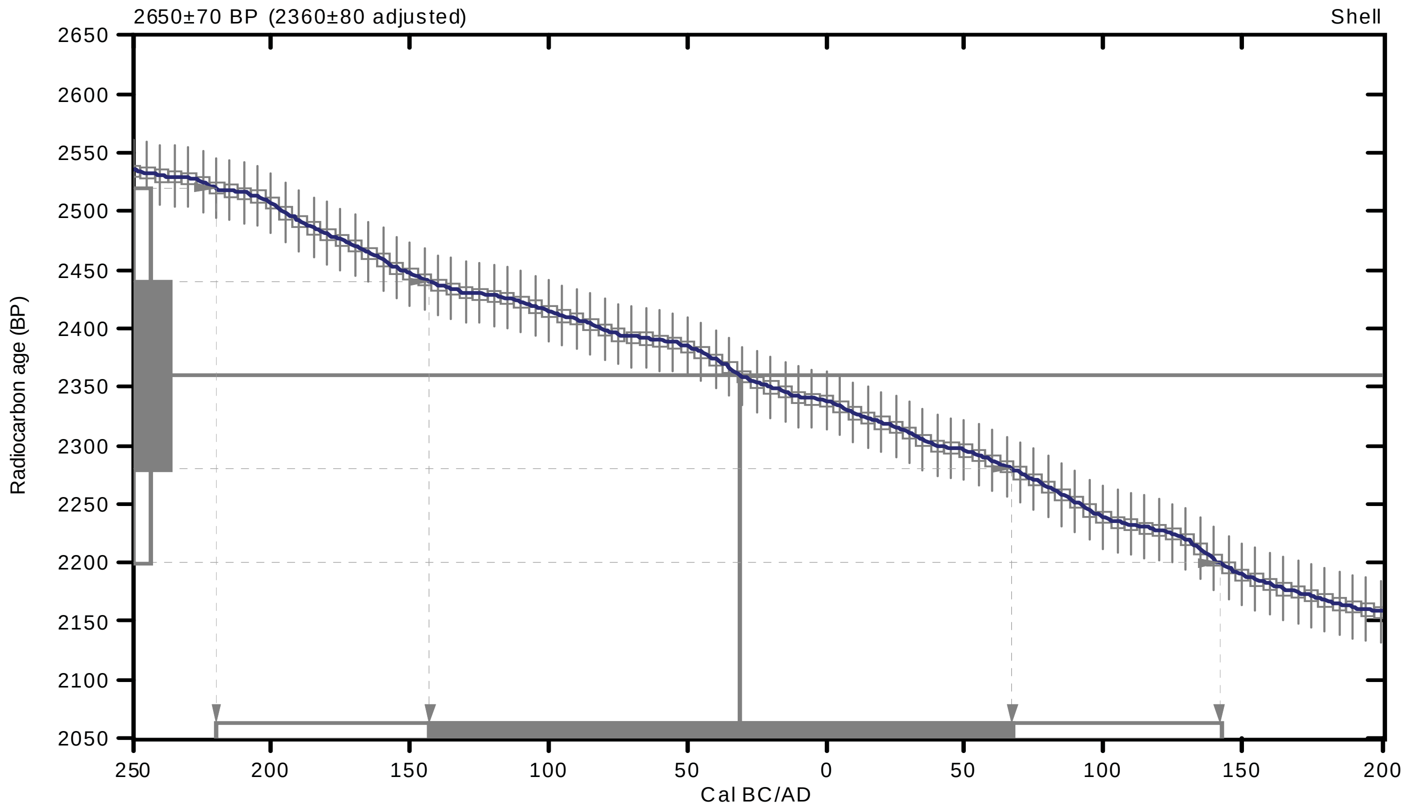
(2360±80 adjusted for local reservoir correction)

2 Sigma calibrated result: (95% probability) **Cal BC 220 to Cal AD 140 (Cal BP 2170 to 1810)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 30 (Cal BP 1980)

1 Sigma calibrated result: (68% probability) Cal BC 140 to Cal AD 70 (Cal BP 2090 to 1880)



References:

Database used

MARINE04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-0.6:Delta-R=290±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-290627**

Conventional radiocarbon age: **2340±50 BP**

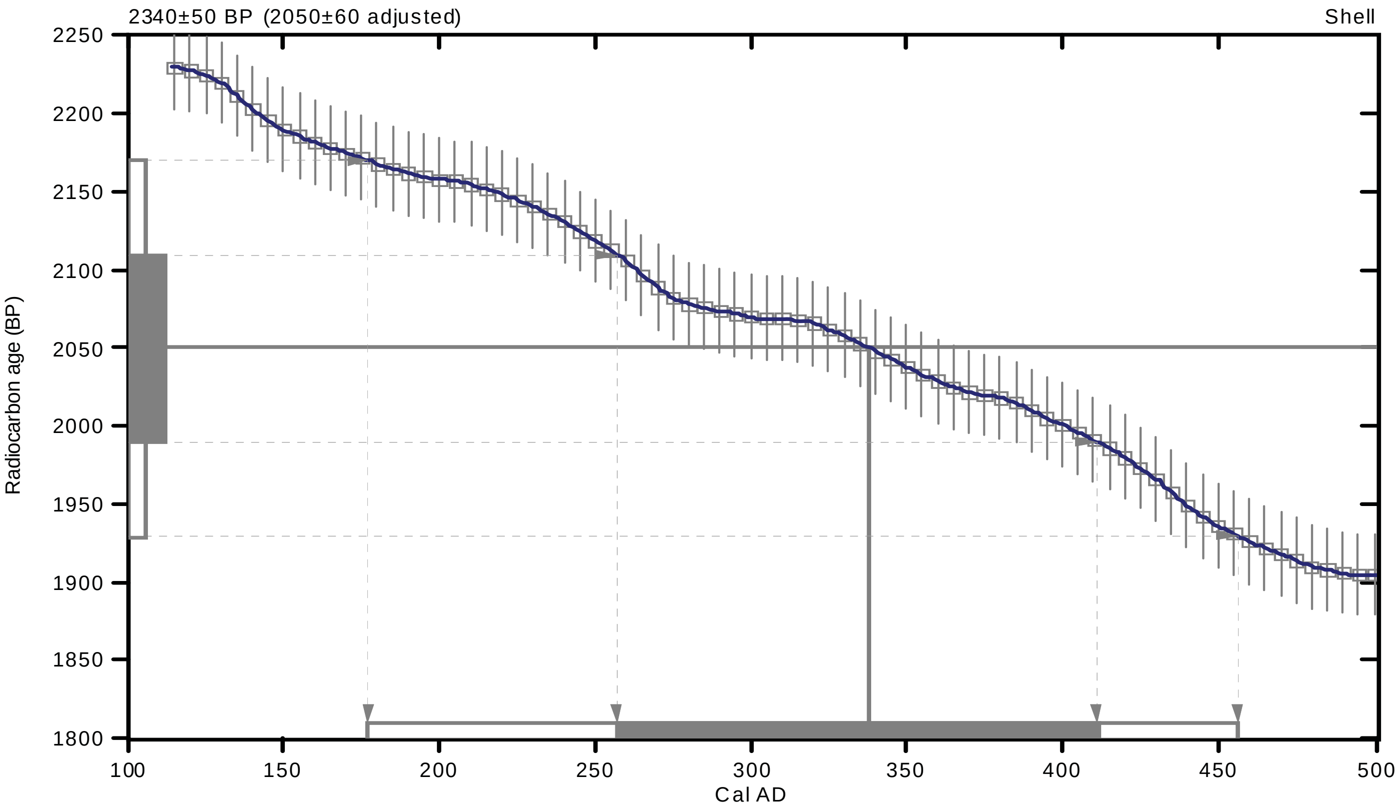
(2050±60 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal AD 180 to 460 (Cal BP 1770 to 1490)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 340 (Cal BP 1610)

1 Sigma calibrated result: Cal AD 260 to 410 (Cal BP 1690 to 1540)
(68% probability)



References:

Database used
MARINE04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=0.4:Delta-R=290±35:Glob res=-200 to 500:lab. mult=1)

Laboratory number: **Beta-290628**

Conventional radiocarbon age: **2020±70 BP**

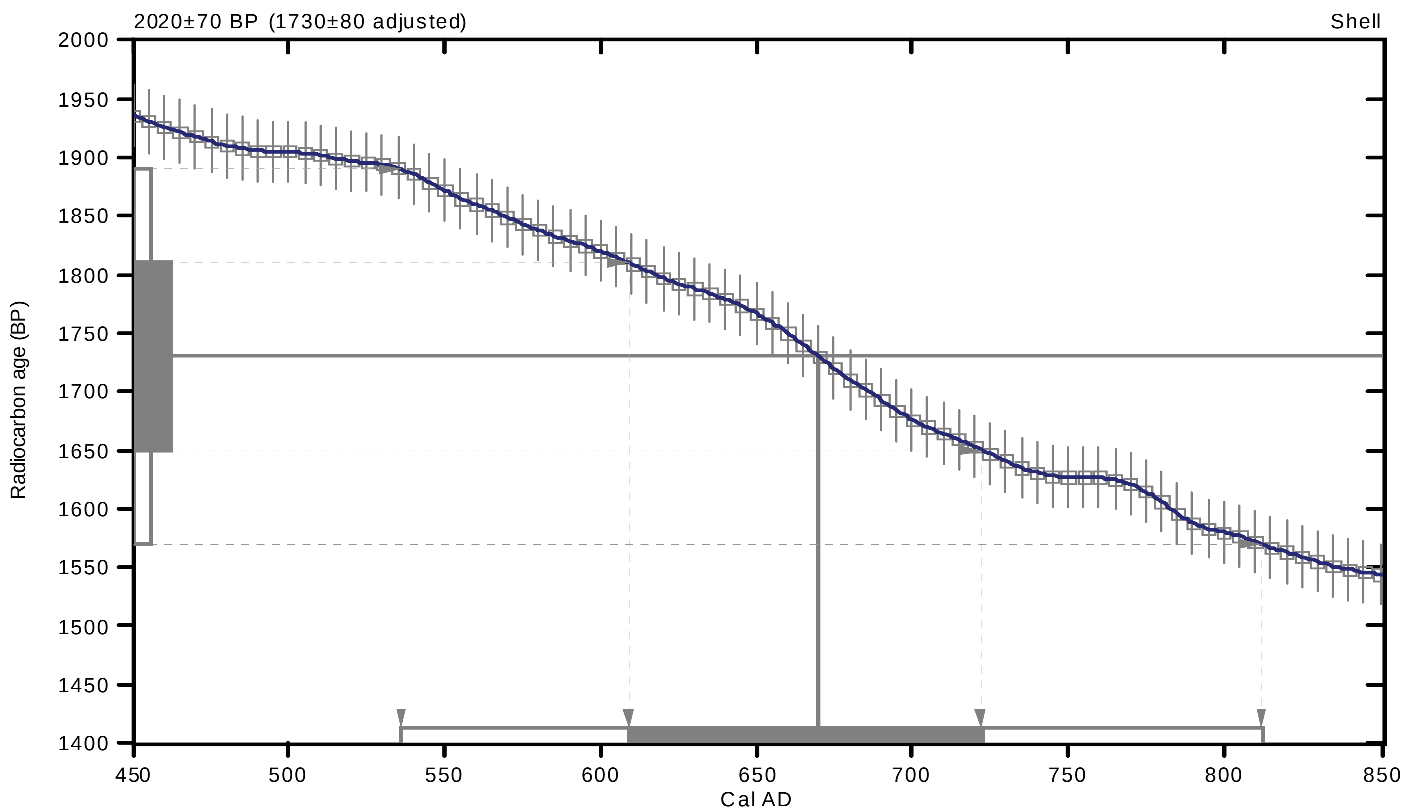
(1730±80 adjusted for local reservoir correction)

2 Sigma calibrated result: **Cal AD 540 to 810 (Cal BP 1410 to 1140)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 670 (Cal BP 1280)

1 Sigma calibrated result: Cal AD 610 to 720 (Cal BP 1340 to 1230)
(68% probability)



References:

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MARINE04
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A Simplified Approach to Calibrating C14 Dates
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