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ARTICLE

Archaeological Site or Natural Marine Community? Excavation of a Submerged Shell Mound in Ninigret Pond, Rhode Island

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ABSTRACT

Submerged shell midden sites and natural shell deposits can have similar characteristics and can be difficult to distinguish archaeologically. We excavated two test units from a large (at least 35 m × 70 m) submerged shell mound in Fort Neck Cove in southern Rhode Island to assess whether it was natural or cultural in origin. This mound had been recognized as a potential archaeological feature as early as the 1970s. Excavation, radiocarbon dating, and subsequent laboratory analysis of excavated materials suggest that the mound was a natural oyster reef rather than a submerged archaeological site. No artifacts were found; there was no clear evidence for human modification of any shells; small species that would not have been targeted as food were present; and δ¹³C values of oyster shells from the mound were consistent with freshwater input into their growth environment, suggesting
that they grew in an estuarine environment that did not exist prior to the inundation of the ponds. The stratigraphically oldest radiocarbon date we could obtain (430–190 cal BP, 2σ range), from 70 cm below the pond floor, placed deposition of shells at least 3,000 years after the inundation of the pond. The excavation methods that we used and the process of testing, irrespective of whether the feature is cultural, are valuable contributions to the methodological literature on submerged site archaeology and help provide insight for other researchers working to discern natural from cultural shell midden sites.

**Keywords**  coastal, chronology, excavation, formation processes, Northeast, paleoenvironment

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**INTRODUCTION**

One of the major challenges faced by archaeologists interested in submerged sites and landscapes is locating sites in the first place. In her 1990 summary of submerged site archaeology in North America, Stright (1990) could list only 35 inundated archaeological sites on the entire continental shelf of North America, and only “a few” more have been found since then (Merwin et al. 2003:43–44). Certainly, there are challenges associated with survey for sites on land, but a layer of water over the site, no matter how deep, contributes significant additional obstacles. Factors such as low visibility, sediment cover, and vegetation can make submerged sites difficult to find. Even when potential sites have been located, determining whether they are cultural or natural in origin is not always straightforward. This is particularly true when dealing with shell midden sites (Claassen 1998). On land, a scatter of shell remains is often clearly attributed to human transportation and deposition, particularly when it is found away from the coast. Underwater, however, a scatter of shells can be the result of human deposition prior to submergence or it could be an extinct natural biological community. Although submerged sites in general can be difficult to locate, archaeologists have found and excavated a growing number throughout the world, providing valuable sources of data (e.g., Easton and Moore 1991; Faught and Gusick 2011; Gusick and Faught 2010; Iba 2005; Keller 1973; Lewis 1973; McCann et al. 1977; Shaw 1970; Webb 2006).

Despite the difficulties associated with finding and later testing submerged archaeological sites, it is an important and useful task. Historic sea-level rise in North America has left many of the continent’s oldest costally orientated sites underwater. Therefore, submerged site archaeology may provide a valuable source of information for testing theories concerning early coastal settlement on the continent including the possibility that the earliest occupation of North America may have been along the coastlines (e.g., Erlandson 1994, 2002; Erlandson et al. 2007; Fedje and Christensen 1999; Fladmark 1978, 1985; Gruhn 1988). Additionally, submergence of a site may allow for better preservation of organic materials that only rarely survive in the acidic, sandy soils of the dry coastal plain in eastern North America (Merwin et al. 2003). Submergence of a site can also sometimes protect it from anthropogenic impacts such as construction and development. Therefore, although other human activities such as dredging, sand borrowing, and pipeline laying can affect underwater sites, those that remain intact can provide important contributions to the archaeological record.

One potential candidate as a submerged shell midden site was the Ninigret Pond shell mound, a large feature in Fort Neck Cove, the northern extension of Ninigret Pond, the largest of the saltwater lagoons that line the southern coast of mainland Rhode Island (Figure 1). This shell mound was observed in 2005 during a side scan sonar survey.

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**JOURNAL OF ISLAND & COASTAL ARCHAEOLOGY**

269
Objects like shipwrecks, shell mounds, or large rocks that have different densities than the surrounding sediment show up as distinct anomalies in side scan sonar output (Carbotte et al. 2004; Coleman and Ballard 2008; Coleman and McBride 2008). This geophysical work was part of the MapCoast project, a collaboration between University of Rhode Island geologists and biologists with the objective of mapping sediments, subaqueous soils, and benthic habitats throughout Rhode Island’s pond region. Because there was a much higher concentration of shellfish in that location than in the surrounding areas of the pond floor, forming a distinct mound, the scientists who detected it reported it to us as potentially archaeological (Figure 2). However, it is likely that this mound was also detected during earlier scientific studies and that it is one of the submerged shell accumulations described by Lee (1980:32) as “Indian shell middens in Fosters Cove and Fort Neck Cove,” since it is the largest shell mound that has been observed in Fort Neck Cove. Conversations with other ocean scientists in Rhode Island also supported the possibility that this mound was cultural rather than natural in origin. These endorsements of the site, along with its ease of access, made it a prime candidate for testing. Although pre-contact period cultural materials have been recovered from underwater and intertidal contexts, to date, no submerged sites have been inventoried in Rhode Island’s archaeological site database (David S. Robinson, personal communication 2010; Charlotte Taylor, personal communication 2010). Furthermore, because the ponds that line the southern coast of Rhode Island were inundated at approximately 4150 cal BP (Dillon 1970; McGinn 1982), any shell midden sites submerged in the ponds would be the earliest evidence for shellfish consumption in Rhode Island (Bernstein 1990; Kerber 1984).

In this article, we present archaeological data from the excavation of the Ninigret Pond shell mound, including the relative contributions of different shell species, radiocarbon dates, and stable carbon isotopic data. We use these data to argue that the Ninigret Pond shell mound is not the submerged remnants of human activity, but rather a more recently deposited, but defunct, natural oyster reef. This study explores techniques for distinguishing submerged shell middens from...

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**Figure 1.** The pond region of southern Rhode Island with the saltwater lagoons and the shell mound of interest indicated.
natural shell deposits. It also presents a method for excavating a submerged shell midden with fine, loose sediment and poor visibility.

**GEOLOGICAL AND ARCHAEOLOGICAL BACKGROUND**

Ninigret Pond is one of a series of nine coastal lagoons that line the south coast of the mainland of Rhode Island. The area surrounding these lagoons has been identified as a distinct cultural landscape (Jazwa 2008, 2011; Leveillee and Harrison 1996; Leveillee et al. 2006). The “pond region” extends from the Connecticut border in the west to Narragansett Bay in the east. The ponds are separated from the Block Island Sound to the south by narrow (200–300 m wide) barrier spits (Boothroyd et al. 1985). The northern boundary of the region is arbitrarily defined by U.S. Route 1, which traces a similar path to a pre-contact walking trail (Leveillee et al. 2006) (Figure 1). The ponds, which formed in ice block basins and low points on an alluvial fan, are relatively shallow, averaging 3 to 4 meters in depth with an overall range from 1 to 8 meters (Boothroyd et al. 1998). Ninigret Pond is the largest of the lagoons, measuring 4,226 ha in area. It is located in the geographic center of the pond region, with Maschaug, Winnapaug, and Quonochontaug Ponds to the west, and Green Hill, Trustom, Card, Potter, and Point Judith Ponds to the east (Hermes et al. 1994).

Fort Neck Cove, the section of Ninigret Pond where the shell mound is located, is an...
ice block basin. By 19,500–18,000 cal BP, the Laurentide Ice Sheet had retreated to the position of what is today the Charlestown End Moraine, located immediately to the north of the pond region (Boothroyd 2001; Stone and Borns 1986). At that time, meltwater from the ice sheet deposited alluvium throughout much of the pond region, including the area surrounding Ninigret Pond. This water flowed through the moraine in a narrow stream and then deposited alluvial material in a widening fan shape (Koteff and Pessl 1981). Ninigret Pond was formed where rising sea levels overtook parts of the alluvial fan where less sediment had been deposited further from the moraine, and where ice blocks held a space as material was deposited around them and later melted to leave depressions on the landscape (Dillon 1970; McGinn 1982). McGinn (1982) placed the date that Ninigret Pond was submerged and became a lagoonal environment at approximately 4150 cal BP based on radiocarbon dates obtained from samples of Mya arenaria shells. This date is consistent with the time for the same event that Dillon (1970) obtained from a radiocarbon date of a sample of wood collected from the western basin of Ninigret Pond. This provides a terminal boundary for the date of occupation of the ponds.

The formation of these ponds was a dynamic event that had clear implications for the cultural landscape, including settlement and subsistence patterns. Before this event, evidence of a human presence in the pond region is largely limited to isolated finds of diagnostic projectile points. Afterward, occupation of the region was less ephemeral and archaeological evidence is much more abundant (Jazwa 2011). Leveillee et al. (2006) have argued that the productivity of the salt ponds was a key factor in the eventual formation of semi-permanent settlements nearby. On the other hand, the peripheries of interior swamps and river drainages to the north of the pond region were intensively occupied as early as 7000 cal BP (Waller and Leveillee 2002). Prior to the formation of the ponds, it seems that what would later become the pond region was likely either an area where people hunted or a path between the interior swamps and the coast. It was not until the centuries leading up to the initial inundation of the ponds that the pond region became a coastal environment. Later, because of the stable and predictable resource base supported by the ponds (Leveillee et al. 2006) along with the possibility of sea trade, the pond region allowed for the presence of some of the most complex pre-contact sites in southern New England, and certainly in Rhode Island (Fowler and Luther 1950; Jazwa 2011; Largy and Morenon 2008; Leveillee and Harrison 1996; Leveillee et al. 2006; Robinson 2007; Taylor 2006, 2009; Waller 1998, 2000; Waller and Leveillee 2006). Included among the other valuable resources provided by the ponds would have been oyster reefs and other shellfish beds, which would have been easily harvested in the shallow, calm waters.

Even though no archaeological evidence of shellfish consumption has been found in Rhode Island predating the time that the ponds were inundated (Bernstein 1990; Kerber 1984), the rich marine resources that would have been available from the coast immediately prior to inundation would have made the pond region attractive to human populations. The earliest extant evidence for shellfish exploitation in the Narragansett Bay region is a quahog (Mercenaria mercenaria) shell dating to 4000 cal BP (Bernstein 1990). Kerber (1984) has argued that shellfish beds may not have been abundant long before 3000 cal BP and therefore would not have been a major resource in many places in Rhode Island before this time. For southern New England as a whole, Mulholland (1984) observed an increase in the percentage of sites that include shell middens beginning during the fourth millennium cal BP. The earliest clear evidence for extensive shellfish collection in the region is from the Lower Hudson River area, where shell midden sites have been dated to the Middle Archaic period (8000–5000 cal BP), with several potentially even earlier (Brennan 1974, 1981; Claassen 1991, 1995). Both Barber (1979) and Brennan (1974) believe that shell middens could have been deposited up to 12,000 years ago on what was then the coast, but these earliest sites have been...
submerged by rising water levels. Therefore, the mound in Ninigret Pond, if confirmed as a submerged midden site, would provide valuable information about the early coastal occupation of New England. In particular, submerged midden sites in the pond region would likely represent evidence of an increasing intensity of human use of the region. These sites could reflect either a continuation of maritime subsistence and settlement from that at earlier coastal sites that had since been either destroyed or submerged under Block Island Sound, or early adaptation to the new resources introduced by the formation of the coastal lagoons. Middens dating earlier in time could potentially reflect inland seasonal sites that were part of a mobile settlement strategy, like the interior swamps and river drainages described by Waller and Leveillee (2002).

**METHODS**

Excavations of submerged shell mounds like the Ninigret Pond shell mound have been relatively rare. Therefore, there are no well-established techniques for excavating sites of this type, particularly considering the unique conditions in Ninigret Pond. During our work, visibility in the pond was poor, rarely extending beyond two meters. It was restricted even further when the fine silty sediment was disturbed. Algae cover also obscured much of the shell mound (Figure 2). During our initial visits to the site between the fall of 2006 and the early summer of 2007, we were able to locate the northern and eastern boundaries of the site. The other boundaries were more difficult to identify. Survey and later excavation were limited because the site was in a boating lane and only under 1.5–2.5 m of water. This limitation and thick algae prevented us from locating the southern and western boundaries of the site. We established a grid of eight points in the northeastern corner of the shell mound, which we marked by placing cinder blocks on the pond floor (Figure 3). Datum points 7, 1, 4, and 6 made up the main north-south axis of the site, and Datum 1 was given the coordinates of N0E0 in an arbitrary grid system. We determined the northern and eastern boundaries of the site by swimming between the cinder blocks and clearing algae at approximately 1.5 meter intervals. Datum points 7, 2, and 5 were outside of the site boundary.

During August of 2007, we excavated two test pits at the coordinates S1E1 and S11E1. Our methodology follows that of Knoerl (1991, 1994), who excavated the small cove that used to be the historical landing area of Old Fort Niagara, located where the Niagara River empties into Lake Ontario. After initially attempting to excavate larger units, Knoerl (1994) eventually decided on cylindrical “bucket tests” with a diameter of approximately 23 cm. Bottomless plastic buckets of this diameter were driven into the sediment and the material inside was excavated by hand. Artifacts were brought to the surface in bags and all sediment was brought to the surface in buckets. This sediment was then water screened through fine mesh screens. Although the opacity of the buckets prevented the team from obtaining vertical stratigraphic profiles, they recorded the depth and sediment color and texture of each layer during excavation. A grid of the survey area was created using two stationary steel cables parallel to each other and a third movable cable perpendicular to the first two, allowing the locations of the bucket tests to be evenly spaced (Knoerl 1994). This is among the best efforts to date to prevent walls from collapsing during excavation in fine-sediment areas, a problem that had confronted previous archaeologists who dug less well-controlled holes in their sites (Flemming 1971; Green 1990; Wilkes 1971).

Much of the excavation of submerged pre-contact sites in the United States has been done on the continental shelf of western Florida (see Faught and Gusick 2011 for a recent summary of submerged sites). At some sites, like the Page-Ladson Site, finesediment does not appear to be a major problem (Latvis and Quimby 2006). However, at other sites, it has been necessary to brace the walls. At Little Salt Spring, aluminum hurricane shutters were used as small cofferdam sections to prevent wall collapse (John Gifford, personal communication 2012). Elsewhere, other techniques have been used.
Figure 3. Site map of the northeast corner of the Ninigret Pond shell mound with the location of the excavation units indicated.

for this purpose. Easton and Moore (1991) sloped their unit walls to prevent wall collapse in British Columbia. Iba (2005) took a more resource-intensive approach, enclosing the excavation area of the Awazu Site in Lake Biwa, Japan, in a large cofferdam and pumping all of the water out before excavation. The same approach was adopted at the site of La Belle, a vessel belonging to French explorer Robert Carvelier, Sieur de La Salle, and lost in Matagorda Bay, Texas, in 1686 (Bruseth and Turner 2006). Each of these approaches has been influenced by the environmental conditions around the site and the resources available to the archaeologists. It is clear, however, that there is not a universal solution to this problem, and each team must respond to it differently.
To adapt Knoerl's methodology to the Ninigret Pond shell mound, we excavated inside large plastic trash cans with their bottoms removed. For each of the two units, we used the top 40 cm of a large rubber trash can with a diameter of 51.5 cm at the top and 47 cm at the base of the part that was used. We then extended Unit S1E1 a further 34 cm within a five-gallon paint bucket of diameter 29 cm at the top and 26 cm at the base with the bottom removed. Therefore, the total depth of Unit S1E1 was 74 cm below the pond floor, the deepest we were physically able to reach. These constraints prevented us from reaching “sterile” soil below the shell deposits. We estimate, based on the relief of the mound from the surrounding pond floor, that the mound is approximately 1 m deep at its thickest points, but this should be confirmed by coring the site. This estimate suggests that we excavated through approximately 75 percent of the deposits.

Excavation was done in 20 cm arbitrary increments, the best precision we were able to obtain during excavation. We were not able to distinguish between strata because of poor visibility and fine sediments. Vertical profiles were unavailable because the buckets we used to stabilize the walls were opaque. Even if they were translucent, it is unlikely that different strata would have been visible given the clarity of the water in the pond. Excavation proceeded by repeatedly using a 1.4 kg hammer to drive the trash can

Figure 4. Excavation of Unit S1E1. The site has been excavated to 40 cm below the pond floor inside a trash can and a 5-gallon paint bucket is being hammered into the sediment.
a few centimeters into the sediment and excavating to the base. In order to prevent the trash can from floating away, it was necessary to attach two 2.3 kg scuba weights to it until it was approximately 20 cm into the sediment. The same process was used for the paint bucket, which we drove into the sediment at the base of the trash can excavation at S1E1 (Figure 4).

Removal of shell from the site was done in two steps. First, we collected large materials from the unit by hand and placed them in a mesh ditty bag. Materials collected in this way were labeled “unit.” We used an induction dredge to pick up small materials, which were then recovered from a fine mesh of approximately 1 mm at the discharge end of the dredge hose. Materials collected in this way were labeled “spoil.” The discharge hose of the induction dredge, which was about 9 m long, could not reach the edge of the site. Therefore, the end of this hose was placed in an area of low shell density and secured by tying it to a cinder block. This prevented it from moving and damaging the site. The dredge pump was stationed on a 6 m long barge owned by Ocean State Mooring, which we secured on a two-point mooring to the north of the site. This also served as a platform for gear storage and diving. The first mooring consisted of a 23 kg mushroom anchor that did not move. The second was a Danforth anchor that we moved to facilitate excavation of the two test units.

We submitted three eastern oyster (*Crassostrea virginica*) shells to Beta Analytic, Inc., for standard radiocarbon dating (Table 1; Jazwa 2008:120). Two, from the pond floor and 10 cm below the pond floor at Datum 1, were submitted during August of 2007. A third, from 70 cm below the pond floor in Unit S1E1, was submitted during November of 2007. We calibrated these dates in OxCal 4.1 (Bronk Ramsey 2009) using the most recent marine calibration curve, Marine09 (Reimer et al. 2009). We used a $R$ value of $112 \pm 22$ 14C yr. This was calculated from a weighted average of $R$ values obtained from shell samples run in southern New England (McNeely et al. 2006). The shells were from the gastropods *Crepidula fornicata* (5), *Eutheura caudata* (1), and *Nassarius trivittatus* (1). All of the samples were from within 100 km of Ninigret Pond. $R$ values with large error ($\geq70$ 14C yr) and with a value differing substantially from the mean were excluded. The resulting value is similar to what has been observed for portions of the Chesapeake Bay, another estuarine system in the northeastern United States (Rick et al. 2012). In OxCal, we used a Bayesian statistical model to further constrain error ranges on dates based on the relative stratigraphic position of the radiocarbon samples. This will be discussed in greater detail in the next section. Beta Analytic also collected stable isotopic data for carbon from these samples ($\delta^{13}C$; Table 1).

*Table 1. Radiocarbon dates from the Ninigret Pond shell mound and modeled boundaries of shell deposition.*

<table>
<thead>
<tr>
<th>Lab#</th>
<th>Provenience</th>
<th>Conventional date (years BP)</th>
<th>Conventional error</th>
<th>Modeled 2σ range (years BP)</th>
<th>$^{13}C/^{12}C$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>—</td>
<td>End of deposition</td>
<td>—</td>
<td>—</td>
<td>230–present</td>
<td>—</td>
</tr>
<tr>
<td>Beta-233053</td>
<td>Datum 1, 0 cmbs</td>
<td>580</td>
<td>50</td>
<td>260–20</td>
<td>−4.4</td>
</tr>
<tr>
<td>Beta-233054</td>
<td>Datum 1, 10 cmbs</td>
<td>750</td>
<td>50</td>
<td>370–130</td>
<td>−0.8</td>
</tr>
<tr>
<td>Beta-237368</td>
<td>S1E1, 70 cmbs</td>
<td>760</td>
<td>50</td>
<td>430–190</td>
<td>−4.9</td>
</tr>
<tr>
<td>—</td>
<td>Start of deposition</td>
<td>—</td>
<td>—</td>
<td>1170–150</td>
<td>—</td>
</tr>
</tbody>
</table>

$^1$Dates were calibrated using OxCal 4.1.3 (Bronk Ramsey 2009) and the Marine09 calibration curve (Reimer et al. 2009) using a $R$ value of $112 \pm 22$ 14C yr calculated by the authors from a weighted average of $R$ values obtained from shell samples run in southern New England (McNeely et al. 2006).
All materials collected during excavation were subjected to three weeklong freshwater baths to leach out salt they had absorbed in the pond. We then dry-screened all material through a \( \frac{1}{2} \)-inch mesh. All material that passed through the screen was collected and stored separately. Large material that did not pass through the screen was sorted by species. Each individual species was weighed by excavation level. Species detected during this analysis were eastern oysters (Crassostrea virginica), mud snails (Illyanassa obsoleta), the small saltwater clam Macoma balthica, soft-shelled clams (Mya arenaria), quahogs (Mercenaria mercenaria), ribbed mussels (Geukensia demissa), boat or slipper shells (Crepidula fornicata), bay scallops (Aequipecten irradians), and oyster drills (Urosalpinx cinerea). Also observed were Labridae (cunner, tautog) fish teeth and Xantbidae crab claw tips. Fragments too small to be identified were weighed together as “unidentified.” All material was analyzed by shell weight and weights for unit and spoil materials from each level were added together for analysis. No potential artifacts were recovered during this analysis. Finally, biologist Sheldon Pratt qualitatively analyzed three subsamples of the small material that passed through the \( \frac{1}{2} \)-inch mesh to determine which species were present. These were 121 g from the spoil of S1E1, 0–20 cm; 85.5 g from the spoil of S11E1, 20–40 cm; and 64 g from the spoil of S1E1, 60–80 cm.

**Figure 5.** Radiocarbon chronology for the Ninigret Pond shell mound. Dates are calibrated using OxCal 4.1.3 (Bronk Ramsey 2009) and the Marine09 calibration curve (Reimer et al. 2009) and presented as 2\( \sigma \) ranges. Dark gray distributions are stratigraphically modeled and light gray distributions are not. The boundaries are modeled from the existing dates. The year of excavation, AD 2007, was used as a terminal date for potential deposition.

**RESULTS**

**Chronology**

The three radiocarbon dates that we ran from the Ninigret Pond shell mound provide strong evidence that the mound formed long after the ponds were inundated at approximately 4150 cal BP (Table 1). Calibrated 2\( \sigma \) ranges for all three samples date within the last 500 years cal BP. This argument is strengthened when the data are stratigraphically modeled using OxCal 4.1, which uses a Bayesian statistical approach (Figure 5; see Kennett et al. 2011). In addition to constraining the 2\( \sigma \) ranges for the radiocarbon dates based on a priori information about the relative stratigraphic relationships between the samples, this technique also provides boundaries that model the earliest and latest deposition of material at the site. The boundary for earliest dated occupation, which has a large 2\( \sigma \) range (1170–150 cal BP), still dates it long after the inundation of the ponds. Even though the shell mound is located in a shallow pond, which may exchange more carbon with the atmosphere than a marine environment, if the shells were deposited by people prior to the inundation of the ponds, they would have had to be collected from a marine environment on the coast of the Block Island Sound to the south. The deepest sample that we tested was from the lowest levels of our excavation, but we
Christopher S. Jazwa and Rod Mather

did not reach the base of the shell deposits. Therefore, it is possible that stratigraphically lower materials could have been deposited earlier. We argue, however, that even if this was the case, the visible mound, which had been previously identified as a large shell midden, would still be a natural feature, deposited on top of a small midden. There is no reason to suggest that the particular location below the bulk of the existing shell mound is more likely to contain cultural deposits than any other place in the pond region.

\[ \delta^{13}C \] Measurements and Freshwater Input

\[ \delta^{13}C \] values from the same three oyster shells that were radiocarbon dated can provide information about the relative amount of freshwater input into the environment where they grew. \[ \delta^{13}C \] in freshwater ranges from 0 to \(-25\)\%, with a typical intermediate value of about \(-12\)\% resulting from the mixing of dissolved carbonate minerals and biogenic carbon (Spiker 1980:647). In estuarine environments, there is often a gradient in \[ \delta^{13}C \] values with salinity (Sackett and Moore 1966; Spiker 1980; Spiker and Schemel 1979; Strain and Tan 1979). Areas that have higher salinity and are closer to the ocean have less negative \[ \delta^{13}C \] values; increased freshwater input is reflected in more negative \[ \delta^{13}C \] values. The values of \(-4.4\%\) and \(-4.9\%\) for the oyster samples from 0 and 70 cm below the pond floor suggest some freshwater input into the system in which they grew. This is likely from a small creek that flows into the northeastern part of Fort Neck Cove approximately 0.5 km from the site (Figure 6). The sample from 10 cm below the pond floor has a \[ \delta^{13}C \] value of \(-0.8\%\), which does not reflect the same pattern. A potential explanation for this

Figure 6. The small (approximately 5 meters wide) stream that flows into the northeastern part of Fort Neck Cove.

value is that the oyster grew during a period of depressed freshwater input into the pond. The values from 0 and 70 cm below the pond floor support the idea that the shells were deposited where they grew rather than imported by people from the coast, where δ¹³C values would have been less negative.

Faunal Analysis of the Excavated Materials

Several qualitative patterns in the faunal record were evident in the field. In all areas of high shell density, either oysters or, less often, quahogs were the most abundant species. In areas of low shell density, particularly around the edges of the deposit, soft-shelled clams were often the only species present and were usually fragmented. Neither mussels nor scallops ever appeared to comprise a substantial proportion of the surface expression anywhere throughout the site. Additionally, no oysters, mussels, or scallops, and very few soft-shelled clams appeared to be alive, although some quahogs were. Large quahogs were common at the surface, but no large individuals were observed below the surface. There were variations in shell density on the pond floor throughout the site, and in some cases, the deposits were covered by approximately 5 cm of fine sediment.

Oysters were by far the dominant species in all of the excavated levels, comprising at least 73 percent of the shell by weight in each (Tables 2, 3). In fact, the second most prominent category in every level was made up of unidentified shell fragments. Given the pattern in the identified shells, it is likely that this category is largely comprised of oyster shell as well. Regardless, even when combining the weight of all other species together, oyster still dominates the assemblage in each level (Figure 7). This is consistent with shell middens throughout southern Connecticut, Long Island, and the Lower Hudson that date to the Late Archaic period (5000–3000 cal BP). These sites tend to be strongly dominated by oyster shells, which in some sites can comprise up to 99% of the assemblage (Brennan 1977; Claassen 1991; Claassen and Whyte 1996; Lavin 1991; Salwen 1970). Many of the earliest deposits at prominent shell middens that have been excavated in Rhode Island also have a strong focus on oyster, particularly during their earliest periods of deposition (Bernstein 1993; Fowler and Luther 1950; Kerber 1984). However, the lack of any clear artifacts in the test units, the lack of any evidence of human modification of any shells, and the fact that mud snails, a non-dietary species, were one of the most prominent species in all levels suggest that the shell mound is a natural oyster reef.

Finally, other species were detected during the qualitative analysis of the smaller (less than 1/4-inch) material (Table 4). In his analysis, Sheldon Pratt observed Acteocina canaliculata, Diastoma alternatium, Hydrobia totteni, Lacuna vincta, Mitrella lunata, Odostomia sp., Gemma gemma, Aligena elevata, and Balanus eburneus plates, which grow naturally in lagoonal environments like Ninigret Pond. Most of these species are too small to have served as viable dietary options. He also noted the presence of Zostera (marine eelgrass) seeds, which would have been deposited in the pond.

DISCUSSION

Four lines of evidence strongly suggest that the large shell mound in the northern part of Ninigret Pond is a natural oyster reef rather than a submerged shell midden: (1) excavation uncovered no cultural materials; (2) not-dietary shellfish species that would live within a natural oyster reef were present in large quantities; (3) stable carbon isotopic measurements suggest that the oysters lived in an estuarine environment; and (4) radiocarbon dates place deposition of the mound long after the inundation of the ponds. The fact that no cultural materials were observed at any time during fieldwork or laboratory analysis was not completely unexpected following the results of previous studies of Late Archaic period shell middens in Connecticut, Long Island, and the Lower Hudson by Brennan (1977, 1981) and others (e.g., Claassen 1991; Salwen 1970), where materials besides shell were relatively scarce. Nevertheless, the absence of cultural material does provide some support for the
### Table 2. Summary table of midden constituents by shell weight and percentage of the total weight by level for Unit S1E1.

<table>
<thead>
<tr>
<th>Species</th>
<th>0–20 cm</th>
<th>20–40 cm</th>
<th>40–60 cm</th>
<th>60–74 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit (g)</td>
<td>% of Total</td>
<td>Unit (g)</td>
<td>% of Total</td>
</tr>
<tr>
<td>Crassostrea virginica</td>
<td>12,200.0</td>
<td>800.0</td>
<td>10,500.0</td>
<td>600.0</td>
</tr>
<tr>
<td>Ilyanassa obsoleta</td>
<td>153.4</td>
<td>99.6</td>
<td>450.0</td>
<td>159.0</td>
</tr>
<tr>
<td>Macoma balthica</td>
<td>3.1</td>
<td>2.5</td>
<td>2.8</td>
<td>16.8</td>
</tr>
<tr>
<td>Mya arenaria</td>
<td>128.4</td>
<td>54.7</td>
<td>110.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Mercenaria mercenaria</td>
<td>251.2</td>
<td>11.9</td>
<td>1.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Geukensia demissa</td>
<td>84.4</td>
<td>64.0</td>
<td>104.9</td>
<td>17.3</td>
</tr>
<tr>
<td>Crepidula fornicata</td>
<td>1.1</td>
<td>0.0</td>
<td>7.0</td>
<td>3.1</td>
</tr>
<tr>
<td>Labridae tooth</td>
<td>0.0</td>
<td>0.0</td>
<td>&lt;.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Xanthidae claw</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Aequipecten irradians</td>
<td>7.4</td>
<td>2.3</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Urosalpinx cinerea</td>
<td>0.0</td>
<td>&lt;.1</td>
<td>1.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Unidentified</td>
<td>2000.0</td>
<td>1600.0</td>
<td>1500.0</td>
<td>700.0</td>
</tr>
</tbody>
</table>
interpretation that the mound was natural in origin. There was also no evidence that humans had modified the shells in any way, whether for shucking or the manufacture of shell artifacts. Although evidence of shucking can be indistinguishable from natural processes, a consistent breakage pattern could have potentially suggested human activity when corroborated with other evidence for human intervention. However, not only was no evidence of this apparent on the shells, no tools or charcoal indicating that activities like prying, bashing, or heating took place was present either.

The faunal assemblage also contributes to this argument. Unfortunately, it is not possible to model the faunal assemblage of an “ideal” oyster reef and shell midden site

<table>
<thead>
<tr>
<th>Species</th>
<th>Unit (g)</th>
<th>Spoil (g)</th>
<th>% of Total</th>
<th>Unit (g)</th>
<th>Spoil (g)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crassostrea virginica</td>
<td>5,600.0</td>
<td>650.0</td>
<td>80.0</td>
<td>7,700.0</td>
<td>800.0</td>
<td>73.3</td>
</tr>
<tr>
<td>Ilyanassa obsoleta</td>
<td>88.9</td>
<td>115.5</td>
<td>2.6</td>
<td>146.9</td>
<td>218.6</td>
<td>3.2</td>
</tr>
<tr>
<td>Macoma balthica</td>
<td>0.8</td>
<td>2.3</td>
<td>0.0</td>
<td>33.3</td>
<td>12.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Mya arenaria</td>
<td>114.2</td>
<td>56.6</td>
<td>2.2</td>
<td>63.5</td>
<td>64.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Mercenaria mercenaria</td>
<td>73.2</td>
<td>0.4</td>
<td>0.9</td>
<td>0.0</td>
<td>1.4</td>
<td>0.0</td>
</tr>
<tr>
<td>Geukensia demissa</td>
<td>3.2</td>
<td>4.4</td>
<td>0.1</td>
<td>169.5</td>
<td>81.9</td>
<td>2.2</td>
</tr>
<tr>
<td>Crepidula fornicata</td>
<td>1.1</td>
<td>2.2</td>
<td>0.0</td>
<td>0.0</td>
<td>1.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Labridae tooth</td>
<td>0.0</td>
<td>&lt;.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Xanthididae claw</td>
<td>0.7</td>
<td>&lt;.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Aequipecten irradians</td>
<td>1.4</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>1.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Urosalpinx cinerea</td>
<td>0.3</td>
<td>&lt;.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Unidentified</td>
<td>500.0</td>
<td>600.0</td>
<td>14.1</td>
<td>1,000.0</td>
<td>1300.0</td>
<td>19.8</td>
</tr>
</tbody>
</table>

**Figure 7.** Percent of total shell weight for oysters and all other identified species by arbitrary 20 cm excavation level in (a) Unit S1E1 and (b) Unit S11E1.
Table 4. Summary table of the species observed by Sheldon Pratt in the small (less than 1/4-inch) material from subsamples of the spoil from S1E1, 0–20 cm; S11E1, 20–40 cm; and S1E1, 60–80 cm.

<table>
<thead>
<tr>
<th>Species</th>
<th>Only observed in &lt;1/4' fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastropoda</td>
<td></td>
</tr>
<tr>
<td>Acteocina canaliculata</td>
<td>Yes</td>
</tr>
<tr>
<td>Aequipecten irradians</td>
<td>X</td>
</tr>
<tr>
<td>Diastoma alternatum</td>
<td>X</td>
</tr>
<tr>
<td>Geukensia demissa</td>
<td></td>
</tr>
<tr>
<td>Hydrobia toteni</td>
<td>Yes</td>
</tr>
<tr>
<td>Ilyanassa obsoleta</td>
<td>X</td>
</tr>
<tr>
<td>Lamellaria vinca</td>
<td>Yes</td>
</tr>
<tr>
<td>Mitrella lunata</td>
<td>Yes</td>
</tr>
<tr>
<td>Odostomia lunata</td>
<td>X</td>
</tr>
<tr>
<td>Bivalvia</td>
<td></td>
</tr>
<tr>
<td>Aligina elevata</td>
<td>Yes</td>
</tr>
<tr>
<td>Crassostrea virginica</td>
<td>X</td>
</tr>
<tr>
<td>Gemma gemma</td>
<td>X</td>
</tr>
<tr>
<td>Macoma balthica</td>
<td></td>
</tr>
<tr>
<td>Mercenaria mercenaria</td>
<td></td>
</tr>
<tr>
<td>Mya arenaria</td>
<td></td>
</tr>
<tr>
<td>Decapoda</td>
<td></td>
</tr>
<tr>
<td>Xanthidae crab claw</td>
<td></td>
</tr>
<tr>
<td>tip</td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td></td>
</tr>
<tr>
<td>Labridae teeth</td>
<td>Yes</td>
</tr>
<tr>
<td>(cunner, tautog)</td>
<td></td>
</tr>
<tr>
<td>Barnacle</td>
<td></td>
</tr>
<tr>
<td>Balanus eburneus</td>
<td>X</td>
</tr>
<tr>
<td>plates</td>
<td></td>
</tr>
<tr>
<td>Plant</td>
<td></td>
</tr>
<tr>
<td>Zostera seeds</td>
<td>Yes</td>
</tr>
</tbody>
</table>

and compare our record to the two, because both vary widely. Our treatment of the faunal data yields two important findings. First, *Crassostrea virginica* makes up a large majority of the assemblage in all excavated levels, which would be consistent with either a natural oyster reef or a shell midden site. Oyster reefs form in estuarine habitats in intertidal or subtidal environments on an existing hard substrate (e.g., DeAlteris 1988; Galtsoff 1964; Lenihan 1999; Lenihan and Peterson 1998; Meyer and Townsend 2000; Soniat et al. 2004). Because oysters prefer to settle on relatively hard substrates rather than soft mud or detritus, oyster reefs include both living and dead individuals with new individuals settling and growing on the existing shells of previous ones (Galtsoff 1964). Oyster reefs have substantial impacts on the surrounding ecosystem. They filter large amounts of water, influencing water quality and the phytoplankton it contains; they also provide recycled nutrients, colonization space, refuge, and foraging substrate for invertebrate and fish communities (e.g., Lenihan 1999; Lenihan and Peterson 1998; Meyer and Townsend 2000; Soniat et al. 2004). Because they support such an ecosystem, oyster reefs should contain a diverse invertebrate assemblage heavily dominated by oysters themselves, as we observe for our assemblage (Tables 2–4). Second, and more significantly, small species that would not have contributed to a human diet and live together in natural lagoonal communities were found among larger shells during laboratory analysis. This includes mud snails, which comprised a large proportion of the total assemblage at all levels. In all, these species were present in large enough quantities that it is unlikely that people would have carried them along unintentionally with target species to a midden site.

We used OxCal to use a Bayesian statistical framework to model the chronology for the part of the shell mound that we excavated. This allowed us to constrain the radiocarbon date ranges from oyster shells from the site and to model the date of earliest deposition of shell material. The calibrated $2\sigma$ ranges for all three samples date within the last 500 years, and the $2\sigma$ modeled range for the earliest deposition of shell material dates within the last 1,200 years, both long after the ponds were inundated at approximately 4150 cal BP (Dillon 1970; McGinn 1982). This clearly places the deposition of
the part of the shell mound that we tested several millennia after the landscape was inundated. Stable carbon isotopic analysis of the same shells suggests some freshwater input into the system in which the oysters grew. The most likely candidate for this is the small (approximately 5 meters wide) stream that flows into the northeastern part of Fort Neck Cove. This would contradict the idea that the shells were deposited prior to the inundation of the ponds because humans would then have had to collect them from the coast, which would have had more of a marine $\delta^{13}C$ signature (less negative).

Although, as we have argued, the evidence suggests that the Ninigret Pond mound is not a submerged shell midden, several aspects of the study are worthy of additional consideration. First, we only excavated the top 74 cm of the mound, which was physically as far as we could reach. The water depth of the shell mound varied from about 1.5 m in the areas with densest shell to 2.5 m of water at what appeared to be the edges of the deposit, suggesting a vertical relief of about 1 m. During our excavation, we were unable to reach the base of this relief, since we placed Unit 51E1 in one of the areas of densest surface shell. It is possible that deposits below the extent of our excavation are older. Because oysters prefer to colonize a hard rock or semi-hard mud bottom, normally settling on areas already inhabited by other oysters (Galtsoff 1964), it is possible that the basal layers of the deposit could have been a submerged shell midden that provided the hard substrate necessary for a natural oyster colony to form. The only way to test this would be to obtain a core through the mound to the relict land surface below. If we find lagoonal sediment between this feature and the start of the shell deposits, it will be a clear indication that the shells had been deposited after inundation. If the shells extend down to, or even below, the land surface, this could suggest that they were deposited prior to inundation. Similarly, we only excavated one section of a large (at least 35 m by 70 m) site, and there may have been a horizontal expansion of the shell deposit underwater as new oysters colonized the existing substrate after inundation. However, our study suggests that even though a submerged site may potentially underlie the deposits that we were able to excavate, the mound itself is not a submerged shell midden site.

It is also possible that the mound was the product of historic oyster farming in the ponds. Attempts were made to farm oysters in the region beginning in the seventeenth century, peaking in the nineteenth century, and even continuing today (Goode 1887; Lee 1980). This would be difficult to detect based simply on field observations, as the remnants of a farmed oyster population would likely resemble a natural community and could only be confirmed with explicit documentation in the historical record. Our observation in the field that many of the oyster shells appeared to be disarticulated is evidence that could potentially support this as the origin of the mound. The radiocarbon dates obtained from our study are also consistent with this interpretation.

Despite the findings of this study, the pond region remains an optimal location to look for submerged archaeological sites. At least beginning with the inundation of the ponds, the cultural landscape there was unique within Rhode Island. This was largely related to the rich marine resources there (Leveillee et al. 2006) and potential access to maritime transport or travel. Shell middens appear in this region, along Potter Pond, at least as early as 3000 cal BP (Fowler and Luther 1950). During the Late Woodland period (1000–450 cal BP), the pond region supported two of the most complex pre-contact sites in southern New England, the Salt Pond Site (RI 0110; Leveillee and Harrison 1996; Leveillee et al. 2006; Robinson 2007; Waller 1998, 2000; Waller and Leveillee 2006) and the Lavery Site (RI 2280; Leveillee et al. 2006). Leveillee and Harrison (1996) have suggested that the Salt Pond Site was part of the larger archaeological landscape of Point Judith Pond. In this model, the Native American occupants would have used the whole perimeter of the pond for a wide range of activities over a period of several thousand years. It is quite possible that the area surrounding the other ponds could have represented similar densely occupied archaeological landscapes (Jazwa 2011). During the period immediately before the inundation of the ponds, the coastal environment provided
by the encroaching shoreline could have provided a similarly high-ranked habitat.

Additionally, any sites that would have been submerged in the pond region have the potential to be well preserved. Stright (1990) argues that sites buried by sediments in low-energy environments (flood plains, drowned river valleys, bays, estuaries, lagoons, lakes, ponds, sinkholes, and subsid ing deltas) prior to marine transgression and buffered from erosion by overlying sediment will be best preserved. Additionally, she argues that areas of preservation are usually marsh-lagoon-barrier systems, which occur behind an ocean barrier such as an island or a reef. The gentle inundation of the ponds and their protection from the Block Island Sound by a barrier beach would lead to better preservation for any sites there. For these reasons, further investigation of the pond region is recommended since it has the potential to yield valuable archaeological data that could provide important information about early settlement and subsistence in southern Rhode Island. The most likely date of occupation for any large submerged sites is the Late Archaic period, a time during which the number of known sites in New England increased substantially. This was related in part to warm and dry environmental conditions and the expansion of nutritionally important mast species such as oak and hickory, which would have in turn allowed for larger populations of animal species like turkey and deer (Davis et al. 1980; Dincauze 1974; Mulholland 1979, 1984, 1988). Submerged sites from the pond region could have the potential to add a maritime component to this system and provide information about how marine resources were incorporated into those subsistence patterns.

CONCLUSION

Using a combination of faunal, radiocarbon, and stable carbon isotope data, we have shown that a large shell mound in Ninigret Pond in southern Rhode Island was a natural oyster reef rather than a submerged shell midden. However, this study makes two important contributions to submerged site archaeology beyond the direct implications for the Ninigret Pond shell mound. First, we outlined a methodology for excavating a submerged shell mound in fine silty sediment in which walls are prone to collapse. Although the rubber trash cans that we used were not completely rigid, they did allow us to control the area that we were excavating. For future projects, we propose the construction of a clear plexiglass structure with a square horizontal profile. This should allow better control over the size and shape of the excavation units and still allow the four sides to be hammered into the sediment to collect material within it. It will also allow for profiles to be traced on the sidewalls to provide additional information about the stratigraphy of the site. The use of an induction dredge during excavation proved useful for collecting small materials and clearing sediment that limited visibility in the water column.

Second, we show how a system of test pitting and subsequent analysis of several types of archaeological data can be used to test whether a submerged site is cultural or natural in origin. This is particularly important for potential shell midden sites. On land, the human origin of a shell mound is rarely questioned, but underwater, it is more difficult to determine the nature of its formation. Certainly, the presence of artifacts and bones from terrestrial fauna in a submerged context can confirm a deposit as an archaeological site. A deposit containing only shell, on the other hand, cannot clearly be attributed to natural processes. Many terrestrial middens are similarly dominated by the remains of marine fauna (e.g., Brennan 1977; Claessen 1991; Salwen 1970). Our study, although suggesting that the site in question is a natural oyster reef, provides a framework for future testing of submerged shell midden sites. Furthermore, the search for submerged sites is an important and necessary pursuit with the potential to yield unique information about human use of coastal areas in the past and levels of preservation that are not possible in most terrestrial contexts. The ponds that line the coast of southern Rhode Island have the potential to provide important archaeological data. This study is an important step in exploring that region and contributes to a small but growing literature on the excavation of submerged archaeological sites.
ACKNOWLEDGEMENTS

Ocean House Marina generously allowed us to use their boat ramp throughout the fieldwork component of this project and the Fort Neck Dock Association allowed us to use one of their slips to store our skiff overnight during the week of excavation. Ocean State Mooring provided a 20-foot barge for a base of operations for our excavations. We would like to thank Sheldon Pratt for discussions about the biology of the ponds and for help analyzing our small excavation material. Kurt Knoerl, Mark Gustafson, Jamin Wells, Cory Gillette, James Moore, John Jensen, and Julia Royster assisted with survey and excavation of the site. Brendan Culleton provided suggestions for the analysis of radiocarbon and stable carbon isotopic data. Charlotte Taylor, David Robinson, Kristine Bovy, Joel Coben, Jim Loy, John King, Robert Bullock, Jon Boothroyd, Paul Robinson, and Kevin McBride were all sources of important ideas and valuable feedback during this project. We would also like to thank Torben Rick and three anonymous reviewers of this text for their insightful comments.

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