Site Formation Processes: Preliminary Study for Wooden Shipwrecks in the Northwestern Hawaiian Islands

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Introduction

The Northwestern Hawaiian Islands is the most remote archipelago of distant atolls in the world. Despite their small size, these islands have harbored shipwrecks for hundreds of years. Due to the unique and high-energy nature of an atoll environment, the way that ships wreck here varies from many other places. While it was previously thought that shallow water sites held little valuable information due to the scrambling processes of the ocean, studies such as the Douglass Beach project have shown that a shallow-water, high-energy site can maintain a high level of site integrity (Ward et al. 1999). The working hypothesis can be stated as follows: the site formation processes for wooden shipwrecks in atoll environments are unique, and this is represented by sites in the Northwestern Hawaiian Islands. Due to the preliminary nature of this research and the small number of sites studied so far, this is an ongoing study, and the site formation theory is not conclusive.

Methods

To develop or apply existing site formation theories to any particular region or type of shipwreck, information about the environmental conditions of the region and case studies of ships wrecked in the area, including site survey and historical record, are the most important resources. Three wooden shipwrecks from Pearl and Hermes atoll and Kure atoll in the Northwestern Hawaiian Islands (NWHI) are used as case studies, those of the *Parker*, *Pearl*, and USS *Saginaw*. An atoll is a ring of coral, generally from an extinct island volcano, that encloses a shallow lagoon. Historical accounts of the wrecking events assist in the interpretation of the archaeological sites. For this study, depending upon the ship and its age, it was possible to find sailors' first hand accounts of the events. Historic newspaper articles, ships' logs, and modern sources were consulted, as well. Each wreck site was recorded to the fullest extent possible. Information about the environmental conditions of the area has been combined with the information about the ships and their wreckages to develop a preliminary site formation theory for wooden shipwrecks in the Northwestern Hawaiian Islands.

Case Study Background

The British whaler *Pearl* was a 97-foot whaling ship originally constructed in Philadelphia of live oak and cedar (Lloyds Register of Shipping 1822). While hunting her quarry in the NWHI, the *Pearl* collided with the reef on the night of April 26th several minutes after her consort ship, the *Hermes,* wrecked on the same reef (Gleason 2005:14). The only information recorded about the shipwreck was by James Robinson (1822), the ships carpenter: "When the vessel struck she was thrown on her beams end." With no casualties, both crews survived on one of the islands until the ship *Earl of Morby* appeared for their rescue on the 1st of July (Gleason 2005:14). The *Pearl* wreck location is an incredibly dynamic site. The majority of the wreckage lies on in approximately seventeen feet of water in one of the grooves of the spur-and-groove topography on the southeast outer edge of Pearl and Hermes Atoll. There are a few scattered artifacts visible within the atoll, as well.

The *Parker* was a 112-foot New Bedford whaler that wrecked during a storm on September 24th, 1842 on the northwest side of Kure atoll (Ship Registers of New Bedford 1796-1850[1]). The crew clearly knew the location of Ocean Island, it was just a matter of avoiding it and the surrounding reef until the storm blew over. Unfortunately, at 2:30 am on the 24th, a wave crashed through her windows and pushed her into the reef.

All but four of the men made it to Ocean Island within Kure Atoll. Some were rescued on April 16th, and the rest on May 2nd of 1843 (*The Friend* 1843). The majority of the wreckage lies on the northwest side of the atoll within the lagoon in approximately ten feet of water, with scattered fasteners on the outer reef connected by a trail of bricks and iron debris.

The USS *Saginaw* was a wooden hulled side-wheel steamer, a fourth-rate gunboat of the Old Steam Navy (Van Tilburg 2002). According to the ship's log, the night of the 29th of October, 1870 was "cloudy but pleasant." The *Saginaw* arrived at Kure atoll to look for shipwreck survivors much earlier than expected, in the dark of night instead of morning, due to an unknown current setting to the westward. By the time breakers were sighted, it was too late to turn the ship around. The Saginaw crashed bow-first into the reef and slowly broke apart (The Pacific Commercial Advertiser 1871). The survivors made it to Ocean Island, and five crew members left behind 93 survivors to make their way in one of the ship's modified whaleboats to go east in search of help. Only Coxwain William Halford survived the 31-day trip and eventual violent surf landing at Kalihi Kai on Kaua'i (Van Tilburg 2003). The wreckage of the *Saginaw* lies in grooves of the emergent reef crest and seaward reef on the Southeast side of Kure atoll. A few scattered artifacts lie within the lagoon.

Site Formation Process in the NWHI

The transformation of a shipwreck site is determined by what happens to the ship before it reaches the seabed and what happens to it during the years it spends underwater; pre-depositional factors include wrecking process and historic salvage. While the crew is still at the grounded ship or nearby on an island, the ship is not yet subject to only physical scattering processes, thus historic salvage can be considered a pre-depositional process. The physical, biological, and chemical processes that act upon a wreck in the years that follow are post-depositional factors. The extent to which certain post-depositional factors influence a wreck site is determined by where it is located on the atoll. It has been found that there are generally two components to a wooden shipwreck site in an atoll environment – an inside reef component and an outside reef component, generally connected by a trail of debris across the reef. Depending upon the wrecking conditions, the majority of the shipwreck will lie on one side or the other, while a scattering of smaller artifacts will rest on the opposite side of the reef.

QuickTime™ and a
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are needed to see this picture.

Pre-Depositional Forces

When a ship is wrecked by a heavy storm, preliminary studies suggest that large pieces of the ship will be pushed over the reef crest across the lagoon, scattering debris from the decks as it travels. Eventually, it sinks inside the lagoon, leaving most of its artifacts in one localized spot. This has been recorded at Kure Atoll by a trail of broken trypots and tryworks bricks, the deck equipment used for rendering whale oil, leading from the reef crest to the *Parker's* main wreck site in the lagoon's interior. Magnetometer scans and dive survey revealed that whatever few remains of the *Parker* were left on the reef crest outside the lagoon have long since washed out to sea. As was the case with the *Pearl* and *Saginaw*, if a ship wrecks not from a storm but due to the captain and crew's lack of knowledge of the complicated topography of the atolls, it is likely that the ship will become stuck seaward of the reef crest and slowly break apart, leaving the majority of its remains scattered on the reef crest. Both the *Pearl* and the *Saginaw* struck the reef bow on, with the rudder breaking off quickly and floating away, as indicated by the fact that the pintle and gudgeon were found far apart. The rest of the wreck scatters along the reef, with heavier metal artifacts falling within gaps and grooves in the topography. Where certain artifacts lie can help determine the path the ship took as it wrecked and subsequently broke apart.

Other than the wrecking process itself, the only other pre-depositional factor is historic salvage by the crew. If the ship wrecks during a storm, it is very unlikely that large-scale salvage is possible due to the rapid nature of the ship's destruction, though this is dependent upon the vicinity of the ship in relation to land. In the case of the *Parker*, the ship was destroyed in less than 45 minutes. Due to the violent nature of the wrecking process, the crew was able to salvage only fifteen or twenty pounds of salt meat and one peck of beans before the *Parker* was completely destroyed (*The Friend* 1843). The majority of the ship was pushed into the deeper water of the lagoon, where it quickly sank. As it took the crew eight days to reach the nearest island, retrieving things from the bottom of the lagoon at the wreck site would have been very difficult, especially since many sailors were not competent swimmers (*The Friend* 1843).

During a low-energy wrecking process when the ship is stuck on the reef for a period of time, as was the case with the *Saginaw*, or close to land, as with the *Saginaw* and the *Pearl*, salvage is much more likely. For the *Saginaw*, the crew made their way into the lagoon and onto Ocean Island, building a camp with supplies salvaged from the *Saginaw*, as well as the *Gledstanes*, an older shipwreck. The crew salvaged what they could from the items that washed into the lagoon; though, as William Halford (Baldwin 1935) of the *Saginaw* wrote, "There was very little of anything saved, only what was washed over the reef into the lagoon in the shoal water, which we later fished up from the bottom." For the next two months, the crew was engaged in salvaging everything from the wreck that they possibly could – as much an effort to keep busy as an effort to survive (*Saginaw* Ship Logs 1870). The wreck was close to Ocean Island, which fortunately made this possible. Though there is little historical information known about salvage on the Pearl, it is recorded that the ship's crew managed to salvage enough wood to build the thirty-ton schooner *Deliverance* as their rescue vessel (Gleason 2005:14). Low sandy islands are in the vicinity of the wreck of the *Pearl*.

Post-Depositional Factors

The post-depositional factors acting upon a shipwreck are far more numerous and complicated than pre-depositional factors. Depending upon where the site is located (inside or outside the reef crest), certain factors play more important roles than others. There are three major factors that influence a ship once it has reached the seafloor – physical, chemical, and biological.

Physical Factors

Once a ship's remains lie within the lagoon, sedimentation, wave movement, and modern salvage play the main roles in physically changing the site. As modern salvage has been ruled out as unlikely in the NWHI due to distance, sedimentation and the associated weathering, along with wave movement, are the most important of the physical factors. Though time did not allow for any rate of sedimentation tests to be conducted during the 2006 field season, it was possible to make some inferences based on observation of the site. Due to the emergent reef crest that breaks up wave energy, the lagoon is more protected than the outer reef crest, which leads to less overall sand movement. Once an artifact is covered with sand, it stands a good chance of remaining covered. Sedimentation, when powered by forceful water movement, can result in artifacts being "sandblasted" and essentially sculpted by the moving sand. For example, deep grooves have been carved into the *Pearl's* pintle and the keel's draft pins have been sculpted into twisted, broken posts.

Storms and the intense wave action associated with them have less effect on the remains of a ship located inside a lagoon, as most storm energy is broken up by the emergent reef crest. Change in artifact position on the *Pearl* site is an excellent example of this. Many of the smaller artifacts from the ship landed inside the lagoon, such as portions of wooden debris (represented by copper fasteners) and glass bottles. Within the lagoon, a broken glass bottleneck has moved very little in the past year. A GPS position of the bottle's location was taken during the 2005 season, and when the archaeologists returned to look for the bottle in 2006, it was quickly found in the same location. Though there is a range of error for the GPS, the fact that the bottle was still in the same basic location speaks volumes about the protective nature of the lagoon relative to the seaward ocean. Similar comparative studies of the outer reef crest reveal that surge has caused sizeable artifacts, such as a large lead pipe, to noticeably change locations within the grooves of the seaside reef crest.

Chemical and Biological Factors

Chemical and biological changes, such as corrosion and concretion, strongly influence any metal and wooden components. Wood in warm marine environments is eaten away by the *teredo* worm, or shipworm. Corrosion of iron involves both chemical and biological processes. Water and sediment with a higher level of oxygen will lead to higher corrosion rates for iron. In the tropical environment of the NWHI, many iron artifacts become covered by algal turf and coral concretions. While the corals and algal turf that can encrust artifacts could slow down the rate of decay, it cannot stop it altogether. Corrosion itself can lead to the encrustation of the metal artifact by metallic salts such as chloride and sulfide, which can help preserve the metal under the corrosion (Renfrew and Bahn 1996:608). This acts to protect the artifact and slow down corrosion, though not stop it completely. The use of a metal detector in a general survey of the *Parker* site revealed coralline algae "molds," the original iron artifacts are completely gone, indicating that the calcium carbonate has absorbed some of the iron from the artifacts. On remaining iron artifacts, there are many dime-sized spots of rust on the surface, indicating recent abrasion and fresh corrosion on a 170-year-old site. But due to the fact that the artifacts, especially the heavier ones, are concreted onto the seafloor, they are not moving around and rusting from damage. Divers on site noticed coralline grazers, parrotfish, eating the algal turf on the artifacts, possibly attracted to the iron rich algae. It is could be that parrotfish, as well as some species of butterfly fish and short bodied blennies, are eating the algal turf that covers the artifact and are thus scraping the metal with their sharp teeth, causing a renewed round of corrosion in that area.

Both biological and chemical processes are affected by changes in temperature, which in the Northwest Hawaiian Islands hovers in the 70s, but can change as much as 10 degrees Fahrenheit from summer to winter (Freidlander et al. 2005). In the shallow well-lit waters of a NWHI lagoon, microorganisms that cause decay and wood-boring marine life thrive. *Teredo navalis*, commonly called shipworm, thrives in Hawaii. Due to the fact that there is such high wave energy in the NWHI, the water is constantly stirred up and oxygenated, increasing the chance for decay. When sand is moved around and mixed up by strong wave events, the sediment in which wood may be buried becomes more oxygenated, as well, increasing the rate of decay.

The Effect of Location

The fate of a ship that rests on the reef crest or in the shallows of the seaward side of an atoll is far different than that of one within the lagoon. For one, physical factors play a far more important role. As with shipwrecks within a lagoon, modern salvage plays little to no role. Sedimentation and storms are the major physical factors that affect a shipwreck on the outer limits of an atoll. Sedimentation on the outskirts of a lagoon is very different from interior sedimentation. The atoll, which is basically a large sand generator, pushes sand and water out of gaps in the emergent reef (Joseph Chojanecki 2006, pers. comm.). Sites that are in front of such gaps in the reef (the *Pearl* but not the *Saginaw*) become covered with sand more quickly. In a high-energy environment such as the NWHI, large-scale sand movement on the outer portion of the atoll, which can be subject to seasonal variation, is possible due to waves and water movement. Any artifact that is initially covered with sand can be uncovered the next season. In the case of the *Pearl*, where there is the most wood preservation (possibly due to sand covering), there was far less sand on the site during the 2006 season compared with the 2005 season, and as a result, more artifacts lying in the sand channel, including wooden planks, were revealed.

Storms play a large role in determining the distribution of sites and the post-depositional movement of artifacts, which generally results in back reef scatter. The Northwest Hawaiian Islands are rarely in the path of hurricanes and tropical storms. However, the Central Pacific is host to an average of between four and five tropical storms per year, the majority of which are generally quite weak. The only hurricane to have winds recorded in excess of 100 knots was Hurricane Patsy in 1959, which passed between Midway and Kure Atolls (Freidlander et al.). Though few tropical storms assail the NWHI, seasonal storms batter different sides of the atoll with varying intensity. The location of the site outside of an atoll is vitally important for its preservation possibilities. In the NWHI, wave movement depends strongly upon the time of year. Winter (November to March) is by far the most dynamic season, with nearly all of the wave energy (with an average wave power of 1.3 watts per meter) coming from the northwest as a result of extra-tropical storms that travel across the north Pacific. Most of the big waves (5 to 10 meters or larger) come from this direction during these months, with episodic storms that have an average wave power of 8 watts per meter. Storms of this magnitude have the ability to alter the distribution of coral, and thus could also have an effect on the cultural resources. Summer (May to September) is the calmer time of the year, with the majority of the wave energy (around 0.3 watts per meter) coming from the southeast due to trade winds. October and April are the transition months,and can thus possess weather characteristics of either winter or summer (Freidlander et al.). It is important to note, however, that the area is so unpredictable that a freak storm can upset any preconceived notions about a calm summer and rough winter.

It is clear, then, that the northwest side of any NWHI atoll receives the brunt of wave battering. The *Parker* site, on the northwest side, reveals little except some fasteners on the outside reef crest. The *Saginaw* and *Pearl* have been more protected on the southeast side due to the fact that they receive less forceful battering and that the NWHI atolls have relatively steep shelves where the shallow sea floor drops off rapidly into the depths of the ocean, which could act in their favor to protect sites on the opposite side of a storm (Patrick Caldwell 2006, pers. comm.). Waves refract more easily around shallow shelves; while this has little effect on the side of the atoll that is being hit by the storm, the other side is relatively more protected when there is a steeper shelf. Since the northwest side receives most of the storms, the southeast side is slightly more protected due to the steeper shelves of the atolls. Despite the fact that ships on the southeast side are more protected, there is not necessarily a large scale artifact movement with the onset of big storms. For example, during the 2005 season, a trypot from the *Pearl* site was recorded as sitting upon the reef crest. It was not previously noticed by any of the vessels or researchers in the area, and it is thus likely that it was a new addition to the emergent reef. During the 2006 season, the trypot was not seen on the emergent reef crest. The trypot was either swept into the lagoon near the emergent reef crest or out to sea, but surf conditions precluded absolute confirmation of the trypot's new location. Suffice to say, it must have taken two significant storm events to move the trypot up the reef and then back down again.

Location and Corrosion

Chemical and biological changes at a site on the outer rim of an atoll are very similar to chemical changes at a site in the lagoon. Both are subject to corrosion and concretion, along with influence by coral predators. Though it was not possible to conduct tests to determine the rate of corrosion at these sites during the previous field season, it was still possible to make some observations. At the *Pearl* site, the trypot that was on a substrate spur at a shallower depth than the rest of the trypots shows far more signs of rust, and the interior of the pot is empty and rusted. While it is possible that more coral predators are feeding upon the algae on this trypot, it is more likely that the pot is subject to greater wave energy that disturbs the coral and causes more rust, as well as keeping the pot free of debris on the inside. The deeper pots are half-filled with coarse sand, bricks, and copper sheathing. There is little to no rust on the insides of these trypots, but the outsides are nearly as heavily marked as the shallower trypot. They are likely influenced by less wave energy than the trypot at a shallower depth. As with the other sites, all of the iron artifacts were covered with algal turf and coral concretions. As most of the artifacts were concreted to the sea bed, what rust did exist was more likely due to coral predators than to movement of artifacts. There were more spots of rust on artifacts at the *Saginaw* site than the *Pearl* site, perhaps indicating a higher population of coral predators, though also possibly due to the fact that the *Saginaw* location on the eastern reef is a higher energy site.

The same biological processes (decay due to microorganisms and *Teredo navalis*) that act upon wrecks within a lagoon also act upon wrecks in the seaward reef and emergent reef crest. However, from occurrences of more wood at both the *Saginaw* and *Pearl* sites, it is possible that these processes occur more slowly. The *Pearl* site, which was likely covered by sand faster than any of the other sites due to its location at a gap in the reef crest, had the most wood still preserved, despite the fact that it was the oldest wreck. The spur and groove topography of the outer reef crest also act to protect wood against physical battering. The only wooden artifact at the *Saginaw* site, a wooden plank, was protected in a groove under a small ledge underneath a spur.

While the non-excavation phase two surveys are basically finished at the *Pearl*, *Parker*, and *Saginaw* sites, this research and the development of a site formation theory for the Northwestern Hawaiian Islands are not completed. There are still many studies relating to ocean conditions in the NWHI yet to be published that could add greatly to this research, and historical documents about the ships themselves, such as the ships' logs from the *Pearl*, are yet to be found. This is merely a preliminary study of three wreck sites in the NWHI and the similarities between them that could lead to the formation of a site formation theory for this particular region and environment.

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Due to the fact that the Northwestern Hawaiian Islands are so remote, very little information about the environment of the region has been published. All research is in the beginning phases, thus it was necessary to contact the oceanographers responsible for this region directly in order to learn about the waves, currents, tides, winds, marine life, and water chemistry. This thesis would not have been possible without the help of scientists from NOAA and the University of Hawaii, including Hans Van Tilburg, Kelly Gleaseon, Patrick Caldwell, Joseph Chojanecki, and Jerome Aucan.

REFERENCES

Baldwin, Hanson W.
1935 Narrative of William Halford *U.S. Naval Institute Proceedings* 1287-1297.

Friedlander, Alan, G. Aeby, E. Brown, A. Clark, S. Coles, S. Dolar, C. Hunter, P. Jokiel, J. smith, B. Walsh, I. Williams, and W Wiltse.
2005 The State of the Coral Reef Ecosystems of the Northwestern Hawaiian Islands. *The State of the Coral Reef Ecosystems of the United States and Pacific Freely Associated States, Center for Coastal Monitoring and Assessment*. NOAA Technical Memorandum NOS NCCOS 11, NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team, Silver Spring, MD.

The Friend
1843 "Whaleship Parker Wrecked on Ocean Island." 27 June.

Gleason, Kelly.
2005 Maritime Cultural Resources Survey Northwestern Hawaiian Islands NOWRAMP 2005 Report. Manuscript, NOAA Pacific Islands Regional Field Office, Honolulu, Hawaii.

Lloyd's Register of Shipping
[1822], London.

The Pacific Commercial Advertiser,
1871 "Loss of the USS Saginaw" 28 December.

Renfrew, Colin & P. Bahn
1996 *Archaeology: Theories, Methods and Practice* London: Thames and Hudson.

Robinson, James
1822 Letter to mother, 16 October.

Saginaw Ships Logs
1870 *Library of Congress.*

Ship Registers of New Bedford, Massachusetts

[1796-1850] Volume 1.

Van Tilburg, Hans K.
2002 Maritime Cultural Resources Survey Northwestern Hawaiian Islands 2002 Report. Manuscript, NOAA Pacific Islands Regional Field Office, Honolulu, Hawaii.

Van Tilburg, Hans K.
2003 Kure and Midway Atoll Maritime Heritage Survey 2003 Report. Manuscript NOAA Pacific Islands Regional Field Office, Honolulu, Hawaii.

Ward, I. A. K. and P. Larcombe, and P. Veth,
1999 A New Process-based Model for Wreck Site Formation. *Journal of Archaeological Science* (26).