Of His Bones are Coral Made: Submerged Cultural Resources, Site Formation Processes, and Multiple Scales of Interpretation in Coastal Ghana

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Abstract

Integrating theoretical and methodological approaches to formation processes across a range of scales from micro-artifact to region and from historical to environmental processes, this work explores the archaeology of the event related to submerged archaeological sites within the Elmina seascape of coastal Ghana. Building on and intersecting with the work of other scholars, this research is a unique approach to the investigation of submerged cultural remains related to historical maritime trade. Remote sensing surveys in 2009 led to the identification of three sites related to maritime trade, adding significantly to the two previously known sites, which include a circa 1650 shipwreck, referred to as the Elmina Wreck, and the remains of an early 18th century vessel in the Benya Lagoon. Drawing on remote sensing survey data, diver investigations, and the micro-sampling sediment coring technique developed over the course of field research, the historic and physical environment of coastal Elmina is studied as a means of interpreting the unique events surrounding a specific shipwreck, and to relate formation processes across the region to this and other sites. While archaeological evidence is limited, the complex study of formation processes, including the historical contexts of trade and the physical environmental has provided insights into events and practices of trade, destruction and preservation of submerged sites, and has provided a foundation for continued holistic investigation and maritime archaeological studies in the region. The methodological and theoretical approaches to formation processes form a model applicable to maritime research across the globe.

OF HIS BONES ARE CORAL MADE: SUBMERGED CULTURAL RESOURCES, SITE FORMATION PROCESSES, AND MULTIPLE SCALES OF INTERPRETATION IN COASTAL GHANA

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Anthropology in the Graduate School of Syracuse University.

March, 2011

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> We are like dwarfs sitting on the shoulders of giants. We see more, and things that are more distant than they did, not because our sight is superior or because we are taller than they, but because they raise us up, and by their great stature add to ours.
>
> John of Salisbury, AD 1159.

It seems that the longer this project took to complete and to write and the more complicated it became, the more indebted I have become to a diverse and amazing group of people. In accordance with the interdisciplinary research philosophy espoused here, this project and the resulting dissertation were truly a collaborative effort. It is not feasible here, however, to name every person who has lent expertise, time, finances, emotional support and encouragement to this project, or to thank each person for showing interest in it, but know that these things have not gone unrecognized, and I am truly grateful for them. As others have said, it is truly humbling to have experienced such intense support and encouragement from so many people, and that perhaps is one of the greatest lessons I have learned throughout this endeavor.

This research would not have been possible without the multifaceted support of Chris DeCorse, who was willing to go out on a limb to enable a few grad students to accomplish the crazy goal of working underwater in West Africa. His creative thinking and constant pushing to achieve a higher level of excellence have been invaluable in numerous ways. Chris Scholz and Mark Staniforth have likewise provided essential support and encouragement to me and to my research; without Mark's leading and encouragement, among other things, to apply for the *Waitt* grant, and without Chris Scholz's willingness to lend remote sensing equipment to a graduate student, the 2009 field project could not have happened. Doug Armstrong and Shannon Novak have been constant supports throughout my time at Syracuse, providing listening ears, critique, encouragement, and numerous letters of support; Shannon also very kindly allowed me extensive use of the macroscope in her lab, which was invaluable. I have learned a great deal about how to be an excellent mentor through my experiences here, and I am grateful to my entire committee for their roles in that.

I am grateful to the GMMB for the research permit to do underwater archaeology in Ghana, and to Nicholas Ivor and Patrick Essien for their support. Benjamin Kankpeyeng, Bossman Murey and Sam Speirs were wonderful friends, supports and advisors in Ghana, and I hope to be able to work with them individually or as a group every time I have the opportunity for fieldwork there. Greg Cook deserves a great deal of thanks and credit for sharing “his” wreck, wisdom, encouragement, data, instruments, and friendship throughout my time at Syracuse University and in the field, regardless of how modest he is concerning his role. This work would not be possible for any of us without Papa Kofi Arhin, and his friendship and interest in it are invaluable. I am grateful for the work Andrew Pietruszka did in getting the 2007 project off the ground and throughout the field season; Shane Pickett and Chris Cartellone were also pivotal in getting the 2007 field season into gear. Without the endless work of John Ricci, who paid his own way to Ghana to help me out, the 2007 field season would not have been anywhere near as productive as it was, and indeed, may not have been possible. I am grateful to Dredging International for their support in the 2007 season and to Bram Desmet, who became my friend and hero in Elmina. Similarly, I also owe Fiona Schultz a debt of gratitude for her friendship, patience and support in the field. Finally, I am grateful to Andy and Eric

Semabia and to Theophilus Onumah for their tireless work in helping me make the trailer and get goods and equipment stored in Accra at the end of the season.

There are no words to adequately express my gratitude to Darren Kipping and Casper Toftgaard, as well as to Kira Kaufman, who also paid her own way out to Ghana, for their endless hours of work in an often brutal working environment in the 2009 season. They made it a true joy to work in any situation, and I hope in the future to be able to work with them again. I am also indebted to Casper for his magnanimous financial contribution of a #10 wrench for the project. The support and kindnesses of Karl Gheysen can only be described as phenomenal and far beyond what I could ever have hoped for in a new friend. Doug Hrvoic's provision of the magnetometer in 2009, enthusiasm for the project, and friendship were, and are, singular. Barnabas Ackon, Joseph Anan, Mr. Blackman, Joseph Arhin and many others in Elmina have variously provided spice and support, some for multiple field seasons; Mr. Albert's special relationship with the Honda engines on the Hurricane made me smile and I am very grateful to him for his patience with them and with me. There are also no words to express my heartfelt gratitude to Jimmy and Sylvia Huey for their support, patience, numerous hugs, listening ears, logistical assistance and love for me and my work in Ghana – I do not think that their support will ever be equaled in the future of underwater archaeology in Ghana, and perhaps not even in all of West Africa.

Many have given up a great deal of time and energy in support of this research in the post-fieldwork phases as well. Peter Cattaneo has spent countless patient hours helping me to work through frustrating new software packages and the interpretation of my data; his friendship has been a real blessing. Rob Gobell also selflessly spent hours helping me wade through the nuances of ArcGIS and other programs. Related to this, I am grateful to Chesapeake Technologies for providing us with a trial version of the *SonarWiz* program that allowed me to do so much in-depth analysis both before and after fieldwork. John Olson has been a fantastic support both in terms of ArcGIS and researching various aspects for the dissertation. Bruce Kaiser of Bruker XRF not only provided training and support, but also lent the Department of Anthropology a portable XRF that proved invaluable in artifact analysis; his patience and assistance in working with us and our data since have been inspirational. Rory Quinn and Colin Breen were very kind in helping me to sort through and develop my remote sensing approach to working in Ghana, and Brian Gilmour was kind enough to run some XRF tests for me and help me to analyze results. I am grateful to Stephanie Kalheber for her analysis of botanicals from the wreck site, and to Amy Mitchell-Cook, who, from what I can tell, for the love of science, her husband, and a friend, also did analysis work on the wood from the shipwreck. Stacey Wall and Connie Barker in Health Services have been fantastic, and done far more than they needed to in order to help me out on numerous occasions. Libby Herndon and Roxanne Broda-Blake provided amazing assistance with some of the post-processing analysis, and I appreciate their tenacity.

My friends Meredith Ellis, Holly Norton and Amy Roache-Fedchenko have spent many hours reading and critiquing often-difficult writing, and have many times been the encouraging words needed to make it through another paragraph. I want to especially thank Liza Gijanto for helping me make sure the dissertation wasn't too interesting, as I understand that's a problem in academia; and most importantly, for her consistent and honest critique, challenge, support and friendship through this process. Heather Gibson, Dwayne Scheid, Steve Lenik, Francois Richard, and many others were amazing mentors and friends as I began and traversed the graduate program, and I owe a great deal to them for their guidance and friendships.

My husband, Alphonso Magri, has been friend, support, critic, and champion throughout these various projects and processes, and his love, unquestioning loyalty, and support have been crucial in carrying the load of this endeavor and in its success. Likewise, my parents, Andy and Linda Horlings, who came to visit during both the 2007 and 2009 seasons, offered essential mental and emotional support, financial help, guidance and unfaltering love through this most recent enterprise, and indeed throughout the multifarious adventures of my life, and I will never be able to adequately thank them. Of course, I have to thank the rest of my family for being sick of how long it took me to get it done, particularly Small Boy, in his daily phone calls of "encouragement." Sara, while still thinking it was ridiculous that it took this long, patiently encouraged and supported me in cards and calls; Christel, I believe, thought it a little less ridiculous, but was encouraging nonetheless. B2 and Don Korthuis have very creatively and patiently helped me to work on the mystery object, and we had a great time doing it. Poor Calvin spent many hours on the phone when I panicked because the computer was misbehaving, and he deserves a medal for solving *clearly* insurmountable problems, over, and over, again. I owe a great debt of gratitude to all of my siblings, but there is no way I would be where I am either academically or personally without the amazing and diverse support, love and encouragement of my brother Bryan. He was able to foster my growth and research in a way totally unique, and there is truly no appropriate or extensive enough way to thank him. Our church family in Syracuse put up with surgeries, exams, dissertations, trips, and no end of adventures for both Al and I, and they are truly a model of Christ’s love. Similarly, friends and people we have never even met around the world spent countless hours praying for safety and endurance, and their support is appreciated more than they can know.

Someone pointed out to me one time that I should thank *David's* sunflower seeds for getting me through college and graduate school. While it is certainly true that I have practically subsisted on them for the past 12 years, I haven’t decided if I should be thanking them, or they should be thanking me for single-handedly keeping them in business for so long. Two more individuals deserve particular attention: Bill Andrews, who lives across the street and could always be counted on for support, a listening ear and a bad joke, and our meow Tripod, for doing absolutely nothing but being cute and providing (mostly) unconditional love and entertainment.

Finally, this research has been funded by a number of different entities. My graduate career at Syracuse University was made possible by NOAA’s Dr. Nancy Foster Scholarship for marine sciences and by a matching grant from Syracuse University. My participation in the 2007 field season was made possible by Chris DeCorse’s National Science Foundation Equipment grant (MRI 0521121). Additional funding sources for 2007 included scholarships from the Syracuse University Goekjian Institute and the Leopold Schepp Foundation. Post-fieldwork analysis support was provided by Syracuse University’s Roscoe Martin scholarship, a Syracuse University Summer Dean’s fellowship, and funding from the Department of Anthropology. I am indebted to the *Waitt Foundation/National Geographic Society* (Grant #W51-09) for providing me with the means to make the truly fantastic 2009 project possible.

For all my grandparents.
Praise God from whom all blessings flow.

This dissertation is also in remembrance of Theophilus Elton Exbert Onumah, who died at the hands of the sea in Ghana on July 19, 2009. He was larger than the limited life afforded him in the village of Komenda, was always willing to learn and to serve, and wanted nothing more than to be as much as he could be.

Photo by A. Schnabel, 2007

Chapter 1
Formations

> Recognizing the importance of formation processes apparently presents archaeologists with the impossible requirement of knowing what is unknown in order to ever have a chance of knowing it (Staski 2000:44).

Never still, the historical seascape of coastal Ghana was and still is constantly in motion. Even on the most monotonous of days the surf continually pounded the coast and the currents transported masses of sediment; people moved along the shore in the course of daily life, and some engaged the sea for fishing, trade or transportation. Sometimes European vessels anchored in the offshore roadstead to take on supplies or to trade, crossing the boundaries between their lives at sea with those on land via local canoes or ships boats. The constant motion of the sea, storms and calm weather, piracy, orders from distant superiors and the good or ill will of local authorities served to dictate their activities and therefore their degree of intersection with those on land. Amidst this constant motion, events of differing scales and magnitude were taking place: a sailor glancing overboard lost his pipe; a woman on shore dumped the remains of her cooking fire into the local lagoon and watched the charcoal as it floated out to sea; a canoe transporting cases of wine for the governor capsized in the surf; whether due to foul weather or human error, a vessel found itself grounded dangerously near the rocky shore. Of the vast majority of those events we will never know any more because there is no longer any record of them, whether in memory, writing or physical remains; but the traces left by a few afford fascinating insights into the dynamic eventscape of the past.

Amidst the events of the mid-17th century, one particular event occurred which left a tangible record that had an impact even centuries after it occurred. Less than three kilometers from Elmina, a vessel loaded with merchandize burned with a fire hot enough to melt metal and glass, but in such a localized position low in the hull that the integrity of the upper deck was probably preserved and ship's guns remained at their stations. Whether or not she drifted while burning is unknown, but she sank quickly and settled on a relatively even keel in six fathoms[1] of water. Her battered masts would have still been visible above the water's surface and the damaged upper decks visible just meters below. There may have been attempts to salvage materials from her, but eventually she was simply abandoned to the power of the sea. For centuries she lay forgotten on the underwater landscape, known only to the fishermen whose nets she caught and the benthic life that visited and colonized her now broken remains. It was not until one day in 2003 that she was once more seen by humans and her story again became part of the dynamic seascape of coastal Ghana.

Parts of the Whole

The tale of one unknown and presently unnamed shipwreck amidst the literal sea of history is perhaps not dramatic in and of itself. What does make the shipwreck described above of true value is its unique role as the only anthropologically investigated shipwreck in sub-Saharan West Africa. Acknowledging the importance of this does not, however, suggest that there is intrinsic significance only in the shipwreck site itself, but rather in understanding it in terms of the larger context of trade, of its relation to the greater history of coastal Ghana, and in relation other submerged cultural resources.

[1] 11-12 meters of water.

Contextualizing this and other submerged sites is accomplished in this research by approaching them as part of the larger whole of historical maritime trade in Africa and an integral part of the past and present physical environment of coastal Elmina. The research discussed in this dissertation is not a search for a single shipwreck; it is not focused only on methodologies for discovering and investigating submerged sites; it is not an intense archaeological and historical investigation of a single site; and it is not focused only on the physical environment and aspects of submerged cultural resources.

What it is, rather, is a holistic, interdisciplinary approach to understanding the archaeological remains of shipwrecks and other submerged sites as archaeological sites and the formation processes that produced and continue to affect them. It includes all of the above, viewed through the lens of a range of scales in which the roles and definitions of what constitute great (macro-, major) and small (micro-, minor) events, spaces, and artifacts are contextually assigned and understood. Foundational to it is the investigation of the interconnected historical and physical formation processes from the perspective of the sea looking onto land, interpreted through the archaeology of the event and understood within the context of the historical and modern seascape. Interwoven throughout the research is the development and implementation of methods that access the widest range of resources possible (Martinón-Torres 2008; see also Wilde-Ramsing and Hermley 2007:132) to help navigate the maritime past and investigate the formation processes that created it and which still affect the physical remains of history today.

This introductory chapter sets out and briefly explores each of the key frameworks and concepts of the dissertation: the foundational work of the Central Region Project in coastal Ghana; Greg Cook's initial maritime archaeological research in the area; the theoretical and methodological approaches of the archaeology of the event and site formation processes; and the methodological avenues of inquiry that were followed in this archaeological investigation of maritime trade in coastal Ghana. Highlighted throughout the chapter are the connecting threads of scale, the historical and physical environments, and introductions to the data foundational for interpretation. All of these facets are framed within a holistic and interdisciplinary approach.

A Holistic Perspective

The holistic approach to this research begins with an understanding of the multifarious interconnected forces that act to create archaeological sites and to destroy and preserve them once created; it is engagement with different types and scales of formation processes. Figure 1.1 is a schematic[2] that represents a classic example of an underwater cultural site and the formation processes associated with it; it is presented here as a summary of this dissertation research. Of overarching concern is the historical context and setting in which the vessel was operating, as this dictated when and where a vessel was, what activities it was engaged in, and what potential dangers it was exposed to. After presenting the historical context, the event of wrecking serves not only to create a submerged archaeological site, but also affects what remains were deposited and, to a degree, how. Other cultural formation factors or processes such as salvage are noted, but the remainder of the schematic presents the incredibly complex web of forces that serve to destroy and preserve the site. All of these factors dictate what archaeologists will find and how they investigate and interpret the physical remains.

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[2] Adapted from Clifton's (2005:270) schematic demonstrating the development of coastal sedimentary facies (sediment types). Because many of the same natural forces affect submerged sites, the schematic simply had to be modified to include the anthropogenic factors and to remove factors less important to archaeological interpretation.

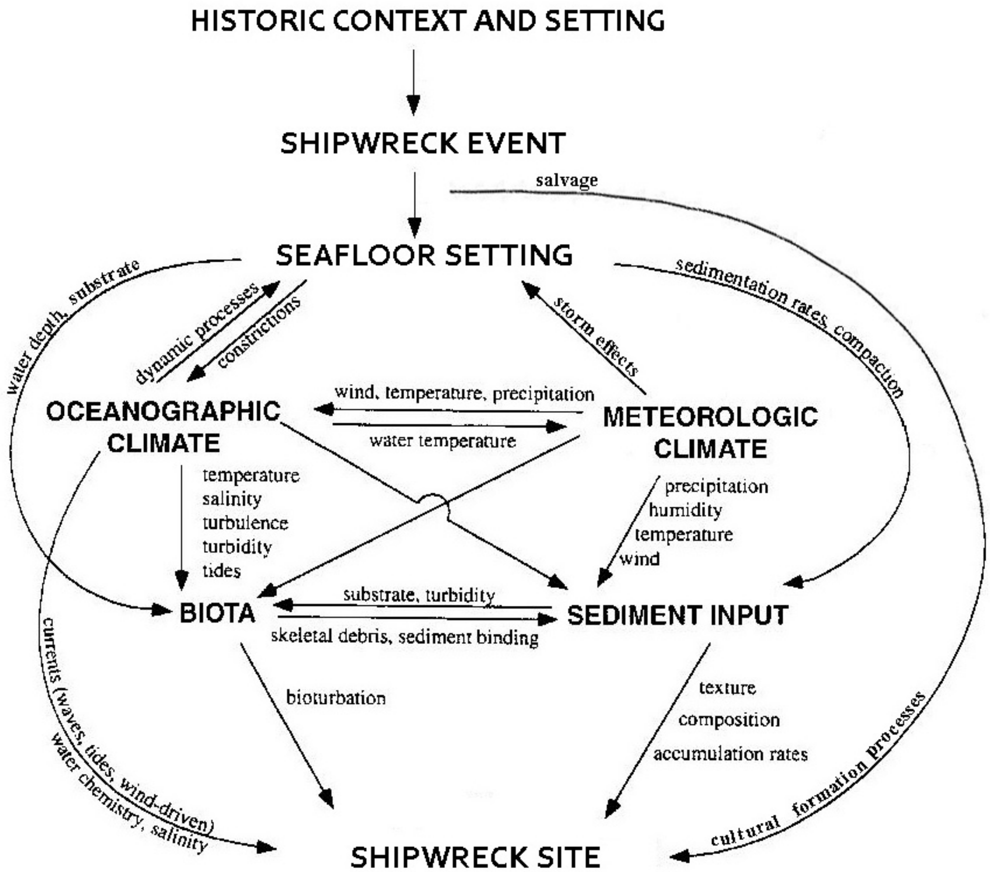

Figure 1.1. This schematic summarizes the formation processes that work to create and preserve submerged archaeological sites; each of these factors is considered and addressed throughout this dissertation on maritime archaeology in coastal Ghana (modified from Clifton 2005:270).

While the example of a shipwreck site is used in the schematic, it is crucial to note that this relates to the deposition and investigation of all submerged cultural material, and it is this larger, holistic approach that informs this research. Each of these different formation processes is addressed throughout the research, some in greater detail than others; all aspects are presented as crucial not only to the creation of archaeological sites, but also to holistic investigation and interpretation.

The following section provides the background and foundations on which this research was built and which continue to inform interpretations and understandings of the historical maritime past in coastal Ghana.

Theoretical and Conceptual Foundations

The entire history of maritime exploration and the resultant international encounters is one of constant movement and change; as Parker (2001:22) writes, "[the] very basis of sea travel, the surface of the ocean, is changeable and mobile" and therefore cannot preserve *on its surface* any record of the past. However, evidence of the activities on the sea does remain on the seafloor and is found in literally every area of the world.[3] As recently as 1998, however, one researcher predicted that because the environmental conditions along the African coast do not appear to be conducive to the preservation of submerged remains, it "would be worth looking for wrecks underwater [in African waters] but the chances of such a search producing a major source of new information is small" (Unger 1998:244). Recent work suggests that Unger's assumption is overly pessimistic. Investigations of a number of submerged sites in coastal Elmina have provided immense amounts of data; work in the region indicates that there is without a doubt additional cultural material surviving that remains to be investigated. While maritime archaeology anywhere in Africa is still essentially in its nascence, this is especially true in coastal Ghana, where its potential has been only peripherally explored.

[3] The work done on studying these remains, however, is not evenly distributed, with some of the smallest numbers of investigations being focused on sub-Saharan Africa.

The Central Region Project

While maritime archaeology in Ghana is a relatively new program of research, historical archaeology has been conducted there and across West Africa for some time. In Ghana, the focus has been at the town of Elmina. Originally called *São Jorge da Mina*,[4] it was established by the Portuguese in 1482 and was the first European trading post in sub-Saharan West Africa, built in an effort to protect the Portuguese gold trading interests. In 1637, Elmina Castle was captured by the Dutch and remained in Dutch hands as a trading establishment until it was ceded to the British in 1872 (Ballong-Wen-Mewuda 1993; da Mota and Hair 1988:9; DeCorse 2001; Feinberg 1989; Vogt 1979; Yarak 2003). The first work at Elmina focused primarily on documenting the architectural history of the castle itself and on some of the surrounding area (Calvocoressi 1977; Lawrence 1963; van Dantzig 1980). In 1985, DeCorse began a comprehensive excavation and investigation into the African settlement associated with the historical structure. Beginning in 1993, his work expanded to also include surveys of prehistoric and historic occupations in areas around Elmina as a means of situating it in a broader cultural and historical context (DeCorse 2001:5).

The Central Region Project of Ghana was developed from this early work and has since grown to incorporate numerous researchers and a range of archaeological investigations both near the coast as well as throughout Ghana (Carr 2001; Chouin 2010; Cook and Spiers 2004; DeCorse 1993, 1996, 1998, 2001, 2005; DeCorse et al. 2000; DeCorse et al. 2009; Kankpeyeng 2003; Kanpeyeng and DeCorse 2004; Smith 2008; Spiers 2007: Spiers and DeCorse 2009; Swanepoel 2004). Many of these scholars

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[4] As discussed by DeCorse (2001:195), the name for the town and the region changed over time. The name Elmina came into common use sometime in the 18th century. For the sake of consistency the name Elmina is used throughout the dissertation to refer to both the settlement and town.

continue to focus on the complex social, economic, and cultural aspects of cultural continuity and change associated with and as a direct result of the Atlantic trade in the region. The investigative, theoretical, and methodological tenets of the Central Region Project provided the foundation and opportunity for maritime archaeological investigations in Ghana (Figure 1.2).

Figure 1.2. The town of Elmina is located in central coastal Ghana (image modified from TapOil.com).

Maritime Archaeology in Ghana

The maritime archaeology component of the Central Region Project was envisioned from the start as an anthropological approach to historical maritime research. After initial research and a summer cultivating relationships with local fishermen in Elmina during the summer of 2000 (DeCorse et al. 2000), Syracuse University PhD student Greg Cook conducted the first systematic archaeological survey searching for shipwreck sites in sub-Saharan West Africa in 2003 (Cook et al. 2003:1).[5] Funded by a National Geographic Society grant, Cook's approach was framed around studying early European expansion and West African trade and interactions. This is an area of investigation that has been poorly studied in any area of Africa, and especially so in terms of the examination of submerged maritime cultural resources (Cook et al. 2003:2). The historically important site of Elmina was initially selected for maritime survey primarily because of its dynamic, pre-eminent, and well-documented role in the maritime Atlantic trade between Africans and Europeans on the west coast of Africa (Ballong-Wen-Mewuda 1993; DeCorse 1996:684, 2001; Feinberg 1989:v; Hair 1994a; Law 1995; Yarak 2003). A large number of international vessels traded in this region for over four centuries, contending with both man-made and natural hazards for the right to trade.

Cook's intended survey centered on areas likely to contain shipwreck sites dating to the era of the Atlantic trade, including areas of the early European trade posts at Shama and Komenda, located west of Elmina, and Elmina itself; this complemented the terrestrial survey work taking place from the Pra River in the west to the Sweet River in the east (DeCorse et al. 2009). He focused in particular on potential sites from the earliest, Portuguese phases of African-European contact, the likeliest of which was Elmina, the earliest European settlement in West Africa. Cook conducted eight days of side scan sonar survey near Elmina (Figure 1.2),[6] and a single day of diving on targets.

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[5] A number of other shipwreck-related projects have been conducted in western Africa, including for instance, investigations of the wreck of the *Mauritius*, located off Gabon, which was encountered during oil exploration (L'Hour et al. 1989, 1990); and survey work in Senegal off Goree (Guerout 1996). No work, however, has been done along the northern Gulf of Guinea.

[6] The offshore areas of Shama and Komenda have not yet been surveyed, but the terrestrial areas have been covered (DeCorse et al. 2009).

Results confirmed the location of a historical shipwreck. Estimated originally to date to the mid-19th century based on a mid-19th century whiteware sherd and Nassau bottles collected from the wreck site (Cook and Spiers 2004), recent evidence suggests a mid-17th century date. In 2005, Cook returned to Ghana[7] with a small team of volunteers, including Syracuse University graduate student Andrew Pietruzska, and in four weeks created a site plan of the wreck despite highly dynamic and nearly zero-visibility sea conditions. His foundational work did far more than just locate and map a shipwreck, as it laid the research and logistical foundations for future work. For example, it developed protocols to handle the challenging logistics of underwater work in West Africa, and made necessary connections with local authorities, and with Papa Kofi Arhin, a local fisherman on whom every researcher has relied. In addition, it explored methods of survey and investigation in an incredibly difficult working environment. Finally, it provided the evidence needed to more fully develop approaches to maritime archaeology in West Africa. Both projects that have succeeded Cook's have been modeled in many aspects on his ground-breaking endeavors, and have built on the data that he collected.

Several funding sources, including a major National Science Foundation equipment grant[8] awarded to DeCorse, provided the funds necessary to continue maritime research in coastal Ghana. In 2007, I,[9] along with Pietruszka and several volunteers, went to Elmina to continue investigations. My component of the project involved examination of formation processes, sediment coring, and monitoring and examination of wrecks across the region, in addition to several shared foci, including

[7] Funded again by the National Geographic Society.
[8] National Science Foundation Equipment grant (MRI 0521121), developed in conjunction with Andrew Pietruszka.
[9] I was also directly supported by the Syracuse University Goekjian Institute, the Leopold Schepp Foundation, a Syracuse University Roscoe Martin grant, and a Summer Dean's fellowship.

investigation of the Elmina Wreck site. The intention for joint research was to use Cook's original data to continue the search for additional shipwrecks. In the event that none were found, the plan was to conduct intensive investigations at the known shipwreck site. Prior to fieldwork Cook, myself, and Pietruszka ranked side scan sonar targets in Cook's original 2003 data; the highest ranked targets were selected for investigation in the field (DeCorse et al. 2009). After spending more than four weeks diving on targets[10] without identifying any additional sites, the focus turned to the known shipwreck site. Investigations included surface sampling, cross-sectional excavations of the wreck site, and micro-sampling in the form of the collection of sediment cores. Additional comparative work, planned from the start of the project, was also conducted at two off-site control areas. As with Cook's earlier projects and for various logistical reasons, the 2007 season was conducted primarily in the rainy season, the time when sea conditions are roughest. While a great deal of data were collected, the truly brutal working conditions had definite impacts on the results of investigation.

With the support of a Waitt Foundation/National Geographic Society grant, in addition to several smaller grants, in 2009 I returned to Ghana with a different team of volunteers. Research objectives of this project included the re-surveying of Cook's original survey area with a side scan sonar, magnetometer, and echo-sounder as a means of creating a comparative basis for evaluating changes on the underwater landscape; investigating additional submerged cultural resources; monitoring the Elmina Wreck site; testing my hypothesis that heavy sedimentation was obscuring submerged sites; and the continued refinement of the micro-sampling technique, tested on a range of scales from the micro artifact to the macro region. Diver investigation of targets from these data (as

[10] A number of these targets are discussed in Chapter 5.

well as Cook's original data) led to a number of discoveries, including three sites related to maritime trade, and evidence that the wreck Cook discovered had become nearly two-thirds covered up in the span of a little more than two years. The team also conducted extensive micro-sampling of various locations across the region.

At present two PhD dissertations, Cook's (n.d.) and Pietruszka's (2011), investigating the cultural identity and material culture of the Elmina Wreck, and my research concerning formation processes, have resulted from the maritime archaeological investigations in coastal Ghana. The theoretical and methodological fundamentals of this research are to a significant extent derived directly from the varied and extensive research conducted in association with the Central Region Project, and specifically Cook's pioneering work. Integration of this research with the Central Region Project as a whole affords it a large historical and cultural context, while also allowing it to explore completely different aspects than have been investigated before. The multidisciplinary framework for this project has been intentionally cultivated throughout fieldwork and analysis, and provides a solid methodology that accesses the widest extent of resources possible.

Of His Bones are Coral Made: A Dissertation

The condensed background of the history, objectives, and methods of fieldwork in historical archaeology in Ghana is important in understanding the foundations of this dissertation research. This work as a whole is incomplete, however, without an introduction to the theoretical frameworks that inform it. My research is framed around the archaeology of the event (i.e. Staniforth 2001 [1997])[11] and physical site formation processes, understood within the overarching and formational context of historical maritime trade and the seascape of coastal Ghana. What sets this work apart is the way in which it works to discover, characterize, and interpret the contextual relationships of shipwrecks and other submerged sites with their historical, social, and natural environments across a range of contextual scales. In doing so, the aim here is to present a more complete picture of the processes that created, affected, and continue to impact historical submerged cultural resources, and of their interpretations concerning international maritime interactions of the past Atlantic world. The dissertation is presented under the title "Of His Bones are Coral Made" not in reference to the limited amounts coral present in coastal Ghana; rather, I am referencing Shakespeare's description of the "sea-change" undergone by shipwrecked people and objects – the formation processes that create the archaeological sites that we see and investigate today.

Events and Formation Processes

A common critique of maritime or underwater archaeology is that it has no specific or unique body of theory (Hocker 2000:392),[12] although such a body is slowly beginning to develop. This research is a significant contribution to both the theoretical and methodological aims of maritime archaeology, and towards the development of a dedicated body of theory that is both anthropological and uniquely applicable to research in underwater contexts. Two primary theoretical perspectives – the archaeology of the

[11] Approached in conjunction with a microhistorical perspective.

[12] Hocker (2000:392) here is actually referring to nautical archaeology, but using the term in such a way that it equates to maritime archaeology. Nautical archaeology is technically different than maritime in that it is focused almost entirely on the vessel itself, rather than the larger perspective of the vessel and every aspect of the sea and shore with which it interacts, as is the perspective of maritime.

event, and site formation processes – are interwoven here with perspectives across a range of scales and within the context of the physical and historical seascape.

For purposes of this research, the archaeology of the event is interpreted and applied as the multi-disciplinary investigation of archaeological sites such as shipwrecks that represent events unique in time and space, although created within complex contexts, investigated through a multi-scalar perspective that encompasses the contexts and events leading up to, and those resulting from, the creation of an archaeological site. Intrinsic to this is an understanding of the larger context in which these events are taking place; this context is considered to be the physical seascape, or the eventscape of history. Explored within this framework is the notion of how the microhistories of artifacts and sites can be related to the wider historical cultural and economic context of the Atlantic trade in Ghana, crossing both temporal and spatial scales and including individual events (Walton et al. 2008). Integral to archaeological interpretation, including events, is an understanding of scale and spatial patterns and processes within the underwater landscape and the historical seascape above it (Garrison 1998; Harris 2006:50).

The archaeology of the event, investigated within historical and physical contexts, then provides an ideal framework within which to situate formation processes of submerged cultural resources, as formation processes include the historical context, the event(s) creating archaeological sites, and the processes affecting them after deposition.[13] Incorporating these components, then, site formation processes are understood as the

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[13] A simple example of applying both of these frameworks in interpretation is the investigation of the processes of transition from a functional vessel within its historical seascape context, through the shipwreck event, and to the shipwreck site and all of the factors affecting it on the submerged landscape (e.g. Gibbs 2005:51; Oxley 1998a:72; Staniforth 2003:29). This example encompasses scales from the region of the seascape to an individual site and even to the interpretation of individual artifacts, but all of them are ultimately interpreted within historical and physical contexts.

historical, physical, chemical, and biological processes which create and transform archaeological sites. Formation process studies examine the relationship between short- (i.e.: the event) and long-term archaeological and environmental trends across a range of scales as a means of identifying and accounting for the biases inherent in the creation and interpretation of archaeological sites. It is most helpful when understood as an interdisciplinary endeavor and applied as both a theoretical construct and methodological approach.

Summarizing the holistic perspective and approach to maritime archaeological research that is applied in this work, Martin (1997:12) highlights the importance of understanding both the historical context and physical processes that affect submerged sites in the following quote:

> Shipwrecks are complex archaeological phenomena whose processes of disintegration and eventual stabilization within the undersea environment are difficult to understand and qualify. Yet an understanding and quantification of formation processes is essential if wrecks are to become more than mere quarries of interesting artifacts…[I]f we can correctly interpret these processes through good archaeological practice driven by a genuine respect for this rich but vulnerable resource, tempered by intellectual rigour and more than a touch of humility, then life will be breathed into our shipwreck assemblages, turning them into the vibrant and very human realities which brought them into being.

The theoretical and methodological approaches to this research are intended as a means of investigating and interpreting physical remains, but the ultimate purpose of any archaeological endeavor is to provide insights into the lives of those who lived in the past. Contextualizing cultural remains within the seascape in which they traveled, lived, and worked, is one way of anchoring the physical remains to the lived context of the past.

Perspective of the Seascape in Coastal Ghana

This research is approached within the historical and physical seascape context from the perspective of the sea looking onto land. This focus is necessitated by the nature of the data, which at present primarily consist of evidence of European trade and navigation practices located offshore. The seascape itself, however, encompasses both the sea and the adjacent shoreline, incorporating both African and European engagements with each other and with the sea. For all of those involved in historical maritime trade, whether viewing the sea or the land, a working knowledge of all of the components of the seascape was vital to assessing international relations, trade opportunities, dangers posed by humans and nature, and even in assessing the more mundane parts of life such as harvesting from the sea. Position within the historical seascape often dictated the boundaries between people, but it could also serve to facilitate the crossing of boundaries between sea and shore, merchant and trader, sailor and land-dweller. The location of submerged cultural resources in the sea is most often a direct result of these engagements with some aspect of, or activity in, the seascape.

As maritime trade and its logistics became more routine for Europeans and Africans alike, the nature of the sea itself was becoming more commonly viewed as benign, and increasingly, “the sea shifted from being a space of mysterious danger to being a space without nature, unpossessable, but also unremarkable” (Steinberg 2001:105). Steinberg continues, noting that “[c]aptain’s logs from the second half of the mercantilist era [the 17th century onward], while replete with poetic descriptions of far-off lands, fail to note any significant nature in the sea…” While the sea may have come to be viewed as a relatively unremarkable part of maritime life, two factors dictated that it was not completely taken for granted. The first was that even though the sea had been harnessed as a facilitator of travel and trade, it was still acknowledged as an unpredictable and untamable force, and therefore was regarded with extreme respect by those whose lives depended on its good nature. The second was related: by harnessing the sea, the sailing vessel had revolutionized trade and international relations, and it was in great part because of this instrument that continents, including most of Africa and Europe, could meet.

In essence, the ship, in its contextual setting of the seascape, which includes everything from the Atlantic Ocean to the mouth of the Benya River in Elmina, was the instrument that blurred continental boundaries and restructured “our mental geographies of space, place, time, culture, and history” (Ogundiran and Falola 2007:35). The strength of maritime archaeology lies in its ability to traverse geographic and other boundaries (McGhee 2007:393), investigating the local with the global (Ogundiran and Falola 2007:41), and the connections and influences of international relations such as those between Africans and Europeans who met in the contact zones at the edge of the African seascape (DeCorse 2001:10; Dellino-Musgrave 2006:28; Mitchell 2005:173). The potential for understanding many of these connections through the physical remains of those interactions in the seafloor is just beginning to be realized for much of Africa, and for West Africa it is truly in its formative years.

Research Methods and Means

The final major component of this research concerns the methodologies specifically developed for maritime archaeological investigations in coastal Ghana. Most of the more general techniques employed in field research are common to underwater archaeological investigations, but many of them were specifically adapted for the rough and typically black-water conditions of coastal Ghana (Cook n.d.; Pietruszka 2011). In addition to adapting to the new and difficult environment in which we were working, there was also a need for efficient and economical methods that could be used in a logistically challenging research environment. Used in concert with other methodologies that were also applied, the development of the micro-sampling methodology was in direct answer to both of the above-mentioned concerns.

Investigation of new environments necessarily includes some form of survey. Cook's original work was conducted with a side scan sonar and focused on the region directly associated with the Elmina Castle. This initial work was intended as a regional survey looking for specific sites such as shipwreck locations within the Elmina seascape. Cook's sampling method for investigating the original survey area was to choose targets from the data based on the highest likelihood that they represented shipwreck sites. This method proved nearly instantly successful, as on the only day he had available for diving, he located a historical shipwreck site. A similar sampling process was used to look for additional shipwreck sites in 2007. In this case, however, no additional sites were identified, leading to an intensive investigation of the Elmina Wreck site.[14] Methods for sampling and investigating the site were developed in 2005 and modified later in 2007 when a systematic, gridded sampling was done at the shipwreck site. In addition, limited excavation was also conducted in 2007.

[14] With every archaeological survey there are factors that can be out of the control of the researcher. In the case of the 2007 Elmina target investigation it is still unknown as to what most of those factors may have been. Two things – the effects of formation processes in a highly dynamic natural environment, which is clearly out of the control of the researcher, and methodological approaches, which are clearly well within the control of the researcher – likely played roles in the lack of discovery and identification of additional submerged sites, but this has not been fully substantiated. As a result, it is not yet possible to quantify the effects of formation processes and the environment on this endeavor. One of the aims of the 2009 field season was to try to isolate some of those factors as a means of improving future research.

A micro-sampling technique was developed in 2007 as a tool to assist in the assessment of the seafloor and the Elmina Wreck, as well as a means of bridging the methodological and theoretical gap between scales. Such scales could shift dramatically from a single bead from a shipwreck to the formation processes active across an entire region. As Kowalewski and Fish (1990:262) note, surface surveys and excavations are techniques that operate at "different scales along a continuum of interrelated phenomena of different magnitudes." Micro-sampling, through the collection of sediment cores, provides an effective means of sampling the surface and different scales from that of the artifact to the region, and also of accessing subsurface information in a relatively non-invasive or destructive manner. This method is strengthened through comparison of data collected in surface surveys, excavations and off-site comparisons, providing both local and regional perspectives on submerged cultural material and formation processes. Analyses of micro-sampling data are necessarily interdisciplinary, as the data collected are historical, geological, and cultural. A significant portion of the data in this dissertation is based on the foundation and product of this micro-sampling technique.

Various historical contexts frame this research and interpretation. Historical context is highlighted throughout the dissertation both in terms of the physical and historical setting and in terms of historical formation processes. Documentary evidence and previous research in the region provide the general context, but more specific documentary data are also pursued. One avenue of inquiry that has been a part of the collaborative nature of this research is an investigation into archival sources for clues as to what historical vessel may be represented by this site. Intriguingly similar to the archaeological tale of the Elmina Wreck presented at the beginning of this chapter, the story of the *Nieuw Groningen*[15] as recorded in historical documents presents us with a tantalizing possibility that she may be the vessel now known as the Elmina Wreck. While using the recorded history of the *Groningen* is a useful and appropriate guide for investigating an unknown wreck site, it should be noted that the ultimate purpose of this dissertation is not to investigate the identity of this particular shipwreck. It is, rather, to use it and all other available evidence to develop theoretical and methodological approaches to maritime archaeology in coastal West Africa, and to provide as much information as possible for the investigation and interpretation of the historic Atlantic maritime trade.

The Dissertation Outline

This dissertation combines all of the above frameworks and methodologies, applying them to a range of sites and material culture on the submerged Elmina landscape. They have been presented in this introduction thematically and, while the order of the chapters is more structured, these themes and concepts are interwoven and repeated throughout. A brief lying out of the chapters here provides a conceptual synthesis of what the reader may expect to encounter, and an aid that the reader may use to follow, interpret, and critique the dissertation.

Chapter 2 presents the theoretical scales which are addressed, followed by detailed discussions concerning the two primary theoretical frameworks: the archaeology of the event and site formation processes. The chapter concludes by introducing the

[15] The name of the vessel was found by Pietruzska in a reference by Porter (1974); the initial archival research was done by DeCorse in the Furley Collection at the University of Ghana. Further archival work was carried out by Eric Ruijssenaar of the Dutch Archives. The name *Nieuw Groningen* is used interchangeably with *Groningen* in the historical texts; where referred to in this dissertation it is called the *Groningen*.

physical setting of investigation, expanded upon in Chapter 3, where the historical context and physical environments of trade are presented in terms of the events and boundaries of the historical seascape. Chapter 4 is a discussion of fieldwork and methodologies, including the development of methodological approaches and the results of field investigations; included also is a brief discussion of data analyses. The following chapters present detailed empirical data and interpretations: Chapter 5 provides insights into formation processes across the region, and Chapter 6 is a case study of the Elmina Wreck and its environs. These two chapters draw together the disparate types of data and avenues of inquiry investigated within the framework of the archaeology of the event and formation processes, and are designed to demonstrate the holistic approach to maritime archaeological work in coastal Ghana, providing both general and specific examples of research. The final chapter, Chapter 7, is a discussion of the efficacy of the methods and frameworks employed in this research, and provides suggested avenues of future research. Numerous appendixes are included that provide details of the data interpreted in this research, as well as discussions of particular aspects of research or methodologies.

Chapter 2
Conceptualization and Framework

> The drama of a shipwreck focuses attention on the event, but the conditions that produced the wreck and the consequences arising from it are as significant as the event itself (Gould 2000:13).

Shipwrecks and other submerged cultural sites represent more than just culture, history, and bits of broken things (Flatman 2003); they are also the embodiment of different scales – scales of time, of culture, of land- and seascapes, of formation processes, and of events. The scale of an event can relate to the entire Atlantic trade (Gilchrist 2005:331-332; Morgan and Greene 2009:7), or to a single wrecking, and formation processes can do the same (Wandsnider 1998:87).[16] It is at the intersection of these varying scales and processes that the value of shipwrecks in understanding past interactions lies; it is there that we see both the individual vessel and its place in the overarching worlds and dramas of which it was a part, culminating in its wrecking (Staniforth 2003; also see Foxhall 2000). By beginning with the extant physical remains, it is possible to explore and understand the importance of the original vessel at differing scales (from single artifacts to entire shipwrecks), investigated together with events, times, processes, and the historical seascapes and landscapes of maritime trade.[17] It is through the investigation of shipwreck sites, their environs and the processes that affect

[16] While many of these concepts can be applied to maritime archaeology, the vast majority of the literature cited here was not written for application in this way. My research is an attempt to engage with these disparate ideas within the realm of maritime archaeology.

[17] Although not referring to underwater archaeology, Kowalewski (1997:288, 295) refers to this idea as a "regional-scale spatiotemporal frame" which provides a means of organizing and understanding archaeological information, and which is also a link between archaeology and history, that is directly applicable here.

them that we can begin to glimpse history from and assign meaning to the tangible bits of broken things we find at the bottom of the sea (Staniforth 2003:29; see also Flatman 2003; Firth 1995; Gould 2001:197).

Delgado (1988:1) writes that a shipwreck "can be said to represent either an event, or the tangible remains of that event." Understanding the circumstances surrounding the vessel and its wrecking (the larger temporal and historical context) provides a means of interpreting both the event of wrecking and the physical remains of it. The archaeology of the event, which encompasses the long term but is primarily concerned with the more immediate time-frame surrounding the wrecking event itself, in tandem with the investigation of formation processes, provides a means of bridging differing scales and interpretations by providing an integrated framework within which all of these aspects can be considered. This chapter is a discussion of the archaeology of the event of shipwrecks and the formation processes which affect them, woven together to form both the theoretical and methodological framework of this research. This melding of shipwreck events and formation processes is an innovative means of using separate paradigms that lend themselves to the analysis of each other, and to an understanding of the larger processes of maritime trade, cultural interactions and the environment. But the structure of the research cannot and does not end with these constructs; it is further situated and intertwined within the historical seascape and landscape of Elmina, producing a unique perspective on historical maritime trade in Ghana in particular, and underwater archaeology in general. This physical historical setting of the research is addressed in the following chapter (Chapter 3).

Theoretical Scales

A long-standing critique of underwater archeology is its history of atheoretical fixation on single or only "important" shipwrecks or artifacts. This has often been associated also with complete disregard for the "less important" wrecks; the cultural, environmental, historical contexts; and the vastly differing and complex scales of interpretation (Anuskiewicz 1998; Breen and Lane 2003; Colin 2001; Delgado and Staniforth 2002; Fontenoy 1998:51-52; Lenihan 1983; Martin 2001; Murphy 1983; Richards 2008; Souza 1998; Staniforth 2001 [1997], 2003, 2007).[18] Those who work in underwater archaeology are slowly coming to realize that it is imperative to balance the minute details of ships and their wreckings with large, overarching ideas and the differing time frames within which events took place. In other words, we are realizing the importance of looking at multiple scales, and thus adopting a multi-scalar approach (Adams 2001; Brooks et al. 2008; Butzer 1980; Hill et al. 2001; Cunliffe 2006:318; DeCorse 2008; Egmond and Mason 1997; Feinman 1997:374; Fletcher 1992; Gosden and Kirsanow 2006; Harris 2006; Head 2008; Lock and Molyneaux 2006; Marquardt and Crumley 1987; Ramenofsky and Steffen 1998; Staniforth 2001 [1997], 2003; Westerdahl 1992; Wobst 2006).[19] Gosden and Kirsanow (2006:27) write that "[h]istory explores a

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[18] Breen and Lane (2003:469) also note that the technology for discovering shipwrecks has come to play a guiding role in maritime archaeology, to the detriment of understanding a more integrated and holistic perspective of the maritime past. My intention in this dissertation is to explore the past using a range of technologies, but then to integrate the results of those methods with a more nuanced perspective of the historical maritime environment, the seascape.

[19] Scale is a concept that is dealt with in many social sciences, the one most nearly related to archaeology being history. History's struggle with scales, from macro- to microhistories is easily related to archaeological grapplings as both disciplines explore interrelated ideas, although using different methodologies and approaches. It is impossible and unnecessary to summarize the vast literature on scale in this chapter. While its intricacies and complications are recognized, its importance to this study is at the basic levels mentioned above. It should be noted howecer, that although simplified, the integrated approaches employed here provide a unique and powerful way to explore maritime archaeology in West Africa in general, and in coastal Ghana in particular. For example, as discussed shortly, a microhistorical

range of timescales, overlapping at the micro end of the scale with anthropology, to the long durations of Braudel as people's relationships with land and sea unfold over centuries and even millennia." This range of scales is also appropriate, and indeed essential, for an in-depth understanding of archaeological research.

Scale includes concepts of space, relationships, and time (Bender 2002; Firth 1995; Foxhall 2000; Rapp and Hill 2006:130-131; Staniforth 2003:19). In the example of underwater research into historical maritime trade, scales of space can include anything from individual site locations to regions to international networks spanning oceans. Relationships may be between objects within a shipwreck site, between artifacts and sites within wider historical cultural and economic contexts, or between submerged cultural artifacts and the roles they play in modern heritage. Concepts of time include time scales of individual wrecking events, of formation processes, and of shorter and longer time frames in history. Essentially, the scales within the "contextual continuum" (Fontenoy 1998:51-52) of a shipwreck or an underwater site and its contexts are as varied as the sea life that inhabits them.

Use of scale in maritime archaeology is contingent on being able to judge the "appropriate resolution" necessary in terms of investigation (Gowlett 1997:166; see also Bower 1986; Rapp and Hill 2006:131; Stein 1993), whether at broad or specific scales (Richards 2008:42), or something in between. It is precisely because shipwrecks and other submerged sites were (and are) part of the "dynamic landscape of human action" (Dellino-Musgrave 2006:22) that they hold merit as viable sources of information about

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approach to dealing with different scales of archaeology in coastal Ghana is explored and applied throughout this research, providing a means of integrating and querying scales across complexes of data. While not an exhaustive list, an authoritative literature concerning microhistories may be found in Ginzburg (1993), Ginzburg and Poni (1991), Muir (1999), and Walton et al. (2008).

history, peoples, cultures, technologies, and environments, which we can investigate and interpret today. Maritime archaeology, if it is to be a mature science (social or otherwise), must engage with each of these interconnected facets of events, site formation processes, and scale.[20]

Scale and Maritime Archaeology in Ghana

The application and interpretation of different scales is central to my investigations in Ghana. Maritime research in Ghana is part of the larger goal of studying historical cultural interactions in coastal West Africa. The current focus of the maritime project, including my fieldwork, is not the complete investigation of shipwrecks or the search for single vessels of any description. Rather it is a regional survey[21] of submerged cultural resources, investigated with the goal of determining the resources present, developing means of effectively investigating them, and then investigating them within the context of historical maritime trade and interactions (Cook and Spiers 2004; DeCorse 2001; DeCorse et al. 2000; DeCorse et al. 2009).[22] And yet it also includes scales of investigation from the grand (the large historical context of maritime trade) to the minute (small artifacts collected in sediment cores). While there is literature extant on this topic in much of archaeology (Bevan and Conolly 2002-2004; Kowalewski 1997; Marquardt and Crumley 1987; Stein 1993; Wandsnider 1998), it is rare in maritime archaeological literature (see Delgado 2009 for an exception to this). Where necessary, modified

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[20] The following chapter anchors these concepts to the physical seascape and history of shipwrecks, which are two additional concepts that must be considered in maritime archaeology, but which fit better in a different discussion.

[21] Funded through National Science Foundation Equipment grant (MRI 0521121); Waitt Foundation/ National Geographic Society grant (W51-09); and Syracuse University's Goekjian Scholarship.

[22] See Bower 1986:23 for similar goals laid out for terrestrial survey in sub-Saharan Africa.

adaptations of concepts articulated in terrestrial archaeology have been applied here to maritime archaeological contexts.

While the broad questions of my research in Ghana are framed around a regional analysis, my dissertation research encompasses scales primarily at the site and intra-site levels,[23] as well as different time scales in history (Denham 2008; Forsythe et al. 2003:134; Goldberg et al. 1993; Knapp 1992:13-14; Kvamme 2003; Morgan and Greene 2009:21; Murphy 1997a:339; Phillips 2003; Russell-Wood 2009:82). Principal concerns that are addressed at the regional scale are focused on the seascape as a whole, including different formation processes across the region, primarily ascertained through micro-sampling and sediment cores. At the site and intra-site levels, the focus is on the formation processes present which created and continue to affect individual sites across the region. Engagement with scales of time is primarily concerned with the formation processes at each site. While the inclusion of social scales[24] of history is implicit, attention is focused on understanding the processes over time which created the sites as they are today. Shipwrecks and other submerged sites are considered within the context of the archaeology of the event(s), and within the major and minor formation processes that created them. Echoing Butzer (1980:419), I have found that in this research "[m]icro- and macro-scale studies are evidently complementary and both are desirable for comprehensive interpretation."[25]

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[23] I use the term "site" to refer to individual shipwreck and other submerged sites and "intra-site" to refer to comparisons and investigations within individual sites. The inter-site (between sites) comparison is a natural means of investigating a larger area or region, which I refer to as the area surrounding and including Elmina Castle and its seascape (see Orton 2000:584-585).

[24] By using the term "social scales" I am referring to the various relationships between individuals such as merchants and traders, between people groups, and between various social relations over time.

[25] In a sense this research is microhistorical (see Brooks et al. 2008), as it deals with the histories of individual vessels within larger contexts, but more applicably, this relates to the method of micro-sampling (discussed in Chapter 6), which looks at the small scale over time as is displayed in the archaeological and

Archaeology of the Event: Ships, Wrecks, Remains, and Formation Processes

Events are understood differently within academic literature, including within archaeology; the archaeology of the event as defined here draws on Staniforth's (2001 [1997]) conceptualization as it relates to shipwrecks. The archaeology of the event is defined as the multi-disciplinary investigation of archaeological sites such as shipwrecks that represent events unique in time and space, although created within complex contexts, investigated through a multi-scalar perspective that encompasses the contexts and events leading up to, and those resulting from, the creation of an archaeological site. [26] The archaeology of the event provides an ideal framework within which to situate formation processes of submerged cultural resources, their effects on the associated material culture, and the larger contexts within which those involved in maritime trade were operating. While this discussion focuses on wrecks and their events because it is an ideal starting point, it should be noted that this research also includes discussions of submerged cultural sites that are not shipwrecks. Focus on shipwrecks in particular delineates a starting point – the change from a vessel being functional to being a shipwreck – from which to begin assessment and interpretation of shipwreck sites and the effects of modern and historical formation processes on them, as well as on other submerged sites. As Gibbs (2005:54) writes:

> …the process of wrecking is the start of the transformation from ship into place[27] [shipwreck site], with the circumstances of the catastrophe, the

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geological record (in sediment cores) as a means of interpreting macro-scale formation processes within sites and across regions.

[26] It should also be noted here that natural occurances, such as storms, are also considered "events," as this is consistent with the way the term is used, for example, in meterological, oceanographic, and geological literature (i.e. Stein 1987:340).

[27] Gibbs (2005:56) contends that (apart from his own work) there "has been little of no investigation of shipwrecks as 'places.'"

> behaviours surrounding the event, and outcomes in terms of the damage of loss of vessel, cargo, or human life, potentially resulting in forms of significance independent of the ship's function.

A wrecking is more than just the end of a vessel and the beginning of its residence on the seafloor – it was the end of something that was intended to be larger. The loss of a ship meant varied things to the people on it, for the people or company who owned it, for the people at nearby trading forts who had to deal with survivors, and for the locals if they had goods waiting to trade. The event of the shipwreck ties together the larger historical setting and context of trade, and at the same time the site itself provides the only tangible remains that may be studied, queried, and investigated (Adams 2001:299; Gould 2001:195; Green 1990:2). These relationships are crucial, because as evidence is interpreted, the social and historical implications concerning the individual vessel and its ties with the larger historical context come full circle. At a smaller scale, the events of the loss of an anchor or the rescue of a vessel from near-wrecking that leave tangible records on the seafloor can also be interpreted within various historical and physical contexts, and provide different insights into historical maritime trade.

Utilizing the framework of the archaeology of the event (Staniforth 2001 [1997]) is particularly applicable to both the short-term and the long-term goals of this research project. At the short-term level, interpretation of the wrecking event itself through the investigation of site formation processes (Oxley1998a, 1998b; Schiffer 1987, 1996)[28] and the consequent characterization of the remaining aspects of the shipwreck provides basic data on historical shipwrecks in this little-studied region of maritime Ghana (Cook and Spiers 2004). It also provides insights into how historical vessel captains used and

[28] See Kenchington et al. (1989) for an excellent example of this.

combated local natural forces and factors such as currents, topography, surf, and climate, and consequently made navigating, anchoring, and even trade decisions. Long-term goals of the project include understanding maritime trade within the larger historic context of the Ghanaian coast, and more intensive investigation of particular shipwrecks and sites. The data collected from each submerged site used in a regional, multi-scalar context and long term comparison provides insights into the cultural behaviors involved in trade and into the natural processes acting to destroy or preserve these cultural vestiges of the past. Only after we understand shipwrecks and other submerged sites in terms of these most basic processes can we "interpret larger scale cultural processes of trade and cultural continuity and change" (Staniforth 2003:29; see also Gould 2000:12; Gladfelter 1977; Foxhall 2000) in coastal Ghana.

Archaeology of the Event

The concept of the archaeology of the event has only recently become a relatively common theme in archaeological research, including maritime archaeology (i.e. Delgado 2009; Richards 2008; Staniforth 2003). Integral to an understanding of the archaeology of the event is the concept that events are specific and contextual (Staniforth 2003; see also Beck et al. 2007:833), and that they must be understood within the social structures of the people being studied. The existence of underwater archaeology focused on ships is largely derived from specific occurrences: namely the shipwreck (Staniforth 2001 [1997]:43; see also Adams 2001:294; Breen and Lane 2003; Oxley 1998a:71). While there is nothing inherently wrong with studying single events or sites, their interpretive value is significantly diminished if they are not understood within these wider contexts, highlighting the need to investigate and incorporate the complete range of scales and contexts in which these sites and events occur(ed). It is argued here that the relation of specific events (for instance, a shipwreck) to processes (various formation processes) within the context of the larger historical environment and seascape of the historical maritime trade in Ghana is essential to understanding the region's connections to the broader economic realm tied to trans-oceanic exchange (i.e. Delgado 2009). This is a simple but effective means of relating the more abstract temporal and spatial notions of investigating historical events with the more tangible and concrete evidence found in historical shipwreck and submerged sites.

Staniforth (2001 [1997], 2003) adapted the concept of the archaeology of the event as a means of interpreting maritime archaeological sites, and as an alternative to the Pompeii premise, a concept widely discussed in maritime literature. In Staniforth's approach to the archaeology of the event, shipwrecks are interpreted in terms of their material culture and understood in terms of the social products of the societies from which the wrecked vessel came or to which it was going, but are not treated purely as static snapshots of the past. In this approach, shipwreck events are also considered in terms of the results of human actions and decisions, as well as being unique in time and space (i.e. Dellino-Musgrave 2006:26-27). This conceptualization provides a means of looking at not only the people, goods and events leading up to and surrounding the wrecking, but also the wrecking itself within a larger context. Adding to this concept, then, is that part of that larger context are the reasons for why the vessel was in a particular location (for instance, trade with coastal Ghana), and events following the wrecking itself, whether intentionally orchestrated (such as salvage or recovery) or natural (including natural formation processes).

The larger context and larger-scale processes in which vessels operated in coastal Ghana are not confined to the coast, or even to the Atlantic trade, but are rather part of European expansion, international relations, capitalism, and consumption, on a worldwide basis (Staniforth 2003). Interpreting archaeological sites and specific events within this larger context then ties small, medium, and large scale processes together within a coherent framework that provides a more complete understanding of sites and their places in history. In his analyses of shipwrecks and the event, Staniforth uses the *Annales*[29] framework of longer terms and larger scales to allow the "specificity of the event to be used to interpret larger scale cultural processes" (Staniforth 2003:27-28; see also Bintliff 1991, 2004:177; Fletcher 1992:41; Veth 2006:19)[30] and to understand history at different scales of analysis. In doing so, he explores the single events associated with the sites, but then interprets the sites and their contexts within the larger social framework in which they were a part. Staniforth then applies the same ideas to discriminate between different kinds of explanations for behaviors and events "entrapped" in one episode of wreckage/loss/abandonment.

This approach is designed to show that "by taking a particular event or site within a comparative framework it is possible for maritime archaeology to raise the focus from a site-specific level to more general considerations of human behaviour, cultural continuity and change over time" (Staniforth 2003:19). This juxtaposition of the single event with

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[29] Based primarily on Braudel's three scales of history: *événements* (which was actually what Braudel considered the least important), *conjuntures*, and the *longue durée* (Bintliff 1991; Braudel 1972-1973 [1966]:17-22; Bulliet 1992:133; Smith 1992; Tomich 2008:225), Staniforth focuses on the shortest time frame, *événements*. Kelly's (1997a, 1997b) work on Bénin provides an excellent application of these concepts to historical archaeology in West Africa.

[30] Bender (2002:S103), in her article entitled "Time and Landscape" discusses time and scales of human engagement with the landscape in what she calls a "nested series of sociopolitical landscapes." This concept of the nested sociopolitical landscape is fascinating and applicable at the widest scale of investigation in this region, but is too abstract to effectively apply to the smaller scales of the event and formation processes.

the human behavior over time highlights the importance of an event, but is also an example of the various scales implicit in this framework. An excellent example of this may be found in Delgado's (2009) work on the San Francisco waterfront, in which he investigates the complexities of scales from individual artifacts to the larger scale "maritime system" as part of the global capitalist system. Basing much of his theoretical framework on Staniforth's archaeology of the event, in this study the "event" is considered to be the creation of the waterfront itself from the years 1849 to 1855, and reciprocating effects of this on both the town itself and the larger world system. Delgado's work, as well as Staniforth's, provide examples of the possible transitions between archaeological events and the dramatic larger historical and transformational socio-economic events highlighted by authors such as Beck et al. (2007), Sewell (2005), and Sahlins (1985, 1991, 2004). This work, while touching on and incorporating the larger, socio-economic contexts of trade in West Africa, highlights primarily the more materialistic, smaller archaeological events and regional perspectives that may be gained through investigation of multiple scales of formation processes; in doing so, it also sets the foundation for an investigation into the larger-scale socio-economic and socio-political transformations along the coast.

Microhistory and the Event

An additional and useful approach that articulates well with the archaeology of the event, while not being confined to archaeology and therefore making it open to an even more interdisciplinary investigation, is the approach of microhistory. Implicit in the name are the concepts of investigating both small scales and history; as Muir (1991:viii) writes, it is "a systematic way to sort out fragmentary clues." While it may be systematic, however, it is still not a rigidly defined methodology; as noted by Walton et al. (2008:4), it is less a defined method of investigation than an orientation or "exploratory stance." This openness of approach and application makes the microhistorical perspective flexible, fitting nicely in the relationship between anthropologists and historians, as well as with a range of other social sciences (Ginzburg and Poni 1991:4; Walton et al. 2008:4-5). Importantly, while the emphasis is on the micro scale, the overarching framework of the microhistorical approach is its insistence on context (Ginzburg 1993:32-33; see also Muir 1991:xi); the application of this approach is therefore excellently situated to inform the archaeological investigations of historical events and the processes that created and still affect them.

The archaeology of the event and microhistory provide means of transitioning between and through dynamic scales of time and space, and therefore, implicit in this approach is that, as noted above, submerged archaeological sites, such as shipwrecks, cannot be considered static snapshots in time. In a related argument to this and to Staniforth's approach outlined above, Dellino-Musgrave (2006:25) suggests that there are two viable conceptualizations or approaches for analyzing shipwrecks: the concept of the time-capsule or "Pompeii premise," or the archaeology of the event. The "Pompeii premise" is a concept that suggests that sites were literally "frozen" in time, like the city of Pompeii, and is responsible for creating the stereotype of the archaeological 'time capsule' (see also Delgado and Staniforth 2002; Schiffer 1985, 1987:237; Staniforth 2003:28-29). [31] She writes that in shipwreck archaeology, "the 'Pompeii premise' idea

[31] See the following works for more complete discussions of shipwrecks as time capsules and the Pompeii Premise: Adams 2001; Barstad 2003; Binford 1981; Dellino-Musgrave 2006; Gibbins 1990; Gibbins and Adams 2001; Gibbs 2005; Gould 2000; Lenihan 1983; Martin 2001; Muckelroy 1976; Oxley 1998a; Schiffer 1983, 1985, 1987; Smith 1992; Staniforth 2003; Steffy 1978; Stewart 1999; Throckmorton 1970;

appears regularly because shipwreck sites involve aspects of a specific event…, the shipwreck event, generally disregarding other cultural and natural factors that alter its natural formation" (Dellino-Musgrave 2006:25-26). She contends that the concept of time-capsule/Pompeii premise neglects topics such as post-depositional processes and environmental dynamics of the area under study, both of which are in fact essential to understand when interpreting submerged sites. While there is merit to the idea of the archaeological time capsule, and shipwrecks, of any category of archaeological site, do most closely fit with it, there are enough problems with the concept that other framing and theoretical approaches are more profitable in terms of studying and investigating them, and are the focus of this research.

I have drawn on Staniforth's model here as the foundation for my application of the archaeology of the event, but some alterations, specifically with regard to the microhistorical approach and a more explicit application of formation process investigation, have been included here to tailor it more specifically to this research and to work in coastal Ghana. While it is acknowledged that "it is at the level of the archaeology of the event and by incorporating the event into the longer term, and the larger scale…that maritime archaeology potentially has some of its most powerful explanatory value" (Staniforth 2003:28), it is important to go to an even more basic level in a region where almost nothing is known about maritime cultural resources. In coastal Ghana, where relatively little is understood concerning the maritime environment and its effects on historical trade and on consequent submerged cultural resources, basic surveys of

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Walker and Hildred 2000. See also the following works for discussions on the contemporaneity of artifacts on shipwreck sites: Adams 2001; Gibbins 1990.

submerged cultural resources and an understanding of site formation processes are foundational in terms of how sites are investigated and interpreted. [32]

The Atlantic trade in West Africa, the largest scale at work in this research, is a well-studied topic for historians and archaeologists alike (Cook and Spiers 2004; DeCorse 1987, 2001, 2008; DeCorse et al. 2000; DeCorse et al. 2009; Feinberg 1989; Flatman and Staniforth 2006:188; Gijanto and Horlings in review; Hair 1994; Hair et al.. 1992; Inikori 1996; Jones 1994; Kelly 2004; Klein 1990; Law 1982, 1997, 2001; Orser 1998; Posnansky 1982; Posnansky and DeCorse 1986; van Dantzig 1975, 1976, 1977, 1982; Stahl 2001; Vogt 1973a, 1973b, 1974). In considering this, Posnansky once suggested that “it is on the basis of manufactured goods that have survived, like certain categories of glass beads and ‘brass’ vessels, that our tangible and dateable evidence of trade [in West Africa] depends. Such goods are, however, rare and until detailed archaeological research over a very wide area of West Africa is undertaken, other lines of evidence must be explored” (Posnansky 1971:1). Only with the initiation of this project has underwater archaeology in Ghana been explored, and only rarely has information from any underwater context in West Africa been included in any anthropological project (Cook et al. 2003, Cook and Spiers 2004; DeCorse et al. 2009). Similarly, while a significant amount of work has been conducted worldwide on underwater archaeological sites (Flatman and Staniforth 2006), there is only beginning to be significant maritime archaeological research in most of Africa (Auret 1977; Auret and Maggs 1982; Breen and

[32] The importance of submerged cultural resources is recognized throughout much of the globe, and while there are significant theoretical and methodological challenges in the field, over the past half-century it has matured and its contributions to an understanding of human history have increased exponentially. Shipwreck site formation investigation, for instance, has played a particularly key role in this intellectual expansion (e.g. Muckelroy 1978).

Lane 2003; Forsythe et al. 2003; Kirkman 1972; Piercy 1977, 1978, 1979, 1981; Quinn et al. 2007; Werz 1993a, 1993b).

Site Formation Processes

For purposes of this research, site formation processes are defined as the historical, physical, chemical, and biological processes which create and transform archaeological sites through time – in this case, such things as currents, sedimentation, storms, benthic organisms, the events that occurred which wrecked the vessel, and any attempts to salvage, or interactions with it, after wrecking. Formation process studies examine the relationship between long-term archaeological and environmental trends, both at the macro- and micro-level (Gladfelter 1977; O'Shea 2002:212; Ward and Larcombe 2003:1223). Additionally, because they are active on the levels of artifact, site and region (Schiffer 1987; Staski 2000:43; Stewart 1999:578), they provide a means of looking at data across a range of scales and set the stage for the interpretation of events from a historical maritime past and wider cultural and historical phenomena. Formation studies try to identify the biases inherent in the creation of archaeological sites and to compensate for them in their interpretation (Oxley 1998a:46; see also Elkin et al. 2007:51; Gibbs 2005:52; Morton 2004:6; Muckelroy 1976; Trigger 1989:359; Ward et al. 1998; Ward et al. 1999b; Wheeler 2002). Oxley goes so far as the write that "[m]aximizing the effectiveness of archaeological interpretation is *predicated upon* attaining a sound appreciation of the site formation processes" (Oxley 1998a:59, emphasis added).

Site formation research is by definition inter-disciplinary and is simultaneously a theoretical construct and a methodology (Shott 1998). It is inter-disciplinary because it involves, at a minimum, archaeological sites directly influenced by cultural and natural factors. Cultural factors necessitate wider anthropological and historical research, and the natural factors require also geological, oceanographic, and even biological research. It is a theoretical construct because it may be used to interpret and explain how sites are formed and changed and how we may learn from them in their present states. It is a methodology because it requires and provides special investigative techniques[33] to collect data on a wide range of aspects integral in archaeological sites, and it is an instrument to use in the delineation and characterization of these various factors. Finally, site formation research is one of the most powerful tools available in the maritime archaeologist's tool kit due to its unique capacity to draw on theories, techniques and methods – from related disciplines such as history, geography, geology and biology (Dincauze 2000:502; Ferrari and Adams 1990; Hassan 1987, Jones 1994:349; McNinch et al.. 2001; Nash and Petraglia 1987; Niemi 1999; Oxley 1998a:12; Schiffer 1987:8) – to produce a comprehensive understanding of an archaeological site, its history, and all it contains.

One key to investigating and interpreting formation processes and the various intricacies they effect lies in recognizing that they are both the processes that act to destroy the site and the agents of preservation (Stein 2001:37; Ward and Larcombe 2003:1223). In general, shipwreck and other submerged sites eventually become relatively stable (Brown et al. 1988; O'Shea 2002; Ward et al.. 1999a:566; Wheeler 2002:1150), but the processes that affect sites and the archaeological evidence contained

[33] Such as using sediment cores to access the records of these processes as they are laid down in the matrix of the shipwreck site. This does not imply that a Harris matrix is necessary for interpretation, although it does not preclude its usefulness.

in them are still dynamic and must be understood (Oxley 1992, 1998b:524; Schiffer 1987: 235; Ward et al.. 1999a:565).[34] Recognizing and defining the various agents and different processes of destruction and preservation provides the foundation upon which to base an analysis of a wreck site – delineating the differences between cultural or human and natural interactions with the site. An understanding of formation processes provides a means of translating observations on the (relative) statics of the archaeological record into statements on the dynamics of past people, cultures and events (Morton 2004:6; see also South 1977). The tools and tenets of geoarchaeology (see Appendix I) are used extensively in this research as a means of answering some of these questions.

The most obvious depositional process seen in maritime archaeology is the shipwreck event itself. It is an event that represents a single, catastrophic incident that incorporated and destroyed (presumably) everything onboard the vessel in one day or perhaps a few short hours or minutes (Stewart 1999:568). While a wrecking event may seem straight-forward, the ways in which the vessel breaks up, is dispersed, settles and changes over time are not immediately obvious (Gibbins 1990:382). An equally complex picture is presented in submerged contexts that *appear* to indicate either a wrecking or near-wrecking event, and yet the evidence is inconclusive as to what event actually took place.[35] It is impossible to fully understand the events represented by these sites without first understanding how to "read" or interpret the physical remains, and by default the processes which affected (and still affect) them. Keeping this in mind, it is also

[34] One of the fundamental concerns of the *Annales* school was to utilize an interdisciplinary approach to draw on "a variety of disciplines including archaeology, history, anthropology, sociology, geography, and psychology" (Staniforth 2003:26). Site formation research can utilize this approach by also drawing on such fields as geology and oceanography, and is particularly important for determining effects on cultural content in regions with little documentation of specific vessels and shipwrecks.
[35] Several examples of this from the waters near Elmina are discussed later in the dissertation (Chapter 5).

impossible to separate the event from the processes that occurred following the ship's sinking that contribute to the structure of the archaeological site. As such, the following discussion is focused on the various forms of site formation processes that occur on shipwrecks and submerged cultural sites, and is necessarily framed within the concept of the archaeology of the event.[36]

The differential preservation and distortion of archaeological sites comes as a direct result of both cultural and natural formation processes, and therefore any archaeological investigation must be deciphered and interpreted through the lens of site formation processes (Delgado and Staniforth 2002; Murphy 1990; Quine 1995; Reitz et al. 1996; Schiffer 1987, 1996; Staski 2000; Stein 1987; Stein and Farrand 1985).[37] Because the wrecking event was just that, a single *event*, there are obvious distinctions between the before (functional vessel) and after (non-functional vessel), and these

[36] Schiffer (1987:7), who pioneered the study of site formation processes in terrestrial archaeology, defines formation processes generally as the "factors that create the historical and archaeological records." He insists that an understanding of them is fundamental to a complete interpretation of the historical and archaeological records and therefore of an understanding of the past. Muckelroy discusses similar factors and processes as they pertain to maritime (shipwreck) archaeology, although he never termed them 'formation processes.' He focuses his attention on the various processes that effect the transformations of shipwrecks, and goes so far as to insist that the "validity of *any* conclusions reached in maritime archaeology depends fundamentally on the understanding of these processes, so that their study must occupy a central place in the sub-discipline" (Muckelroy 1978:157) (emphasis added). Although it does not yet occupy quite the central role either Schiffer or Muckelroy envisioned, the importance of these factors in interpreting and understanding archaeological sites of any variety is becoming more widely understood and accepted. Detailed discussions of the history, development and application of formation process theory in both its terrestrial and maritime contexts may be found elsewhere (Aberg 1997; Dellino-Musgrave 2006; Dunbar et al. 1992; Garrison 1998; Gibbs 2006b; Goldberg et al. 1993; Gould 1997:110; Gould and Conlin 1999; Hassan 1987; Lenihan and Murphy 1998; Maarleveld 1995; Marsden 1976; Martin 1997; MacLeod 1991; Muckelroy 1975, 1976, 1978; Murphy 1990; O'Shea 2002; Palma 2005; Rapp and Hill 2006; Schiffer 1972; 1983, 1987, 1988, 1995, 1996; Sheridan 1979; Simms and Albertson 2000; Stein 2001; Ward et al. 1999b; Ward and Larcombe 2003; Ward et al. 1999a:561; Wheeler 2002), but are not central to the discussion here.

[37] Deagan's 1996 discussion of environmental and historical archaeology in America may be extended here in a somewhat different discussion of environmental (the seascape and site formation processes) and historical maritime archaeology in coastal Ghana.

distinctions clearly demarcate points against which to measure formation processes of the shipwreck in its seafloor environment.[38]

The first formation process to affect a vessel is the event of sinking itself. The ways in which a vessel is then broken up or buried and consequently becomes "archaeological" are dependent on what type of vessel it was (wooden, sheathed, large, small, sailing, steam) and how (storms, intentional sinking, fire), where (proximity and access to shore and therefore to the possibility of salvage or a location in a rough area), and when (season, historical period) the vessel wrecked. Which objects remain at the wreck site and in what state they remain depend heavily on cultural factors as well as on the physical environment. For instance, shipwrecks are often contaminated by trapping rubbish[39] carried by currents (Parker 1981:320), and historical salvage attempts may have introduced material. Adding to the complexity, wreck sites often also contain objects that would be considered non-contemporaneous, but due to curation[40] or trade were actually original to the vessel. An assessment of the formation processes that contributed to the types, locations, and conditions of artifacts now present offers a more effective means of interpreting the "original" site.

As Adams (2001:297) writes, "[t]hrough analysis of formation processes, the relationships between component objects, assemblages and structures and their varying

[38] I recognize that this is a simplistic view of formation processes, as at this point it does not account for such things as the formation of the situation in which the vessel was operating, nor predepositional factors such as warfare, vessel rot, or seasons. However, as there must be a point of delineation for any project, this is the foundational point here – that which connects both the sinking event and the subsequent formation processes.

[39] All manner of material, both natural and intrusive to the maritime environment becomes trapped on shipwrecks. I have seen whole trees, trash bags, modern bottles, clothes, and dishes, as well as fishing nets and lines become entrapped on submerged material sitting proud of the seafloor.

[40] Extensive reuse of certain objects, for example, bottles.

qualities of contemporaneity and selection can be recovered…on even the most dynamic of sites.” O’Shea (2002:212) adds:

> In essence, formation theory is designed to deal with two related archaeological problems: (1) how do materials pass from a systematic context, where they are part of an ongoing behavioral system, into a static archaeological context;[41] and (2) what happens to these material remains and their spatial interrelationships between the time they are deposited and the time they are recovered by archaeologists.

Implicit in O’Shea’s quote and formation process studies in general is that the environmental context of shipwrecks is of prime importance in determining what remains and consequently what can be learned from shipwrecks and other submerged sites. The inter-disciplinary nature of site formation research lies primarily in the investigation of the role of the natural and cultural environments acting as the processes that serve to break down and yet stabilize the wreck (Muckelroy 1977, 1978; Schiffer1996; Ward et al. 1999a:566; Wheeler 2002:1150).[42]

Because there is a danger of becoming too focused on only the physical factors affecting submerged sites, it is critical to remember that this is an anthropological endeavor – one which has anthropological and historical goals and which situates the methods and theories of the primarily physical processes of shipwrecks within the context of historical maritime trade. The purpose of formation studies is to provide a foundation

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[41] While one can debate the term “static” in relation to archaeological sites, particularly those located in high-energy marine contexts, the general concepts are sound and important to a holistic interpretation of shipwreck sites. For example, Gibbs (2005:56) writes that the “values of a shipwreck as static site are primarily articulated around the archaeological or physical qualities of the wreck as a source of structural remains and artefacts, or as a laboratory for investigation of site formation processes.”

[42] Three excellent case studies demonstrating the utility of holistic site formation research are found in Ward’s work on the *Pandora* wreck in Australian waters (Ward et al.. 1998, Ward et al.. 1999b), and on the work done on the vessel thought to be the *Queen Anne’s Revenge* (*QAR*) in an inlet of the inter-coastal waterway near Beaufort, North Carolina (Hageman 2001, McNinch et al. 2001, McNinch et al. 2006). An additional example may be found in the SS *Xantho* project (Veth 2006:19).

for the understanding and interpretation of culture and history from the remains of submerged archaeological sites.

People and site formation processes

It is easy to discuss the importance of site formation research, both in terms of methods and theories, and to understand the importance of it in terms of the "science" of archaeology. But it is more difficult to explain what it has to do with anthropology and the bigger picture of the people involved with historical maritime trade, such as that in West Africa. This is clearly a challenge, even when considering formation processes within the framework of the archaeology of the event, and it is important to ask the question: In the end, why does the student of history or anthropology care whether a shipwreck took two days or twenty years to disintegrate, as long as we still have some of the artifacts from the wreck and can therefore say something about it in terms of history and people?

Just as a cultural anthropologist or human geographer must be able to abstract from various clues to understand how people got to be where they are, an anthropologist studying shipwrecks must be able to interpret events and situations in the past from often obscure material remains. In shipwreck archaeology, the way to understand the original vessel – how it was laded and organized, what people were on it and how they viewed their worlds – the stuff of anthropology, one must be able to understand the mechanisms that produced the sites we have *now* in order to understand what they were all about *then*. As Heilen et al. (2008:604) write:

> The archaeological record is created by behavior, refracted, or distorted by postdepositional…processes, and sampled according to both theoretical and methodological biases. In order to draw reliable inferences about systemic behavior,[43] archaeologists need to establish frameworks that conceptualize the nature and organization of formation processes, assess their relationship to past behaviors, and empirically identify relationships between formation processes and specific deposits.

The questions that maritime archaeologists ask are anthropological, and the means by which we ask them and seek answers are also, although we may utilize varying methods. When investigating the archaeological record, “a thing of shreds and tatters” (Ramenofsky and Steffen 1998:3), one cannot artificially separate theory from method; theory is meaningless if it cannot be applied, and methods are only useful if they are used to answer meaningful questions and as the “bridge between ideas and entities” (Ramenofsky and Steffen 1998:3; see also Flatman 2003; Gibbs 2006b; Knapp 1992:4; Richards 2006). In the same way, the commonly held view of the “false history/science dichotomy” (Feinman 1997:374; see also Bender 2002; Butzer 1980; Cederlund 1995; Hassan 2004; Maarleveld 1995; McGovern 1995:80-82; Sewell 2005:16-17, 113; Smith 1992:24; Staniforth 2003), which implies that archaeology and long-term studies must be either historical or scientific, is not in fact a dichotomy, but rather presents two complimentary approaches (Kowalewski 1997:304). Anthropologically-guided methodologies such as formation process research, in using *both* historical and scientific research agendas (theories) and methodologies, offer insights into worlds we can only see right now as random mounds and bits of things on the seafloor. The goal of using anthropologically directed formation process research is to emphasize the “dynamic

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[43] Whether one is a supporter of behavioural theory or not, the quote is still an appropriate discussion of the range of issues addressed by the study of formation processes.

interactions between humans, the natural environment, and their depositional records" (Goldberg et al. 1993:vii), as it relates to the historical maritime international trade in West Africa.

Shipwrecks are the primary and most commonly studied archaeological or material record of maritime trade. Artifacts (including ships) are the products of humans coping with nature, and these artifacts are always modified and affected, both before and after they enter the archaeological record, by culture, nature and natural processes (Morton 2004:6). Ships were one of the most efficient means by which people dealt with the problem of distance between regions and cultures, and every vessel that wrecked has been and is affected by different formation processes[44] in a unique history. Like the interconnectedness of method and theory, the relationships between artifacts, historical events and the processes that produced them, the archaeological record, formation processes, and the investigation of these things, are interwoven. They can only be understood in relation to one another, and that only through first identifying the biases that affect the physical associations of material remains, and therefore the interpretations of the past (Gould 2000:9, 12). "Simply put, this means that post-depositional factors of whatever kind relevant to a particular underwater site or survey area must be evaluated before attempting cultural explanations of any kind" (Gould 1997:109).

It is within a historical cultural context that one first begins to ask questions of the physical remains, but archaeologists are able interpret the cultural context of the wrecked

[44] The emphasis here is on the natural formation processes in the region primarily because we have very little evidence of *historical* cultural formation processes. While the effects of fishing and water transportation (nets/fishing lines, trash thrown overboard, and dragged anchors) are visible at or near the site, any historical cultural formation processes must at this point be conjectural. Cultural processes include both decisions or events that may have contributed to the wrecking, and activities after wrecking, but at this point in time this is difficult to assess. A further discussion of potential factors affecting sites in this region can be found in Appendix II.

vessel or submerged cultural site only *after* having accounted for site formation processes and their resulting distortions. The physical associations and contents of wreck sites can then be understood within the context of the historical vessel, its wrecking event, and within the larger historical context of regions, peoples and cultures; within its story. Delgado (1988:3) writes that it is "not the bare event of a shipwreck that fascinates society, but the connotations. The loss of a ship highlights the capricious nature of the sea[45] and the fragility of human pride and endeavor." It highlights stories of human decisions, ventures and histories, and the contexts within which they occur. It is through the study of all aspects of vestiges of that past, including an understanding of the physical processes at work in the past and present, that we are able to tell some of the stories of those who have directly interacted with the "capricious sea," and the worlds within which they ventured.

The Setting/Environment of Formation Processes

Delgado's (1988:3) description of the "capricious sea," the place where vessels sailed and met their demise, is not simply a dramatic illustration used to conjure up wild images in the mind – it is a reference to the maritime seascape in and on which history took place. Submerged cultural research, and particularly site formation research, should be integrated with the context of the entire historical maritime landscape (or seascape) within which the vessel functioned, as well as contemporary cultural contexts (Adams 2001, Cooney 2003, Firth 1995; Westerdahl 1992). As discussed at the beginning of this chapter, implicit in this argument is the need to understand scale and to transition

[45] This understanding of the ocean as restless, unpredictable and uncontrollable is one that has been prevalent in coastal communities for millennia (Cunliffe 2001:554-555). It is a particularly apt description of the seas of coastal Ghana for much of the year, and played a significant role in the timing, logistics, and character of historical trade.

between the small scale of an individual shipwreck or site and all its component parts to the large scale of the economic, political and social networks within which the vessel was operating.[46] Contextualizing the socio/economic events of shipwrecks and the events of their formation processes within their historical cultural seascapes inherently incorporates vastly different scales of space and time. The maritime investigation of shipwrecks and other submerged sites, set within the theatre of history, is particularly appropriate in facilitating understanding across these different scales. The following chapter discusses the setting of historical maritime trade in Ghana, focusing on the seascapes and landscapes of Elmina.

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[46] Formation processes themselves occur at different scales; they physically affect a specific shipwreck or site, but they are also acting at much larger scales, such as time, globally, and locally. We can, for instance, look at the reason a vessel was in Africa in the first place: a merchant vessel, acting either alone or as part of a larger company, sailed from somewhere in Europe to the Ghanaian coast to trade, anchored offshore of the prominent trading fort of Elmina, and may or may not have commenced trading with residents on shore, using the canoe system of goods transport. Then, for any of several reasons, the vessel ended up on the seafloor, where it was affected by a range of physical environmental factors. All of those factors acting together can be seen as the formation processes which created the archaeological site we see today.

Chapter 3
Setting the Scene

> It has been the fault of shipwreck archaeologists in the past to focus only on the shipwreck and the wrecking event itself. If we as archaeologists seek the regularities of cultural practices, then we must try to understand the reasons behind the sinking and the pre- and postdepositional factors that led to the remains we are studying… Shipwrecks should not be seen as "synchronous snapshots frozen in time"; they are, as any archaeological site, part of a culture history that must be put into perspective in order to be fully understood (Burns 2003:vii-viii).

Burns' eloquent quote provides an excellent segue from the discussion of the archaeology of the event and site formation processes to that of the physical and cultural seascape within which submerged cultural remains are located. The sea was the connection between the disparate places of the Atlantic world, and the seascape was the theatre of history in which historical maritime interactions took place and which incorporated the physical, social, economic, and cultural interactions and embodiments of trade. It was primarily from the sea that European traders viewed international trade and the people with whom they interacted (see Baesjou 1988:5, 32, 45; see also Curtin 1984:57; Meredith 1967 [1812]:17, 35; Rømer 2000:16, 27), and it was towards the sea that African merchants[47] viewed the same (Claridge 1964:46). These places of cultural mingling and interface, with their attendant interactions on the water, whether in a harbor, anchored offshore, or somewhere in the middle of the ocean, formed vital parts of the multifarious historical seascape and are integral to the study of historical maritime trade

[47] Enslaved people would have had an entirely different view of the sea as they were forced to leave Africa, but as my intention here is to focus on the sailors and merchants, I approach the sea from two basic viewpoints – those of the African living along the coast, and the European merchants visiting the coast, which necessarily includes the perspective from the vessel itself.

today (Anuskiewicz 1998:224; Ash 2005; Breen and Lane 2003; Chapman and Chapman 2005; Cooney 2003; Dellino and Endere 2001:219; Dellino-Musgrave 2006:27; Flatman et al. 2005; Lenihan and Murphy 1998:237; Parker 2001; Van de Noort 2004; Westerdahl 1992). The perspective espoused in this dissertation is that of looking from the sea onto land and all that that entails.

To the maritime archaeologist every aspect of this seascape – the winds and currents, the position of a settlement or post on shore, the location of anchored vessels, the most minute artifact in a shipwreck site, those who interacted with the sea and shore, and the economics driving trade – is a vital component in understanding peoples of the past (Cunliffe 2001). The long-term goals of my historical maritime research in coastal Ghana focus on the investigation of issues of connecting the physical, temporal, social, and spatial scales between submerged cultural sites (such as shipwrecks) and the larger social, physical, cultural, and economic contexts of the Atlantic trade (see DeCorse 2008; Falk 1991; Staniforth 2001 [1997], 2003). As discussed in the previous chapter, site formation processes and their effects on historical shipwrecks near Elmina are explored in this work within the framework of the archaeology of the event in an effort to understand what can be inferred about each unique wrecking or trade logistics event, sailing, anchoring, and trading practice in coastal Ghana. The project includes not only study of the remains of shipwrecks and other submerged maritime sites, but also of the maritime landscape (seascape) in which they were and are a part, and the boundaries which served as hindrances or advantages to those involved. All of these considerations make up parts of the maritime landscape (i.e. Cooney 2003; Flatman and Staniforth 2006;

Parker 2001; Westerdahl 1992), and provide the backdrop and a framework within which to understand submerged historical sites in the region.

As with site formation processes, the seascape/regional approach is a methodology as well as a framework. By way of explanation, while the study of submerged resources is nicely situated to provide insights into the activities of past events that occurred within the historical seascape, an understanding of the past and present seascape (including environmental and cultural factors) is also vital in terms of actually looking for submerged cultural resources. All of these pieces of the puzzle inform each other, allowing for the discovery, investigation, and interpretation of submerged sites. Combining the investigation of events, site formation processes and the historical seascape, as well as how these three concepts are necessarily connected, provides a unique means of understanding the situations and events that contributed to the creation of the archaeological record that we have today.

This chapter tacks back and forth between history/culture and environment as a means of highlighting the immensely important roles that these factors had on each other and on the development of the Atlantic trade in West Africa. Theoretical frameworks centering around the landscape and seascape are used to tie the physical environments and historical events together. Various aspects of the history, development and roles of Elmina are woven throughout the chapter, emphasizing the importance of its development within the framework of the burgeoning world system and the constraints of technology, cultural (mis)understandings, and the environment. No intention is made here to give a complete account of any of these features and factors – I have instead chosen to highlight the most pertinent aspects, and in most cases have either provided footnotes directing the reader to additional sources on the topics, or have referenced the included appendixes for extended discussions.

A Theatre of Maritime History

> The study of human cultures cannot be divorced from a study of their environment and the mutual interaction between human activities and environmental processes. (Rapp 2000:243)

Even in archaeology, working usually with only bits and pieces of the often-obscure material record of the past, we need to have some means of trying to understand how people "engaged one another across space, how they chose to manipulate their surroundings," (David and Thomas 2008:38) and how their actions were dictated by their surroundings and environment. One approach used to grapple with questions of situating people and history within their diverse settings is that of landscape archaeology. Aspects of landscape archaeology are employed here as a means of incorporating the physical and social worlds (Crumley and Marquardt 1990; Firth 1995; Hood 1996:121; Knapp and Ashmore 1999:2) in which historical maritime trade took place and as a means of "establishing a more integrated understanding of past coastal landscapes or seascapes" (Breen and Lane 2003:469). Engagement with landscapes incorporates scale, time, and materiality (Crumley and Marquardt 1990; Hassan 2004:320; Linse 1993), and as such, provides a meaningful way of integrating the physical environment and the places of historic interactions with historical events that created submerged archaeological sites (Gosden and Head 1994:115). It is impossible to understand the international maritime interactions and cultures apart from the marine environment or seascape in which they existed. The following section is a brief discussion of the use of seascape and its application to maritime archaeology, as well as of two related concepts: that of the landscape and maritime cultural landscape. Each of these ideas differs from the other in its conception and application, as well as in more subtle ways. Emphasis in this research is placed on the seascape, but because it is intimately related to the others, a brief account of each is warranted.

Preucel and Meskell (2009:215) write that "[p]lace has come to be a key organizing concept in the social science." They suggest that one reason for its "broad appeal is that the term retains a sense of its Cartesian origins as a physical quality and, at the same time, implies the affective and the phenomenological." Applying this to archaeology, Binford (1982:6) wrote that in order to "understand the past we must understand places."[48] He located place within the concept of "landscape" (Binford 1982:20), and in doing so provided a simple model for incorporating the important discussion of landscapes (and seascapes) into archaeological discussions, including the investigation of historical maritime trade. For instance, the location of Elmina Castle was a place to which merchants came, but the coastal zone, the ocean, and the surrounding lands made up the larger landscape and seascape within which historical maritime trade actually took place (c.f. Torrence 2002:766; see also Branton 2009:52; Preucel and Meskell 2009:215). Humans conceptualize and modify many of these spaces in culturally specific ways in an interactive process in which people both condition and are conditioned by the environment or landscape (David and Thomas 2008; Gosden and Head 1994:113; Hood 1996:139), although there is a great deal less *intentional*

[48] While his article was a discussion primarily of place within the idea of systems, his general ideas are still applicable to a range of research questions.

conditioning of the sea than there is of the land.[49] There is a vast literature on the archaeology and interpretations of landscape,[50] but for purposes of this research its particular relation to the seascape is of concern.

I am going to take advantage of landscape being a "usefully ambiguous concept" (Gosden and Head 1994:113) and sculpt it as I see is the most fitting way in the context of historical maritime trade on the west coast of Africa. The perspective on landscape that most approximates its relation to the seascape in coastal Ghana is provided by Branton (2009:51) when she writes that:

> Landscapes are bounded spaces in which human behaviors occur. Landscape refers not only to scale but to the nature and context of the bounded space and the human behaviors that occur within it. However, a landscape is not simply a container [or stage or theatre] for human action. A critical component of landscape approaches in archaeology is the interrelationship between a place and the human behaviors that occur within it. [51]

In other words, the landscape is active, "not merely the world we see, but rather a way of seeing the world" (Preucel and Meskell 2009:219). Kelly and Norman (2007:173), in their discussion of the use of landscape theory in Africa, write that landscape archaeology

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[49] While humans have always used the sea as a disposal zone, nothing in the historical period can begin to compare to the sheer quantities of pollution and trash that are currently transforming the oceans and other water bodies on earth into literal trash dumps. Because of this, I do not consider that humans had a significant impact on the sea itself during the period of the Atlantic trade. People can pollute the waters, deplete resources, build vessels that can traverse the surface and under the sea, and to an extent control the form the sea takes when it contacts land, such as creating jetties, moles, or breakwaters, but they cannot, in fact, shape or morph the sea itself. Any contact that they do have with it must be on the terms of the sea.

[50] See Ashmore and Knapp 1999; Aberg and Lewis 2000; Bruno and Thomas 2008; Countryside Council for Wales et al. 2001; David and Thomas 2008; Dellino-Muscgrave 2006; Gale 1993; Hirsch 1995; Johnson 2007a; Martin 2000; McCarthy 2008; McNiven 2008; Oxley 2000; Parker 2001; Preucel and Meskell 2009; Rössler 2009; Tomalin 2000; Van de Noort 2003; and Wandsnider 1998 for just a snapshot into this literature, as well as some perspectives on the maritime cultural landscape and seascape.

[51] Landscape archaeology is, therefore, "an interpretive framework that specifically addresses the relationships between past human behaviors and the physical (or social) space in which they occur" (Branton 2009:53; see also Gosden and Head 1994:116).

in Atlantic Africa "addresses the social creation of the landscape within the complexities of the localities that were nested within global systems of distribution and exchange…"[52] The concern of this research is not in the social *creation* of the landscape of maritime trade, but rather in the ways that the landscape *shaped* social interactions and the ways in which it affected all of the actors "nested" in the trade (Branton 2009:62).[53] It also takes for granted the importance of the sea and its role as the primary *eventscape* (discussed in the conclusion of this chapter) upon which both the mundane and dramatic events of historical maritime trade took place.

Westerdahl (1992:5) describes the maritime cultural landscape as the "human utilization (economy) of maritime space by boat: settlement, fishing, hunting, shipping and its attendant subcultures." This maritime cultural landscape meets and intersects the boundary of land and sea, interacting with and including aspects of the seascape. But the seascape is a somewhat different perspective than the maritime cultural landscape, because its focus is on the sea and its interactions with the land, and not primarily on the landscape interacting with the sea. An understanding of the seascape entails having a picture or view to the sea, but more importantly its views are from sea to land, along coastlines, and on the conjunction of sea and land (Countryside Council for Wales et al. 2001:1). But, as is demonstrated in the explanation of the maritime cultural landscape, any understanding of these physical places must be couched in terms of human interaction with it; the seascape is only a valid concept if in it people are placed as central

[52] See DeCorse (2001), Richard (2006), and Stahl (2001) for various applications of landscape analysis and theory in African archaeology.

[53] While acknowledging and including in this the importance of local actors, it should also be understood that the perspective of trade looking landward from the sea presupposes an emphasis on the external European influences, perspectives and experiences. Parker (2001:32) goes so far as to write that the "seaman's perspective must be a principle target of maritime archaeological reconstruction."

players on the stage. As Semple (1931:59) writes, "[w]e are in a certain sense amphibious, not exclusively connected with the land, but with the sea as well…The sea and the land in which we dwell furnish theatres for action, limited for limited actions and vast for grander deeds."

Westerdahl's holistic approach to the maritime cultural landscape applied to the study of the seascape provides a framework within which human activities, limited or grand, related to the sea can be integrated (McErlean et al. 2002:2). For example,[54] in the investigation of historical maritime trade in Ghana, study of the maritime cultural landscape would include the settlements on the coast with vessels coming to them, the activities of those who lived on shore, including trade with other people indirectly associated with the Atlantic trade, and their understanding of the events taking place offshore. In subtle contrast, study of the seascape incorporates the vessels on the sea (and the perspectives of those on them), the sea and everything in it, as well as the coast and the settlements along it (i.e.: Elmina). It also includes all the activities that took place in this setting – fishing by Africans and Europeans, navigation and anchoring practices of the European vessels, logistics of trade and exchange between ocean-going vessels and the shore using local canoes, wars between Europeans on the sea and influences of wars on land and, perhaps most significantly for this study, it also includes the vestiges of those activities – shipwrecks and other submerged cultural resources. The subtle differences in approach provide questions and answers to widely varying perspectives of

[54] Another excellent example can be found in the maritime archaeological work of Breen and Lane in Mombasa, Kenya. They write that their project was "about assessing the nature and extent of surviving maritime cultural remains. However, it also sought to assess the potential for developing maritime landscape approaches in East Africa. Given its varied maritime past, where the sea as a facilitator of trade, communications and resources has been an underlying constant in a period of continual flux. Mombasa was ideally suited to this objective" (Breen and Lane 2003:479; see also McConkey and McErlean 2007; Murphy 1983:85).

the past, and provide increased awareness of the potential variations in types of activities that characterize different zones from the coast out to the open sea (Cooney 2003:325).

As discussed in the introduction to this chapter, the broad premise of this research is that it seeks to understand historic international trade from the perspective of the sea looking onto land. It is focused on the intersection of the small scale or finer resolution (individual submerged sites and their component aspects of time and spatial distributions, including site formation processes) and the large scale (that of the wider environment and historical setting) of historic international maritime practices. It seeks to contextualize submerged sites within the historical seascape of coastal Ghana (Breen and Forsythe 2001), and views the past from outside the boundary of sea and land, because it encompasses both (Morgan and Greene 2009:12-13), including the blurred boundaries between peoples who met and lived and interacted and traded within the historical seascape setting.[55] Spatiotemporal analysis of the seascape begins with physical places on the stage of history, and then "watches" as people and the environment change and events transpire (Kowalewski 1997:291-292). As articulated by Richard (2006:73), this analysis facilitates the study of the "politico-economic processes and the socio-cultural environments that nurtured them." The seascape is primarily, therefore, the medium for action – for trade, social interactions, conflicts and exploration. The focal point on this stage of history is Elmina, straddling the boundary of land and sea.

Approaching the Seascape

Engagement with various scales associated with the Atlantic trade is foundational for this work. The contextualization of submerged sites is dependent on an understanding

[55] In fact, following Beinart's (2000:271) discussion, the sea itself could be considered a "non-human agent" in the maritime history of West Africa, and indeed, the world.

of the physical setting, whether localized on the seafloor or within the area of Elmina and its environs, and within the larger and smaller social contexts encompassed in the Atlantic trade. The seascape, by necessity, must be approached at a regional scale, as it encompasses a wide range of locations, actors, and interactions; it is the stage of maritime history. For purposes here, the “region” is defined as the coastal and near-coastal zone of interaction between historical maritime traders on this historical coastline, particularly in the immediate proximity (within a 20 kilometer radius in the sea) from Elmina, during the period of the Atlantic trade.[56] All of the smaller scales of interactions and relationships that relate to submerged sites are then nested within that region. Murphy (1997a:339) suggests several approaches to maritime regional analysis that can be appropriately applied to this work: a cultural approach, which researches a single maritime culture, or a more geographical approach, which looks at maritime activities across a region. As he notes, both approaches can be investigated synchronically or diachronically, and in both, the primary objective is to understand the relationships between archaeological sites and their physical and cultural environments (the seascape).

While there is merit in both approaches, Murphy’s second approach is far more emphasized in this research. The potential avenues for exploration of historical maritime data offered by the approach of investigating all of the maritime cultures active in a geographic area allow for immense creativity and flexibility in analysis and interpretation. In West Africa, where very little has been done archaeologically on maritime history, this provides a means for encompassing and incorporating vastly

[56] Crumley and Marquardt (1990:75) caution that a region must be adequately conceptualized both in terms of physical and temporal relationships and scales.

differing data sets and frameworks, such as those of the archaeology of the event and site formation processes of submerged sites.

Hill et al. (2001:15) point out that in investigating the concept of seascape, the determining factor of applicability in the approach is the shared intervisibility of the region in question (see also Phillips 2003). This is demonstrated in the location of the Elmina Castle and its environs, as from it, and from the roadstead/anchorage offshore, a wide panorama of the seascape and the landscape is clearly visible, including the competitive British fort of Cape Coast Castle which is within clear view from Elmina. Intervisibility was also vital in terms of navigation. Understanding the complex and varying (inter)relationships between regional factors and sites, for example, between shipwrecks, between submerged sites and the Elmina Castle or other trading points along the coast, and between historical contexts that affected logistics, trade and sail, is one of the primary objectives of this research.

In their seminal work, *The Corrupting Sea*, essentially a lengthy discussion of the seascape, Horden and Purcell (2000:123) discuss the connectivity of diverse micro-regions around the Mediterranean. Within the context of historical maritime trade in West Africa, the concept of the connectivity of micro-regions can be well-applied to the historical Ghanaian coast; for instance, before the Europeans arrived, Africans were using canoes to trade (connecting micro-regions) all along the coast, a system that the Europeans integrated with, at times working their way all the way to Angola (Law 1991:44, 70, 122, 148-150; Mitchell 2005:182; Rodney 1969; Smith 1970; Vogt 1979:57, 70-72; Wesler 1998:333). By participating in the larger Atlantic trade the Europeans were agents of connectivity of micro-regions, macro-regions (Hopkins 1973:88; see also

Adams 1966 [1823]:170; Feinberg 1989:29; Martin 1972:61-63; Morgan 2009:227; Wilks 1993:74[57]), and indeed, of continents. Regardless of whether they were connecting micro- or macro-regions, the sea and the seascape was always the stage for these links. Obviously the Mediterranean, a bounded region, had different lines of connectivity than along the extensive (and basically linear) West African coastline, but the idea is still definitely applicable.

Although they mention the importance of the physical landscape in connectivity, Horden and Purcell also tend to de-emphasize its importance. Here, however, I would like to emphasize it. In historical maritime trade, the physical environment was one of the most, perhaps even the greatest, formational factor in determining how and where trade was conducted. It was "actively inhabited space" (Knapp and Ashmore 1999:8) used for navigation, it determined the locations of suitable anchorages, fresh water, food supplies, people with whom to trade, and it dictated the modes and methods of trade. The aim here is not to blur the distinction between the maritime and terrestrial realms (McCarthy 2006:7) in coastal Ghana; rather, the intention is to demonstrate their interconnectedness, and that submerged cultural resources occur at and across the boundaries of the physical and social land/seascape, especially when viewed from the perspective of the sea (i.e.: Cunliffe 2001).

Steinberg (2001:18) argues that the sea itself is often ignored as a player in its own right. He states that many of those who investigate aspects of the sea "fail to investigate the ocean itself [and the land with which it interacts] as a space within which the social contest is played out." His discussion of the sea (ocean) as an arena wherein

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[57] The Portuguese, for example, sold slaves from other areas on the coast *to* Elmina in exchange for gold; most of the slaves were then taken northward, and some were possibly used at Elmina (DeCorse 2010:214; Hair 1994a:58-59; Rodney 1969:13; Wilks 1993:74-75).

social conflicts happen articulates well with the tumultuous historical seascape of coastal Ghana, and to it can be integrated the study of submerged cultural resources as the remainders and reminders of this. All of the cultures that participated in maritime trade in coastal Ghana were part of the construction of sea-space “as an arena wherein states competed to contain, control, and steward the essential social interaction of trade” (Steinberg 2001:75). The ocean/seascape is clearly not a product of human culture, and yet it molded, shaped, and determined how cultures would interact and conduct themselves. Any approach that attempts to study the historical seascape and the submerged cultural resources within it must acknowledge the deterministic roles of the sea and the responses of various cultures to it, as well as the extent and the boundaries that defined historical maritime trade.

The Context of West African Trade

It is important to have a general understanding of the foundational tenets that lead to the establishment and development of the complex systems of trade, resources, cultural interactions, technologies and competition within the maritime seascape of trade in West Africa. At the heart of it was the interaction between vastly differing cultures, meeting in a land foreign to some, and in ways foreign to all. It is at this intersection that anthropology, history, and archaeology meet to try to understand the workings of the past in the Atlantic trade. As Kelly (1997:353) writes, “[t]he establishment of sustained contact between previously isolated cultures has long been viewed as a setting of great anthropological interest. Trade is frequently the engine that moves these interactions.” The fundamental aspect of this trade that is my focus is the often ignored or overlooked fact that ships were the engine that moved the trade (Dellino-Musgrave 2006:18).[58] Shipping was so important, in fact, that until the development of air and rail transport, the most efficient and cost-effective means of transshipping goods was waterborne travel, despite the inherent risks of storms, pirates, and shipwrecks in the various regions that sailors dared to venture (Blake 1967:47; Fernández-Armesto 2004; Inikori 1996; Thornton 1992:14). However, it was not until improved navigation equipment and vessels had been developed, initially in the late 15th century by the Portuguese, and later by Spain, the Netherlands, France and Britain, that Europe was able to consistently utilize the natural elements of wind and currents and the large Atlantic trade, and indeed the world system of trade, began to flourish (Pomeranz and Topik 2006:41-47; Rawley and Behrendt 2005:9, 18; Russell-Wood 2009:96; Steffy 1994; Taylor 1949; Vogt 1979:3).[59]

Because it was the largest context in which trade in West Africa occurred, it is useful here to note quickly the importance of the World System.[60] While there are debates concerning the efficacy of using world-systems theory in studying historical trade in West Africa, it should be noted that it is virtually impossible to understand the European/international historical maritime coastal trade with West Africa in any context other than the World System (Blake 1987:398; Bruijn 1990; DeCorse 2001:11-12; Eltis 1994; Hopkins 1973:89; Inkori and Engerman 1992:9; Manning 1992; Orser 1998, 2009; Priestley 1969:3, 76; Rawley and Behrendt 2005:8; Walvin 1992:41; Williams 1994

[58] Particularly important for this research is that shipwrecks are often the best evidence that we have of this, and, particularly in West Africa, at the source of much of the Atlantic trade, this is an especially important resource and receptacle of information. Shipwrecks hold immense potential to provide clues as to the "totality of interaction" (Kelly 1997:354) involved with historical maritime trade.
[59] Fernández-Armesto (2004:29) takes issue with the idea that technology for world travel was unique to Europe. His point is well taken, as there is ample evidence for much earlier Chinese and Arabic maritime advances, but it is important to recognize that the Atlantic expansion did not occur until the Portuguese navigational ventures.
[60] The modern World System and world-system theory have been amply discussed elsewhere (Frank 1999; Manke 2004; Pomeranz and Topik 2006; Wallerstein 1974, 2000).

[1944]). In a similar manner to the way Delgado (2009) ties the San Francisco waterfront into the entire Pacific maritime system (and therefore the World System of trade), it is necessary to understand West Africa's intricate role as the source and mover of much of the trade in the Atlantic, and therefore a significant player in the historic World System. It is within this largest context that the smaller, or more individual, contexts of maritime trade along the coast must be understood.

Sea transport was the major mover in terms of international trade in West Africa during the Atlantic era. Although the trans-Saharan trade was responsible for a great deal of transcontinental trade, and continued to be a formidable trading avenue well into the 19th century (Curtin 1984:21-26; Fage 1969:52; Feinberg 1989:v; Klein 1990:289; Manning 1992; Searing 1993:75-76; Vogt 1979:1; Wilks 1993:7-8), the Atlantic trade superseded it in size and general importance along the coast (DeCorse 1996:682; Mitchell 2005:170; Posnansky 1971:10-11; Ward 2003:2).[61] In terms of the sheer quantities of goods transported by sea versus by human or animal, the Atlantic trade far surpassed any other network of trade in West Africa.

As the Atlantic trade burgeoned into a truly global affair[62], various European nations rose to economic and trading power, competition and manipulation between nations and between private traders, smugglers and pirates versus state enterprise developed, and fierce confrontations for control of trade monopolies were fueled (e.g. Ballong-Wen-Mewdua 1993:457-459; Bandinel 1968 [1842]:49; Bean 1974; Blake 1977;

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[61] It is important to note here that the decline of the trans-Saharan trade was neither immediate nor complete (Getz 2004:42). For instance, as Law (1995:6) notes, when the slave trade was abolished, the trans-Saharan route that was still in operation provided an alternative export route, and may have even grown for a time, until the end of the 19th century.

[62] Enthoven (2003:389) notes that the Atlantic must be characterized by its openness; no country ever really had full dominance because it was just too big and complex, a fact which clearly played a significant role in ways in which the trade developed.

Bourret 1949:16; Brooks 1970:4; Calvocoressi 1968; Crooks 1973 [1923]; da Mota and Hair 1988; de Marees 1987:188; Ellis 1969 [1893]:29-38; Mancke 2004:161; Nørregård 1966; Rømer 2000; Vogt 1979; Ward 2003). Also during this time trading posts and depots were established, captured and recaptured; vessels were captured or destroyed; difficulties in communication and conflicts of interest created endless confusions between and within different nations; and competitions and wars between various African states were intentionally incited by Africans and Europeans alike for political and monetary gain (Eltis et al.. 1999; Hopkins 1973:92; Nathan 1904a; Schwartz and Postma 2003:176; Thornton 1992:108). As will be seen later, these competitions and trade rivalries were key factors in the establishment and development of Elmina as a major trade entrepôt on the West Coast of Africa (see also Feinberg 1989:vii).[63]

Once trade was more regularly established between Africans and Europeans on the Ghanaian coast, it accelerated rapidly. Between the end of the 15th century and the third quarter of the 18th, more than fifty European posts were built on the so-called Gold Coast[64] alone (DeCorse 2010; Posnansky and DeCorse 1986; Van Dantzig 1980),[65] *São*

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[63] Although the focus of this dissertation research concerns maritime trade from the perspective of the sea (cf. Parker 2001:35) , and therefore primarily from the perspective of European sailing vessels, it is important to emphasize that the work is not intended to be Euro-centric, nor is it intended to highlight one aspect of the Atlantic trade over another. This research cannot do justice in addressing the massive impacts on both coastal African tribes and inland peoples of the Atlantic trade. It is instead concerned with the mechanics of trade between African traders and European merchants, using the maritime cultural resource of European shipwrecks as a means to do so.

[64] As with the term Elmina, “Gold Coast” refers to a historical name given to the area between central coastal Ivory Coast (modern-day) and the Volta in coastal Ghana because of its reputation as being a source of gold for trade (DeCorse 2001:195). The name is not in common use today.

[65] Trade was generally conducted through the conduits of trading forts or entrepôts established by the Europeans with the consent of the African leaders (DeCorse 2010; Fyfe 1974:30). The chief function of these entrepôts was to act as wholesaling depots for trade, but they also protected the people stationed there, supplied provisions for trading (especially slaving) vessels, and “helped to synchronize exchanges between [slave] gatherers, shippers, and employers” (Hopkins 1973:106; see also Bosman 1705; Feinberg 1989:2; Vogt 1979:61-62). In addition, the trade entrepôts supervised the storage and distribution of the goods exchanged for slaves and other commodities (Hopkins 1973:110). Finally, entrepôts also acted as bases for “permanently” assigned coastal policing squadrons, such as the 1534 Portuguese squadron briefly assigned to Elmina to prevent French trade on the coast (Blake 1977:120). While several of these forts or

Jorge da Mina, or Elmina being the first. Over time trade along the coast became somewhat more standardized. For instance, certainly at the beginning, but also through much of the trade, the Europeans tended (or were forced)[66] to stay on board their vessels, only occasionally venturing on shore (Martin 1837:228; van Dantzig and Jones 1987:xvi).[67] Even in locations where the Europeans did have a permanent post, the typically rough shores and shallow bays forced larger vessels to anchor offshore, and ship's boats or local canoes were used to facilitate trade (Gutkind 1989; Hair et al. 1992:382; Brooks 1970:235; Feinberg 1989:68; Smith 1970:516-517; Thomas 1969 [1860]:193). The wide array of items that were traded between nations also became more standardized.[68] Already-established African trade networks became more focused on the Atlantic trade (Fage 1969:54) and the effects of burgeoning world capitalism connections

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trading posts in Ghana have had varying amounts of archaeological work conducted at them (Boachie-Ansah 2008; Calvocoressi 1977; DeCorse 1987a, 1987b; DeCorse et al. 2009), Elmina is the only site that has had maritime investigations conducted in association with it.

[66] See the following authors for discussions of initial and developed relationships between Africans and Europeans in the establishment of trade: Blake 1967:44, 55, 1987:399; Coombs 1963:6-12; de Marees 1987:58-59, 202-212; DeCorse 1996:681, 2001:13; Feinberg 1989; Hair 1994b:101; Meredith 1967 [1812]:103-104; Nørregård 1966:4-5; Priestley 1969:8; Rawley and Behrendt 2005:11; Rømer 2000:162-169; Searing 1993:71; Thomas 1969 [1860]:194-195; Vogt 1979:63. Writing in general about the workings of maritime endeavors, Parker (2001:37) ties this concept nicely into the discussion of the landscape when he writes that the "control of access [on shore] by rulers is a feature of the landscape which applies especially to waterborne communications: rulers like to control, not only goods, but also knowledge or even persons coming from distant parts, so the organisation of… waterfront open spaces may be expected to reflect attitudes to exploration or distant trading ventures."

[67] A comment by Howard (2010:9) on modern sailors provides an interesting perspective on the lives of historical sailors when she writes that it was "the boat, not the sea, that was directly worked in and lived on, and the sea was almost always felt through the boat's responses to it. Work at sea was carried out through the boat, and through the perception of the skipper's perceptual abilities…" For those sailors who rarely, if ever were allowed on shore, the interactions of their vessels with the sea made up the vast majority of their experiences in coastal West Africa.

[68] Beginning with the early interest by the Portuguese (expanding to the other European nations who also came to trade) in acquiring gold and expanding to include ivory, dyewoods, wax, lime juice, gum, malaguetta (pepper), rice, cardamom, and eventually most strongly emphasizing the procurement of slaves. Typical goods traded to West Africans for these items included raw materials and manufactured goods such as cloth, military supplies (guns and ammunition), alcohol, tobacco, beads, some hides, and various forms of raw and manufactured metals such as brass basins and manilas (Alpern 1995; Ballong-Wen-Mewuda 1993:301-364; Blake 1967:107; Claridge 1964:161; Cook and Spiers 2004:17; da Mota and Hair 1988:33-34; DeCorse 1989, 2001; Feinberg 1989:49-52; Hopkins 1973:111; Kea 1971:185, 189; Rodney 1969; Van Den Boogaart 1992; Vogt 1979:8-9).

on local peoples began to have dramatic effects (DeCorse 2001). As Ken Kelly (2004:226) writes,

> The relative importance and the directions of trade routes and contacts brought…changes in certain West African societies. The advent of ship-based trading fundamentally altered existing trade relationships in many parts of the region. Coastal societies in several areas found themselves suddenly thrust into the gateway position of international (indeed, intercontinental) trade entrepots, whereas previously they had generally been minor players, involved on the margins of local and regional trade networks.

One such society was that of the small fishing village located where the Portuguese established their trading fort of São Jorge da Mina.

Elmina and Its Environs

> Three Miles below our Fort Vredenburg at the Village or Town of Mina is situate the Caſtle of Saint George d'Elmina, ſo Famous throughout the world…and it is indeed juſtly become Famous; for to ſpeak but the bare Truth of it, for Beauty and Strength, it hath not its Equal upon the whole Coaſt (Bosman 1705:41-42).[69]

> "…A worse place than Elmina I can hardly imagine" (Thomas 1969 [1860]:200).

In 1471, two men by the names of Juan[70] de Santarem and Pedro de Escobar discovered a place in the central region of coastal Ghana[71] where there was a great

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[69] The old English translation of Bosman (1705:41-42) presents this quote as dramatic and colorful; unfortunately, the more accurate and also more mundane translation reads as follows: "It has not unjustly become famous throughout the world, because it does not have its equal in strength and beauty of build on the *Coast*" (emphasis original, van Dantzig 1975:204). While this is not such a dramatic difference in interpretation and meaning, this does illustrate the problems inherent in relying solely on documentary sources. Because historical documents are only varyingly accurate, and because it is notoriously difficult to read and translate, discrepancies and inconsistencies are common; it is necessary to be discriminatory about which sources and which translations are used (e.g. DeCorse's (2001:47-54) discussion on the use of historical illustrations; see also DeCorse 2008).

[70] Also called João de Santarem.

quantity of gold (Blake 1967:4; Claridge 1964:43; Fage 1969:52; Hair 1994a). The Portuguese believed that there was so much gold within a 160 mile stretch of the coast that the entire area was called "Mina," or the Mine (DeCorse 2001:7).[72] This discovery immediately served to set off a clamoring among Europeans for control of the land (Hair 1994a:51,1994b:101-103; Vogt 1979:15).[73] In 1482 the Portuguese established the first permanent European trading fort on the coast of West Africa, the castle called *São Jorge da Mina*, in an effort to protect their interests in the gold trade (da Mota and Hair 1988:9; Rodney 1969:14; Vogt 1973a).[74] As was common in the establishment of most subsequent European forts, castles, or trading posts, the Portuguese founded their fortress of Elmina in an already-occupied area in an effort to tap into already existing networks of trade and resources (Feinberg 1989:41-42).[75] In addition to these resources, the large promontory that protected the mouth of the small river, the Benya, could provide moderate protection to small vessels anchored behind (north) of the promontory. Most importantly, the promontory was made of sandstone and other rock, and could provide adequate building materials for the construction of the fort. Related to this, the heavy seas

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[71] Sailors had been familiar with the Ghanaian coast for several decades before this, but it was not until 1471 that this particular region was discovered (Hair 1994a, 1994b:110).

[72] In reality, however, the gold along the Mina coast was in gold dust form and was primarily collected in alluvial basins or (possibly) dug pits (Blake 1977:80-81; de Marees 1987:188-191). Regardless of its form, most Europeans did not know the source(s), and the local people worked hard to keep it that way (Ballong-Wen-Mewuda 1993:138-139; de Marees 1987:198).

[73] While it has not been proved historically or archaeologically that any European nation was at the coast before this (see DeCorse 2001:87-88), it is interesting to consider that Europeans may have had a sailing presence on the coast of West Africa perhaps more than 100 years earlier that the original Portuguese ventures, and to consider the potential ramifications of that, should shipwreck materials dating from the 14th century ever be found in the waters of Elmina or along the coast.

[74] Associated with the fort was a mission which appears to have remained a part of the fort's functions even after it changed hands multiple times (Blake 1987:393). While initially (generally) mutually agreeable and profitable for both the local people and the Portuguese (Feinberg 1970:359), relations did not stay consistently pleasant. Nathan (1904b:16) reports that the local people were welcoming of the Dutch takeover in 1637.

[75] For instance, among other things, the village of Elmina exploited lagoonal resources and likely engaged in limited marine fishing (DeCorse 2001:104-109), providing a convenient and readily-available food source for the Portuguese.

and large swells/waves breaking over the rocks (in all seasons) south of the castle provided a defense against potential enemies (Ballong-Wen-Mewuda 1993:73; Lawrence 1963:103; US Navy Hydrographic Office 1951:52; Vogt 1979:25-26).

Not only was it the first permanent European establishment in sub-Saharan West Africa, but the town and trading fort of Elmina was considered by many to be the most important trading center on the Ghanaian coast for at least two centuries (Feinberg 1989:v, 2; see also Blake 1967:40; 1987:391; Baesjou 1988:49-50; de Marees 1987:218-222; den Heijer 2003:149; Van Den Boogaart 1992:373[76]). Although Elmina proved to be Portugal's strongest position on the West African coast, Portugal was not able to hold monopoly of the region much after the end of the 16th century and the beginning of the 17th. The fortress of Elmina was captured by the Dutch in 1637,[77] and shortly thereafter most of the Portuguese strongholds in West Africa fell. The Dutch maintained control of Elmina until the fort was ceded to the British in 1872 (DeCorse 2001, 2010; Israel 1989).

The early establishment and continuous use of the permanent trading location on the coast are particularly important in terms of understanding the potential for shipwrecks and other submerged cultural resources in the area, as the more vessels that visited and the longer the time frame in which they visited increased the likelihood of wrecking, misadventures, and the creation/destruction of other submerged cultural remains. The principle advantages in the location of the castle were that it could be easily defended, had access to fresh water, and had a bay and beach area in which to careen, conduct

[76] Van Den Boogaart (1992:373) reports that the WIC (the Dutch West India Company) "sent more and larger ships there [to the Gold Coast] than to Senegambia and Guiné de Cabo Verde." While not directly referring to Elmina, this highlights the general importance of this region.
[77] Rømer (2000:32), a Dane writing about the Ghanaian (Gold) coast in the late 18th century, calls the Dutch "arrogant" for wanting sole control of the coast and trade.

trade,[78] and protect small vessels and goods against storms (da Mota and Hair 1988:61; Hair 1994a:16-17; Lawrence 1963:103). This is an immensely important factor to contend with in trying to study the remains of maritime trade in the region, both in terms of predicting the locations of wrecks and sites associated with trade, and in terms of preservation (i.e. Garrison 1998). Because vessels that wrecked nearer to shore are likely highly disintegrated and scattered or deeply buried (likely both), it is necessary to have an understanding of anchoring practices in order to help predict this and find and interpret sites. A brief look at the physical setting of the sea near the castle and of the logistics most immediately involved with conducting trade will help to cement the importance of the seascape and boundaries within the context of the archaeology of the event and formation processes.

The Physical Environment of Trade

The physical environment played a significant role in the shaping and expansion of maritime trade. It affected historical trade patterns and significant events, provided the arena within which the Atlantic trade in West Africa was enacted, and continues to play a dramatic role in the destruction and preservation of the traces of historical trade. This environment, both past and present, is an intrinsic part of the formation processes that created and affect submerged sites, and as a result, a basic familiarity with its various features is essential for understanding how the past was wrought, navigated, shaped and ultimately endures, albeit in history books and on the seafloor.

[78] Even when a vessel was in the harbor outside the mouth of the Benya, however, smaller boats such at the ship's launch were used to transport goods from the vessels to the beach (de Marees 1987:116-119; Dent 1826; Dickenson 1965; Hair et al. 1992; Phillips 1746; Vogt 1979:35).

Ships were the mechanism or means that allowed the Atlantic trade, and indeed, the World System as we know it, to happen, as without them, it would have been impossible to move the vast amounts of goods between continents and across seas. At the forefront of that means were the ship captains, who were in charge of physically maneuvering the vessels to, around, and back from the African coast (Witt 2001).[79] Captains' decisions were influenced by a combination of the (in)convenience of anchoring, the supply of food and water at the trading post, conditions of war and peace (both between Europeans and the African kingdoms), familiarity with particular African traders, and, during the slave trade, the quality and supply of slaves available (Martin 1972:93; see also Klein 1990). In addition to this, weather, sea conditions, and physical geography played decisive roles in dictating what could or could not be accomplished, and the ways in which they were done.

Finding suitable anchorage either to restock and replenish shipboard necessities or to trade was one of the most rigorous tasks faced by a captain on a regular basis. Access to the coast of much of West Africa is difficult, with few exceptions such as the Gambia and Niger rivers, because of the lack of large river mouths and natural harbors, and the abundance of high waves (Allersma and Tilmans 1993:235; Bourret 1949:8; Dickson 1965; Rawley and Behrendt 2005:10; Zook 1919:183). Because of this, and other inherent dangers of sailing and navigation on the West African coasts (Feinberg 1989:67;

[79] Depending on the vessel, the financiers of the endeavor, and various circumstances, there may also have been a number of other individuals who also played key roles in decision making. Two of these were the merchants (who may or may not have been the captains) who had significant sway over choices of trading locations and partners, and the supercargoes, whose primary job it was to represent the stakeholders in the ventures, and who often carried more sway in decision-making than was wise, particularly in such a hostile sailing environment as the West Coast of Africa.

Mitchell 2005:178-180),[80] Martin (1837:228), writing in the 19th century, notes that merchant vessels would sail and anchor off the mouths of rivers or as far offshore as necessary to avoid dangers such as reefs or shoals (Figure 3.1). This meant that they

Figure 3.1. As can be seen in this image of part of the Kanka Reefs, located 10 kilometers west of Elmina, the rock reefs that line portions of the coast are formidable obstructions to navigation. Even while surveying outside of this reef we were forced to maintain a much further distance from what was visible on the surface due to the extensive rocks on the seafloor on either side of the reef (photo R. Horlings, 2009).

generally anchored in seven or eight fathoms[81] of water if possible, depending on the vessel's draught,[82] but even up to 24 fathoms' depth, equating to three or four miles

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[80] See also Adams 1966 [1823]:239, 243; Barbot's comments in Hair et al. 1992:382; Brooks 1970:235; Feinberg 1989:68; Smith 1970:516-517; Thomas 1969 [1860]:193.
[81] A fathom is approximately 2 meters.
[82] Mouser (2002:42-43) suggests that "pilferage" was also a problem if a vessel anchored near shore or at a dock or wharf.

offshore (Bold 1823:56). The unpredictable seafloor topography, even at these depths, needed to be constantly and closely monitored (US Navy Hydrographic Office 1951:10).

Visibility along the coast was often obstructed, regardless of the season. Heat refraction resulted in problems taking sights, making the approach to land particularly dangerous, and harmattan dust[83] in the summer or dry season months also obstructed vision, as it created a haze of dust thickest close to shore, but which that often extended up to 20 leagues[84] offshore (Bold 1823:39-42; US Navy Hydrographic Office 1951:16). Besides the room for navigational error caused by these things, Bold (1823:42) also notes that harmatan "possesses a peculiar tendency to absorb all moisture, materially affecting every thing [*sic*] of wood, opening the seams of ships, decks, casks, &c…;" clearly a significant issue when one's life and livelihood is dependent on the structural integrity of a wooden vessel.

Because of the often violent weather in the rainy season, optimal sailing to, from, and along the coast of West Africa was from September through April (Adams 1966 [1823]:164; Awosika et al. 1993:31; Gu and Adler 2004:3366; Hopkins 1973:107; Opoku-Ankomah and Cordery 1993:552; Vogt 1979:37), during the (mostly) dry season.[85] Winds were fairly predictable during this time, which favored not only sailing (US Navy Hydrographic Office 1951:17), but also shipboard trading conditions. Describing how these conditions affected trade interactions, de Marees (1987:45-46) wrote the following:

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[83] Harmattan is the name for winds that blow from the Sahara desert in the north, usually carrying large quantities of dust (Schwanghart and Schütt 2008:425; see also Appendix II); the dust itself is also often referred to as harmattan.

[84] A single nautical league is approximately 3.4 miles, or nearly 5.5 kilometers.

[85] While this is the *general* pattern, weather on a day to day basis the West African coast is unpredictable at best, as is amply described by Mr. J. Hillier in his 1688 account of daily weather over the period of a year at Cape Coast (Hillier 1695-1697).

> Early in the morning they [the merchants or traders] come from the Shore with their Canoes or small Boats,[86] heading for the ships in the Roadstead of their town in order to trade. The reason why the traders come aboard to trade early in the morning is this: in the morning the wind from the Land, which they call *Bofone*, blows, and then there is a lull and bad water; for towards noon the wind begins to come from the sea and they call it *Agom Brettou*. They make sure that they are back on Shore by the time the wind comes from the sea [because the seas often become so rough in the afternoon that they are too seasick to trade].

If trading logistics were a challenge in the dry season, they were far more so in the rainy season. In fact, when possible, vessels generally avoided the west coast of Africa between about May through September, but this was not always possible. For instance, vessels often left Europe at the beginning of winter, but that meant that they could be caught in storms off Europe (particularly northern Europe), or meet contrary winds and currents that delayed their arrival in Africa. And vessels that were caught in the doldrums often did not manage to get to the coast until well after they were scheduled. If merchants could not find people willing to trade for their goods, if they were forced to wait for a longer than usual time for slaves or other goods, or if they had problems with their vessels, they could find themselves still on the coast when the rainy season came. This was a concern for many reasons, including the need to acquire and pay for extra provisions for the extended stay, but also had potentially very serious deleterious effects on the ships themselves, as the warm waters of the coast hosted numerous wood-boring molluscs and other organisms that made the wood of the vessel extremely susceptible disintegration.[87]

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[86] Whether accurate or not, De Marees (1987:45-46) does add, however, that the boat pilots and rowers were unaffected by the weather.
[87] This is discussed in more detail in Chapter 6.

Quite apart from the inconveniences of having to be gone longer than anticipated, the difficulties in seeing where one was in relation to shore or the potential damage to the hull of a vessel due to other maritime environmental factors was the very real danger for a vessel having to ride out the storms and weather of the rainy season. Towards the end of the dry season (called “summer” by the sailors), storms and squalls began to hammer the coast.[88] These, like many of the facets of a West African rainy season, were actually relatively easy to predict (although less easy to avoid), and, as Bold (1823:40) explains, “they [came] on generally towards the evening, giving ample warning to the navigator to prepare against their incredible impetuosity.” Even in his description of the natural course of weather events the very real danger for a sailor is evident. The rainy season also meant that it became more dangerous to access the shore, as “in the winter season along this coast, when the winds are from the S.W. the swell and surf on the beach are excessively high, and dangerous in many parts to attempt landing” (Bold 1823:55). Even at Elmina, the site of a major (and necessarily accessible) trading fort, it has been noted that waves “break at a distance of about 300 yards off Elmina Point in fine weather but in bad weather breakers may extend as far as 600 yards from shore” (US Navy Hydrographic Office 1951:17). At this distance the water depth was beginning to be sufficient for anchorage of larger vessels, but safety was not guaranteed. The potential detriment to trade and to the vessels involved with it was the constant concern of sailors.

The dangers that this coast posed to sailing ventures were very real, but reading historical accounts also provides insights into perspectives into the natural world of which sailors were a part, and the awe mixed with deep respect and even terror of their surroundings that is portrayed in what they witnessed. It would be easy to sum up the

[88] Storms were often referred to as tornados (Adams 1966 [1823]:165; Bold 1823:40).

dangers by listing the storms and their effects, but so much is lost in a simple summation or statement of fact.[89] I would like to indulge for just a short time here in sharing some of the rich descriptions of the majestic seascape to which sailors were bound, and in so doing, to highlight one aspect of the historical environment of trade; what better way to view the weather than through the eyes of a sailor? What follows is a rather lengthy but captivating description of rainstorms on the coast, made up of the observations and thoughts of a sailor named Joseph Hawkins (1797:123).[90]

> [A] black, particularly thick and heavy cloud…advances rapidly, extending itself over the greater part of the horizon, attended with the constant and reiterated claps of thunder, and the most severe flashes of lightning which appear to contend for pre-eminence with the extraordinary darkness which would otherwise prevail; torrents of rain succeed, which, by their weight and violence, would threaten to force away even the earth itself in its course…I thought it the most awfully majestic of any sight I had ever beheld…To see a partial midnight, like a monster winging its course through the air, darting from its horrid brow the incessant streams of electric fire, enforcing silent and awful attention by the constant and

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[89] Technical details concerning currents, weather and such may be found in Appendix II.

[90] Accounts by another sailor, Edward Bold (1823:39-42), add colorful details to this account: The winter months in these regions, generally speaking, make their appearance in early June, by strong breezes and occasional heavy gusts from the Southward and S.E. accompanied with rains, that increase with violence and continue until the latter end of August; this is succeeded by a series of close foggy weather, during which the land appears enveloped in vapour, occasioned by exhalations from the earth, which has been so plentifully saturated with humidity during the rains; and, from fatal experience, is justly considered to be the most inimical and pernicious season to the European constitution of the year; the whole atmosphere, at that time, is impregnated with a superabundant quantity of deleterious matter, generated by decaying vegetation, a considerable proportion of which must be inhaled in the operation of breathing…[The power of a] thunderstorm… is impossible to convey to the minds of those who have not witnessed this wonderful meteor and its effects… it first announces itself by the appearance of a small silvery cloud in the zenith, which gradually increases and descends towards the horizon, and becomes veiled over with the most impenetrable darkness; at this moment the functions of nature seem to be paralysed, and the elements to have ceased their operations; the most profound and solemn stillness reigns around, with scarcely a breath of air from the heavens, in consequence of which the whole system feels oppressed with sensations of approaching suffocation… [T]he gust arrives with, sometimes, the greatest irresistible violence, the impulse of which no sails can frequently withstand: it is fortunately not of long duration, extending from one to three hours, and concludes with a furious deluge of rain, that descends rather in columns than in drops. The great danger is the sudden impulse of the gust, which would immediately dismast or overturn a vessel unprepared for the event… Nothing can be more exquisitely delightful than the subsequent clear and pure state of the air, creating an apparent regeneration of the animal as well as the vegetable world.

> reiterated peals of dreadful thunder, and marking its progress by the vast deluge of rain which uniformly falls as it advances, leaves an impression on the mind of the most imposing grandeur that can be imagined.

Weathering storms at sea or at anchor would have been disconcerting at best and dangerous at worst (Bold 1823:42). Not only did the forces of wind and waves pose serious potential damage to vessel integrity, but they would also have put obvious restrictions on trade for the day and possibly longer, depending on how long the effects of the storm (in terms of surf and current) lasted, restricting access to and from shore. The seasonal rainstorms also posed serious issues to those who were ready to move on to other destinations, as sailing in the constantly heavy and difficult seas greatly increased the already high chances of encountering trouble, and possibly wrecking. Alternatively, as mentioned previously, waiting out the rains by sitting in the relatively warm waters of tropical Africa posed serious structural concerns such as shiprot to the vessels.[91] Sitting for long periods of time also meant that there was greater danger of being surprised and attacked by competitors (i.e.: Vogt 1979:15-16).[92] These forces, combined with the political and economic struggles constantly at play, made the work of the sailor/merchant challenging indeed.

Coastal Navigation

Trade with West Africa (also called the Guinea trade) may have been lucrative, but it was also notorious for its uncertainty, both in terms of profits[93] and the very good

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[91] Vessels that were waterlogged or taking on water as a result of this would have been even more unwieldy and difficult to handle (Bowditch 1837:302).
[92] Here Vogt cites an account in a 1949 article by Mauny.
[93] Particularly in the early years of the commodity trades, it often occurred that outfitting a vessel and paying for its cargo surpassed the value of the trades that were made. This may have been one of the

possibility that those involved in the trade would never return from Africa due to mismanagement, illness, warfare, shipwreck and any number of other mishaps (da Mota and Hair 1988:28; Hopkins 1973:92; van Dantzig and Jones 1987:xiv; Williams 1994 [1944]:38). Depending on conditions, the availability of trade goods on both sides, [94] and on whether or not the European nation[95] had permanent land-bases or merchandise stations, voyages from and back to Europe in the early 17th century, for example, could take up to 18 months (de Marees 1987:214), although by the early 18th century it appears that trips of closert to eight mongths were the norm (den Heijer 1999:58-59).[96] Citing several 16th century accounts, Vogt (1979:35, 107) notes that it was generally far easier to sail from Europe to Africa. For instance, in the 16th century the travel time from Portugal to Elmina required about a month, but the return to Europe could take four times that, depending on the destination. These unpredictable travel times meant that planning for a trading venture was incredibly difficult at best and impossible at worst, regardless of whether the venture was successful and profitable or not.

A particularly dangerous phenomenon at sea was the unpredictable doldrums, or calms, that were common in equatorial regions (Horlings 2008; US Navy Hydrographic Office 1951:16). When caught in these lulls vessels were reliant on currents to carry them into winds or near to shore and ran the risk of running out of supplies. Most important

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impetuses for the expansion of the more lucrative, although even more unpredictable, slave trade (Van Den Boogaart 1992:381).

[94] Supply and demand for goods fluctuated greatly along the coast, and often European traders who anticipated a market for particular goods were left scrambling for trade when demand had shifted in their absence, or if their intended journey took too long. See Eltis 1994 for a fuller discussion on the importance of various trade goods, and Alpern 1995 for a master list of European trade goods.

[95] America also played a relatively minor role in trade with the West Coast of Africa (Bandinel 1968 [1842]; Brooks 1970; Inikori and Engerman 1992).

[96] It should be noted that while this discussion is given as a general description of the logistics of sailing to and from Europe, there was a great deal of variation in times that depended on the types of vessels sailed, the seasons of sailing, sailing technologies, and familiarity with the coast; these factors changed over time, and were very different, for example, in the 15th century versus in the 19th century, as well as on a case by case basis (i.e. den Heijer 2003:145; Lynn 1989:230).

was water, which often led to death and loss of profit, especially if the vessel carried a cargo of slaves. Travel was difficult and erratic even on the coast, principally owing to the weather and currents. For instance, de Marees (1987:86) comments that it would take only 24 hours for the Dutch to sail between Cape Coast (Cabo Corso) and Mori (Mourre) (a distance of less than 10 kilometers), but it could take three or four weeks to make the return journey because of the powerful east current.[97] Van Dantzig (1980:17-18) notes similar challenges that occurred most commonly during the rainy season.[98] While Ghana's coasts may have been suitable for building forts, having in many places direct, although often difficult, access to the sea (as opposed to through sand barriers or lagoons) (van Dantzig 1980:ix-x), it was not a kind place for ships.

Besides the difficulties inherent in trying to plan and execute trading ventures to the African coast, captains also had to contend with unwieldy, often old vessels, other sea traffic, dangerous coastlines, and other potential hazards, such as the shipworm (i.e. de Marees 1602:45; Glasgow 1967). The roadstead passing in front of Elmina was one of the most trafficked zones along the West African coast due to Elmina's trading prominence and its central location on the coast.[99] In addition, the constant longshore (Guinea) current running from west to east served as the most efficient conduit for sea

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[97] The currents along the coast of West Africa are incredibly powerful, and also incredibly complex, depending on the time of year. While more specifics of the currents can be found in Appendix II, several notes may be helpful here. There are two principal currents flowing along the coast: the South Equatorial Current and the Guinea Current. The Guinea Current is the predominant current lying directly along the coast, and consequently the one which most vessels had to regularly contend; the South Equatorial Current lies just north of and on the equator. "A vessel placed in one or the other current will have her progress aided from 40 to 50 miles a day, or retarded the same amount [also dependant on the time of year]. The greatest velocity of the Guinea Current is experienced off Cape Palmas, and between it and Cape Coast Castle; in the month of June it sometimes attains the rate of 85 miles a day…" (US Navy Hydrographic Office 1951:17-18).

[98] See also Rask (2009 [1754]:57).

[99] While trade to Elmina declined dramatically after the destruction of the settlement in 1873 (DeCorse 2001:30) century, the palm oil trade flourished during the late 19th and early 20th centuries. Hughes and Farrant (1963:1) note that steamers were still occasionally seen anchoring at Cape Coast, just a few kilometers from Elmina, in the 1960s, a tribute to the well- and time-worn travel route along the coast.

travel along the coast, bringing vessels often within sight of the castle. Vogt (1979:166) [100] records that in the early 17th century the Dutch alone had about 60 vessels a year on the Mina coast. While 60 vessels in a year may not sound like many, when taking into consideration that vessels usually anchored for several weeks to months at a time, it meant that there were often multiple vessels simultaneously in the vicinity (e.g. de Marees 1987:7-8). For those at anchor, this would have posed relatively few problems, but for those navigating to, from, or around the roadstead on the way to another destination, the presence of other vessels was just one additional navigational hazard to account for.

Like ancient mariners, sailing along the coast for the Europeans (and presumably the Africans as well) depended heavily on the recognition of coastal or sea marks. Sometimes the errors made as a result of this reliance were easily remedied, but others, as in the scenario related by de Marees (1987:7) in the early 17th century, were less easy to rectify. His account reads:

> On the 28th, early in the morning, we saw a ship; and when we came near, we saw that [her captain] was a Hamburger who had lost his way, thinking he was in the West Indies. We told him he was on the Grain Coast. He had wanted to go to Brazil and lost his topmast in a Thunderstorm.

The combination of weather, unfamiliar territory, and the reliance on visual landmarks had proved incredibly unfortunate for one captain, and this was by no means the only example of this occurrence. Even as late as 1823, after Europeans and others had been

[100] Here Vogt is citing codices in the Lisbon archives. This may in fact be a very low estimate of the numbers of ships visiting the coast, as later records indicate highly increased volume. For instance, Coombs (1963:2) writes that in 1858 "only 102 ships put in at Elmina." If this is, as Coombs implies, a greatly reduced number of vessels, extrapolation would mean that in earlier years of the trade there was a great deal more traffic in the area. Further east, at Anomabou Dickson (1965:103) notes that in the early 19th century "fifteen to twenty ships daily anchored in the roads to load on merchandise."

navigating the coast for over 300 years, there were still not very good navigational aids available for West Africa.[101] This was primarily a result of the areas not having been surveyed or being poorly recorded, but it was also because different nations and individual traders kept information for themselves as a means of preventing others from successfully trading in the region (Bold 1823:i-iv). Bold suggested that in the period after the abolition of the slave trade, this commerce of legitimate goods was the "great stimulus for nautic [*sic*] research," and he used the opportunity to produce a "new and improved" navigational aid to the coast of West Africa. His efforts at accurately recording the coast were principally aimed at correcting errors, particularly longitudinal errors, but others as well, "whereby ships were much misled, and frequently greatly endangered" (Bold 1823:ii; also see Cook and Spiers 2004:18). Even at this point, however, he still depended on markers such as distinctive groves of trees along the coast, or different shapes of hills, demonstrating just how complex, even in the 19th century, the logistics of trading in coastal West Africa really were.

In looking at the dynamics of economic and political structures that formed the Atlantic trade, details of the weather, the hazards posed by the environment, the navigational struggles constantly faced by historical mariners, a picture is painted here of the complexities which people faced while conducting maritime trade. In a somewhat flippant critique, Gowlett (1997:153) wrote that "[i]t may be current fashion to talk of 'dynamics of past behaviour', but that has the solid meaning that we wish to trace what people did: we are looking at human navigation through space and time, as shown by

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[101] This is contra to St Clair's (2007:11) comments (his sources are not cited) that state that the captains arriving on the coast had "charts and maps that gave them excellent information about the winds, the currents, the shallows, the rocks, the underwater reefs…" Although this is possible, and while individual captains may indeed have known the coast, this information was generally tightly controlled, making it less likely that charts and maps were readily available.

individual events and interactions."[102] My maritime archaeological investigations in coastal Ghana are focused on exactly this goal, and it is through the lens of events relating to the logistics and mechanics of maritime trade (such as anchoring processes and shipwrecks), the formation processes that effected these events and affect remaining sites now, and through the historical seascape that I hope to shed some light on the complexities of historical navigation through coastal West Africa and the period of the Atlantic trade.

Anchoring at Elmina

One of the challenges of trade on the West African coast was finding suitable anchorage, [103] and this was certainly relevant at Elmina. Because vessels spent so much time at anchor while offloading, loading, and refitting, among other things, it is highly likely that events related to their stay on the coast will be visible in, although not restricted to, the roadsteads and anchorages most commonly utilized. An accurate understanding of the practical logistics of navigation and anchoring in this region provides a richer perspective on historical maritime trade, as well as a means of predicting and interpreting the archaeological remains of such activities. While inconsistencies in historical accounts of use and anchoring in and near the Benya River and Elmina harbor area are problematic in terms of reconstructing historical trading and anchoring practices, these reports are useful in highlighting some of the historical uses of the area. They are presented here as a means of illustrating both the varied uses and

[102] Whether intentional or not, Gowlett very nicely articulates in this quote the intentions of the microhistorical approach, which are also applied in this research.

[103] As noted earlier, there were actually very few locations on the West African coast where merchant ships could approach the coast itself; the most notable exception to this are the Sierra Leone Estuary and the so-called Oil Rivers of Calabar in the Bight of Benin, Nigeria (Behrendt and Graham 2003; Horlings 2008b).

changes over time in the region, as well as the difficulties in interpretation of historical records. Although it is unfortunate that not enough is presently understood about sailing and navigational practices along the coast, particularly since most of the accounts we have were not written by sailors, these accounts can also provide glimpses into how the maritime world was accessed, understood and manipulated over time.

As discussed in Chapter 3, Elmina Castle is situated on the Elmina peninsula, which is separated from the mainland by the Benya Lagoon. To the east of the Lagoon and Castle is the shallow Elmina Bay, and to the south of it is the Gulf of Guinea. Proximity to the Benya was one of the attractions for the location of the Castle, and the lagoon was heavily used by African and European alike. What is more contradictory in the historical accounts, however, is the extent of the intentional[104] use of the Benya watershed and Elmina Bay area by merchant vessels in regard to anchoring during interactions with Elmina Castle. The changing physical environment of the Castle and Lagoon area, [105] including intentional modifications of both the Lagoon and the peninsula, in concert with changes in ship technology and sizes, likely dictated what activities were plausible at different times.

Although there have certainly been changes in the near-shore environment surrrounding Elmina Castle in the past 500 years, as the Bay or harbor area exists at

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[104] Although located within close proximity to the mouth of the Benya, I would argue that the Single Anchor Site most likely represents an *unintentional* event (see Chapters 4 and 5).

[105] In terms of the changing nature of the coast, the incredibly dynamic nature of sediment movement at the mouth of the Benya and across the region has been documented (see Chapters 5 and 6, and Appendix II), and may also account for at some periods vessels being able to enter the bay and lagoon area, and not at others. A frustrating lack of historical and modern data concerning the dimensions, depths, etc. of the Benya and other water ways in coastal Ghana makes assessments difficult. Because of this, they are made based on available accounts of usage, as well as the scant information currently available on lagoons (including the Benya). In summary, the Elmina Bay area, at its deepest (seaward side), is no more than seven or eight meters, and in most locations it is closer to five or six; the Benya Lagoon is more shallow than this at present. It is not possible at this point to determine the original depth nor fluctuations in depth of the lagoon or harbor area, and even current data vary considerably (i.e. Ansa-Asare 2008; Nixon et al. 2007:S147).

present (Figures 3.2, 3.4, and 3.5), *anchoring* at the mouth of the Benya and the immediate bay area to the east of it would have been difficult and unwise for full-sized merchant vessels (for example, a caravel drawing more than two or three meters), as it is

Figure 3.2. This GoogleEarth image provides a nice overview of the Elmina peninsula and Elmina Bay as they are today; the approximated 19th century shoreline is outlined in red. Note the modern harbor entrance to the east of the Castle and the Benya Lagoon running roughly parallel to the coast. Historically, access would have been closer to the Castle and more direct, although the shallows and rocks to the east of the Castle would still have been problematic to many vessels.

far too shallow to allow a vessel of any draft to safely enter or anchor there. Tides, shifting sand spits and breakers associated with the Castle peninsula itself would have further complicated the process. Any large vessels that did enter the Benya Lagoon would have done so through the use of towing, kedging or warping (Bowditch 1837:285-286;

Figure 3.3. The bridge crossing the Benya Lagoon in this image is clearly a modern construction, and the width of the lagoon at this point may have varied somewhat over time (photo D. Kipping, 2009).[106]

Norie 1805:310-302) with the ships boats.[107] The construction of a draw-bridge over the Benya in the 17th or 18th century (DeCorse 2001:53; Hair et al. 1992:380) would still have permitted masted vessels to enter the Benya, but it is uncertain what sized vessels would have done so (Figure 3.3). [108]

[106] An interesting tradition in modern Elmina, which is also depicted in this image, is the townspeople gathering on the bridge to welcome fishermen back after a night at sea. From their vantage point on the bridge, they can see whether there is a catch or not, and applaud those who have had a fruitful evening.

[107] The single archaeological example presently known of European use of the Benya Lagoon for shipping-related activities may be found in the remains of a vessel, likely a hulk, that were discovered by dredgers in 2007 in the western or upper part of the lagoon (Pietruszka 2011). While this is clearly an indication of intentional European use of the lagoon, it should be noted that hulks were ships "without masts or rigging" (Bowditch 1837:295), and therefore it would have been dragged up the lagoon by warping or some other method, and likely permanently moored in the lagoon, similar to the early depot ships of the slave trade in other areas of Africa (Cowan 1935:397; Lynn 1989:230) and moored holding stations in other areas of the world (Klein et al. 2001:106). Because the masts and rigging would have been removed, the vessel would have drawn a shallower draft, making it easier to move a relatively large vessel up the lagoon. The fact that the hulk was excavated from under three meters of sediment (Pietruszka 2011) may suggest that the Benya was deeper in the past. Alternatively, this could also be the result of the hulk settling through the sediments over time and as a result of the multiple dredging projects in different areas of the lagoon (DeCorse, personal communication, 2010; see McNinch et al. (2001) for a discussion of the settling of the wreck of the *Queen Anne's Revenge* more than four meters below the level at which it wrecked; see also Chapter 6 for a discussion of the mechanisms of settling).

[108] In a seemingly contradictory discussion, Barbot (Hair et al. 1992:379) states first that: "Access to [the Castle] is by nature difficult; for besides the fact that when coming from the sea you have to cross a small bar which breaks at the mouth of the Banja [Benya], the only place you can disembark is near the bridge…" He then goes on to write (Hair et al. 1992:380) that the "bridge which connects [St. Jago hill]

While some larger trading vessels may have ventured close to the Castle or shore of Elmina Bay, either under duress or for special purposes such as careening, the norm was for the larger vessels to anchor offshore in deeper water and to use the ships boats

Figure 3.4. The most probable area of the historical Emina roadstead/anchorage is indicated in this GoogleEarth image by the dashed lines. Note, however, that the further east a vessel anchored, the more difficult it would have been for ships boats or canoes to beat against the prevailing west-east current in order to reach the Castle, suggesting that there was a fine balance between choice of anchorage and efforts required in trading.

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with Mina has a break in the middle [to form a drawbridge]…to let ships pass further up the river in order to refit." The apparent contradiction here is between the difficulty in accessing the Castle on the river because of the bar at its mouth and the bridge being able to allow the passage of ships upriver for refitting. Based on the other accounts discussed here and the navigational and environmental data available, I propose that it is likely Barbot is referring to the refitting of the smaller vessels and ships boats, which were commonly used in the Benya, could have passed over the sandbar at the mouth, and would also have had masts that could not have gone under the bridge, necessitating it being drawn out of the way. It is possible, however, that it does relate to larger vessels as well.

and local canoes[109] for landing people and materials (Feinberg 1989:12-13) (see Appendix VII for a more detailed discussion). Numerous records indicate that European vessels trading in this region would normally anchor offshore up to two miles (3.2 kilometers) out and usually in eight fathoms (16 meters) or more where possible (Barbot 1746:456; Blake 1967:40; Bosman 1705; Cook et al. 2003:2; Feinberg 1989:67; Thomas 1969 [1860]:229); in fact, Phillips (1746) regularly reports anchoring in greater than fifteen fathoms (30 meters) water depth (Figure 3.4).[110]

A small selection of accounts will illustrate the complexities of navigating and interpreting the historical records and physical environment, and will serve to inform the archaeological evidence of maritime trade known to date. These are taken from various first and second-hand accounts and are not presented as comprehensive; they are, however, informative for purposes of illustration.

[109] The importance of the canoe in the Atlantic trade, and on the Ghanaian coast in particular cannot be overemphasized, as it was one of the primary means of transporting goods, people and communications from the inland to the coast (see also Adams 1966 [1823]:242; Boateng 1967:127-128; Smith 1970[109]; Searing 1993:95), and almost the sole means of transportation of people and goods between vessels anchored off-shore and land. Use of the canoe was integral in many African cultures long before the arrival of Europeans on the coast, and in fact it was the ready-presence of the canoes that facilitated the development of trade and trade relations between Africans and their foreign visitors (i.e. Feinberg 1989:69). For example, Vogt (1979:176) writes that the Portuguese even launched an attack on a Dutch trading vessel by sending troops out in war canoes manned by Elminans, and succeeded in overwhelming the crew of the (admittedly) small sloop; they were also used to just harass Dutch trading vessels. Feinberg (1898:44) notes that a group of Elminans in a canoe attacked a Dutch vessel lying at Komenda and killed all but one of the crew. Law (2007:149, 152) notes that a fleet of canoes was sent by the Dutch at Elmina to blockade the British at Komenda in 1696. As Smith (1970:521) writes, "[f]or hundreds of years the canoe…has played a major role in the political and economic life of West Africa." All of this comes intertwined with the historical and cultural relations that people from both parts of the world had with the marine environment, both in West Africa and elsewhere. While each European country's practices differed from the others, the use of the canoe in trade was universal, dictated by the natural environment itself. This is particularly fascinating when considering the wide variety of cultures, vessels and trading traditions that interacted on the coast of Ghana and West Africa, and is an important element to remember when investigating remains of the mechanics of historical maritime trade. The history of the West African trade and the Atlantic trade is ultimately and intimately intertwined with the sea.

[110] The 1951 US Navy Hydrographic Office (1951:52-53) survey, written two centuries later, supports this in stating that an "anchorage may be obtained off Elmina in 5 fathoms, over black mud, with the southwest angle of Fort St. George del Mina bearing 277°, or in 7 to 8 fathoms, over sand, shells and mud, with the same fort bearing 294°." The report also notes that vessels may anchor in water (13 fathoms or 26 meters) about five miles offshore between Elmina and Cape Coast, indicating that anchorage to the east of the castle is only advised in very deep water.

The first example may be found in the reports that after the establishment of the fort by the Portuguese in 1482, "[w]ithin the calm waters of the harbor, ships of 300 tons' burden could anchor conveniently near a wide beach upon which goods and supplies could be unloaded. Smaller vessels could sail even farther upstream to a shallow lagoon at the northwestern side of the peninsula. There they could be careened and repaired safe from storm or attack" (Vogt 1979:25-26;[111] see also Hair 1994a:17). Basing his information on a map from 1620, A. W. Lawrence (1963:103) also notes also that ships of 300 tons[112] could anchor in the "calm waters of the bay." This description of the bay is problematic, since for much of the year the bay is not calm due to its relatively exposed and shallow nature and the heavy swell, surf and surge common in the area, and the tidal ranges active in the Benya Lagoon "harbor" area (i.e. Hair 1994a:78) would have posed problems for large vessels in particular. However, it is possible that the original authors were simply commenting on it relative to the surrounding seas, which are usually far less calm.[113]

One type of vessel, however, the galley, was unquestionably able to maneuver into and out of the river mouth (Lawrence 1963:118), as it was small and not dependant on the wind for power. The galley was a small vessel that was rowed by slaves and some European prisoners and was used extensively by the Portuguese for defense, patrolling and possibly some trade along the coast (da Mota and Hair 1988:73; Vogt 1979:112-113).

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[111] Note that Vogt does not cite his sources (see Hair 1994a).
[112] There is debate over the definition and determination of tonnages of historical vessels; while there could be significant variation in the actual size of the vessel called "300 tons," it was still a large vessel for the day (da Mota and hair 1988:6). See Cook (n.d.) for a more complete discussion on varying tonnages.
[113] This term implies seas that are less than 1 meter in height, slower currents, and which are relatively easily maneuvered in sail-powered vessels.

These vessels were also responsible for sinking a number of larger anchored trading vessels (da Mota and Hair 1988:15).

Another example is found in the correspondence of a governor of Elmina to the Queen of Portugal in April of 1557. The governor writes that a caravel was anchored off Elmina but was under threat of being taken by a “pirate” *galleass*,[114] so the governor placed it “inside the reef and there saved” it (da Mota and Hair 1988:61). This account is difficult to understand because the closest reefs near Elmina are located several kilometers to the west, in an area that would have been difficult to defend from the Castle or to access quickly, as it would have entailed sailing against the strong prevailing current. It is possible that the vessel was brought closer to the Castle and anchored on the lee side of a natural breakwater that extends from the peninsula on which the Castle was built,[115] but it is difficult to see how this breakwater may equate to a reef. Regardless, the governor was somehow able to bring the vessel close enough to the castle to protect it.

A final example, which can either indicate change over a period of several hundred years from the time of the Portuguese to the Dutch period, or else may indicate inconsistencies in the record, may be found in the 17th or 18th century writings of Barbot,[116] who reported that the Benga (Benya) River mouth near the fort at Elmina could also be used by vessels of 100 to 120 tons for careening and off-loading of cargoes (Hair et al. 1992:374; see also Blake 1987:396; Feinberg 1989:27; Meredith 1967

[114] A galleas was a small sailing vessel that could also be propelled by oarsmen; it was often used as a means of combating the strong current when messages and goods needed to be transported west along the coast, and was also used to patrol the coast, as it was maneuverable in both shallow and deep water environments.
[115] Incidentally, this is also the location of the Single Anchor Site.
[116] I recognize that the use of historical documents by men such as Barbot and Bosman are at times problematic (Law 1982; van Dantzig 1975, 1976, 1977, 1982). However, I use them primarily for their descriptions, and endeavor, wherever possible, to use them in conjunction with other, more reliable sources.

[1812]:83; Vogt 1979:25).[117] This significant difference in tonnage – the difference between 100 and 300 tons – suggests several possible scenarios, including the Benya becoming shallower and more restrictive over time, or simply a more plausible description of the size of vessel that was actually able to safely maneuver, including directly off-loading goods, for example, at the Castle wall, in that setting.

In a 19th century discussion of smaller craft using the Benya, Bold (1923:57) commented that "[t]o the right of the fort [Elmina] there is a small river [the Benya] where coasting craft may shelter or haul on the beach in cases of emergency, for repair, &c.; large vessels anchor in 9 fathoms, sand and mud." It is interesting to note that Bold suggests that by the 19th century only small craft can be hauled up in the river area of the castle. Any mention of larger vessels in the harbor of the castle or bay near it is conspicuously absent, particularly as he mentions that larger vessels were to anchor in nine fathoms (approximately 18 meters of water),[118] which, as noted earlier, in this

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117 Similarly, in 1837 Martin (1837:230) wrote that "vessels of 100 tons can come close to the walls" of Elmina. Note also that this relates to a specific task of offloading vessels, but does not necessarily imply that this was the location where the vessels anchored before and after offloading.

118 An example that at face value appears more difficult to interpret may be found in Nathan (1904b:16), a translation of a late 17th century account of sailing directions provided by a Dane, Eric Tylleman, who described himself as formerly the Lieutenant in the Danish Fortress of Christiansborg, on the Elmina coast, Tylleman wrote that the "anchorage d'el Mina is in from 8 to 6 fathoms of water, with sandy bottom. From it the fort of St. Jago is full in view on the east, and the two forts are quite clear of each other." It is unclear from this description exactly where the "anchorage d'el Mina" is located: since he indicates that St. Jago is "on the east," the anchorage could not be in Elmina Bay or in the harbor mouth, as in that case St. Jago hill would be to the north or even to the northwest, not to the east of the anchorage (see illustrations in DeCorse 2001:50-53 and Figure 3.3); in addition, it is highly unlikely that the water depth in this area would have reached "8 to 6 fathoms" (12-16 meters). A conversation with Dr. Mark Staniforth of Monash University, however, suggested that these directions, rather than being taken literally, should be read in reference to the body of the sailor describing them. In this case, then, when a vessel was approaching the anchorage from the sea (the south), and then turning to face or approach the Benya (literally the west), the sailor would perceive of what was in front of him as the north, and therefore what was to the right of him as the east. In this reading, even several miles offshore, if one was facing the Castle, the two forts would indeed be clear of each other, with St. Jago to the "east" (Figure 3.4). This does not imply, however, that vessels actually had to be near the Castle, as the directions also indicate a depth of "8 to 6 fathoms of water;" this depth places vessels in the roadstead or anchorage well outside Elmina Bay and into the deeper offshore waters. What is important is that the directions are understood as they would historically and culturally have been interpreted by a sailor in the region. While this explains the seemingly odd instructions here, it raises the

particular region, would have meant anchoring at least one to three miles offshore, and not actually near the castle. [119] A much later, 1951 nautical survey by the US Navy Hydrographic Office (1951:52-53), states that "[l]anding [near the Castle] may be effected in *ships boats* at high water in the Beya [*sic*] River during the dry season when the surf is not very high, but it is not safe at or near low water. In making for the river give the rocks off Elmina Point a wide berth and steer out into the bay until the river is well open" (emphasis added). Certainly before the mid-20th century, it was no longer plausible for vessels of 300 tons to anchor near the Benya or even in the shallow Bay to its east.

A final, more problematic source of information concerning anchorages may be found in historical illustrations (e.g. Hair et al. 1992:xcvi-xcvii; Iselin and de Marees 1992),[120] but as I have not conducted extensive research into them, they are only noted here (Figure 3.5).

As illustrated by the brief examples and discussions above, the history of the use of the Benya Lagoon and Elmina Bay areas is complicated and is not yet clearly understood. Patterns in both the historical and archaeological records concerning the Benya Lagoon and Elmina peninsula (i.e. DeCorse 2001:52-53) suggest that there have been dramatic changes in patterns of use of these areas over the centuries (Figure 3.6). All of these factors being as they were, the seascape around Elmina still offered one of the few relatively ship-hospitable areas along the west coast of Africa (Hair 1994a:16; Feinberg 1989:27; see also DeCorse and Chouin 2003:10-11), and there is a great deal

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question of how literally other accounts can, or should, be taken, and makes the process of interpreting historical documents relating to navigation and anchoring that much more difficult, but also intriguing.

[119] For reference, the Elmina Wreck is located one and a half miles offshore and is located in only 11 meters of water.

[120] Already briefly touched on with Lawrence's referencing of a 1620 map.

Figure 3.5. **As can be seen in this 17th century engraving, the large European trading vessels are all anchored well away from the castle (in center). Smaller vessels of unknown origin fill the space between the roadstead and the castle ("Anonymous engraving," in O. Dapper, *Nauwkeurige beschrijvinge der Afrikaensche gewesten van Egyptn, Barbaryen, Lybien, biledulgerid, Negroslant, Guinea, Ethiopie, Abyssinie* (Amsterdam: Jacob van Meurs, 1676), 2: 68. Courtesy of the Koninklijke Bibliotheek, The Hague [185 B 12]).**

still to be learned from both historical and archaeological source material concerning trade, navigation, and anchoring practices in coastal Elmina. There is also clearly still a need for much more detailed study of the historical sources in order to create a more nuanced understanding of the past. While maritime archaeological investigations have begun to address these questions, it is also anticipated that additional investigations will be able to shed greater light on this interesting aspect of historical navigation and anchoring on the Elmina Coast.

Figure 3.6. This panorama of coastal Elmina was taken facing ESE from Fort St. Jago, which overlooks the Elmina peninsula and Elmina Castle to the south, in 2009. The newly-constructed moles/breakwaters are visible in the east (left side of image), and are significantly different from any other structure that has been built at the mouth of the peninsula. As discussed by DeCorse (2001:52-54), there have been other significant modifications to the mouth of the Benya; the current formation is the most extensive modification to date. Regardless of how far to the east the modifications have been made, however, Elmina Bay and the harbor mouth are shallow, which would have been a significant factor in determining anchorage and vessel interaction with the Castle. In addition, the Benya itself, as dictated by the rock peninsula that constrains it to the south and the mainland to the north, was not a wide drainage; any large vessel entering, whether for careening or some other purpose, would have been towed or kedged upstream. The breakers to the south and southeast of the Castle, seen as the white line behind it, indicate the sandbar created by the rock peninsula; the Single Anchor Site is located just to the lee (inshore) of this line of breakers. While the perspective of this dissertation is viewing the land from the sea, it is also useful to switch viewpoints and to view the seascape from the land looking seawards (photos C. Toftgaard, 2009; mosaic R. Horlings).

Boundaries

The boundary between sea and land is not arbitrary (cf. Crumley and Marquardt 1990:74), it is concrete and real, and yet ever-changing and unpredictable. The social consequences of its presence are highly contextual, yet have some of the same effects on every culture and interchange that occurs along that boundary. The boundary of sea and shore is integral to an understanding of the seascape, and any investigation into historical maritime trade must address the presence and the consequences of physical and social boundaries of the seascape.

Green and Perlman (1985:4) write that "[b]oundary research such as the study of trade…focuses on the social, political, and economic factors that guide the interaction between societies." [121] It is argued here that just as important a factor in maritime trade is the physical environment in which these interactions take place. Incorporating this idea, Head (2008:379) eloquently describes past landscapes as "fields of human engagement." What more appropriate description could there be of the historical seascape in coastal Ghana? The ocean, foreshore and shore made up the arena upon which historical contacts, trade, wars, rivalries, and communications were staged, and within which international relations were engaged during the time of the Atlantic trade (i.e.: Russell-Wood 2009). But there were physical, social, and cultural boundaries (Bower 1986; Marquardt and Head 1987; Preucel and Meskell 2009:220) to these engagements as well.

[121] This quote is part of a larger idea that encompasses frontiers as well. The Atlantic maritime trade was a frontier for both the Africans and the Europeans, but this is not central to the arguments I am making here. For reference, the larger quote reads as follows: "Frontier studies direct their attention to the peripheries or edges of particular societies, and the characteristics of the groups occupying that space. As a complement, boundary studies examine the interactions that occur at societal edges. On the one hand, frontier research addresses questions about the causes of political and economic expansion into new habitats, and its effects on indigenous societies and ecological systems. Boundary research such as the study of trade, on the other hand, focuses on the social, political, and economic factors that guide the interaction between societies" (Green and Perlman 1985:4).

For Europeans and Africans alike, the maritime trading space became a new frontier (Morgan and Greene 2009:13). While Europeans had been traversing vast areas of the ocean coasts for centuries (Cunliffe 2001:37-39),[122] operating in West Africa was for some time a new frontier. Africans/people of the Ghanaian coast had for a long time been fishing in the ocean and conducting lateral trade along the coast (DeCorse 2001:108; Feinberg 1989:5, 19; Morgan 2009:223; Smith 1970), but the concept of venturing out into the ocean, and essentially *across* oceans, was not at all practiced in most of Africa and indeed was still relatively new for most of the world (Chaplin 2009; Mitchell 2005:178-179; Parker 2001:38).[123]

Within this environment, the Europeans were constrained by the cultural and physical boundaries of the rough coastal waters (DeCorse 2001:17), and were not able to bring their large sailing vessels (their mobile cosmoses) in direct contact with the African world. And yet, with the help of local peoples who allowed and assisted them (using canoes) to come to shore they were able to traverse physical, cultural, and social boundaries (Pearson 2008:22). Likewise, the Africans who engaged with the Europeans on their vessels were given snapshots across cultural and space boundaries into worlds mostly alien to them (Feinberg 1989:vii). These exchanges, part of what Kelly (2004:225) terms the "mutual discovery of Europeans and Africans," represented the blurring of the social and physical boundaries of two completely different worlds (Johnson 2007a:15; Marquardt and Crumley 1987:8-9; Ward 2003; Yarak 2003), made

[122] Mitchell (2005:101) notes, however, that though the Atlantic Ocean served effectively as a barrier to European exploration and expansion until the 15th century, the Indian ocean, in contrast, had been well-traveled and explored for hundreds of years, and was, by the time of European exploration, effectively a "Muslim lake."

[123] Cunliffe (2001:13) records the story of a group of "Muslim sailors" venturing to sea and landing on Madeira and the Canaries before making it to Morocco, but he does not record where the sailors were from.

possible primarily through the advent of complex sailing technology and an increasing understanding of navigation[124] (Mitchell 2005:181. Morgan and Greene 2009:8; Murphy 1983:65; Rawley and Behrendt 2005:9, 18; Steffy 1994; Thornton 1992:35; Vogt 1979:3).

Boundaries were also challenged by competing Europeans jostling over territories, trading rights, and alliances (Coombs 1963:6-12; DeCorse 1996:681, 2001:22-24; de Marees 1987:202-206; Hair 1994a:101). Every nation was constrained by the same sea[125] and the physical environments, and while technology (cannon/guns, ships, etc.) allowed some adaptation, all of them remained reliant on mutual cooperation and the tenuous good favor of the local peoples to accomplish their aims (Ballong-Wen-Mewuda 1993:444; Curtin 1984:15-16; de Marees 1987:81, 207; Feinberg 1989:vi, 2; Hopkins 1973:108-109; Mancke 2004:149-150; Meredith 1967 [1812]:103-104; Mitchell 2005:202; Morgan 2009:225; Pearson 2008:16, 22-23; Priestley 1969:8; Thornton 1992:7; van Dantzig 1980).[126] All of these boundaries shifted and got rearranged over time, but they still revolved around the very real, physical seascape, which enabled and at the same time constrained international maritime trade. And it was within the constraints of the sea, within the context of these boundaries and frontiers, that vessels struggled and sank (Adams 2001:292; McCarthy 2008; Phillips 2003), leaving a concrete record of both physical and ephemeral events of the past.

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[124] Particularly the ability to determine latitude (Grady 2008:31).

[125] Ward (2003:3) highlights this point in his discussion of the "other Atlantic World," writing that "[w]hatever the power of Europeans in the early modern Atlantic, they could not colonize the sea; the way we approach the history of the Atlantic World ought to reflect the complexity of the ocean that gives the field of study its name."

[126] While there are those who claim a pure European dominance and exploitation of the West Africans, they actually lacked the manpower or technological prowess to control the African peoples, and were able to trade only with their explicit support and assistance (Grady 2008:34).

Whether one is discussing the historical maritime seascape, or the archeological landscape of the seabed, "it is important not to confuse a broad-scale land[sea]scape approach with holism of synthesis. This is not the total picture, but rather a means of situating our archaeological knowledge, of specifying some of the things we do not know" (Head 2008:383; see also Branton 2009:53). There are vastly differing scales of the sea, of the seascape, of the shipwreck site, and of the artifacts within the site, and even with a carefully crafted and balanced approach to investigation, it is impossible to create a complete picture or synthesis of any history based on the archaeological record. The concepts of the seascape, boundaries, scales, and sites within the framework of the archaeology of the event and site formation processes are used here as a means of "situating our archaeological knowledge" and "specifying some of the things we do not know."

Delgado (1988:2) writes that "maritime disasters do not respect nationality," nor do they respect location, so it is not as odd as it may seem to be exploring the wrecks of European vessels in the waters off the African coast. In fact, it is a unique opportunity to learn about historical interactions within the context of both a focused, localized and a global perspective. International maritime trade at Elmina is uniquely suited for archaeological research because it *must* be understood within its wider context (DeCorse 2008:89) in order to be properly understood.

Vestiges of Trade

Shipwrecks and other submerged sites are what remain of activities that took place within the historical seascape. Shipwrecks are the remains of vessels that (generally unintentionally) transitioned from the air/water boundary to another, that of the water/seafloor, but they are not the only submerged testimonies to crossing boundaries in the past. For example, the following chapters (4 and 5) include discussions of some sites in coastal Ghana that *may* represent vessels that escaped that fate, but left markers of the struggle to avoid it, adding even more complexity to the concepts of maritime disasters and boundaries.[127] Gould (2000:65), in a discussion on the boundaries between water, earth and air and the relationship of vessels and shipwrecks with each writes the following:

> Any ship other than a submersible operates simultaneously and continuously in two media, the sea and the air, while avoiding contact with a third, land, except under specific conditions such as docking or beaching. The combination of sea and air movements, fluid and ever-changing, dominates all maritime activities. Each of these media independently affects the movement of a ship at sea.

A shipwreck is the irreversible effect of the event of crossing one of these media (or boundaries), each of which then also affects the remains of shipwrecked vessels and plays a role in natural formation processes that affect shipwreck sites. Jones (2003:13) writes that it is at the solid/liquid boundary or interface of the marine environment in which wrecked vessels are found, and suggests that because of this, the seabed environment will have the greatest effect on these submerged cultural resources. The shipwreck and its environment, located at this boundary, makes up what Tomalin (2000:85) describes as the “archaeological landscape of the seabed.” People, storms, tides, currents, flora and fauna all act as the agents and formation processes which change the face of the archaeological landscape of the seabed, and act to preserve or destroy the shipwreck and its site. It is through the investigation of the interrelated, contextual scales

[127] Alternative possibilities are also discussed in Chapters 4 and 5.

of the seascape, events, and formation processes that the archaeological remains on the seafloor can provide us with a nuanced, complex, and yet broad understanding of historical maritime trade practices in coastal Ghana.

One further idea, that of the *eventscape,* should be briefly explored here as it will serve to tie the previous discussion, and indeed, the dissertation, together.

A Theatre of Maritime History: The Elmina Eventscape

The complex of people and events and settings that makes up the past provides the backdrop against which we can examine component parts of it represented by submerged archaeological materials. The interdisciplinary approaches, frameworks, and methodologies applied in this investigation provide a means of exploring and understanding this eventscape of history. This chapter has engaged with this eventscape, and it is useful now to tie the disparate ideas presented in it together. According to Branton (2009:61),

> An *eventscape*… consists of a network of thematically connected places associated with a social group's [or several social groups] participation in a culturally critical, persistent event… Eventscape encompasses not only locations within a landscape but also the behaviors such as commemoration, storytelling, visitation, and instruction in appropriate behavior that take place at those sites as part of the cultural transmission of information about the event across generations.

Branton's description of an eventscape[128] is primarily concerned with the phenomenological, but I propose that it can be modified to a more pragmatic purpose used to understand historical maritime trade in Ghana through the framework or lenses of

[128] See also McNiel (2001).

the archaeology of the event, site formation processes, and the seascape. As such, I would modify Branton's definition and state simply that

> An eventscape consists of a network of thematically connected places associated with a social group's [or several social groups] participation in an event or related events. Eventscape encompasses not only locations within a land- or seascape but also the behaviors that took place within it, including international relations, maritime trade, and the events of daily life of those whose lives were intimately entwined with the seascape. It also encompasses the physical remains of human interactions within its sphere.

With this as a foundation, the theatre of maritime history and trade can be understood as both an all-encompassing arena in which events from the past occurred, and as the repository of the remains from those events.[129] Application of this concept in no way diminishes the unique importance of each of the frameworks applied to this research. Rather, it synthesizes the interrelatedness of a number of concepts into one descriptive framework that can then be used to tell an integrated story of the past.

The next chapter is an account of the methods used in and results of investigations across boundaries and within the sea- and eventscapes of historical maritime trade in Ghana.

[129] It is also a source of inquiry, narrative and instruction, all of which are vital components in interpreting and telling a story of the past. In addition, this inherently and importantly includes the storyteller as part of the eventscape, but, as noted earlier in terms of the phenomenological application of the concept, this is not the strength or the focus in relation to this research.

Chapter 4
Things They Left Behind

Investigated within the frameworks outlined in the previous chapters, the objectives of my maritime archaeological research in coastal Ghana emphasized a number of methodological aspects of survey as well as differing scales and forms of interpretation. Methodologies included the development and refinement of techniques appropriate for survey and investigations within the coastal Ghanaian environment, an emphasis on investigating the environment itself and site formation processes within it, and an overarching goal of using disparate forms of data to understand the multifarious facets of historical maritime trade in coastal Ghana. The two areas of major emphasis in this chapter are these various aspects of survey and micro-sampling, as well as the multi-scalar perspective that encompasses the micro and the macro. Included in each discussion of the methods and means of fieldwork are short engagements with the methodological and theoretical bases for investigation, as well as succinct descriptions of sites and artifacts that were identified.

The chapter begins with a brief discussion of the methodological framework within which research was conducted as means of anchoring the field work itself to the larger investigative picture of the project. This is followed by a summary of field methodologies employed in the 2007 field season. These two sections provide the foundation on which the research design for the 2009 season was built. It should be noted here that while the beginning of the chapter follows the first field season, the intent is not to discuss methods and data purely in chronological order. Rather, because the methodologies developed and refined in the 2009 field season were built on those developed in the 2007 season, in terms of understanding the process of building methodologies and theoretical frameworks it is important that certain aspects be discussed in the order in which they occurred.

The remainder of the chapter focuses on the various aspects of field research, most of which are discussed regardless of the season in which they were employed. The specific goals of each avenue of investigation/methodology are intentionally outlined at the beginning of sub-sections to provide background as to the rationale behind them and to aid in tying together the disparate avenues of inquiry. The following chapters discuss interpretations of the data in light of the events that created the sites, various formation processes, and environmental and historical research.

Methodological Framework

My work in maritime archaeology in Ghana is distinct in terms of research focus, as the multidisciplinary investigation of the archaeology of the event combined with site formation processes is unusual in maritime archaeology. It is also distinct in terms of geography, as maritime archaeology in West Africa is in its nascence. This research melds the regional/macro approach and the local and micro approach – in a time and place of maritime trade about which very little is currently known archaeologically. The unique focus of this research therefore required a suite of methodological approaches that provide answers on many different levels and in many different aspects, and which was appropriate for and practical in this environment. The tools and methodologies themselves were not in and of themselves necessarily unique (Denham 2008; Muckelroy 1977:111; Nutley 2000:35-36; Parker 1979:7, 12), but their combinations and applications made them aptly suited to my unique research questions and to the research environment in coastal Ghana.

Gould (2000:1-2) observes that there are many scholars and researchers, including archaeologists, who tend to consider the underwater world "a chaotic mix of disassociated and dissolved features lost to human view for all time," assuming that "[w]ave action, currents, silting, deterioration due to the action of marine organisms, and other little-understood factors…make the study of shipwrecks impossible or impractical." It is impractical to deny that these factors are indeed significant, with very real implications for underwater research, but this is not the end of the story. Gould (2000:1-2) goes on to say that the "challenge to underwater archaeology today is the application of scientific methods to the archaeological record in an effort to construct a picture of the human past that is not distorted by intervening natural processes and human activities." This is precisely the goal of this research: to look at extant cultural remains from the historical maritime trade in West Africa, to be able to understand the processes that affect them and their results, and from this to be able to understand what questions can be asked of the data and evidence, and what can be learned from it.

One of the reasons for skepticism concerning maritime or underwater archaeology stems from the fact that projects are often focused rather myopically, typically on a single, famous shipwreck, which is an approach that unfortunately portrays the archaeologist as incapable of seeing the larger picture or significance of a site or sites. Unfortunately, it is also often the case that these projects lack sufficient or significant theoretical grounding, further compounding the issue. However, even when projects are not myopic, underwater archaeology is frequently necessarily constrained. As Flatman

(2003:144) explains, “given the particular working conditions of much maritime archaeological work – often performed under water in poor visibility on a small area of the site at a time, reducing individual awareness of the ‘big picture,’…” concerns about methodology/ theory dichotomy are legitimate in multiple ways. He continues, “[p]aradoxically, maritime archaeology also has much to gain from its environment in this respect” (Flatman 2003:144-145). It is precisely this perceived dichotomy that is addressed in this research. Here I explicitly incorporate specific theoretical foundations with an emphasis on site formation processes and the physical environment, and explore the methodological tools most appropriate for investigating questions related to these ideas.[130]

This dissertation is a compilation of work and analysis from two field seasons. In 2007 the primary emphasis was on diving targets identified in Cook’s 2003 sonar data (Cook n.d.; Cook and Spiers 2004), and on partially excavating and collecting sediment cores from the known shipwreck site. Investigations in 2009 focused on new remote sensing surveys, diver investigations, and continued sediment core sampling. As discussed in Chapter 3, the stage on which the historical maritime interactions took place (and therefore the location of research) is necessarily framed within the multiscalar land/seascape of the region. The physical environment, then, set the framework or guidelines within which my research was carried out, particularly during the 2009 field season, and plays a continuous role in the interpretation of the events that took place there. Complementing this emphasis, French’s (2003:6-7) four scales of resolution for interpreting archaeological landscape contexts offered an ideal starting place for

[130] As argued in Chapter 2, the methodologies associated with the investigation of site formation processes are also considered to be theoretical. This assertion is considered to be implicit in discussions of methodology throughout this chapter.

developing the framework for both the field research and interpretation of data, and can be summarized in Table 4.1.

Scales of Resolution	Explanation
macro-environment	includes the effects of climate, geology and topography as important controlling factors
meso-environment	includes the immediate area around the site [approximately 5 kilometers for purposes of this research], in which land (or sea) use may be a major controlling factor in the preservation of both environmental and archaeological data
immediate environment	for instance, a wreck site
micro-environment	the within-sediment micro-environments; includes all potential sediment forming and transforming factors that can either destroy or skew evidence and therefore affect the validity of interpretations

Table 4.1. All of the methodologies and areas of research described in this chapter address at least one of these "resolutions," and usually more.

2007: Developing Questions and Techniques

The premise of my research in 2007 was to explore the site formation processes of shipwrecks in Ghana and to develop suitable and effective methodologies to study them. Five basic questions guided my initial approach and remain central to it:

1. How did vessels wreck (what was the event?), and was it possible to investigate those causes in this environment?
2. What has happened to them since (basic site formation processes)?
3. What is left of them and how do we find them?
4. What questions can the extant remains help to ask and then inform about historical cultural processes in this region?
5. What is the best way to investigate and study submerged cultural resources in this region?

Cook's work in 2003 and 2005 had demonstrated that there was at least one historical shipwreck in the seascape of coastal Elmina, and his investigations, including the site plan he had drawn, provided a solid basis on which to ask these questions and to begin to try to answer them. In addition to the work on the historical shipwreck, I also participated in diver investigations of potential shipwreck targets, developed a micro-sampling technique using sediment cores, conducted experimental archaeology in two different comparative control areas, and monitored a modern shipwreck on an Elmina beach. Each of these is discussed below.

Background

The side scan sonar survey that Cook conducted in 2003 (discussed previously in Chapter 1) provided the base data from which to begin investigations, and in preparation for fieldwork the data were reanalyzed by Cook, myself and Pietruzska, and nearly 100 possible targets on which to dive were identified. Not all of them were necessarily marked as potential shipwreck targets, as I was also interested in doing a general survey of submerged cultural resources in the area. All three of us collaborated on identifying the most likely targets and on ranking them in terms of importance for diver investigations. Due to a number of factors, it was decided that field work would be conducted in the summer months, which unfortunately coincided with the rainy season. Weather and water conditions are rough at best during this time of year, as is evident in historical records and in the previous experiences of Cook and his volunteers there, but it was unavoidable that the field season take place at that time. It should be noted that while the rough conditions are not the sole reason there has been little underwater archaeology in West Africa to date, it is a significant reason for the lack of diving infrastructure along this part of the west coast of Africa, and highlights one more of the challenges of working in this environment.

As discussed earlier, this research was part of the Central Region Project and made possible primarily by funding allocated to the project. As a result, my research was conducted as a collaborative effort with Pietruzska.[131] We were assisted by several volunteer field staff.[132] Although we experienced considerable challenges in terms of water conditions and equipment problems, we were overall able to collect a great deal of information concerning the Elmina Wreck and some of the surrounding areas.

Fieldwork

The initial testing of the side scan sonar targets was directed by Pietruzska.[133] Diving was conducted initially from a 28' Zodiac Hurricane purchased for the project, but engine problems often necessitated hiring a local canoe, culminating in working entirely from the canoe. Diving was conducted generally using a surface-supplied air unit while using SCUBA tanks as back-ups.[134] Targets were investigated by going to the target coordinates identified on the side scan sonar data and dropping a weighted buoy over the side of the boat. Divers then descended the buoy line, at which point the diver would take a reel with distances marked out on it in knots and perform circle searches of

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[131] While we had different research agendas, overall this was beneficial in terms of pooling resources and ideas, and we worked in conjunction for most of the field season (July through October, 2007). Funding for the 2007 season was provided by a National Science Foundation Equipment grant (MRI 0521121), from Dr. Christopher DeCorse (our mutual advisor), and I was awarded a Roscoe Martin grant and a Goekjian scholarship (both from Syracuse University's Maxwell School), and a Leopold Schepp Foundation scholarship.

[132] John Ricci, a recent Master's graduate of the Maritime Archaeology program at Flinders University, Australia, spent several months on the project. His presence on the project proved absolutely invaluable, and both Andrew and I owe a great deal to his efforts. Several other volunteers, Shane Pickett and Chris Cartellone, were also field volunteers and were instrumental in developing the survey techniques we used for the project.

[133] When I first arrived in Ghana I was assisting in teaching an archaeological field school elsewhere with Dr. DeCorse. I was able to help to investigate a number of targets, but did not fully participate in the diver investigations until almost August, by which point nearly 30 of the most promising targets had been investigated.

[134] There were also problems with both of these air supplies, necessitating different configurations depending on which happened to be working at the time. The tanks and compressor were purchased new for the 2007 field project.

the area. Because of the season, conditions were so rough that the current and surge[135] made it difficult to swim a full circle, and there was so much sediment in the water that it was literally impossible to see one's hand in front of the mask. As a result, the circling diver had to feel his or her way – usually crawling along the seafloor to maintain traction, holding the reel in one hand, and feeling with the other.[136] The premise behind this method was that if there was an object on the seafloor, the reel line would get caught on it, and the circling diver would find it when reeling up. This is a classic method of searching underwater (Green 2004:55), but there are indications that perhaps it was not the most effective means in that environment and those conditions, as the reel line had a tendency to float, which meant that unless an object was significantly proud[137] of the seafloor, it was unlikely that it would catch the reel line. However, this was the most effective means available at the time, and was used to investigate over 30 targets (DeCorse et al. 2009).

In addition to the target and subsequent wreck investigations, my research was designed from the beginning to include various explorations of formation processes in the

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[135] Seas often reached 2-3 meters (up to 10 feet), which significantly affected conditions on the bottom.

[136] Because it was not possible to see one's diving partner, a second diver was underutilized in this process. While searches initially involved two divers, the system was eventually modified so that a single diver could descend, clip the search reel into the buoy line, and conduct searches; this allowed there to be more eyes on the surface watching the bubbles of the diver, and proved more efficient than wasting a diver sitting at the buoy line. While there are clearly significant risks associated with this method, every precaution was taken that all dives were well below dive table limits and the diver had a "spotter" at all times. The "wasting" of a diver refers to the build-up of nitrogen in the blood – divers have to remain below certain levels in order to continue diving, and the unnecessary time under water meant that the second diver could not complete another dive until a certain period of time had passed. In a situation with many divers this is not an issue, however, as we were working often with only two or three divers, this meant that there was a lot of time wasted while we all sat on the surface waiting for the nitrogen levels to decrease. Single-diver dives meant that this wasted time was reduced, but significantly increased risks in other ways. In the event that something was discovered, the diver would tie the reel to the object, ascend the buoy line, and an additional diver would go down to investigate. This system of single divers was maintained for the season, unless a task required the presence of multiple divers.

[137] This is a term commonly used in maritime research to describe objects that protrude to some extent above the surface of the seafloor (e.g. Church et al. 2009:53; Clarke et al. 2006:7; Horrell et al. 2009; Wessex Archaeology 2008; Wheeler 2002:1155).

region, including non-wreck areas; this research was conducted concurrently with the work done on investigating the targets and on the shipwreck site itself, as discussed below.

In the event that the target searches identified additional submerged sites, the plan was to concentrate on those. However, in the event that no additional sites were discovered, the back-up plan going into the project was to continue with intensive investigations at the wreck site discovered by Cook in 2003. Accordingly, when nothing significant was identified at any of the 30 targets, we changed our focus to the known shipwreck site, called the Elmina Wreck. The shipwreck site was systematically surface-collected, and a moveable 5 x 1 meter rebar grid was built to aid in survey and excavations. Problems with a dredge system[138] required that excavation was done by hand and sediments were put into a 30 gallon bucket that was raised to the surface for screening at the end of a level or dive (which generally corresponded).

A total of 26 1 x 1 meter units were excavated on the site (Figure 4.1). It is interesting to note that for the majority of the units, the sediment cover was rarely deeper than 30-40 centimeters, at which depth a solid concretion[139] was encountered. This concretion is consistent across at least the central area of the site, as it was noted in almost all the excavation units, and we presume it is iron-based, but did not attempt to

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[138] Different variants of dredges are typically used in excavations of submerged sites to remove excess sediments or overburden. The dredge was intended to be used in a similar manner on this project, but was unsuccessful.

[139] Concretions are masses of material that typically form in marine contexts. They can be the result of chemical reactions between items such as iron with the seawater, or can be conglomerates of different materials such as calcium carbonate build-ups. Most materials on submerged marine sites are concreted in some manner (particularly the metals), and in the case of this shipwreck, some form of concreted material appears to cover much of the extent of the main or central part of the wreck site. It is unclear at present exactly what factors contributed to its existence. The concretion is different in texture, appearance and hardness than the lithified sediments or bedrock in the area, which tend to be reddish or purple and soft enough to be easily broken off in the cores. The concretion is not penetrable and shatters any cores that came in contact with it. There is also no clear outcrop of the sandstone or lithified bedrock in region of the Elmina Wreck site. See Chapter 6 for further discussion on this.

investigate it further.[140] Because of the concretion across the wreck, I subsequently did not attempt to collect samples using coring in the center of the site. It is useful here, however, to highlight both the utility and the limitations the micro-sampling method. As noted in Figure 4.2, the sediment corer could not be used in the areas in which the concretion was present, as it simply snapped the cores. On the other hand, the cores also provided a means of testing the limits of this unknown feature, and provided us with significant information that other data sources, such as excavation, did not. Figure 4.2 illustrates the estimated extent of the concretion across the site based on visual observations, excavation data, and core data. Note that its extension in the northeastern quadrant is based on core data, which indicate that the concretion is buried closer to 50 centimeters and even deeper below the surface in this area. It should also be noted here that the concretion may or may not be as solid in this region as in others; what is known is that it is present in all of the areas where the cores were attempted and failed, or which caused damage to the cores as they were collected. Because the excavation units did not extend to the southern end of the wreck site, and it was known that close to the wreck there were obstructions, no cores were taken inside the southern quadrants of the site. As a result of this, the estimated extent of the concretion across the site extends only to the location of the known material.

The deepest excavation units were at the extreme ends of the excavation trenches (Figures 4.1 and 4.3), likely owing to the fact that there was either less structural or cargo

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[140] Because of the heavy scouring in the northern part of the wreck in 2009, an area of more than ten square meters of the concretion was visible. Even with the visibility, however, there was nothing noted that was diagnostic enough to indicate what its source may be.

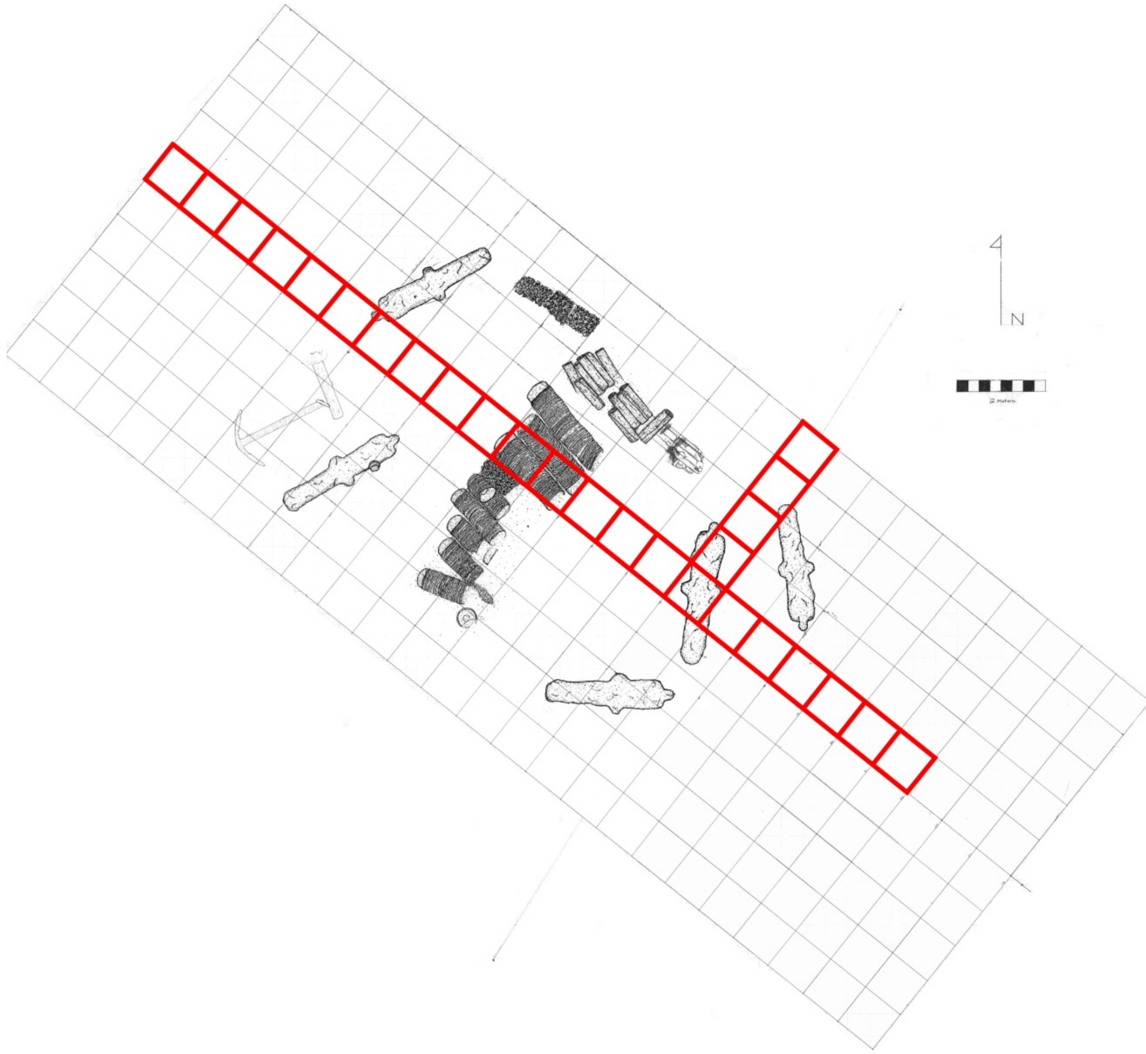

Figure 4.1. The site plan above was compiled by Pietruszka from the original site plan created by Cook in 2005, measurements taken in 2007 and 2009, and objects recorded by Horlings in 2009. This version of the plan does not include a collection of stacked basins in the southeastern side of the wreck site (see Figure 4.2), as they were mostly covered with sediment during the 2007 season. While it was not possible to collect sediment cores in the center of the wreck site, there is correlation between sediment strata observed in the excavation units and across the site, as recorded in sediment cores.

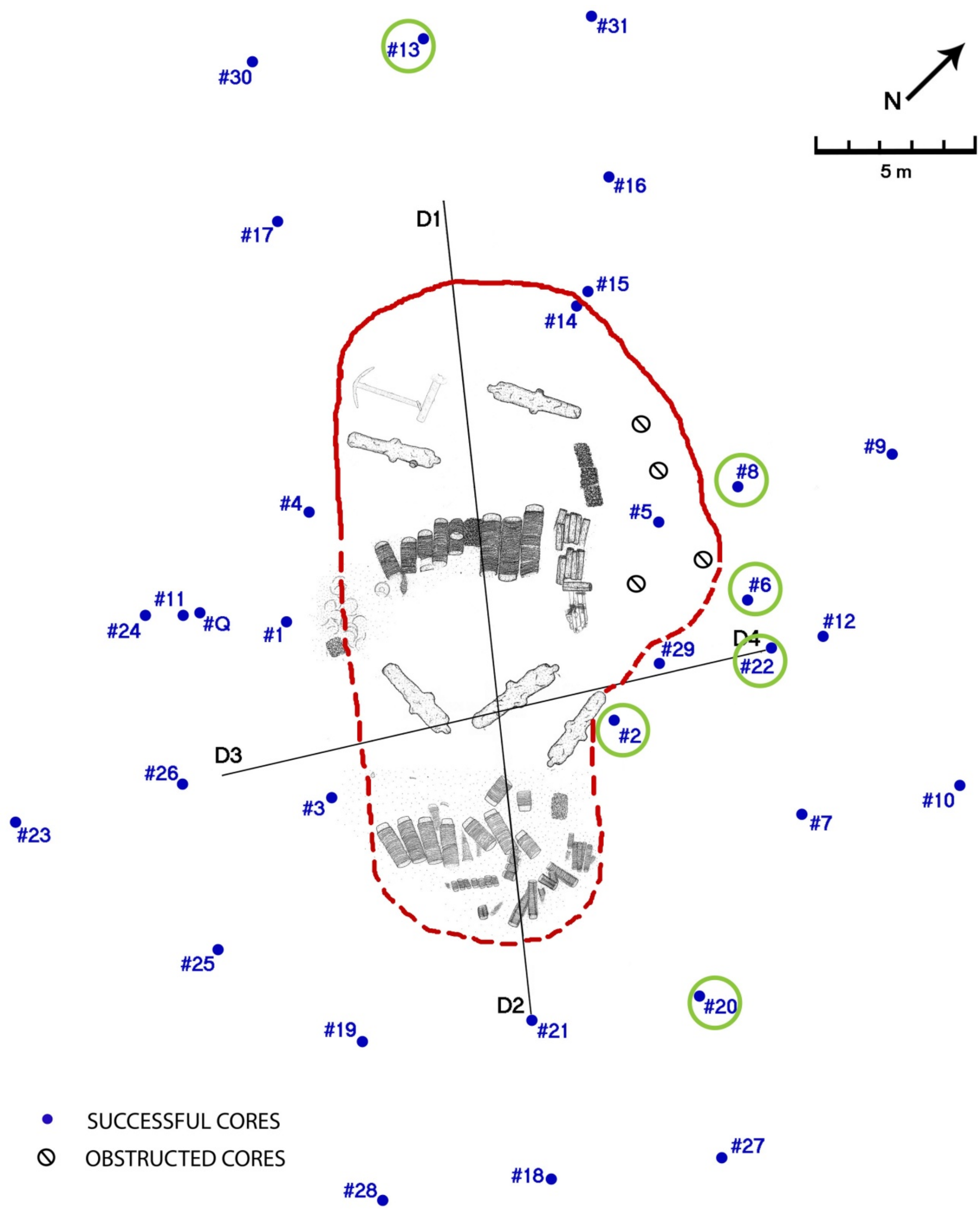

Figure 4.2. The distribution of cores in and around the wreck site was designed to build as representative a sample as possible of the cultural material at the site, evidence of site formation processes, and data concerning the local environment of the wreck. A solid concretion (outlined in red) through most of the center of the site, as well as large artifacts such as cannon and basins prevented us from collecting cores there. The dashed lines indicate the estimated extent and position of the concretion. Note also that all the wood (green circles) was collected on the eastern side of the site, some of which is just outside the estimated limits of the concretion.

Diagnostic Artifacts in Profile

S-N Profile looking West

AA11	Z11	Y11	X11	W11	V11	U11	T11	S11	R11	Q11	P11	O11	N11	M11	L11	K11	J11	I11	H11	G11	F11
					z/o/x, M	X, X			X, z/o, M			X, z/o, M	M	M	M	M		M		M	M
		M	M						M, z/o			z/o, M	z/o	X, z/o, M		z/o, M	z/o, X, M			X	
M																			X, Z, M	o/x, X, z/o/x	
																			X, z/o, o/x, M		
																			X, O, M		
																			X, z/o, o/x, M		

E-W Profile looking South

U15	U14	U13	U12
		o/x, X, Z, M	z/o/x
	X, M		
	o/x, z/o/x, M		

X	Denotes 19th century artifact
O	Denotes 18th century artifact
Z	Denotes 17th century artifact
M	Modern obviously intrusive material
x/o/z	Any combination denotes artifact type spanning indicated centuries

Figure 4.3. This schematic illustrates the number of levels excavated in each unit, clearly demonstrating the concretion covering the entire central area of the wreck which prevented deeper penetration in the units. Symbols illustrate the range of dates of artifacts currently associated with the wreck, as determined through the diagnostic artifacts recovered from each unit. While there is additional cultural material in the units, symbols represent only the presence or absence of artifacts of determined date ranges, not numbers of individual objects. It is noteworthy, however, that the greatest number of artifacts from a single unit came from H11 at the north end of the site; this may have implications for lading and/or formation processes active in the region and at the wreck site (i.e. Baker 1978). Artifact analysis was conducted by Pietruszka (2011).

material in those areas of the site. Artifacts were collected from the units,[141] and it was noted that there appeared to be considerable mixing of both modern and historical material in all of them (Figure 4.3). This mixing has significant implications for site formation processes on the wreck site and across the region, and is discussed in detail in Chapter 6. The most notable feature discovered in the excavation trench was what appeared to be a complete tree, including bark, branches and leaves. It has been identified as birch by Dr. Stefanie Kahlheber (see Appendix IV).

Sediment Cores and Micro-Sampling

The foundation of this research was the sediment cores collected at the site and at several control areas (discussed below). One of the emphases of this research has been the integration of various scales from that of the micro-artifact to stratigraphic layer to sites and all the way to the region (Courty et al. 1989:3; see also Hassan 1978:208-209). The primary tool used to navigate across and between these scales is micro-sampling through use of the sediment core, which provides both microscopic insights as well as indications of larger regional processes such as sedimentation and storm events. Originally adapted in this research as a means of measuring environmental variables, the sediment corer has also emerged as an effective means of sampling cultural material. While sediment coring is not a new technique to archaeology on land or underwater, the development of the technique of micro-sampling in association with sediment cores and post-processing analyses of both the sediment matrixes and the cultural material embedded in them is a new and unique contribution of my research.

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[141] Artifact analysis has been completed by Cook and Pietruzska; here I focus on site formation processes and an understanding of the archaeology of the event. As such, I refer you to Cook (n.d.) and Pietruzska's (2011) dissertations for full treatment of this topic.

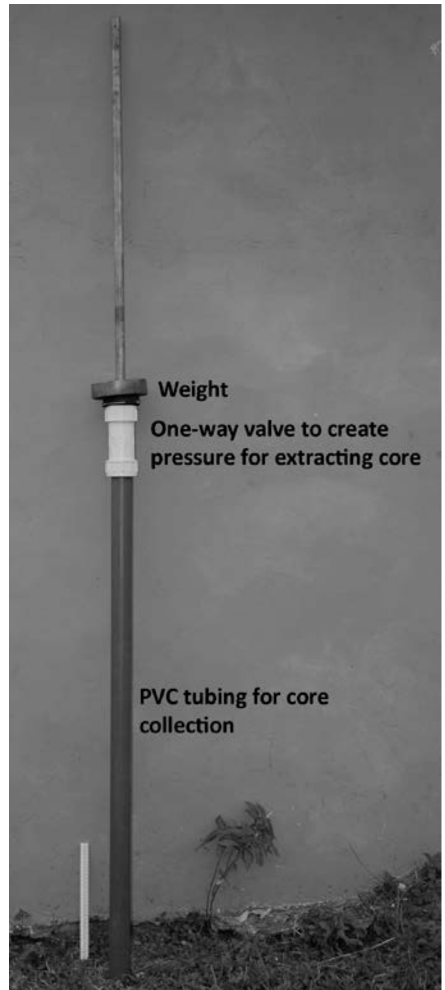

Figure 4.4. The total length of corer is more than 2 meters, rendering it unwieldy in heavy seas. Additional weights are used to pound in the PVC and removed before the core is extracted (photo C. Cartellone, 2007).

Using a modified version of a diver-controlled sediment coring device (Figure 4.4) (Horlings 2009), 32 sediment cores were collected in and around the shipwreck site (Figure 4.2).[142] The location chosen each core was determined by a number of factors. In order to collect a representative sample in and around the wreck site, the first cores were located as close to the center as possible. A number of cores encountered solid material (most likely concretion) somewhere in the sediments and shattered as a result. The clear presence of solid material at these locations meant that it would not be possible to collect cores there and cores were subsequently taken at a slightly greater distance from the main collection of wreck materials to prevent further problems. Known landmarks on the wreck site, such as the cannon that were prominent in the wreck material, were used to provide controls in terms of locating the cores, as the zero-visibility precluded visual confirmation.

To ensure consistency, a five meter or ten meter piece of twine with clips on either end was used – one end was clipped to the landmark in question, the other to the

[142] Details concerning the process of collecting the cores may be found in Horlings (2009) and in Appendix I.

diver taking the core; once the planned direction out from the wreck was established, the diver could simply transport the corer to the extent of the tether and collect the core.[143] The 5 x 1 meter rebar grid and the four main datum points were also used as known anchor points from which to collect cores. Once cores were collected throughout the five meter radius of the wreck site, the tether was extended to ten meters to ensure wider coverage. Evidence collected in these cores indicates that the extant of the wreck site was at least 10-15 meters beyond the surface scatter, implying that the ship itself was significantly larger than what is suggested from surface indications alone. In addition, a number of cores contained wood from the shipwreck, an exciting discovery because it was not anticipated.

Because it was not possible to preserve the complete cores for analysis upon return to the US, it was necessary to complete initial processing in the field. This procedure consisted of extruding the sediment from the PVC tube,[144] splitting the core lengthwise to reveal details of the stratigraphy, (Figure 4.5), physically delineating/ separating the strata, washing the silt and light sediment out of each strata by using a fine ($<{}^{1}/_{16}{}^{th}$ inch) screen, drying the remaining material, and bagging each strata separately (more details of field processing can be found in Appendix I). Photographs were taken at each stage of the process, and notes characterizing the different strata were taken while processing and augmented during later analysis. Detailed microscopic analysis of the

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[143] To ensure that the weights used for the corer were not lost, they were tethered together on a different line that was anchored at a predetermined location on the wreck itself and transported as a unit to the location where the core was collected. The incredibly rough conditions made it a minor victory every time a core was successfully collected and transported to the surface.

[144] Cores were stored vertically to make certain that they were kept in the correct orientation (Hardy 1997:407) and were extruded from the PVC from top to bottom.

material in the core was completed upon return to Syracuse University, and is discussed further in Chapter 6 and Appendix I.

Figure 4.5. Splitting the core reveals the complex stratigraphy of a site: the sediment color, texture and contents change with depth, indicating different environmental and cultural processes and events; sediment changes are highlighted by green arrows. The left side is the top of the core, the right the bottom (photo R. Horlings, 2007).

As mentioned previously, one of the goals of this field season was to develop techniques and tools appropriate for this environment, and the sediment corer proved to be invaluable in this regard.[145] Although the excavations and surface collections provided a great deal of information on the cultural remains of the wreck, they were far less informative concerning the event of wrecking, the condition and extent of the wreck site, as well as the abundant and dynamic site formation processes at work in this region. While they are less destructive than excavation, it is not suggested here that sediment cores should replace excavation, as it can clearly provide a great deal of information. What I propose is that coring provides a more efficient and less destructive means of

[145] Sediment core sampling has been used in archaeological investigations, albeit in minor roles, since at least the 1960s (Price et al. 1964; Girard 1978; Holliday 2004:31; Sheridan 1979; South 1978), but usually with complex and expensive coring techniques (Stanley et al. 2007, Webster 2008; see Gifford 1982 for an exception to this) that were not feasible on this project. My modification of a coring device designed for geological and lacustrine contexts (Horlings 2009) combined with my theoretical framework and application is entirely unique.

collecting data quickly, and supply comparable information to that collected from partial excavation, as well as different information than what is available through excavation. In addition, in an environment such as coastal Ghana, where equipment issues, weather, and sea conditions continually compound excavation efforts, having a reliable yet simple means of collecting data is invaluable.

The cores proved to be efficient conduits of information because they could be collected relatively easily and over a wide area. They provided significant information concerning site conditions, as well as limited information concerning cultural material at the site. Through initial processing, cores could be quickly referenced to provide information concerning locations for excavation. Finally, the tool for collecting cores is so simple that it does not require constant mechanical care or maintenance, making coring an even more invaluable method for investigations in a setting such as coastal Ghana. Data collected by micro-sampling (discussed in detail in Chapters 5 and 6**,** and Appendix I) with the sediment coring device became the backbone of my research in 2007 and remained a mainstay in 2009.

Control Areas

To help investigate the specific site formation processes at work in the study area and their effects on submerged archaeological resources, several controls and experiments were used that could provide quantitative data from which other interpretations could be made. Experimental archaeology has been relatively common in the terrestrial arena for some time (Dethlefsen and Deetz 1966; Hilton 2003; Schiffer 1985), and is becoming more common in maritime archaeology (Carrell 1992; Gibbins and Adams 2001; Keith 1992; Martin 2001).[146] One form of experimental archaeology involves off-site comparisons as a means of creating an objective comparative database of anything from sediment/soil formation to cultural site formation processes (French 2003:43; Holliday 2004:30; Stein 1985). Because one of my objectives in terms of formation processes was to understand them on both site-specific and regional bases, two different control areas were created to study the deterioration of cultural material, with the intention of monitoring the sites over a period of years. A more complete discussion of these experiments is available in Appendix V, but a brief summary is pertinent here.

Two sites were chosen: Control Area 1 (**C1**) was chosen based on its distance from any potential targets but close to an area of distinct ripple patterns on the seafloor and in deeper water than the known shipwreck (based on the 2003 side scan sonar survey); Control Area 2 (**C2**) was located to the east (downcurrent) of a potential target in much shallower water, closer to shore and within the heavy surf zone (see Appendix VIII for more of a discussion on these locations). Partial mock-up or model "shipwrecks"[147] consisting of bulkheads of different wood (70 x 38 x 30 centimeters) with a variety of cultural material placed inside were built, covered in tar, and positioned on the seafloor in the targeted areas. Because the wood was buoyant and the conditions were so rough, more than 40 lbs of rock (ballast) were positioned on top of each model to pin them to the seafloor. A piece of rebar was driven into the seafloor next to the models in the event that the models were covered with sediment or simply disappeared and we needed to relocate

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[146] Most experimental maritime projects have to do with site formation processes (Ward et al. 1999b), or the deterioration of various materials commonly found on shipwreck sites (Bastida et al. 2008; Elkin et al. 2007:52; Gregory 1995; Pournou et al. 2001).

[147] These were clearly not full-sized, but they were intentionally built in a form to mimic part of a bulkhead and hull of a vessel; while the models were small, the wood was more than four centimeters thick, which would have been comparable to different aspects of the wooden structure of historical vessels, and could also simulate parts of modern canoes.

the sites. We returned to **C1** three days after setting up the model and found that the wood and most of the artifacts were gone. A core was collected at the site and we never returned to it. We were not able to return to **C2** for two weeks, at which point there was nothing remaining on the seafloor anywhere near the site except for the rebar we had driven in. We returned at the end of the project and collected six cores in and around the control area site for environmental comparisons with the core data collected at **C1** and the shipwreck site; some results of the analysis and comparison are discussed in Chapter 5.

Shore Shipwreck

Local fishermen often anchor their vessels in the shallow bay outside of the Benya Lagoon as they are either preparing to go to sea or returning. There was a series of powerful storms in September, 2007, and during the night one of the fishing vessels broke anchor and was smashed on the rocky shore. I was informed by Papa Kofi[148] that in situations like this, none of the local people would touch the wrecked vessel or salvage

Figure 4.6. The keel of the fishing vessel was located relatively near the hull after initial wrecking, but less than a month later it was moved nearly 150 meters along the beach to the west. In that time the vessel's back was also broken, leaving only the bow intact and no other related material visible. In 2009 both elements were pushed further inland (photos R. Horlings, 2007).

[148] As mentioned in Chapter 1, Papa Kofi Arhin is a well-respected local fisherman who has proved instrumental, and indeed, invaluable in each of the field seasons conducted in Elmina.

any wood from it out of respect for the owner; as such the wreck lay naturally, and was not disturbed by human agents. I was able to monitor and photograph the wreck site for the next four months, and record the natural formation processes that continued to break it apart, remove loose timbers, and shift the positions of the various elements. At the end of the 2007 field season only two main elements – the bow and the keel – remained on the shore (Figure 4.6).[149]

2009: Things They Left Behind and How We Found Them

Background

As discussed above, one of the primary purposes for field work in 2007 was to continue and modify the survey for historical shipwrecks initiated by Cook in 2003. The fact that no additional shipwreck or submerged sites were located in the 2007 target survey was surprising on at least two accounts. First, some objects identified on the seafloor were easily correlated with targets in the survey data (such as large rocks), but in other instances no features were identified at target locations, and the complete lack of features was difficult to explain. Second, the archival record on historical shipwrecks directly associated with Elmina is limited, but records exist of at least five vessels sinking in the vicinity of Elmina, or along the Mina coast (Furley Collection Notebook 1646-

[149] A very short amount of time was devoted to continuing documentation of the shore shipwreck located on the north shore if the large bay area to the east of the castle. In accordance with what I had been informed concerning the prohibition on people interfering with someone else's property (Papa Kofi Arhin, personal communication 2007), it appeared that nothing on the two remaining elements of the wreck had been affected by human action. In fact, although the keel and bow were in slightly different positions and had been pushed further onto the rocks and beach, respectively, likely by storm surge, there was little perceptible change in wreck itself. This exercise of monitoring the wreck over a period of two years (a form of informal experimental archaeology) has provided some valuable insights into site formation processes in the near-shore and surf zone regions; however, it appears that the long-term benefits will come from observing it over a much longer period of time (as would be the case with a submerged shipwreck site). For this reason, little more will said concerning this in the remainder of this dissertation.

1647; Hair 1994a:94; Inikori 1996:64; Vogt 1979:110-112[150]),[151] as well as numerous accounts of vessels trading with the castle or passing by en route to other trading destinations. Based on this historic data, it was anticipated that there were both additional shipwrecks and other submerged sites or objects that were associated with sailing and trade region, but for various reasons we had not yet discovered or identified them. In addition, based on experiences from 2007, I suspected that one of the reasons we had not identified additional sites was due to the heavy sedimentation in the region; alternatively it may also have been the methodologies we were using. These ideas, framed within the idea of needing to investigate the formation processes that created and still affect (and possibly hide) submerged sites, formed the foundation for my 2009 field research.[152]

As has been discussed previously (Chapter 3), the west coast of Africa was known historically as a difficult and dangerous coast for sailing and it remains today an incredibly difficult environment in which to conduct maritime archaeological research. Due to various factors, the previous research seasons had been conducted during the rainy season, making conditions even more difficult. In an attempt to avoid those issues,[153] the 2009 fieldwork project was scheduled for October through December.[154]

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[150] Taken from Hakluyt, R. *The Principal Navigations, Voyages, Traffiques, and Discoveries of the English Nation* 6:216-230.
[151] I am grateful to Greg Cook for providing me with many of these references.
[152] Funding for this project was provided by the *Waitt Foundation/National Geographic Society* (grant W51-09).
[153] This was based on previous experience and on the advice of the local fishermen.
[154] I arrived in Ghana in mid-October in order to meet with the Ghana Museums and Monuments Board (GMMB), which provided the permit for research, to condition equipment and our survey vessel (a 28 ft Zodiac Hurricane), to connect with research partners, particularly Dr. Benjamin Kankpeyeng of the University of Ghana, and to handle other logistics before my volunteers, Darren Kipping, Casper Toftgaard, and Kira Kaufman, arrived. With the funds from the Waitt grant I was able to pay for Darren Kipping (M.A. in Maritime Archaeology from Flinders University) and Casper Toftgaard (Danish Navy Diver, Ship Captain, and Master's student in Maritime Archaeology in Denmark). Kira Kaufman (Ph.D. in Anthropology and SCUBA Instructor), financed her own trip in order to participate in the project.

Fieldwork

As mentioned above, the experience gained during the 2007 season and the results of data analysis formed the foundation on which I was able to build my field research in 2009. There were four basic goals for the 2009 season:

1. To re-survey Cook's original survey area as a means of creating a comparative data set, and to successfully use a magnetometer and echo-sounder in the region.[155]
2. To investigate targets identified in the new data.
3. To monitor the known shipwreck site and to build on the baseline shipwreck data collected in 2003, 2005, and 2007.
4. To continue to investigate formation processes and to identify the reason or reasons that no additional cultural material were discovered in the 2007 season.

Over the course of six weeks of fieldwork, we were able to accomplish each of the goals which had been outlined: a) we successfully used three forms of remote sensing over a period of two and a half weeks, spending six days with the side scan sonar, ten days of magnetometer survey and a single day of echo-sounder[156] work; [157] b) divers investigated 15 targets from the various remote sensing data sets (including data from 2003), completing 80 individual dives in approximately three and a half weeks, totaling nearly 66 hours under water, and identifying three sites associated with maritime trade

[155] Specific goals associated with this are discussed below.
[156] This was the first time that the echo-sounder had been used for archaeological research in Ghana, and was also the first successful use of the magnetometer.
[157] Challenges presented themselves with each remote sensing instrument, and engine issues on the Hurricane made diving from a canoe necessary on a number of days, but each of these problems was successfully addressed. The side scan sonar and echo sounder consisted of two separate transducers with one central processing system, it required the switching out of motherboards in the CPU and thus they could not be used simultaneously. Because of this, we reserved the echo sounder until the last day that we were able to survey, and used it only to monitor known sites as a means of building up a comparative database of how known targets appear in echo sounder data. The side scan sonar/echo-sounder had to be returned to Syracuse University before the end of the project. The remaining ten days of field time were spent doing magnetometer surveys and diving on targets. After the close of the research period, we processed cores, broke down equipment and prepared it for long-term storage, and hauled equipment back to Accra, where it is stored.

and navigation, although none was a shipwreck; c) we monitored the known shipwreck, as well as collected underwater photos and videos, and identified several unknown features of the site; and d) through environmental monitoring we were able to gain insights into sedimentation and formation processes across the region, made dramatic discoveries about the condition of the known shipwreck and several other sites, and also identified other methodological and environmental factors that may be affecting the visibility/discovery of additional cultural materials on the seafloor.

In addition to the remote sensing and diver surveys, sediment cores, used in micro-sampling, were collected at almost every location on which we dived.[158] In some cases when we were able to spend more time at a site, a number of cores were collected from a single location. Such an emphasis was placed on the cores because sediment cores and micro-sampling are keys to understanding this dynamic environment and its effects on submerged cultural resources both at the immediate and regional levels.

Remote Sensing Survey

Perhaps the most powerful tool available to the maritime researcher, particularly in an area about which little is known, is the extensive suite of remote sensing (also known as geophysical) tools that has become both more informative and more accessible (e.g. Garrison 2003:81; Sever 1995:84). As archaeology begins to place a greater emphasis on non- or minimally-invasive techniques, remote sensing is being applied in more varied ways and becoming a more powerful tool to answer an ever-widening array of questions (e.g. Dix 2007; Kvamme 2003; Mindell 2007; Murphy 1997b; Quinn et al. 2002; Ward et al. 1999b). These various instruments offer electronic glimpses of the

[158] Conditions were too bad at two of them to allow for core collection.

seafloor and sub-seafloor (Sever 1995:83), and provide the most efficient means of collecting data over large and small areas, usually in preparation for more intensive or focused investigations carried out by divers or other instruments (Quinn et al. 2002:415).[159] Like Cook, whose preliminary work in Ghana in 2003 also followed these established methodologies (Cook and Spiers 2004), remote sensing surveys and subsequent diver investigations formed the primary basis of research in 2009.[160] As the seas generally became rougher to the point of creating unworkable conditions in the early afternoon, most days we tried to be at the harbor by 6 a.m. in order to get as much work done as possible before conditions worsened.

As the means of accomplishing this, three different remote sensing instruments[161] were utilized: The Knudsen Side Scan Sonar and Echo Sounder[162] (320 B/P, side scan sonar 200 kHz, echo-sounder 20/200 kHz), and the Marine Magnetics magnetometer (Explorer s/n: 21073).

Goals of Remote Sensing – Discovery and the Environment

Five primary goals were outlined for the 2009 remote sensing survey:

1) To resurvey the area that Cook surveyed as a means of creating a comparative data set;

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[159] In particular, Remotely Operated Vehicles (ROVs); are often used on large, well-funded projects, and usually in deep water (>200 ft) environments (i.e. Ballard 2007, 2008; Søreide 2000).

[160] The project made use of the 28 foot Zodiac Hurricane for survey and diving and a rented local 30 ft canoe as a diving platform, tanks and an air compressor owned by the project for filling tanks, an *AirLine* Surface Supplied air system (purchased new for this project with Waitt funds), and each diver brought his or her own personal dive gear for the project.

[161] This suite of instruments is applied to maritime research whenever possible (Garrison 2003:81; see, for example, Sordo 2008).

[162] My original plan was to take a sub-bottom profiler to explore the substrate, but two reasons prevented this: the first is that Dr. Scholz (of Syracuse University) was concerned about its ability to penetrate the sandy sediments, which may have rendered it a pointless exercise, and the other was that the sub-bottom was a very large and heavy instrument, which would have been incredibly difficult and expensive to ship. According, since the echo sounder had the potential to provide comparable data, and was already part of the side scan unit, it was decided that this was the more efficient, economical and potentially productive instrument to take.

2) To use different instruments in addition to the side scan, also to create comparative data sets;[163]
3) To locate new submerged sites – based on both old and new data;
4) To test if improved weather and sea conditions allowed the side scan sonar to be used more efficiently to map, characterize and model the seafloor/environment;[164]
5) To evaluate what can actually be learned considering the disparate formation processes at work in the area from the remote sensing instruments I had available.

The choice of survey locales near to Elmina in the 2003, 2007, and 2009 seasons incorporated factors such as natural navigation hazards, known shipping routes and anchorages, specific historical accounts regarding the loss of vessels, and reports by local

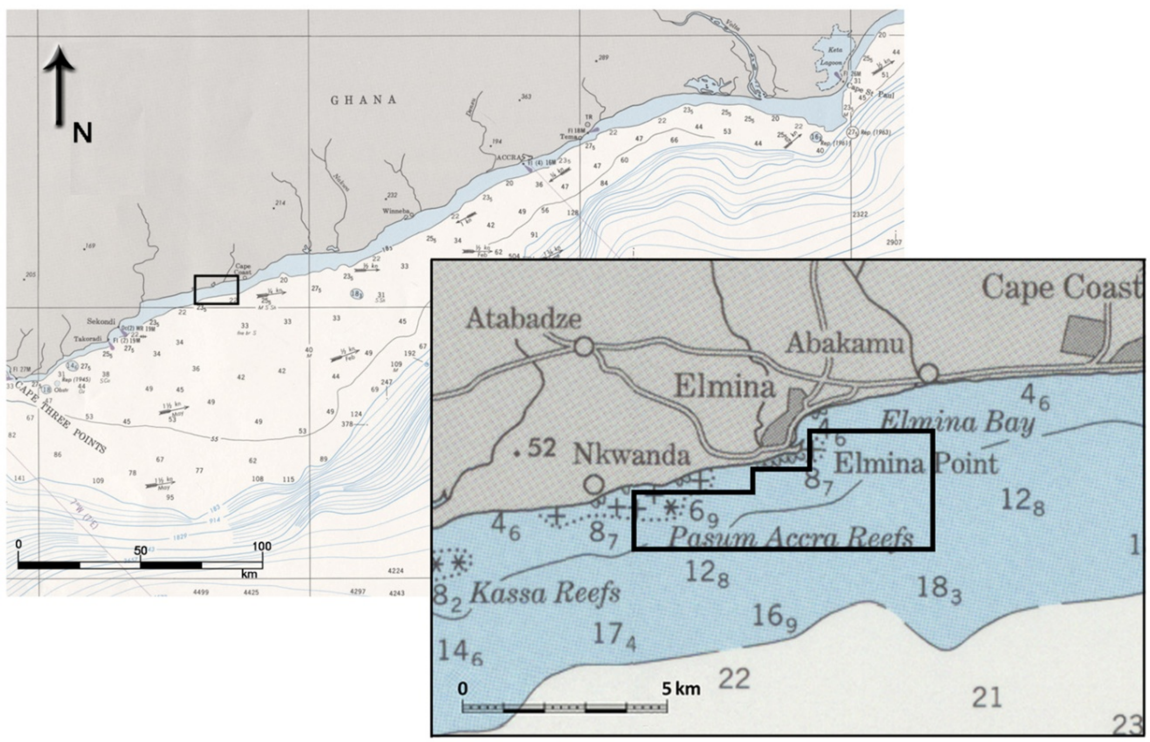

Figure 4.7. Cook's survey area, as well as the basic area surveyed in the 2009 field season, are illustrated on this 1996 British Admiralty nautical chart.

[163] Cook attempted to use a magnetometer in his survey, but for various reasons it was not possible, so he focused entirely on the side scan. As a result, my use of the magnetometer in Ghana is the first successful application of this technology for maritime archaeological purposes there.
[164] Because the sea conditions in which Cook collected his 2003 side scan data were so rough, much of the data is not useful in terms of accurately portraying features on the seafloor. I hoped to collect a calmer data set to use as a comparison and to be able to track sediment and seafloor conditions over time.

fishermen of seafloor net snags (Cook and Spiers 2004; Horlings et al. forthcoming), all of which potentially indicate submerged archaeological sites. Incorporation of these different sources of information, including data concerning features on the seafloor collected in the 2007, determined the primary locations in which survey and diver investigations took place in 2009, although the majority of the survey was focused on re-covering the areas originally surveyed by Cook in 2003 (Figure 4.7).

One of the advantages of having the opportunity to work in this area multiple times is that it provided the opportunity to hypothesize explanations for different phenomena observed in the region and then to test those hypotheses in the field. For example, returning in 2009 provided the opportunity to go back and test some of the targets that were hypothesized to have been covered by sediment during the diver investigations in 2007, as well as to test uninvestigated areas and targets.[165] In addition, data collected in sediment cores provided information concerning the nature of the seafloor and sediments in and around the wreck site and at **C2**. This provided the basis on which to continue micro-sampling and sediment analysis on the local site level, as well as on a regional basis.[166] Finally, intensive investigations of one area (the shipwreck) in 2007 provided fundamental information concerning shipwreck site formation processes, which helped to frame how I asked questions and went about answering them in 2009. Determining the appropriateness of the remote sensing instruments and methodologies

[165] The cycle of exposure and reburial of submerged sites is well known (Arnold et al. 1992:50; Muckelroy 1977; Parthesius et al. 2005:222; Simmons 1998:163; Williams 2006), but has not been investigated in coastal Ghana, and therefore is not well-understood there.
[166] The only site at which we were able to collect cores in consecutive field seasons was at the Elmina Wreck site, at which one successful core was collected in 2009. Repeated coring in a number of areas across the seascape will be an important part of future investigations.

used for these tasks is an ongoing process.[167] A final note on purpose concerns the continued search for submerged historical resources, including additional shipwreck sites. An integral part of the 2009 survey was to find a way of delineating and interpreting baseline information for wrecks and other submerged sites across the region, and results from that survey have furnished us with a great deal of invaluable data.

Remote Sensing

The side scan sonar and echo sounder consisted of a single processing unit and two different transducers which could not be used simultaneously. Because the echo sounder "looks" subsurface in a narrow swath that covers a limited area,[168] it was more efficient for the survey to focus primarily on the side scan sonar[169] and magnetometer,[170]

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[167] Dix (2007:17) also advocates that remote sensing data can be used in the development of conservation and heritage management strategies. While this is beyond the scope of this dissertation, I do touch on it with relation to sites in coastal Ghana in the concluding chapter.

[168] The echo-sounder is a variant of a sonar instrument that is designed to provide data on seabed types, textures and sedimentation or erosion conditions (Häkkinen 1995: 97; for an applied example see Quinn et al. 2002). It is used for collecting sub-surface (cross-sectional) data and providing a means for measuring sub-surface remains on archaeological targets. Results are similar to the data provided by ground penetrating radar typically used on terrestrial sites, which, incidentally has also been used for maritime archaeological surveying (Koponen and Grönhagen 1995). See Bass (2000:584), Frey (1972), Garrison (2003:82), Klein (1997b:406) and Mather (1999:179-180) for discussions on a similar instrument, the sub-bottom profiler, and its application.

[169] The side scan transducer sends out sound waves that essentially bounce or reflect off of objects on the seafloor and are then received or collected by the transducer upon their return (Fish and Carr 2001). The effect of this is to produce an "image" of the features on the seafloor based on the lengths of time it takes for the transmitted pulse to travel from the transducer and to return (Häkkinen 1995:97; see Church and Warren (2008), Johnson and Helferty (1990); Mazel 1985:1-2; Quinn et al. (2005), and Rodgers et al. (2006:37-68) for a more technical discussion of the analysis of these images). Analysis of these features then provides the likely physical and cultural targets that may be investigate through diver-truthing. As with all remote sensing instruments, a number of factors must be considered and accounted for before analysis, including, for example, accounting for scale distortion (Jones 1999:43). An interesting note, however, is that while the side scan is not *designed* to penetrate the seafloor (Garrison 2003:82), there is evidence that a certain amount of penetration does occur in certain circumstances (Johnson and Helferty 1990:362; Jones 1999:47). This can serve to confuse the investigator if upon diving at the site there is no surface indication of the target, and based on the remote sensing investigations that have been carried out thus far, it is *possible* that this is occurring in surveys in Ghana.This conundrum will only be solved through further investigations.

[170] In their simplified form, magnetometers work by essentially measuring differences (ferrous interruptions) in the earth's magnetic field (Garrison 2003:69-71; Mather 1999:179-180; Rapp and Hill 2006:114; Shope 1997). An understanding of the complex suite of factors including geographic location

which are both tools that can be used for larger area surveys and have been used in concert for many maritime archaeological projects (e.g. Garrison 2003:81; Klein 1997a:384-385).[171] As a result, we used the echo sounder only to investigate specific sites on one day towards the end of the project. The side scan, which covered a 100 meter swath of the seafloor, and magnetometer,

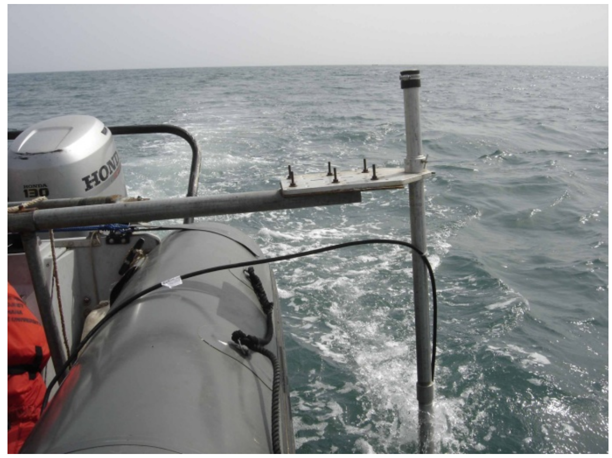

Figure 4.8. The elevation of the side scan transducer could be adjusted as necessary and was positioned in the water so that the hull of the zodiac did not interfere with the signal (photo K. Kaufman, 2007).

which covered approximately 30 meter in a swath,[172] were used simultaneously as much as possible for the duration of the survey period, or about two and a half weeks. This was possible because the two instruments are separate units: the magnetometer was a towed transducer and the side scan sonar was a fixed system,[173] requiring a solid support system

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and diurnal variation in the earth's magnetic field, as well as the susceptibility contrasts of different materials (objects) that affect the outcomes of magnetic surveys is important to maximize the effectiveness of their interpretation (Aspinall et al. 2008; Jones 1999:173). Magnetometers have been used to locate such small items as artillery shells to much larger things such as anchors and cannon, and it is often possible to tell from the magnetic signature (its strength and display) what type (size or magnetic intensity) of feature the signature may be representing. Because they can detect the presence of buried material, when they are used in conjunction with an instrument such as a side scan, researchers can determine whether there is a surface signature or not, and from this can decide the best way of investigating the anomaly. Dive-truthing for magnetometer targets involves the same procedure as for side scan targets.

[171] The use of multiple remote sensing tools is highly recommended for providing the most efficient returns from survey, particularly when different scales of investigations are involved (Forsythe et al. 2003; Garrison 2003:79-80; Häkkinen 1995; Kvamme 2003; McManamon 1984).

[172] These settings can be adjusted for different purposes and environments, but these were the settings at which we used the instruments. The quality of the data collected across the swaths also differs, with the best detail available closer to the transducer, and the information becoming more difficult to interpret further away.

[173] Because the side scan unit was fixed and could not naturally compensate for ocean movement, it was affected more by rough seas than the magnetometer, although it generally performed much better than expected in all but the worst seas.

that could be fixed to the survey vessel and the instruments therefore did not interfere with each other (Figure 4.8).

There were some significant problems with the remote sensing instruments. While it was intended that the magnetometer and side scan sonar be used in concert to produce complimentary data, the configuration required that both the magnetometer and the side scan sonar sync with our GPS. Unfortunately, as we were not able to test the magnetometer with our GPS before arriving in Ghana, we did not discover that our GPS was too old and that the magnetometer could not sync with it, so the magnetometer data are not geo-referenced and therefore cannot be directly related to the side scan sonar data. To compensate for this and still collect useful data, the magnetometer was used as an auxiliary instrument to the side scan. When both units were running, "hits" on the magnetometer were marked on both the magnetometer and the side scan sonar data for cross-referencing, and a mark was taken on the GPS to record it. Notes were taken for each of the instruments, including the GPS mark number so that targets could be correlated. On days when it was necessary to use the magnetometer independently, notes were taken on paper, on the magnetometer data, and with the GPS, always noting the distance of the magnetometer behind the vessel and its subsequent relation to the target and GPS mark. The magnetometer was used for ten days for survey, including some surveying of specific sites or locations to build a database of comparative magnetometry signatures in the region.[174] The side scan sonar was somewhat more temperamental than the magnetometer, and we were only able to use it for six days of survey.

[174] One of the things that we were trying to learn and develop was a methodology for using a magnetometer in coastal Ghana. Because the earth's magnetic field is not constant across the globe, it may be distorted by various features including man-made and natural things, such as high concentrations of iron in the sediments (Hocker 2000b:642), and it was necessary to be able to determine areas in which there were

One further consideration for the survey is that while we were able to use each instrument's manufacturer's software for reviewing targets, we did not have access to a post-processing software package, which limited in-field analysis. Essentially what this meant was that we were not able to directly correlate targets on the different instruments with each other, and it was not possible to see the overall big picture of what we were doing. For example, using the software available to us, we were able to compare specific targets or sites identified in the 2003 side scan sonar data set with some of those collected in 2009. This gave some insights into the presence/absence of targets on the seafloor and comparison between different data sets. An additional example of this is that we monitored our survey areas using the GPS, which allowed us to see where we had surveyed in the past, but did not show which instrument was used in which area. In addition, it did not distinguish between targets taken as hits on the magnetometer or other marks, such as those indicating the end of a survey line. While this system worked, it was far from ideal and any future field work should absolutely include a substantial post-processing software package. This will provide not only a comprehensive compilation of data and a big picture perspective, but also to allow in-field comparisons with past data sets and more productive in-field analysis of targets.

As stated in the goals section, the first goal of survey was to cover the same areas that Cook had covered in 2003 as a means of comparing the data sets (c.f. McManamon 1984:242). This was important because: a) we were working at a different time of year with the assumption that the data would be more clear; b) we were working six years later, leaving ample time for there to be significant effects from formation processes in

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legitimate targets, and areas that were more affected by natural phenomena. While there is a great deal left to learn concerning this, we were able to make significant headway in understanding the earth's magnetic field in this region and the magnetometer's response to it.

the region; and c) it would provide a concrete means of analyzing remote sensing data sets in the region – baseline data that had been subjected to detailed analysis with which to compare remote sensing data in the future. In addition to covering much of the same area, we also explored regions that had not previously been affected, particularly areas to the east and west of the original survey area. This was important because it expanded the area that had been surveyed at least once, including more of the areas in which historical vessels were likely to have anchored. We were particularly interested in identifying any "new" sites that might lie in these zones.

Our use of the echo sounder was the first application of this instrument in maritime archaeology in coastal Ghana. Because of the process involved in switching the motherboards for the side scan sonar and echo sounder we used the echo sounder only one day. Unfortunately, for some reason on this day the unit would not sync with the GPS, so the echo sounder data is not geo-referenced. However, since we were mostly interested in testing its usefulness in this environment, we decided to collect the data anyway. We tested a total of 14 sites, some of which had magnetometer signatures, some of which were side scan sonar (from both 2003 and 2009), and some had both. We crossed each site with the echo sounder at three different headings, collecting data for 100 meters on either side of the center target/location. Some targets had clear signatures, while others were less clear, and some had none at all.

Diver-Truthing of Targets

Although remote sensing tools offer insights into the features of the seafloor, it is impossible to really understand what is happening without closer investigation of sites (Quinn, Forsythe, et al. 2002). Diving to investigate targets is known as diver-truthing and is the standard way of investigating targets in shallow water environments. Goals of diver-truthing were to identify any "new" sites, to collect data on the environment of the region, and to collect sediment cores in as many locations as possible[175] (discussed in more detail below). Table 4.1 below summarizes each of the sites on which we dived, as well as the most pertinent information for each of them. Additional dives were conducted on the different sites that were discovered.

As was the case with diver investigations in 2007, some problems and potential problems were associated with diver-truthing in 2009. The first was that, although sea conditions were significantly improved in 2009, currents were still extremely strong and visibility was usually very low, if not zero. This again made it difficult to conduct circle searches, particularly if using the surface supplied air unit, which caused extra drag on the diver.[176] The lack of visibility made it imperative that the diver be very aware of any features that could be felt on the seafloor, such as scouring or differences in sediment composition, that could provide information on sites or objects that were there. In addition to this, some of the searching methods were still problematic, particularly the tendency of the reel line to float, thus missing any object sitting proud of the seafloor. While we did not have the time or resources to fix this problem while in the field, it will be both necessary and advantageous to come up with either a different system or better line on the reel that will prevent that issue. Until we are able to dive with visibility on every dive to enable the diver to actually see what the reel is doing and what features are

[175] The intention behind collecting the cores was primarily to collect subsurface data on the targets on which we dived and not for the sole purpose of site discovery (contra McManamon 1984:253-255).
[176] While in some ways it was easier to conduct the searches only on SCUBA, it was safer in rough conditions to have a direct line to the surface (the unit's hose). In addition, since there was a lot of physical exertion involved, which meant harder breathing and the need for more air, it was both more convenient and far safer to have a constant supply that would not run out, as opposed to relying on the finite source that could be stored in a SCUBA cylinder.

actually visible, it is not possible to attribute the lack of discovery of additional sites solely to this problem. However, it is likely that this has played a significant role in the past, that sites have been missed as a result of it, and that the problem will persist until more effective methods or tools are devised.[177]

One solution that we tried to fix or minimize this problem was making the search circles smaller to ensure that the line remained taut and that a full circle could be made. However, there were also problems with this approach, the most significant of which is that for various reasons, GPS coordinates are often off by 15 meters or more.[178] This typically means that even the marker buoy is consistently dropped at the same target coordinates, it is uncertain how close to the target the buoy is actually located, necessitating the incorporation of up to 15 meters of survey area simply for potential errors in GPS coordinate positioning. In an attempt to ensure coverage and compensate for this, on most sites we tried to complete concentric circles out to 50 meters, but in the process likely miss a good number of targets.[179] Regardless of whether the coordinates are off by five meters or 15 meters, smaller circles (less than 15 meters) are ideal; the problem is that, like the larger circles, it is likely that circles that were too small also missed targets. A secondary problem was that because there were problems coordinating

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[177] An additional methodological phenomenon that we encountered occurred at Waypoint **397**. Divers following their compasses thought that they had made complete circles around the buoy, but it was obvious on the surface that they had not – in one case the diver did not complete more than half of a circle. One explanation for this may be the extreme currents, but I suspect that this is not the entire explanation, and suspect rather that there was significant ferrous material buried near where the divers were, which would have thrown off the compass and therefore confused the circling diver. Perhaps hand-held metal detectors would be the best tool to use in sorting this out, but whatever it is, I recommend reinvestigating the site at which this occurred.

[178] At least two factors are involved here: the use of different GPS systems in collecting data (Cook's 2003 survey) and in investigating targets; and variations in tropical atmospherics that impact GPS accuracy and precision (Kim and Tinin 2007).

[179] We experienced this at the Single Anchor Site, discussed below, where, although our coordinates showed us to be positioned directly on top of the site, we were more than 15 meters off and re-found it only after extensive searching.

the GPS to the magnetometer, any targets that we investigated that were solely based on magnetometer readings had to be carefully recalculated to compensate for the difference between the position of the transducer and that of the GPS taking the mark. Consistently geo-referenced magnetometer data will significantly improve this situation.

Results of the Surveys

Sixteen targets (including the known shipwreck site) were investigated in the 2009 season (Figure 4.9; Table 4.2). Each target was selected based on distinct remote sensing signature (from data collected in 2003, 2009 or both), and was investigated using

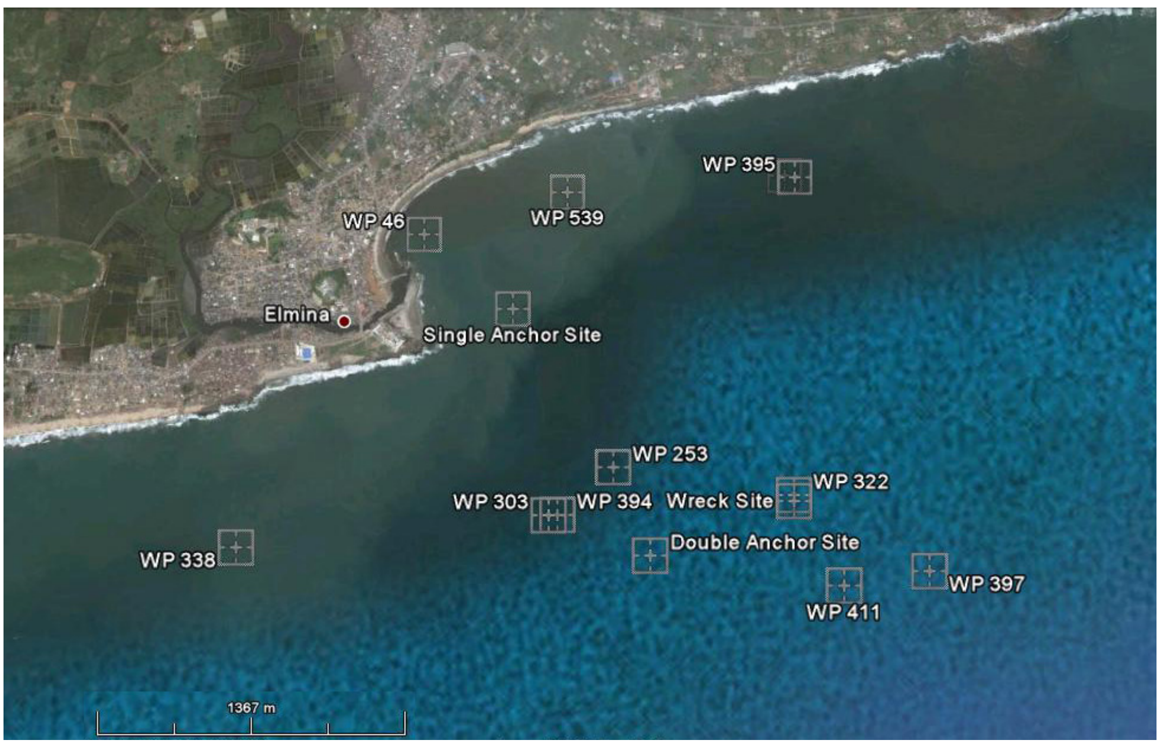

Figure 4.8. **Superimposing the locations of the targets on this GoogleEarth image provides not only perspective of the sites in relation to each other, but also to the shore and surrounding seascape. The target designation “WP” refers to the waypoint # by which each site was identified. The Chain Site is located 10 kilometers to the west.**

Target	Signature Source	# Dives	Methodology	Core	Results/Comments
Elmina Wreck Site	side scan sonar (2003, 2009); magnetometer; echo-sounder	8	survey; photo; video; measure; probe	1	documented additional cannon, anchor, and feature; documented site sedimentation
Waypoint **46**	magnetometer	3	20m and 45m circle searches	2	no cultural features identified; very hard packed sediment made it extremely difficult to take cores
Waypoint **303**	side scan sonar (2009) and magnetometer	2	circle search out to 50m		no cultural features identified; found a scour 50m SE of buoy and took Waypoint **394** there
Waypoint **394**	none - diver observation	2	circle search	1	no cultural features identified; found only two shallow 2m-long scours
Waypoint **397**	side scan sonar (2009)	4	22m and 45m circle searches; probing	1	no cultural features identified; on two search dives diver never made it between about 0 and 140° - possible that there was compass interference; site is very sticky black mud; probing and core did not reveal any cultural material in the sediments
Waypoint **395**	side scan sonar (2009)	1	22m circle search	0	no cultural materials identified; found and drew a rock
Waypoint **398**	side scan sonar (2009)	1	circle search	0	no cultural materials identified; found and drew rocks
Waypoint **322: Near Wreck Site**	magnetometer and echo-sounder	3	45m circle search; probe	1	site is located near the shipwreck and Waypoint **326** (not dived); core hit something about 4 ft down, but nothing was located in later probe survey
Waypoint **338**	side scan sonar (2009)	2	45m circle search	1	no cultural material identified; black silt covering the site
Waypoint **537: Double Anchor Site**	side scan sonar (2003); magnetometer	23	circle search; probe; photo; measure	6	dived in 2003; located two anchors; probed around site thoroughly but found no additional cultural material; dug near smaller anchor
Waypoint **538: Near Single Anchor**	side scan sonar (2003, 2009)	4	25m and 45m circle search; probe	1	no cultural feature identified at target; found anchor 25m from buoy, so took Waypoint **541** there
Waypoint **539**	none	3	5m, 10m, 15m circle searches	1	no cultural feature identified; working on search methodologies - testing shorter reel line; nothing at site
Waypoint **253**	side scan sonar (2009) and magnetometer	2	circle searches	1	no cultural material identified
Waypoint **555: Chain Site**	magnetometer	5	circle and random searches; mapping	0	chain snapped over reef; very strange sandstone reef environment; most covered by sediment and difficult to follow
Waypoint **541: Single Anchor Site**	side scan sonar (2003, 2009)	6	probe; measure	1	did limited and unsuccessful digging around fluke; initially 50cm of fluke visible, one week later it was only 20-25cm; no other associated materials
Waypoint **411**	magnetometer	2	45m circle search	1	no cultural material identified; difficult conditions, so core taken 20m from buoy; nothing at site

Table 4.2. Of the sixteen different sites or targets that were dived in 2009, three were identified as being submerged sites associated with historical maritime trade, and one was the Elmina Wreck, known since 2003. Sites at which no cultural materials were identified provided information concerning the seafloor and other features, such as rocks, offering insights into the wider submerged environment of coastal Ghana.

the standard circle search methodology.[180] There are several possible explanations for the sites where nothing was noted on the seafloor, including errors in coordinates or location, sediment coverage, or artifacts in the data.[181] While at this time it is impossible to determine why no features were identified at some of these sites, this is part of the process of trying to understand this dynamic coast and developing the methodologies most appropriate to maritime archaeological research there.

At three of the targets on which we dove, however, we did discover new sites, each of which represents a separate event related to maritime trade in Ghana. The identification of these sites brings the known submerged maritime sites in Ghana up from two[182] to five, which represents a significant increase in both numbers and varieties of known sites. A brief description of each site and the work we did there follows; limited interpretation and discussions may be found in Chapter 5.

The Single Anchor Site

This target was identified in Cook's 2003 side scan sonar data and was dived on several occasions in 2007, although nothing was discovered at the site. In 2009 it was also noted in the side scan sonar data and re-dived, this time resulting in the identification of historical cultural material. The site consists of a single anchor that appears to have been set, and is located approximately 400 meters ESE from the Elmina Castle, just inshore of a large natural sandbar at the southern end of the Elmina peninsula and in

[180] This site was discovered prior to experimenting with smaller circle searches, and was in fact the impetus for it.
[181] In remote sensing terminology, an artifact is actually an artificial feature in the data which could have been created by any number of things and often looks convincing, but in reality does not represent an actual physical feature (e.g. Clarke et al. 2006:2; Schmidt et al. 2010; USGS 2011).
[182] The other two known sites are the Elmina Wreck site, discovered by Cook in 2003 (Cook n.d.), and timbers from a vessel discovered by dredgers in the Benya Lagoon in 2007 (see Pietruzska 2011).

approximately five meters (16 feet) water depth (Figure 4.10). Only a single fluke was visible above the sediments; it measured approximately 50 centimeters across, suggesting that the total size of the anchor is likely between three and four meters in length (Cotsell 1858:14-17; Curryer 1999:49; Rubin 1971:237). Although this site is located in the area relatively protected area on the lee side of the sandbar and near the Castle, which should

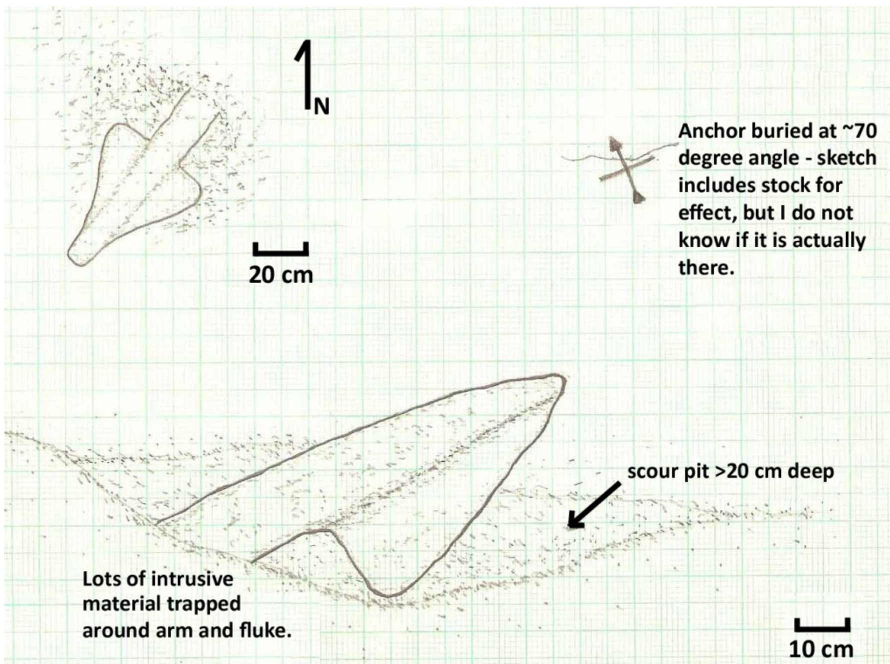

Figure 4.10. Conditions at the Single Anchor Site did not permit photo documentation, so drawings provide the best visual description. When we found the sight 50 centimeters of the fluke was visible above the sediments, but one week later only 20-25 centimeters could be seen, a testament to the dynamic nature of this environment (sketch R. Horlings).

suggest easier working conditions, its location in the near-surf zone made conditions difficult, and usually meant that there was little to no visibility. The location of the site in a zone heavily affected by surf made the process of collecting cores significantly more difficult, but analysis of the cores has provided invaluable data concerning the local processes at work in this region, as well as in terms of cultural material (see Appendix I and Chapter 5 for more discussion on this). Interestingly, when we discovered the site, approximately 50 centimeters of the fluke was visible above the sediments, but upon our return one week later only 20 - 25 centimeters was visible, a testament to the dynamic nature of this environment. It is possible that there is more cultural material associated with the anchor, but as we were not equipped to excavate and made little headway with the methods that we did attempt, any additional material at the site remains unknown.

The Chain Site

The second site was discovered during the 2009 magnetometer survey carried out in an area not previously surveyed or investigated along the coast to the west of the Elmina Castle. It is located approximately ten kilometers west of the castle in a shallow bay separated from the sea by a rock reef nearly one kilometer long, which lays in an east-west orientation, parallel to the coast. Approximately inshore 50 meters from the lee side of the reef, near the only possible inlet into the bay coming from the west,[183] we discovered a very large anchor chain (Figure 4.11) lying approximately five meters water depth. The chain measures at least 18 meters long, with links measuring more than 19 centimeters in length, and more than five centimeters in diameter in section; one end of the chain consisted of a link that had been broken or cut, and the other had a ring with a diameter of more than 30 centimeters. Poor visibility did not allow an assessment of whether the chain was cast or molded. The lack of studs in links[184] and the presence of a ring as opposed to a shackle on the end suggests that it could be of early 19th century

[183] This is the predominant direction of wind and current, and is the most likely entrance for a vessel coming into the natural harbor area.
[184] In addition, the lack of studs may also suggest that it would fall into the category of “heavy chain” as opposed to “chain cable,” something that may help with identification in the future (Gale 1955:196).

construction (Curryer 1999:90-106; White 1995:21),[185] although this does not mean that it was deposited at this location at that time. It appears to have been either snapped over the reef, or cut and discarded,[186] and is firmly concreted to the sandstone bedrock below it in a configuration that suggests that it was pulled taut and then suddenly released.

The seafloor environment in the immediate area of the chain is one of the most unusual I have ever seen. The bedrock is visible over much of the area (which is strange, as most places along the coast are sandy), with the large reef rocks rising from one to over two meters in the background (when facing seawards) and the bedrock littered with smaller sandstone rocks that appear to have eroded off the larger reef rocks. There are areas with piles of the smaller rocks in configurations curiously reminiscent of ballast piles from shipwrecks, but on closer inspection it appears far more likely that they are simply natural collections of sandstone. Just west of the chain site, apart from a few of the larger reef rocks, the area is completely covered in sediment and looks like much of the rest of the submerged landscape along the Elmina shoreline. We were not able to explore the area beyond about 50 meters east of the chain due to time and weather constraints.

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[185] As will all aspects of historical maritime interactions, the sizes, styles and uses of chain varied between nations and with time, but it is generally accepted that the first chains were not used for sailing or watercraft until the very beginning of the 19th century (Gilman et al. 1902:339); after this time they slowly gained acceptance, and by the middle of the 19th century were used regularly, particularly by naval vessels (Curryer 1999:90-106).

[186] Anchor chains are less flexible and more cumbersome than hemp cables, which most historical vessels used. It is not possible to tell at this point whether the chain snapped from strain, as discussed in the following quote, or was cut to free the vessel across the reef. As Pering (1819:77-78) writes, "[m]oreover, it is to be observed, that a chain is a series of connected links, separately inflexible, and when thrown from a straight line will form as many angles to the length of each separate link. The larger the chain the longer must each link be formed, and, in proportion to their increased length, so will it diminish in strength. When bitted, and passing through a hawse-hole, the link will frequently extend beyond its bearing point, forming a fulcrum, and a lever thereon, in proportion to its extension." On the other hand, as noted by Brande and Cauvin (1842:177-178), anchor chains were excellent for use in rocky environments.

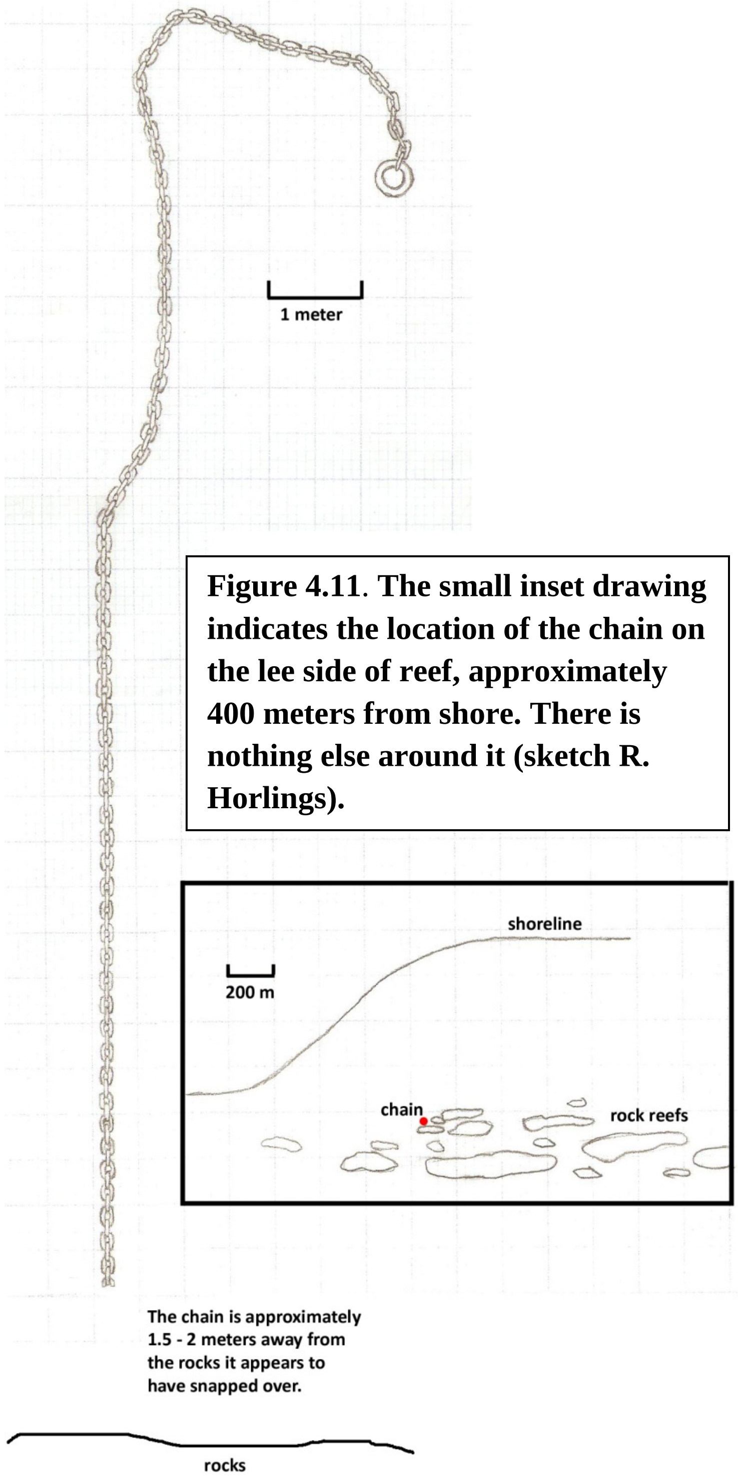

Figure 4.11. **The small inset drawing indicates the location of the chain on the lee side of reef, approximately 400 meters from shore. There is nothing else around it (sketch R. Horlings).**

Three meters of the chain were visible on the bedrock, but the majority of it is covered by more than 30 centimeters of sediment. The sediment was hand-fanned away in order to follow the chain, but new sediments re-covered the chain in seconds, making it extremely difficult to map in high turbulence and low visibility waters. Interestingly, there is a ring on the end of the chain, but no anchor is present. It is possible that this ring was originally the end attached to a vessel[187] and the snapped end to the anchor, but without further investigation it is difficult to say. While it is not possible to determine exactly the size of vessel that was involved in this incident, it must have been large enough to manage both the weight and cumbersomeness of the

[187] Or some other object, discussed in Chapter 5.

chain, clearly with some form of winch. It is difficult to imagine why such a large vessel was in the vicinity of the reef, particularly on the lee side in extremely shallow and dangerously rocky water. The lack of shipwreck evidence in the area suggests that it did, indeed, escape, but how such an escape could have been executed is a mystery. It is possible that the remains of the vessel are still located nearby, but if that is the case, they are well hidden either under sand or among the rocks of the reef.

An alternative explanation for both the Chain Site and/or the Single Anchor Site may be that their deposition in their respective locations was not actually related to a shipping incident, but may rather have been associated with some other aspect of navigation, such as a marker buoy or other floating platform. During the later 19th and early 20th centuries the British invested in infrastructure to support the growing palm oil trade and steamships (DeCorse, personal communication, 2011; see also Lynn 1989), and it is possible that the anchor and the chain may have been incorporated into some sort of navigational aid, such as anchoring a marker buoy or floating platform. Certainly, their locations in areas clearly inhospitable to vessels makes this an interesting idea, particularly since at present we have no indications of attendant shipwrecks. That being said, however, the locations are equally as problematic when considering that they represent, for example, marker buoys, as both the single anchor and the chain are located on the lee sides of physical barriers in rough and shallow water, and therefore would have been completely ineffective in warning vessels of imminent danger.

While theorizing as to what conditions may have created these sites is important to an understanding of the logistics of trade and navigation, it is important also to consider that all of these sites represent events that were integrated with the broader historical seascape. Understanding these different scales, from individual events to the history of an entire seascape, is at the heart of this research. One final site, which also represents an unknown scenario, is presented below; continued discussions of each of these sites and their integration with the Elmina seascape are presented in Chapter 5.

The Double Anchor Site

The third site identified in 2009 was also a side scan sonar target noted in the 2003 data and dived in 2007 because it was a prominent and promising target (see Chapter 5). Interestingly, when it was dived in 2007, the anchors were actually discovered but were not identified as anchors, and so the site was not considered historically important. It was re-dived in 2009 because it was also a prominent magnetometer target; on the initial dive a diver discovered a great deal of fishing line (rope) and net, but it was not attached to anything. The presence of the line indicated that there was likely something there to have caught it, however, and so the site was re-dived and the anchors discovered. This is just one example of the many factors at play in this research: the survey area may have been located just far enough away from the site (due to GPS inaccuracies) that the diver encountered an object on the seafloor, but there was no indication of why it was there. If the decision had not been made to return to the site based on a hunch that something was entangling the line, it would once again have been checked off a list and no further information recovered from it.

The site is comprised of two anchors with their shanks standing (relatively) vertically out of the sediments, which is particularly strange, since anchors are *designed* to tip over (Pering 1819:59; Thomson 1902:1401); their arms and flukes completely buried. The anchors are located approximately two and a half kilometers directly south of

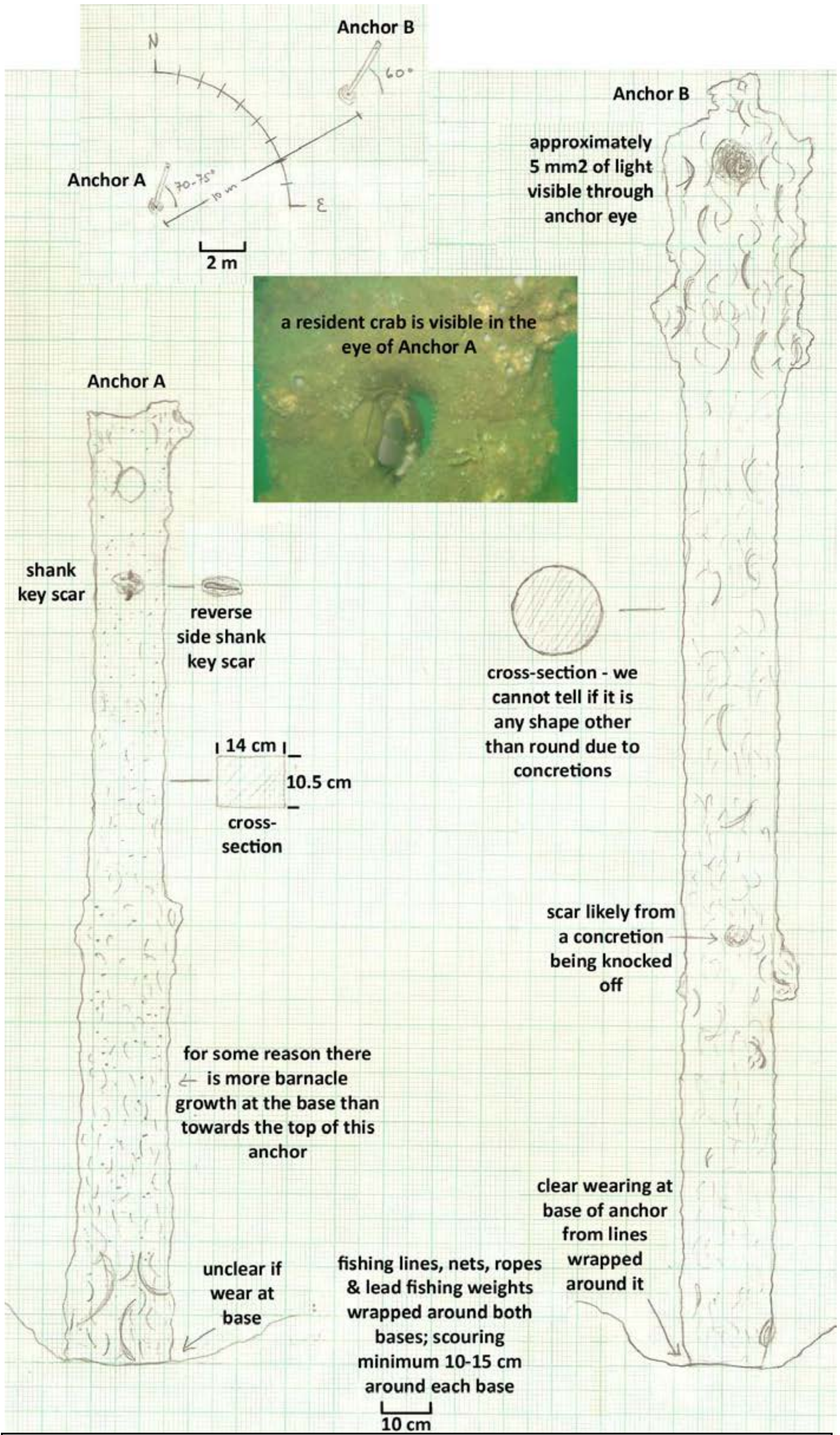

Figure 4.12. The anchors positioned in a vertical stance on the seafloor is highly unusual, suggesting that a unique set of circumstances or events contributed to their current conditions (sketch and photo (2009) R. Horlings).

the Elmina Castle in 12 meters of water. The anchors are two different sizes; the smaller of the two stands nearly two meters out of the sediments, while the other stands approximately 2.65 meters above.[188] They are positioned ten meters apart and oriented in the same direction, indicating that they are associated (see the inset image in Figure 4.12). The anchors would have had wooden stocks, as indicated by the scar on the smaller anchor (the area of the stock is obscured by barnacle growth on the larger). It is also interesting to note that neither anchor had a ring in it, which is also unusual, as they tend to survive relatively well in the marine environment due to their thickness/size, and it is unlikely that they would have been intentionally removed before being lost.[189] The differences between these anchors do not preclude them from being linked; in fact, it was a regulated practice on European vessels for the main starboard anchor to be the largest, with the port anchor second in size, but generally drastically smaller (Pering 1819:63-64; Rubin 1971:233; Tinniswood 1945:87; Upham 2001:13).

Even once it was determined (in 2009) that the site was indeed culturally significant, it has proved difficult to understand and interpret. The presence of two anchors standing up from the sediments unsupported is so unusual that there is no parallel incidence of this yet found. The basic assumption upon discovery of this site was that since the anchors were still vertical, there was likely ship structure between them that had supported them long enough to allow them to set in the sediments, even as the wood from

[188] In cross section they are rectangular and round, respectively, both of which are standard forms for 19th century anchors (Cotsell 1858:98), but also appear to be common in anchors from before and after that (Rubin 1971).
[189] It is possible that there were shackles on the anchors as opposed to rings, in which case the pins were often made of a different metal than the ring and tended to corrode more easily, which would have lead to the shackles falling off (Cotsell 1858:4); if that is the case the anchors are likely later 19th century. Similarly, if the rings were of a different composition, they could have fallen off as well, but this is not possible to determine without further investigation of the site. In the more unlikely event that the sites represent an intentionally created offshore mooring system, the rings may have been intentionally removed before deposition; even in this instance, however, it is difficult to see why they would have been removed.

the vessel gradually disappeared. However, there is no additional cultural material located on the surface either between or around the anchors. In order to determine if there was cultural material below the sediments, six cores were collected at the site, and extensive probing was conducted (in one location to nearly three meters below the sediments) in and around the site (Figure 4.13). In addition, a small test hole was dug[190] adjacent to the smaller anchor

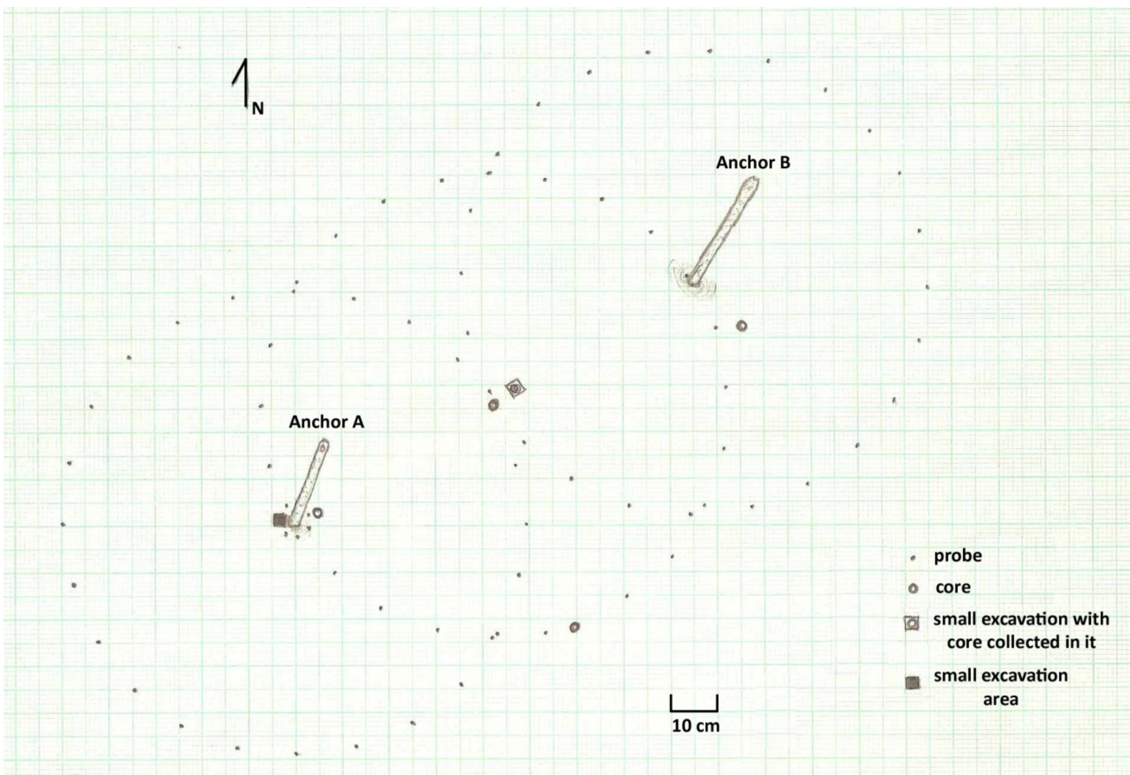

Figure 4.13. The site was probed in a five meter radius around each of the anchors and from a center point between them. Just off-center between the cores a hole was dug to approximately one meter, then a core was taken in it, and then it was probed to between two and a half and three meters, but, as with the probing, but no cultural material was encountered. Six cores were collected at the site, but the exact location of the first one is not known, as the anchors had not yet been discovered when it was collected (sketch R. Horlings).

[190] Excavation was difficult, as the anchor was completely entangled with modern fishing line, weights and shell that collects around such objects. The test hole was approximately 15 centimeters across and approximately 50 centimeters deep.

to investigate any material near it; in the process it was discovered that that simple action had loosened the anchor significantly, so it was immediately halted. Each of these tests produced only negative results, and it was concluded that there is no additional cultural material present at the site. Potential interpretations of this site are offered in Chapter 5.

Surveying in Review

The goals of the remote sensing survey in 2009 included a re-survey of the area covered by Cook in 2003 using side scan sonar as well as magnetometry and echo sounding, and to investigate natural environmental and site formation processes through remote sensing. Related to this was an evaluation of how conducive different weather patterns were for remote sensing research. Data sets from 2003 and 2009 were compared while in the field, although this effort was less effective than it could have been with a comprehensive software package. Using the instruments in conjunction with each other was still a powerful tool, as we could compare for instance magnetometer and side scan sonar signatures even as we were collecting the data, and could use that to determine the most important targets to dive-truth. While not much time was spent with the echo sounder, it was enough to provide an additional data set on the known shipwreck site that can be used for comparative purposes in the future and to help created a data base of how other known sites, such as a large rocky area, appear in echo sounder data. While the echo sounder is clearly a much more limited instrument in scope than the side scan sonar or magnetometer, it is an excellent tool that should be used in the future and further developed.

We dived on both new targets identified in 2009 and on targets from the 2003 data, some of which were also investigated in 2007. In addition, we also dived on at least one site that we were quite certain was not a cultural site (Waypoint **395**) as a means of verifying what it actually looked like on the seafloor as compared to its remote sensing signatures. This information can in turn be used in the analysis of remote sensing data in the future, as we have more of a foundation on which to base interpretations of remotely collected data from this particular environment. Part of the comparative analysis of the various remote sensing instruments and environmental data it is useful here to discuss specific points concerning the investigation of sediment changes in the region over time.

Tracking Sediment Changes

While it has been known by visitors for centuries that this was an incredibly dynamic coast, it is difficult predict or confirm from extant literature exactly what that means in quantifiable terms and at the scale of specific near-shore regions/environments such as near Elmina, or even smaller scales such as a shipwreck site.[191] Additionally, while a great deal of equipment exists to scientifically track sediment movement, types, and textures, things which can directly answer some of these questions, funding constraints have not to date allowed for their use in this context.

Three things that were feasible, however, have been done in an experimental method of tracking changes to provide a rudimentary dataset: sedimentation observations were made at the known shipwreck site over a period of four years, data collected in sediment cores from across the Elmina region has been analyzed for information

[191] For instance, while conducting field work in 2007 there was a dredging operation in the Benya Lagoon, and both from speaking to the dredgers and making our own observations, there were significant visible changes in sediment levels on a daily basis at the mouth of the lagoon and in related sandy areas (see Verlaan and Spanhoff (2000) for similar observations at the mouth of the Rotterdam Waterway, although the mechanisms there are likely very different). The siltation of harbors in Ghana was noted by Dickson (1965:111) as being a serious impedance to the dredging and construction of harbors at both Sekondi (west of Elmina) and Accra (east of Elmina) in the early 20th century.

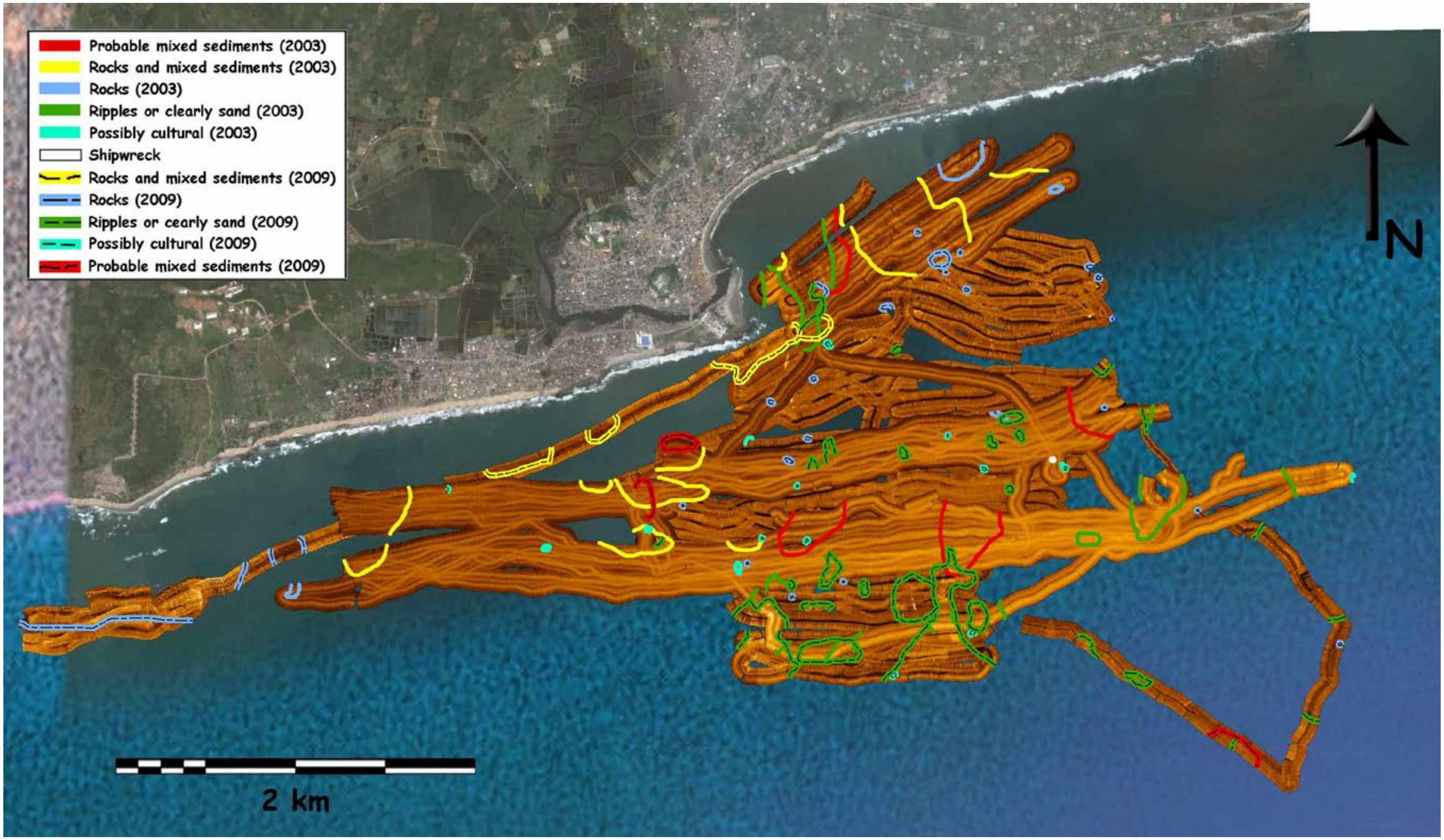

Figure 4.14. This composite image shows both side scan sonar surveys with their geological interpretation overlaid on a GoogleEarth image of the Elmina area. Note the distinct areas with geological features related to the peninsula and the Benya lagoon output.

concerning sedimentation[192] (discussed in Chapter 5 and Appendix VIII), and side scan sonar data sets from 2003 and 2009 were compared using Chesapeake Technology's SonarWiz program and ArcGIS. As can be seen in Figure 4.14, the major areas of distinct sedimentation in the survey areas appear to have remained *relatively* consistent in terms of sediment composition over time, indicating that while there may be seasonal differences in intensity and direction of movement, the factors that control the creation and maintenance of these features appear to be constant (see Appendix II for in-depth discussions of these). This observation implies that if an area is analyzed in terms of oceanographic elements, shore features, and weather elements, over time it may be possible to predict the condition of sites in a particular area, and possibly to predict the likelihood of being able to identify sites based on whether or not the sediment has lessened in one area or another. This is clearly contingent on continued observations and studies in the region, but one immediately apparent example of this may be found in the sedimentation epic of the Elmina wreck site.

Monitoring the Elmina Wreck Site

Based on observations of the shipwreck site and environment in 2007, I had three goals for monitoring the wreck site in 2009:

1) To check for any disturbance of the site, including attempted looting or damage from dragging anchors;[193]

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[192] While I have completed this analysis to the best of my knowledge, it will benefit in the future from a professional geological and oceanographic analysis, and I hope in the future to work with such a multi-disciplinary team that can provide more thorough and informed answers to some of these questions.

[193] In 2007 several Chinese fishing vessels nearly dragged anchor directly over the site; fortunately we were there and were able to prevent it by convincing the vessels to anchor elsewhere, but there is no guarantee that this is not a common occurrence in the present, and it is likely that similar near-misses occurred in the past. It is also interesting to note that larger vessels still anchor in the same roadstead that was used during the Atlantic trade and use local canoes for ferrying between ship and shore, an indication both of the lack of a sufficiently deep harbor to accommodate larger vessels, and of the approximate location in which vessels would have typically anchored in the past.

2) To monitor any sediment changes or any other results of local site formation processes at the site;
3) To continue the process of correlating the original site plan created in 2005 to features visible at the wreck site.[194]

I maintain that consistent monitoring of a site is crucial to studying and preserving cultural heritage, so while we were not able to allot a great deal of time to accomplishing these goals, we were able to conduct a total of eight dives on the site. Amazingly, for two of those dives we had at least two to three meter visibility for at least a portion of each

Figure 4.15. The eel in the image on the left lives between stacks of the basins; amorphous concretions can be seen on the seafloor in front of the eel. The image on the right is a close-up of a concreted barrel of manilas, one of the trade items on the vessel. The wood from the barrel has long since disappeared, leaving only the concreted manilas.

dive,[195] and we were able to collect both still and video documentation of parts of the site (Figure 4.15).

[194] While Cook and his team did an amazing job creating the site plan in 2005, conditions during the field season were dismal at best, making the job incredibly difficult. In 2007 a significant amount of time was spent re-taking measurements and bearings of objects in an attempt to correlate them with the site plan, but conditions were only marginally better, making the task also very difficult. It was hoped that in better conditions later in the year in 2009 we would be able to take some measurements and bearings to continue to improve the site plan.

While it was expected that there would be some sedimentation of the shipwreck site, I was not prepared for the drastic changes that had occurred on the site in just over two years. As can be seen in Figure 4.16, the site was nearly two-thirds covered in sediment and looked so different that I was tempted to believe it was a completely different wreck site. The sediment was clearly being deposited on the WSW edge of the wreck and moving across the site, eventually covering much of it with more than one meter of sediment – enough to obscure three cannon entirely from view. In addition, while sediments had been deposited on what amounts to the leading edge (and eventually middle) of the site, after depositing their sediment load the currents had scoured more deeply the NNE and eastern portions of the wreck.[196] In this process a number of different features were more exposed than they had been in the 2007 season, including numerous amorphous concretions and an anchor and cannon in the north portion of the site (Figure 4.16).[197] In addition, it revealed one feature that had not been recognized before, a unique object that has yet to be conclusively identified.

[195] Visibility would often change literally by the minute, and it was completely unpredictable when this would happen. As a result, the images and video were usually shot in the process of accomplishing some other goal, such as surveying the site or investigating unique features.
[196] As is discussed further in Chapter 6, while there is scouring at present on the north side of the site, as soon as there are no more objects sitting proud of the seafloor that can act as current disruptors (the reason that the north end is being scoured), the sediments will simply fill in any voids and the site will be covered up.
[197] I had identified them by feel in 2007, but it was not until 2009 that their existence was visually confirmed.

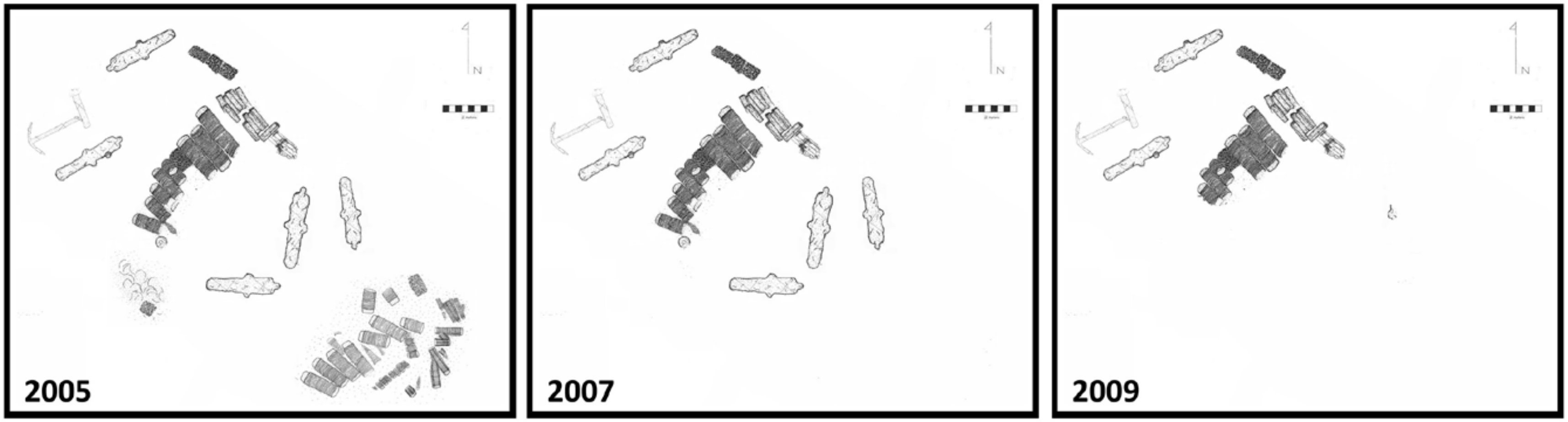

Figure 4.16. This composite image (re-modified from the image in Figure 4.1 by R. Horlings), illustrates the changes occurring at the Elmina Wreck site over a period of four years. It should be noted that in the 2005 image the anchor and small cannon (NW corner) and the object positioned just south of the lead rolls, were not identified, and therefore it is not possible to know whether or not they were exposed; they are illustrated here because they are clearly associated with the site, whether or not they were fully visible. The anchor and cannon were identified in 2007, but not verified until 2009, and the object by the lead rolls was not identified until 2009. In my two seasons at the wreck site (2007 and 2009), I was able to observe changes in the locations of scour: in 2007 there was significant scour underneath the central southern cannon, but there did not appear to be extensive scouring elsewhere; in 2009 the scouring was north of the rows of basins (center of the site).

There were no obvious signs of recent *intentional* disturbance of the site.[198] However, one feature had obviously changed since the last time we were on the wreck. During the 2007 season we had constructed a 5 x 1 meter rebar grid to assist with surface collection, mapping and excavation, but had not been able to retrieve it at the end of the field season. In 2009 it was discovered that the end had been pulled up and folded backwards, likely by a fisherman's anchor, and it now rises approximately one and a half meters out of the sediments and its end sits approximately one meter above the seafloor. Ironically, it is likely that if trends continue, the shipwreck site will be entirely covered by sediments in the next several years, and unless it is further disturbed, the remnants of this grid will be the only indicators of the site's location. Further observation of the grid showed colonization by barnacles and is providing clues as to the process of benthic colonization of submerged sites. This is discussed further in Chapter 6.

While there was some visibility we were able to take some measurements of different features, including the anchor and sixth, previously unmapped, cannon, to use in comparison with the measurements collected in 2003 and 2007, but we were not able to spend a great deal of time in that task. Some time was also spent on the examination of intrusive and "loose" material visible on the wreck site, including the character and location of each object. These data are particularly relevant to an understanding of the site formation processes of the site, and, as is shown in the following chapter, to the

[198] Although there was an obvious indication that it is clearly visited regularly when our marker buoy was stolen from the site, something that had also occurred in 2007. Fishermen in the region are keen to fish there because it acts as a natural reef and attracts a variety of marine life (see Chapter 6 and Appendix III). Fishing there is risky, however, as the site often entraps nets and fishing lines, which is obvious from the amount of fishing material on the site. Incidentally, the fishing line and nets trapped on the site are one of the greatest dangers for a diver, as it is extremely easy to become caught by them or have equipment tangled in them and the diver must always be attentive and ready to cut him or herself free to prevent serious entrapment. Having improved visibility at the site greatly reduced this risk.

identity of the site itself. Four potentially diagnostic historical artifacts[199] were collected from the wreck site for conservation and analysis.[200]

In order to study the sediments that had been deposited on the site, we attempted to collect two cores, both in locations where cores had been collected in 2007, as a means to compare the material in them. Although it was difficult to tell while taking the core, it appears that we struck some sort of concretion or solid object while collecting the core on the north side of the wreck, rendering the core useless, but were successful with the one on the south side. In addition to the cores, we used the probe to measure the depth of sediments over the site on the south side as a means of quantifying the rate at which the site was being (re)buried.[201] Results of this core analysis, as well as of the other cores that were collected, are discussed in more detail in Appendix I.

A final observation concerns the original assumption that working later in the year, in the dry as opposed to wet season, would significantly improve both surface and sub-surface conditions. It is indisputable that this was indeed the case, particularly since the roughest days we experienced in 2009 paralleled the best days we experienced in 2007, but conditions were still difficult. For instance, while we did have five or six days when there was visibility reaching two meters or more at times (a *significant* improvement over zero visibility), it was inconsistent even on the best of those days, making it difficult, for instance, to find, photo or video sites. In addition, there were very

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[199] Consisting of one bottle, the base of a ceramic vessel, part of a stoneware jug, and a partial pelvis exhibiting what appear to be cut butcher marks.

[200] As mentioned previously, the cultural significance of artifacts is less significant to this discussion than it is for Cook's work and Pietruszka's work, so collection of those artifacts was more for the collective understanding of the shipwreck itself than for direct application to this research.

[201] Based on known cycles of exposure and reburial of other wreck sites (Muckelroy 1977; Parker 1980:57) Simmons 1998:163; Williams 2006), observations concerning burial and scouring at the Elmina Wreck site combined with evidence for mixed material culture at varying depths within the site, it is assumed that this is a cycle at this site as well. Chapter 6 discusses this in more detail.

few days in which the seas did not kick up to well past two meters in height, making survey in particular difficult or impossible. Currents were also unpredictable, and at times were so strong as to prevent divers from being able to move on the seafloor. Some of these issues may have been related to the abnormal weather the region was experiencing, but it is difficult to tell. Finally, while conditions will always depend on location (surf zone versus deeper water) and tides, it is highly recommended that the next maritime research project in coastal Ghana is carried out in the very early spring, when in theory things should be even calmer.

Multi-scalar Micro-sampling

Because micro-sampling is at the heart of both the theoretical and methodological frameworks of this research, a discussion of the premises and methods of micro-sampling is useful here. The collection of sediment cores forms the foundation of micro-sampling and investigations into site formation processes and historical events is built on this base. The concepts and methodologies of micro-sampling through the collection of sediment cores were developed in 2007 and formed the basis for much of the material analysis of data collected in that season. It then formed the basis of the research design for the 2009 project. As discussed earlier, because no additional shipwreck sites were discovered in 2007, the focus of investigation was the Elmina Wreck site, which provided an excellent opportunity to test and refine micro-sampling techniques and concepts. Although there was material visible on the surface of the wreck site,[202] it was recognized that there was a great deal more to be learned from what was below the surface than we were able to learn solely from the surface collection/ investigations and limited excavations carried out at

[202] Since we did not have other sites to compare to in 2007 this is the assumption that was made, although it was not tested. We were able to test it in 2009 when we did discover new sites.

the site (e.g. Dunnell and Dancey 1983:269; [203] Simmons 1998:165). Because time and funding restraints did not permit what may have been the ideal situation of full excavation,[204] the simple but effective tool of sediment coring (micro-sampling) offered insights into what lies below the surface, and in fact provided data at both at a local or site-specific and a regional basis.

Micro-sampling, as I have developed it, is based on the fundamental principles and techniques of geoarchaeology and multi-scalar methodologies (e.g. Dalan 1993; French 2003; Rapp 2000; Rapp and Hill 2006; Rosen 1993; Stein 1993).[205] The aim of this technique was to understand human and nature interactions within the seascape by means of an investigation of site formation processes[206] and an exploration of the events associated with the wrecking and post-wrecking processes of the shipwreck. Essentially, I used basic concepts to try to explore the local and site specific, as well as the wider, regional seascape, and to understand historical maritime trade within the seascape context.

This exercise resonates with the somewhat elusive concept of microhistory (discussed also in Chapter 2), which, as explained by Walton et al. (2008:4), "underscores the need for local perspective in understanding global patterns and wider narratives, as well as offering unique insights into phenomena and patterns that may lie

[203] See Sullivan 1998 for a somewhat contrasting view on surface artifacts as site signatures.
[204] By this I am not claiming that every shipwreck discovered should be fully excavated, but as this is the first historical shipwreck discovered in coastal Ghana, it would be ideal to be able to fully excavate it as a comparative base for future investigations. The prohibitive costs of extended fieldwork and conservation, as well as a growing emphasis on non-invasive investigations are sufficient reasons to not fully excavate the site at present, although in the future it is possible that at least a more thorough excavation will be able to answer many of the questions raised through the limited research that has been conducted (see Cook (n.d.) and Pietruzska (2011) and provide other types of data concerning shipwrecks in this region in general.
[205] See Appendix I for a brief discussion of geoarchaeology.
[206] Formation processes, which geoarchaeological techniques are used to examine, affect things both at the surface and under the sediments, particularly because most sites (shipwrecks, anyway) that may have subsurface components now, originated as surface sites.

outside macrohistorical[207] narratives or flatly contradict them." This is particularly applicable to micro-sampling because, as the authors continue,

> "[a]ppeals for grounded and eventful history risk descending into trivia or nostalgia. To confront this pitfall, microhistory claims, explicitly or implicitly, to illuminate more general truths, wider patterns, or at least to draw some analogy to other cases. In the best of circumstances, microhistorical studies reveal in fine-grained detail how larger processes operate, how the case serves as a useful hypothesis for exploring other cases. The microhistorical place, event, or personage may function – to borrow Clifford Geertz's recent simile – 'like a magnetic field passed through iron filings' to arrange and chart seemingly random scatters of historical debris" (Walton et al. 2008:5).

It is precisely this that micro-sampling is designed to accomplish: micro-sampling is a means of making microhistory tangible. It is a tool for accessing both the minute and the grand, both the natural and cultural, and both the physical and historical. While it is clearly not the only means to interact with microhistory, in a setting where very little is known concerning either the micro or the macro history of historical maritime trade and the tangible remains from it, it is a concrete and practical means of using an archaeological toolkit to investigate history.

The practical heart of this is the concept of what it means to actually "micro-sample." First, it entails sampling/collecting what amounts to a small vertical section of a much larger area (i.e. approximately two horizontal inches out of a 25 m^2 area). Then it means a characterization of the sediments and their positions in the column, including stratigraphy to understand site formation processes, contexts of the shipwreck site, and the environment. Finally, it is an analysis of the materials embedded in it, particularly

[207] An example of this in terms of the likely burning of the Elmina Wreck is discussed in Chapter 6.

those with cultural significance. Data collected in this manner can then provide information concerning specific locations within or around the site, similar to shovel tests in terrestrial contexts, and some extrapolation can be done from this about the site in general. It is from these tangible materials and practical methods that information concerning a range of scales and data sources can be accessed.

Micro-sampling in 2009

We took sediment cores on nearly every site on which we dived, collecting in total 18 successful cores (see Table 4.1 above). Most of the cores were collected at sites across the survey zone, unlike in 2007 when the majority of the cores came from the shipwreck site itself. [208] The premise behind this was that we could collect data concerning the environment and site formation processes across the region, and also use the cores as a back-up for confirming the presence or absence of sites or objects. While this second intention did serve as a means of interpreting sites in the field after the cores were processed,[209] most of the data collected from the cores was the result of the microscope analysis conducted after the close of field work (discussed in Chapter 6).

Finally, a simple tool, which can be considered a variation on the micro-sampling methodology that we employed at a number of sites, was a 1.75 meter rebar probe. This was used on targets that appeared to be promising in the remote sensing data but for which nothing was discovered on the seafloor. It was also used to investigate the Double Anchor Site, the Single Anchor Site, and the shipwreck. This is a simple but effective tool (Skowronek and Fischer 2009:90) that not only provided information concerning

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[208] Unsuccessful cores, primarily encountered at the shipwreck site, are considered those in which for some reason there was no sediment in the core upon retrieval, the core hit something and so had to be moved, or some other condition such as surge prevented a core from being fully taken.
[209] Cores were processed in the field in the same manner as the cores in 2007.

presence/absence of artifacts, but also helped to monitor sedimentation and other natural formation processes at different locations.

Geoarchaeology is essentially the use of geological ideas and techniques to answer archaeological questions (Rapp 2000:237). The combination of diver observations, the collection of sediment cores, and some use of a sediment probe served as the tool kit that allowed the extraction of data ranging from cultural to environmental and local to regional, and it is the way in which those data are interrogated both in the field and in post-processing that provide insights into archaeological queries.

Post-Processing

The primary field data processing techniques used have already been noted, primarily, some analysis of remote sensing data with basic, instrument-specific software packages, and the initial processing of cores to allow them to be shipped back to the US for detailed analysis. Each means or method of data collection in the field requires different post-processing and analysis before the data can be interpreted and integrated into larger pictures of historical maritime trade and the environment of the seascape. The following brief discussion outlines the two data sets that have provided the foundational information for this dissertation, namely, analysis of the cores and of remote sensing data. Multiple additional analyses were completed, including, an analysis of artifacts from cores, botanicals, flora and fauna, and pXRF analysis. These different data sets are important, but as the focus here is on the cores and remote sensing data, they are more fully discussed here; discussions of each of these other avenues of inquiry are included in Appendix IV.

Two other unique avenues of inquiry should be noted, as they have contributed in unique ways to this research. First, analysis of still images and video footage collected in 2009 has provided significant insights into a number of aspects of submerged sites; these images are displayed throughout the dissertation, and the analysis itself is discussed in Appendix IV. Second, as mentioned in the Introduction, documentary research conducted by historian Eric Ruissenjaar into historical archives in the Netherlands has provided information on a vessel called the *Groningen* that wrecked off the coast of Elmina in the mid-17th century. While there is no conclusive evidence that the Elmina Wreck represents the remains of the *Groningen*, this study has provided a concrete history of a vessel that appears to have wrecked under very similar circumstances in a very similar location, and has been useful in tailoring my research questions and investigations for this project. This is discussed in somewhat more detail in Chapter 6.

Cores

Two primary forms of post-processing were necessary for the sediment cores, not including the analysis of materials recovered from the cores. The first consisted of creating a drawn profile of each core which depicted the characteristics of each stratum (Figure 4.17). The drawings were based on the initial determination of stratum character made in the field while post-processing; for the most part these are accurate, although in a number of cores the characterization may be noted as different after the microscope analysis of each stratum. Profiles for the cores allow for both visual comparison of strata as well as for observations concerning site formation processed and the environment in different locations (whether in and around the wreck site or elsewhere).[210] The second form consisted of microscopic analysis of each stratum of each core.[211] Characteristics of each stratum were recorded, including grain size and weathering, biota,[212] artifacts, and modern or obviously intrusive material. Each category was removed and bagged separately to allow for future analysis. After separation categories of objects or artifacts collected in the cores were considered to be their own entities and were treated individually in further methods of post-processing and analysis. As will be discussed later, one of the most dramatic types of evidence collected in cores (from 2007) was wood from the hull of the vessel. Among the evidence provided by the wood was a confirmed *terminus post quem* date for the vessel in the middle of the 17th century.

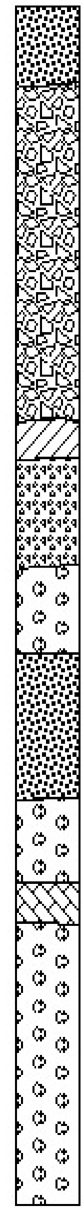

Figure 4.17. **Even without detailed explanation, the variety of sediments and characteristics seen in sediment cores can be seen in this example from Core 09_10. Full details of each core may be found in Appendix I.**

Analysis of Remote Sensing Data

Prior to fieldwork in 2007, I re-analyzed the side scan sonar data collected by Cook in 2003. This study

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[210] Profiles of cores collected in the 2007 season are color-coded to represent colors of the sediments, but there are two different issues with this: the first is that colors, since they were determined from wet material in variable light conditions in the field are relatively arbitrary, and the second is that since the cores were washed, there is usually no sediment remaining in them from which to determine colors consistently, for instance with at Munsell color chart. For these reasons, I have determined to base the sediment analysis primarily on sediment consistency, shape and wear, although where applicable I do note the observed colors.

[211] Details of this process may be found in Appendix I.

[212] This category included both flora and fauna. In analysis of the cores collected in 2007, shells were analyzed in terms of type as much as possible, but poor comparative resources made this extremely difficult. I finally determined that the amount of effort I was putting into it was not nearly equal to the return and I was not actually able to say very much substantial, so analysis of fauna and marine flora will have to wait until I can either gain the expertise myself, or pay a professional to do it.

offered insights into both what potential targets or sites might look like in the data, and also a tenuous familiarity with the seafloor environment. The investigation of targets in 2007 provided first hand observations of the seafloor environment, and offered some insights into the correlation between side scan sonar targets and the reality (at least of the time) of the seafloor. Experience with these two data sets became the foundation on which the research design was built in 2009. In it, I proposed that there were indeed submerged archaeological sites present in the region, but that sedimentation had likely obscured them over the four years between when Cook had collected his data and they had been dived in 2007. To test this proposition, it was necessary to re-survey the areas Cook had covered and immediately dive any targets identified; this would not only provide answers to the question of sedimentation, but would also serve to create baseline comparative data for future surveys. In addition to re-surveying the area with the side scan, a magnetometer and an echo sounder were used. As mentioned previously, rudimentary analysis was performed on these data sets in the field, but it was not possible to thoroughly assess them until a comprehensive third-party software analysis package was accessible.

Post-processing of the raw side scan sonar data entailed creating mosaics, bottom-tracking, and clarifying the data using Chesapeake Technology's SonarWiZ 5 program.[213] This permitted spatial analysis of targets as well as a basic analysis of the seafloor geology as is visible in the side scan sonar data (Flemming 1976; Johnson and Helferty 1990). These post-processing techniques were applied to both the new data collected in 2009 and to the original data collected in 2003 to allow for more accurate

[213] Dr. Christopher Scholz of Syracuse University kindly permitted me access to this software package. Bottom-tracking and data clarification are both common post-processing techniques that simply present a clearer and presumably more accurate image of the raw data.

comparisons of coverage, targets and geology. These data were then analyzed both as separate data sets and while overlaid in order to observe changes over time and to try to identify consistent targets or features versus either “artifacts” in the data or features that may have been obscured over time (see Figure 4.13 above and more discussion in Chapter 5). Much of the comparative work between the data sets was completed using ArcGIS.

As noted earlier, side scan sonar is a powerful tool for investigating large areas of seafloor, but as a result of its relatively extensive coverage, if features are small or not well-defined,[214] it is often difficult to analyze or assign an interpreted meaning to them based solely on the side scan sonar data. These small targets are important because, like the tip of an iceberg, they may in fact represent only a fraction of what is present beneath the sediments. As more surveys are conducted, analyzed and diver-truthed in this environment this is likely to become an easier task, but at present it remains an albatross to the maritime researcher in West Africa.

The magnetometer, which observes the presence or absence of ferrous material in excess of that in natural environment and is considered the workhorse of maritime surveys, was used in 2009 as a means of trying to fill this gap between the observed and the unknown. Used in conjunction with the side scan, which provides sonar images of the seafloor, the magnetometer can be used to verify the proverbial iceberg by documenting whether or not there is also metal present near the side scan sonar target. Iron in particular is a common material on submerged sites, and any target that had both a side

[214] This could be because of the material the object(s) is made from, the surrounding sediment characteristics, or even the angle at which the signal reached and bounced back from the object, which affects how it is portrayed in the image (Flemming 1976). Until more is learned about how to determine which of these is the cause (or the causes) of how some objects are depicted, it is difficult to effectively identify what many of these smaller features may be.

scan sonar and a magnetometer signature was considered to be highest priority for diver investigations. As mentioned previously, the facts that a) the magnetometer data could not be geo-referenced and therefore could not be directly tied to any related side scan sonar targets, and b) that it was not possible to post-process both data sets in the field, made this a significantly less effective endeavor than anticipated. That being said, there have been several means of post-processing the magnetometer data to at least allow some comparisons[215] that will be useful in future research,[216] and in the future it is hoped that this issue will not be repeated.

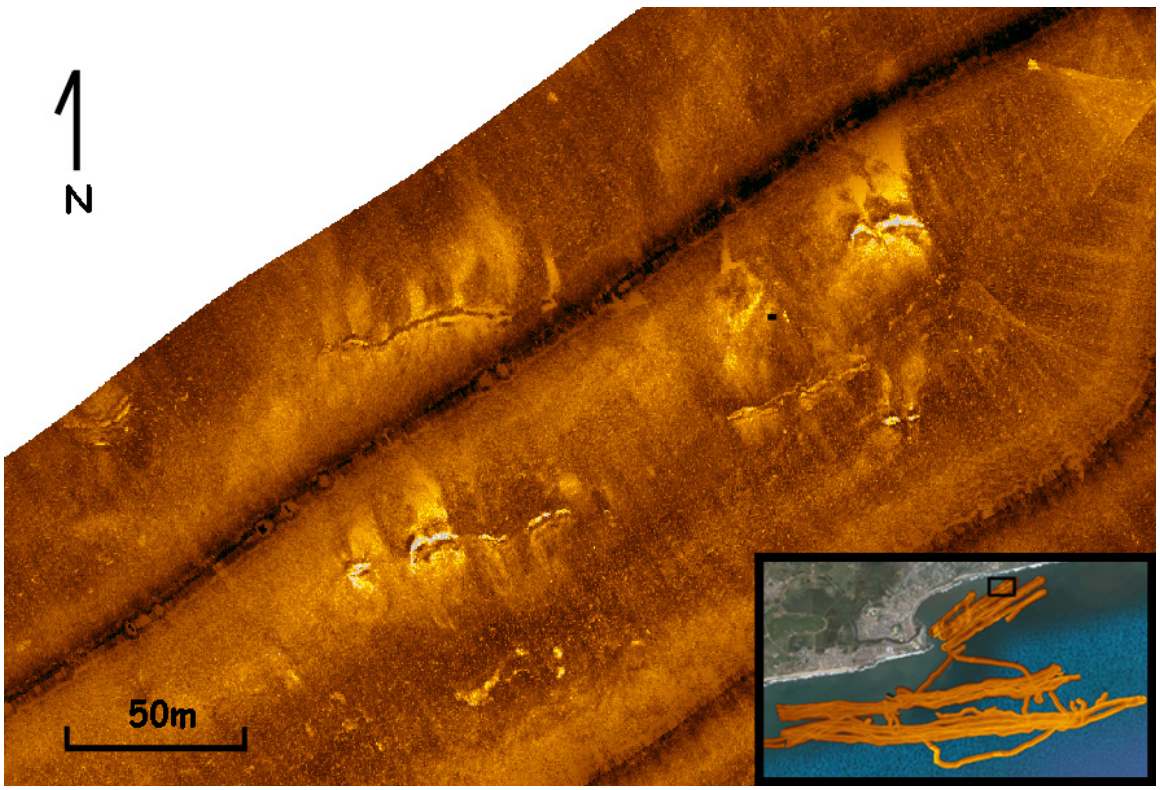

Figure 4.18. This side scan sonar image shows the rocky area in the northeastern-most survey area (inset). The rocks appear to be primarily linear formations of sandstone. Several dives have been conducted in this area, but no cultural material

[215] Much of this work was done by my volunteer, Darren Kipping.

[216] Because these data are not as easily quantified, they are not presented in this dissertation. They will, however, be used for baseline data in future investigations.

has been found. However, as is imaged in the echo sounder data (below), there may be cultural material between some of the rocks that has yet to be identified.

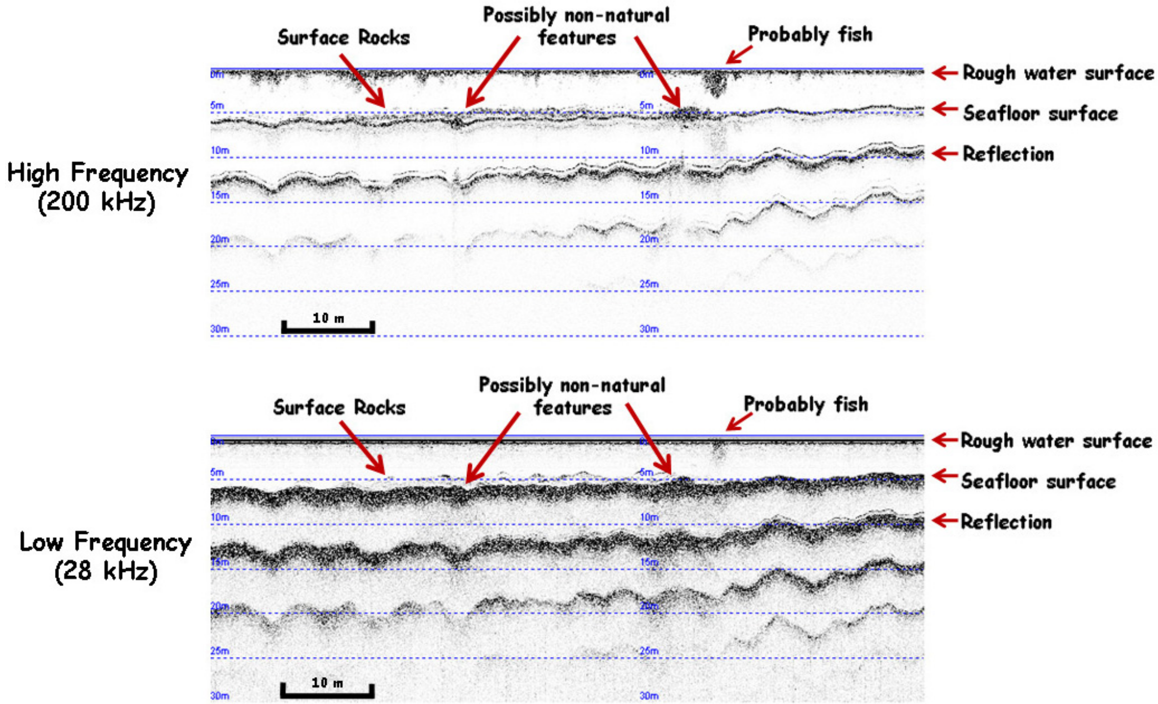

Figure 4.19. **These echo sounder images both represent the same transect but are shown in high and low frequency resolutions. The line labeled “reflection” is also known as the water bottom multiple and is a “reflection” of the seafloor. The data were collected over the rocky area depicted above (Figure 4.17), although unfortunately, as the echo sounder data are not geo-referenced, it is not possible to tell exactly where the transect crossed. It is clear from these simple images that although the echo sounder has relatively shallow seafloor penetration (< 5 meters in this location), it is enough to provide important data concerning submerged cultural resources. The low frequency tends to provide good depth penetration, while the high frequency tends to achieve less penetration but provides a higher resolution image.**

The final remote sensing instrument that was used was the echo sounder.[217] As was also noted earlier, this instrument also did not sync with the GPS, so data collected are not geo-referenced. As the intention of using this instrument was to investigate

[217] Interestingly, the echo-sounder images we collected of the known shipwreck site are nearly identical to the sub-bottom profiler images collected by Church and Warren (2008:117) of another wooden shipwreck, confirming the usefulness of the echo-sounder in this environment.

individual targets, however, these data are easier to interpret in the post-processing stage.

Data from various known and unknown targets or sites and in various sediment

Target/Coordinates	Target Source	Transect Bearings	Comments
Elmina Wreck	Cook 2003 side scan	**300°, 000°, 240°**	good readings on two of the three transects, transect **300°** was less clear
Waypoint **397**: **N05 04.376 W001 19.538**	2009 side scan	**090°, 330°, 210°**	nothing in the echo sounder images
Waypoint **322**: **N05 04.563 W001 19.869**	magnetometer	**300°, 180°/190°, 060°**	something clearly present on the **180°/190°** line, also very possibly on the **060°** line
Waypoint **303/394**: **N05 04.513 W001 20.480**	2009 side scan sonar and magnetometer	**270°, 150°, 030°**	no clear indications of targets
Waypoint **326** **N05 04.550 W001 19.861**	magnetometer	**90°**	There is some confusion with this site: we knew it was close to the Elmina Wreck site, but the coordinates were at least 45m from the site, so we thought it was fine to go over; however, when we crossed it, we got the same signature as when crossing the wreck site. This may be an issue with GPS accuracy, or there may actually be something else there. We moved on to the next site after one crossing.
Waypoint **385** **N05 04.284 W001 19.823**	magnetometer	**150°, 030°, 270°**	possibly something on the **270°** line, but it was unclear
Waypoint **242** **N05 04.670 W001 20.290**	2009 side scan sonar	**300°, 060°, 000°**	nothing but possible rocks in the echo sounder images
Waypoint **258** **N05 04.547 W001 20.912**	non-target area	**240°, 000°, 300°**	nothing in remote sensing images
Waypoint **338**: **N05 04.434 W001 21.254**	2009 side scan sonar	**270°, 150°, 030°**	possibly saw something in all three transects, but it's most likely rocks
Waypoint **491** **N05 04.669 W001 20.215**	echo sounder target en route	**060°, 180°**	target was too close to shore to complete another pass; didn't see anything in echo sounder images
03-09-06-2003-054L N5 04.865 W001 20.815	Cook 2003 side scan sonar	**300°**	tried to complete the transect, but target was too close to shore, so it was abandoned
09-10-2003-013R N05 04.414 W001 20.228	Cook 2003 side scan sonar	**180°, 300°, 060°**	saw something significant in Low Frequency in all three transects
09-05-2003-055R N05 05.021 W001 20.583	Cook 2003 side scan sonar	**330°, 210°, 090°**	saw something significant in one transect
Rocky area in NE N05 05.460 W001 20.160	Cook 2003 side scan sonar	**100°**	The water was only 4m deep at its deepest, so the other transects were run in a manner to avoid the rocks, and as such they are not clear, straight lines. The rocks showed up clearly in the echo sounder images

*** Note:** While the swell was relatively minor in terms of diving and even side scan sonar data collection, it did appear to be affecting the echo sounder more

Table 4.3. Two of the areas investigated with the echo sounder were intentionally covered because there were no targets there as a comparison with other areas. More work needs to be done to use this instrument to its full capacity in this environment.

environments have been assessed and a small data base containing these signatures has been compiled (Table 4.3; examples are shown in Figures 4.18 and 4.19). It is anticipated that future surveys in this region will be able to build on these data set as a means of continuing to refine investigative methodologies in coastal Ghana and West Africa.

Conclusion

Ervan Garrison (2003:1) has made the observation that the "practice of modern archeology demands an understanding of earth science." The research discussed in this chapter was based on an interdisciplinary foundation of archaeological and historical questions and techniques merged with those of earth and oceanographic sciences, and it would not have been possible apart from that foundation (Gifford and Rapp 1985). In particular, the development and results of the micro-sampling technique as a means of informing multi-scalar phenomena illustrate the complimentary natures of these avenues of inquiry and the potential that they hold in maritime archaeological research in coastal West Africa.

One final comment should be made concerning the in-depth analysis of the cores used to build the following chapters: individual cores are described in Appendix I and have been analyzed in detail. That being said, however, the interest in this research is not an individual assessment of every core, but rather in an overall understanding of the site formation processes recorded in them for sites (such as the known shipwreck site) or areas across a region. For this reason, although the value is recognized, no in-depth geological assessment of the cores is presented in this dissertation. The disparate and yet intertwined data sets that form the raw data discussed in this chapter are analyzed in the next chapters to present an integrated picture of historical events and formation processes of maritime trade in coastal Ghana.

Chapter 5
Site Formation Processes across a Region

> Human lives are lived on surfaces, but archaeological surfaces are not necessarily those on which the archaeologist walks (Dincauze 2000:195).

> Archaeology pursues the evidence about past human behavior at a variety of scales susceptible to archaeological analysis (Kowalewski and Fish 1990:276).

In 1561, a French ambassador in Lisbon provided a report on the obstacles to French trading on the Ghanaian coast presented by a new Portuguese naval strategy at Elmina that utilized the operation of galleys.[218] As he explained, "the place [Elmina] being only sands, our ships are obliged to anchor far out, so when they want to trade with the local blacks they can do so only in [ships] boats, and these are always weaker than the [Portuguese] galleys; moreover, the ships, themselves, when encalmed, are often sunk by the galleys" (da Mota and Hair 1988:15). Accounts such as this and others like it suggest that maritime research near Elmina has not yet come close to finding everything there is to discover in terms of the submerged remains of historical maritime trade, and my recent investigations have lent credence to this assumption. Research has also demonstrated that the environmental formation processes at work in the region are exceptionally active; these processes are the agents responsible for the conditions of submerged remains and are possibly a reason for the lack of sites identified archaeologically.

This chapter is a discussion of formation processes across the eventscape of coastal Elmina as they relate to submerged cultural material and the physical/ environmental contexts in which they operate. Included in it are discussions of the

[218]Small, fast warships propelled by oars (Woodman 2002:21-22).

methodologies used to investigate formation processes, the geomorphological setting of the submerged seascape, an overview of the primary physical agents of change (formation processes) responsible for the creation, deterioration, and partial preservation of submerged sites, and a brief description and discussion of selected individual targets that are representative of both cultural and physical formation processes and are integrated within the Elmina seascape. Site formation and environmental assessments are made based on remote sensing data, on diver observations, and on data collected in sediment cores.[219] Framing the chapter is an understanding that the interpretation of data and the "patterns of variability" observed within the archaeological record across the region "requires an understanding of both the behavioral and the physical conditions that influence the final character of the… record" (Rapp and Hill 2006:63; see also Garrison 1998). Discussions here focus on the interpretation of submerged sites within those contexts as interpreted through the study of formation processes. As noted in the title of this chapter, the frame of reference is the region, but, perhaps counter intuitively, key to the regional interpretation are assessments built on a range of scales from the macro, including the surrounding environment, to the micro, such as individual artifacts

[219] A brief review may be helpful here: based on my previous research, I proposed that it was likely that a number of historical shipwrecks and other submerged cultural materials are present in coastal Elmina but are buried due to the dynamic environment and heavy sedimentation rates in the region. In addition, I suggested that the failure to identify additional sites may have been due to survey techniques, or, unlikely, to a lack of additional wreckings or other sites in the area. In order to test this hypothesis, Cook's original survey area was resurveyed as a means of creating a comparative data set, three different instruments were used to investigate the region and their results compared, at least three new sites related to maritime trade were identified, and all of the means of testing were evaluated within the framework of site formation processes across the region. The ultimate goal of the research was then to integrate these data into the overarching goals of the project as a means of investigating European expansion and West African trade interactions. The purpose of this chapter is to discuss interpretations of these data across the region.

recovered from cores at specific sites using the micro-sampling technique (i.e. Ramenofsky and Steffen 1998:5).

The comprehensive approach to studying the historical maritime seascape and submerged cultural remains in coastal Elmina employed in this research has provided insights into historical maritime trade practices in the region, into a number of different submerged sites and what they inform us about the patterns of activity in the historical seascape, and into the environment and formation processes creating and affecting them. As discussed in Chapter 2, the formation process research foundational to this project is interdisciplinary; it is both a theoretical and a methodological approach and it provides a means of querying multiple scales. As an interdisciplinary theoretical construct, it is useful in interpreting and explaining how sites are formed and changed, and how we may learn from them in their present states; as a methodology, it requires and provides special investigative techniques to go about asking those questions. Because formation processes include the overarching cultural, historical, and economic processes that contribute to the presence of a site, as well as those processes directly contribute to the creation, destruction, and preservation of a site. From the macro to the micro features, formation process inquiries necessarily query a range of scales. This approach has been implemented with the assumption that it provides a "robust analysis of maritime culture that focuses on the associations and relationships among various aspects of the living and nonliving resources"[220] (Vrana and Vander Stoep 2003:26-27). In addition, the approach provides a framework that allows a more systematic basis for evaluating the relationships

[220] Vrana and Vander Stoep's original discussion is based on the benefits of implementing a maritime cultural landscape approach, which, as explained in Chapter 2 is somewhat different than the seascape approach, but as it is related, it can also be used as a basis for this research.

of submerged resources with each other, with historical navigational practices and events, with the natural environment, and with site formation processes.

Quine (1995:81-82) nicely sums up the comprehensive nature of this research when he writes that an informed interpretation of site formation processes must go beyond the limits of “statistical comparison of quantitative descriptors to consideration of the evidence obtained in the light of ‘whole site formation.’ This objective demands the development of improved conceptual models of site formation which employ historical, ethnographic, and experimental evidence. The “whole site formation” focuses on context which, for purposes here, includes the physical environment and site matrixes, historical and natural events, the seascape as a whole, and, fundamental to this research, an incorporation of varying scales, particularly scales of space and geographical extent, and of time.

In the discussion and analyses here the intent is to create neither a purely environmental[221] nor a purely cultural history of the region. Rather, the aim is to understand the archaeological history of the sites and the region in order to relate them to the historical and environmental events and happenings of the past and present. In order to do this it is also necessary to understand the aspects and vast expanses of seafloor that do not contain cultural material[222] and, to that end, both sites of confirmed cultural nature, and sites that are clearly purely natural are considered. An understanding of all these components provides a far more comprehensive perspective of the underwater landscape and therefore of the historical eventscape that is the ultimate focus of investigation. As discussed in the following section, in order to understand the upcoming

[221] A comprehensive discussion of the environment may be found in Appendix II.
[222] To serve as comparisons and controls for those that do.

data, it is necessary to review both the methods of investigation used and the contexts in which they were applied.

Survey, Micro-sampling, and the Region

Archaeological investigation of a geographical region such as coastal Elmina by necessity incorporates the concept of a land- or seascape as a region; this is the case regardless of whether it encompasses two square kilometers or 200 square kilometers. Embedded in the regional seascape are also the historical, social, cultural, and economic spheres which make up the anthropological region of interest.[223] Details of the historical and physical seascape of coastal Ghana are discussed in Chapter 3,[224] but for purposes here, the importance of the seascape is focused on human interactions on and with the sea, and on the determinative roles that the sea and seascape played in historical maritime trade and therefore in the subsequent creation of submerged cultural resources and sites. In working with regional-scale data, however, there must be a way of connecting data at the level or scale of the region with that of archaeological sites and even of individual artifacts (Dunnell and Dancey 1983:268). Two approaches, those of regional survey and of microsampling, are used here to investigate the region. Remote sensing surveys provide extensive coverage of an area, but can also be used to investigate individual sites. Microsampling, as it is presented here, is also a means of transitioning between scales, because in it the same data set is being used – the same method of data collection and

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[223] Land- or seascape can be treated as basically a cultural or a natural concept, or both (Rössler 2009), and I touch on both, but focus more on its role as a boundary and restraining factor, rather than a culture-creator.

[224] The concept of landscape studies has been applied in a number of areas of Africa in various capacities and in different ways, all associated with various interactions of humans with their environments (Bollig and Bubenzer 2009; Croucher 2007; Lenssen-Erz and Linstädter 2009). The term is primarily used in relation to the cultural landscape (although definitions of this vary widely), and often in relation to how the natural environment has shaped human culture or life, and how in turn humans have shaped and affected their environments.

analysis is applied for testing both at the regional and at the site-specific levels. Remote sensing data are useful in locating sites, as well as defining their characteristics; hand-in-hand with remote sensing is diver-truthing[225] and observation. Microsampling is useful in investigating sites already discovered and in characterizing their physical environments; it can be used at both established cultural sites and in locations across the region, regardless of whether or not they display cultural material.

As has been discussed throughout this dissertation, an understanding of the marine environment, including geomorphological and coastal oceanographic factors, is vital for a thorough understanding of the depositional history and formation processes of submerged cultural sites and resources (McNinch et al. 2001; Ward et al. 1999b:42; Werz 1993). It is possible, and even likely, that some of the difficulties in locating submerged cultural resources in coastal Elmina are the result of low site visibility (McManamon 1984:224) due primarily to the heavy sedimentation observed in the region (Figure 5.1). While research carried out through remote sensing and microsampling provide supporting evidence for this assertion, it is still unclear at present how much of problem is due to sedimentation, methodological factors (including poor visibility), the presence or absence of submerged sites, or some as of yet unidentified factor(s).

The archaeologically surveyed area off the Elmina coast is at present relatively small, and the number of identified submerged cultural sites is limited (five sites identified to date);[226] however, the potential in these waters for maritime cultural resources is phenomenal. The intersection of history, coastal oceanography, geomorphology, and archaeology shows rich potential for offering insights into a little-

[225] The physical investigation of sites by divers as opposed to analysis purely based on remote sensing data.
[226] These include the Elmina Wreck, the Benya vessel remains, the Single Anchor Site, the Double Anchor Site, and the Chain Site.

known or studied facet of the past, and the investigation both of the known sites as well as various locations throughout the seafloor environment is already providing invaluable data concerning the mechanics of historical maritime trade. Two primary data sources, remote sensing surveys coupled with diver investigations, and microsampling, are discussed below.

Figure 5.1. **This GoogleEarth image nicely illustrates the complex movement of sediments near the Elmina peninsula. Note that although the sediments are being discharged from the Benya Lagoon and clouds of sediments to the south of the peninsula extend to nearly one kilometer offshore, all of them are being pushed inshore from the predominant current as it rounds the end of the peninsula. Note also the sediment plumes coming from the Sweet River in the upper right hand corner of the image. This image was taken October 28, 2007, towards the end of the rainy season.**

Remote Sensing and Diver Observations

Remote sensing is a non-destructive and non-intrusive technique that is capable of the identification, quantification, and monitoring of submerged archaeological sites (Dix

2007:23), and can be used for subsurface characterization and/or the identification of targets for diver survey.[227] It is incredibly useful in large- and even small-scale surveys; for instance, the side scan sonar is useful primarily for detecting anomalies on the surface of the seafloor (Jones et al. 2005:187), as well as for mapping general geomorphological characteristics (Johnson and Helferty 1990). Side scan sonar is limited, however, in that it is not designed to penetrate the substrate, and therefore presents a picture only of what is on the surface of the seafloor. The result is that at times what is below the targets may be masked, or there may not even be an indication that any anomalous material is present at all.[228] Other remote instruments, such as the magnetometer and echo-sounder, do see below the surface and therefore hold the potential to discover archaeological traces where there appear to be no surface indications (Cheetham 2008:565).[229] It is a matter of necessity that any targets identified in the remote sensing data be diver- or ground-truthed as a means of verifying the presence of the anomaly and identifying it (Dix 2007:18). Related to this, remote sensing also plays a formative role in sampling designs, particularly since the targets to be diver-truthed in this research were determined almost

[227] As will be seen throughout this discussion, each of these applications has been utilized to various degrees with the data collected thus far in coastal Ghana and holds the potential for informing research in the future.

[228] It is interesting to note that in certain matrixes the side scan is known to penetrate slightly into the substrate, but unless one is aware of which matrixes these are and where they are located, this is actually a problem with side scan analysis, because when analyzing it, it is no longer clear when one is seeing only surface features versus when there may be subsurface features displayed as well. It is very possible that this confusion has played a role in the interpretation of data from Ghana, and perhaps even contributed to the confusion of investigating a site with a known side scan signature, yet finding nothing on the surface to indicate a feature. More work remains to be done to fully understand this aspect of the relationship between side scan sonar and the geological matrixes of coastal Ghana. It should be expressly noted here, however, that the side scan sonar has not and will not be used intentionally to provide subbottom information – seismic reflection units such as sub-bottom profilers or echo-sounding units are appropriate for this purpose. With that in mind, however, cognizance of this issue is important.

[229] It should be noted that three different forms of remote sensing have been applied and used in tandem in coastal Ghana. The magnetometer was used specifically to identify particular targets but was not used in terms of environmental indicator, and the echo-sounder was used only to investigate particular targets. Where pertinent the results of these instruments are discussed in relation to particular targets or sites.

solely from the remote data. Analysis of the sampling design and collected data then inform the relationship between the data and the universe[230] about which research questions were asked and conclusions drawn (Dunnell and Dancey 1983:276).

As noted elsewhere, the remote sensing survey in 2009 was intentionally carried out primarily over the same area covered by Cook in 2003 as a means of creating a comparative database of the seafloor environment, including documenting any changes that could be seen in the seafloor character or topography over time. The results of this survey were successful in that we were able to re-survey the original area and in many instances were able to see both consistencies and changes in the seafloor character. However, the quality of the side scan sonar data differed significantly due to weather conditions: the 2003 survey was carried out in rough seas in the month of September, and the 2009 survey was carried out in substantially calmer conditions in November. Because of this, the data from 2009 tend to be much clearer, and as a result, geomorphological analysis based on remote sensing data has leaned heavily on the 2009 survey data. That being said, however, it will be noted throughout this chapter that comparisons between the data sets and diver investigations from two different years (2007 and 2009) have provided information in terms of the environment and site formation processes.[231]

Sediment Cores and Micro-sampling

The application of microsampling at a regional level through the use of sediment cores in my research is not at all new in the natural sciences such as oceanography or geology, nor is it in a sense new to archaeology, as shovel- or auger-testing could be

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[230] The universe here is considered the historical seascape and contexts of trade, as well as the physical environment in which submerged cultural sites are located.
[231] Additional examples and discussions of this may be found in Appendix VIII.

considered near approximations. In addition, researchers have done a great deal of looking at or below the sea bottom through different forms of remote sensing such as side scan sonar, multi-beam sonar, and sub-bottom profiler surveys for some time. The new or innovative aspect of this research is that it applies these methodologies both to specific underwater sites and to regions, encompassing the scales from micro to macro, as well as looking at the environment and formation processes. In addition to trying to answer questions at multiple scales, this research is contextualized within the framework of archaeology of the event and site formation processes, which incorporate historical factors and the methodologies used to investigate the past. Answers, some more limited than others, to questions that encompass these scales and multidisciplinary avenues of inquiry are being answered primarily through one simple tool: micro-sampling using the sediment core.[232]

The microsampling technique can best be defined as a methodology similar to what Murphy and Russell (1997:278-279) term "minimum impact archaeology." It is a "methodology for extracting the most archaeological data from a site with the least physical disturbance…[and is] distinguished from non-impact archaeology, which does not include any disturbance of any kind." Minimum impact archaeology forces the investigator to pay more attention not only to surface remains and the formation processes affecting the site or region, but also to the larger picture factors such as behaviors specific to historical vessels including "regional stranding, salvaging, repair,…anchorage activity areas" and historical and economic environments in which the vessel(s) wrecked. It also contributes to the "refinement of data collection

[232] One of the additional, practical objectives of this research was to develop a methodology for exploring these ideas that was both effective and efficient in terms of time, finances, and the incredibly rough environment of coastal Ghana.

methodologies complementary [or alternative] to more intrusive investigations…" (Murphy and Russell 1997:278-279). The rough environment of coastal Ghana has tested the capability of the sediment core to extract the maximum data efficiently with minimum damage, and has proved its effectiveness as a microsampling tool at a range of scales.

Most underwater archaeological sites and projects that have made use of coring have applied this technique relatively simply as a means of answering environmental[233] and some site formation process questions, with varying degrees of success (Elkin et al. 2007; Gorham and Bryant 2001; Stanley et al. 2007; Stein 1986). The use of cores has also been discussed in terms of a discovery technique for new sites (McManamon 2000:607), but while it may, on occasion, produce results in such a capacity, it is not the most effective use of this tool. It is a far more effective tool when used in site examination, including inquiries into the complexity of stratigraphic deposits and sequences, into the spatial distribution or extent of sites (Hassan 1978:200-201; McManamon 2000:607), and into site formation processes. As Schuldenrein (1991:132) comments, "[w]hen applied to the detection of subsurface cultural deposits, coring becomes the initial means for detecting site formation by previewing the articulation of cultural and natural residues."

This research has made use of sediment coring as a means of documenting and studying the environment and formation processes as they can be observed in the sedimentary matrix; it has also expanded the usefulness of this technique to include in-

[233] Including chemical and biological analyses, and radiometric dating. I have to acknowledge that I have not had the resources in either field season to do what many consider baseline environmental assessments, such as temperature, salinity, current flow, etc., beyond what we could observe ourselves. This is clearly a good idea, but at this point the incorporation of environmental research into what we were able to do in the field is providing both micro and macro baseline data.

depth analyses of the cultural material contained in the cores. While this is not the first project to engage in in-depth analysis of cultural material in cores (Casteel 1970; Hassan 1978; Stein 1987), as far as can be seen from extant literature, its emphasis on holistic sampling and scales of analysis in submerged archaeological investigation is unique. This synthesis of technique and multiple avenues of inquiry has resulted in a new way of querying archaeological data at multiple scales, and has created a new means of investigating the "correlation of cultural variables with environmental features" (Dunnell and Dancey 1983:270) within the contexts of the historical maritime trade and seascape. These environmental and cultural data collected in sediment cores provide the basis on which the scales of the micro and the region can intersect.[234] The following discussion is an introduction into the physical matrixes and environments of historical submerged cultural resources related to maritime trade which are central for contextualizing submerged sites and their relationships with the historical seascape, and possibly with each other.

Elements on the Submerged Landscape

The need to know the seafloor as well as the conditions on the surface of the sea is something that sailors have understood likely since the early days of water travel. Parker (2001:33) writes that since ancient times sailors have tested the seafloor to sample bottom conditions, in effect creating for themselves a map of the underwater landscape of

[234] For example, clear strata were visible in every sediment core collected and most were distinct in terms of color, texture, or both. In some instances the strata could even be further delineated in terms of artifact content. While there is not necessarily a continuous pattern in the strata across the entire region, the importance of being able to delineate and interpret individual strata and patterns in them and between areas within the submerged seascape lies in the fact that it is still possible to interpret aspects of the macro processes and micro events that have served to build and shape the environment of individual sites and across a region, all from the relatively micro record preserved in sediment cores.

the seafloor. This knowledge of the underwater landscape provided sailors with indications of their positions and environment and provided additional means, albeit often indirect, by which they could "articulate their voyage" (Parker 2001:33). While historical sailors on the west coast of Africa were by necessity familiar with sea bottom conditions along the coast, their pictures of the underwater landscape were clearly different than those available through the technological tools and advances available to sailors and researchers today. A basic description of the underwater landscape around coastal Elmina will provide not only a picture of the physical setting of submerged cultural resources, but will also highlight local formation process agents that have served to destroy and preserve the underwater resources. Descriptions of the seafloor are based on side scan sonar data collected in 2003 and in 2009; they are compared to available literature and observations made by divers at particular locations within the underwater landscape.

Seafloor Details

There are three basic seafloor characteristics, found singly or in various combinations, that for the most part may be seen in the side scan sonar data and are corroborated by the literature[235] and diver observations (John et al. 1977; Koranteng 2001:2). These include rocky areas consisting of rock reefs and low relief sandstone formations; large expanses of sand, some of it formed into ripple patches of various sizes and shapes; and a few, relatively small and isolated patches of distinct black, sticky mud which are discussed in the literature (i.e. Koranteng 2001:2) and have been observed by divers, but appear relatively featureless and having very low backscatter returns in the

[235] See Appendix II for a more comprehensive literature review of both the seafloor and environmental forces.

side scan sonar signatures.[236] Combinations of some of these features, such as sand ripples in conjunction with rocky areas, were considered to be "mixed," but because a wide variety of combinations was observed, the component characteristics were recorded, but this was not considered a separate or distinct category. Divers surveyed targets in each of these different substrate zones, cores were collected in every area possible, and cultural materials were discovered in rocky reef, sand, and mixed sediment areas (see Table 5.1 below). Comparisons between the side scan sonar data sets collected six years apart (in 2003 and 2009) demonstrate both consistency and some variation in the different geomorphological seafloor features, showing evidence that there is some change over time, but also indicating that certain features, including large areas of ripples, are relatively constant over time, likely the result of relatively consistent interactions between oceanographic agents and local geomorphological features.

The basement of the study area is composed of predominantly fine-grained quartz and feldspar sandstone[237] and is characterized by a lack of biogenic structures.[238] Most of the area is covered by fine to medium sand, and there are also localized pockets of carbonate sands[239] in distinct places (Ly 1981:236), particularly just inshore of the sand barrier/spit to the south of the castle peninsula.[240] More than 50% of the sediments[241] on

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[236] Lower backscatter signatures (i.e. Ehrhold et al. 2006:1604; Mazel 1985:3-14) generally appear as slightly darker than the surrounding sediments, although are often amorphous.
[237] Sandstone is primarily composed of quartz fragments (approximately 65%), feldspars (10-15%), clay minerals and fine micas, and other rock fragments (15-20%) (Boggs 2001:134-137). The sandstone in this region is called Elmina Sandstone (Dei 1985:593; Ly 1982:200) and primarily has a red or purple color.
[238] Features such as reefs that are created by still-living organisms.
[239] One of the major sources of carbonate sand is the marine carbonates that live in the intertidal waters to the inner shelf (Short 2005a:822). As Short (2005a:822) explains, "carbonate detritus is more easily broken and abraded by physical processes [than quartz and other mineral sediments], their *in situ* and shore linear sources, [*sic*] can act as a continual supply, with waves and tidal currents eroding, abrading, and transporting the sand size and coarser material shoreward (emphasis original)."
[240] Discussed in more detail in the Single Anchor Site section.
[241] Banning (2000:235) defines sediments as "layers or collections of particles that have been removed from the place where they were originally weathered from rock and redeposited elsewhere."

the continental shelf are sand, with grain size tending to decrease offshore. The remaining sediments on the shelf are generally made up of varying combinations of coarse sand, silts and clays, the latter two of which are termed "muds" for purposes of this work (Intergovernmental Oceanographic Commission 1990:138-140; Stride et al. 1982:97-98).[242] Included in the sediments are organic[243] materials, usually in the form of discrete dark gray/black or olive-gray colored deposits and usually no more than several centimeters across. These materials indicate the presence of reducing[244] chemical conditions somewhere in the coastal system (Courty et al. 1989:79; Rapp 2000:240), possibly in the Benya Lagoon, or in other inland coastal waterways. They have also been found in sediment cores collected at the Elmina Wreck site, indicating that the site itself may also be a possible source.[245] With the exception of the often-sticky organic deposits, marine sediments, including muds, tend to be relatively unconsolidated and "vary greatly in chemical composition, particle size, origin, sedimentation rate and geomorphological distribution" (Jones 2003:15). Sediments can be classified or described by using these characteristics, or, more simply, on the basis of grain diameter or size, such as mud, sand, granule, or pebble.

The interrelated systems[246] responsible for the movement, transport, erosion, and deposition of sediments on the continental shelf are extremely complex (Weggel

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[242] See Appendix I for details and divisions of sediment sizes and classification.
[243] Or biogenic.
[244] Meaning that there is a lack of oxygen intermixed with the sediments, creating a different chemical environment than when oxygen is present.
[245] Adams (1985:276) noted that unexcavated/undisturbed sediments on the *Sea Venture* wreck site were more organic in color and texture than disturbed sediments. Because the organic inclusions in sediments at the Elmina Wreck site were not contiguous, this may also indicate more recently disturbed material, but this hypothesis needs extensive investigation. An additional possibility is that the organic inclusions/muds may have been derived from rotting materials such as seaweed (i.e. Martin 1979:26).
[246] Including, in particular, currents, waves, storms, surge, upwellings and downwellings.

1972:2).[247] Some of these are highlighted below, but it is important here to note the significance of these formation agents in distributing and modifying sediments.

Different sediments, transported either as bedload or as suspended load[248] (Weggel 1972:2), move at different rates and in different directions depending on the agents acting on them and the level of energy represented in those processes, and may be well- or poorly-sorted, depending also on these agents and their interactions with the local geomorphological settings (Gladfelter 1977:532; Rapp and Hill 2006:51; Soulsby 1997:6). However, although there are processes that act to move sediments in different directions and at different rates, sediment transport in the ocean does have a general magnitude and direction (Soulsby 1997:8; Weggel 1972:2), generally in the direction of the dominant currents and longshore drift.[249] Study of the ways that sediments are transported, deposited and sorted, essentially particle-size analyses, are widely used in the sciences and archaeology to investigate and understand the nature, dynamics and environments of archaeological sites (Courty et al. 1989:18; Rapp and Hill 2006:32). For instance, the shape and roundness of sedimentary particles can be indications of conditions[250] of transport and depositional environments (Wadell 1935:250), and in archaeology a similar assessment can be made concerning the movements and conditions of artifacts in the seafloor environment (Rapp and Hill 2006:47, 52) (see, for example, the discussion of the Single Anchor Site below).

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[247] They are discussed in detail in Appendix II, the Environmental Appendix.

[248] Bedload refers to materials traveling along the bottom, usually in some form of rolling; suspended load refers to the finer sediments that are light enough to be transported in suspension in the water column (Goldberg and Macphail 2006:86; Nittrouer and Wright 1994:96).

[249] In the case of coastal Elmina, this means that the sediments are transported in a predominantly west-east direction, with some sediments also traveling either shoreward or seaward on storm surge and with the up- and downwellings.

[250] In terms of the amounts and intensity of transport each particle has undergone, see, for example, Warne and Stanley (1993).

Two particular features of the seafloor, ripples[251] and scour marks, merit a brief discussion, as they are indicators of both environmental formation processes and potential indicators of submerged site locations and characteristics.[252] Both sediment ripples and scour marks can be considered to be simultaneously active agents and also passive players in terms of site formation, controlled by other active agents, and yet playing formative roles themselves in terms of site conditions; they are both constant and yet changing entities. Sediment ripples are clearly visible in the side scan sonar data collected in both 2003 and 2009 (Figure 5.1), and scour marks are also distinctly seen in select areas in both data sets.[253] In addition, divers have observed both of these features in numerous areas of the seafloor.

Ripples are commonly found at the boundary between flowing or moving water and a coarse sedimentary bed, (Andersen et al. 2001:066308-1; Hanes et al. 2001:22,575; Langlois and Valance 2005; Murray et al. 2003:1; Stride et al. 1982:109-110; Zoueshtiagh and Thomas 2003:031301-2), and are common in the nearshore environment (Blondeaux 2001:342; Davis 1985:426). They play an important role in the mechanics of sediment transport in coastal environments as, by their creation, presence, and migrations, they are active players in increasing or reducing the mass transport of sediments, generally in a shoreward direction (Blondeaux 2001:359-362; Blondeaux et al. 2000; Faraci and Foti 2002:47; Murray and Thieler 2004; Trenhaile 1997:71). Interestingly, although they move sediments shoreward, ripple patterns tend to align

[251] All of the ripples observed by divers were small; an example of one of them was even captured in a sediment core. There is a remote possibility, due to the generally poor to zero visibility conditions in which we were working, that the small ripples we are seeing are actually on top of or superpositioned on larger ripples and dunes and we simply did not have the visibility to get the perspective to see this, but it is unlikely.

[252] A more in-depth discussion of both of these features may be found in Appendix II.

[253] Specific examples of scour marks may be found in the discussions below concerning individual targets and sites.

perpendicularly to flow, or the direction of the current (Andersen et al. 2001:066308-6).[254] One characteristic of ripple patches is that they tend to highlight obstacles or features as seen in remote sensing data. Breaks or truncations in ripple patterns could be the result of the natural mechanics of sediment creation and movement, or a result of the presence of an intrusive object into the seafloor.[255]

Highlighted in, but not restricted to, ripple patches, is sediment scouring. While scour marks are found in association with both rocky and sandy areas, the marks tend to be more well-defined when they are associated with ripples, perhaps due to the contrast of the scours cross-cutting the very different bedform of the ripple.[256] Obstacles such as shipwrecks or other intrusive objects proud of the seafloor obstruct or disrupt water flows and sediment transport, the result of which is a scouring out of the sediments that are present (Fish and Carr 1990:92; Inman and Jenkins 2005:825), usually in very predictable patterns, depending on the obstacle's orientation to predominant currents (Caston 1979:198). Storms have also been known to create or exacerbate scour marks around submerged sites (Quinn 2006). The movement of sediments, including in the form of ripples, can have effects on the preservation or destruction of submerged sites due to their ability to either cover and protect or abrade objects. The results of scouring are often useful in terms of identifying potential submerged sites in remote sensing data, but

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[254] While it was possible to make observations concerning the relationship of ripples to current direction, it is not possible at this point to effectively use the ripples to discuss current velocity and strength (other than the velocitied provided in other literature), because we could not see the ripples in order to measure them (i.e. Hanes et al. 2001:22,575-22,576). It is hoped that in the future, more work will be conducted in the dry season, when there is more visibility, and this will provide opportunities to better visually study the seafloor environment, as opposed to primarily tactily investigating it.

[255] And example provided by Häkkinen (1995:99) clearly shows the same feature, but also clearly shows that a shipwreck is the reason for the break in ripples. I do not have evidence that that is the case here, but it is not impossible, as is evidenced by something clearly interrupting the ripple patterns at Target 2 in Appendix VII (Figure VIII.4).

[256] Scours manifect differently in different sedimentary environments, but, like ripples, they are also useful indicators of current direction, dominant tidal flow, and net sediment transport (Caston 1979).

scouring also has a tendency to structurally undermine areas of sites, causing collapse and exposing objects to further deterioration. Examples of both of these unique features, as well as of the other indications of formation processes discussed above, are presented below in relation to particular sites investigated during field research.

Finally, sediments can be deposited over a period of time, several hundred years, for instance, or during specific events, such as storms or upwellings. There may be pockets or areas and time periods in which there are extreme differences in the characteristics of the sediments deposited, but across the region of coastal Elmina there are basic, consistent patterns that appear to be relatively permanent. The time-scales involved in this maritime research are, for all intents and purposes, geologically insignificant (Anthony and Orford 2002:10; Wright 1995:171). However, in terms of historical shipwrecks and other submerged cultural sites, they are enormously important. In the same way, the amounts of sediments that are either deposited or removed from archaeological sites in the course of one or several events, or over years is also critically important for their destruction and preservation. As different sediments are deposited, disturbed or buried by other sediments transported by various agents such as changing surge, tides, currents or storms, distinct layers are eventually built up. The boundaries or interfaces between the layers or lenses often provide information on the environmental changes that have occurred (Rapp and Hill 2006:58). The sedimentary history[257] that can then be observed in sediment cores collected through micro-sampling across the region and at individual sites incorporates "evidence about the scale, frequency and rates of

[257] Another term for this is the stratigraphy of the sediments, something that is notoriously difficult to see or capture in underwater contexts. The sediment core is a fantastic solution to this problem, as it can provide not only information concerning stratigraphy of specific areas within or around a site, but through comparing cores a general idea can be formulated of formation processes and archaeological histories over a larger site or area.

depositional and erosional events" (Dincauze 2000:268) and provides insights into the formation processes affecting them.[258] Changes in environmental agents or processes are recorded in the sedimentary record, indicating both events and processes in time and across space (Stein 1987). Sediment cores collect and preserve a basically intact[259] record of sedimentary history and interpretation of that record provides insights into the environmental and cultural processes at work at submerged archaeological sites.

The Seafloor as a Region

Figure 5.2 below illustrates general seafloor characteristics and sediment patterns based on geomorphological interpretation of side scan sonar data sets collected in 2003 and 2009, respectively. Unsurprisingly, the patterns of rocks visible in the nearshore zone along the coast are also visible in the side scan sonar data, although it is interesting that some distinct areas appear to be more prominent or visible in one year or the other, but are not necessarily exactly the same in both data sets. This could be a function of formation processes acting to cover or expose different areas, and is also certainly a factor of sampling or surveying methodology, as some areas were more thoroughly

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[258] The process of deposition and the information preserved in the physical record of it are nicely described in the following quote: "Materials mobilized by ice, water, or wind are carried as long as the transporting agent maintains sufficient energy to move them. Deposition, therefore, represents a change of environment for both the materials and the transporting medium. This change is recorded, more or less clearly, in the structure of the deposit itself, whether stratified, graded, sorted or not. Variation in physical characteristics within sediment bodies, in either the vertical or horizontal dimension, indicates variation in the immediate environments of deposition. Vertical differences reveal the stratification or a sediment mass, expressing change in time. Horizontal differences in sediment bodies (facies) reveal environmental differences in space" (Dincauze 2000:267).

[259] There is some indication that there may be some vertical compression in the collection of cores, but this does not interfere with the interpretation of the strata themselves, as the compression does not change the fundamental nature or character of the sediments.

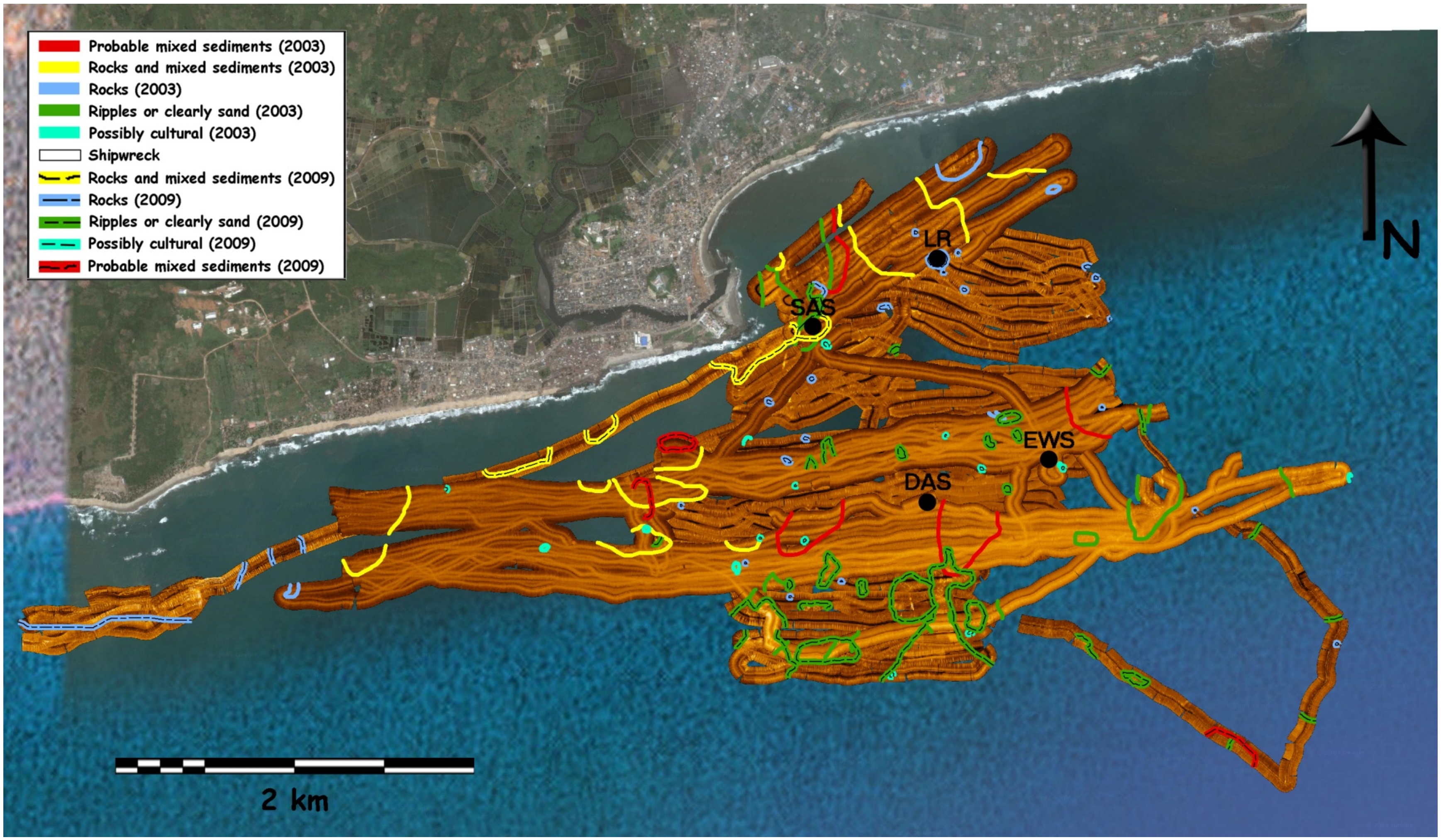

Figure 5.2. **The geomorphological interpretation presented here was based solely on the side scan sonar data from 2003 and 2009; while most of the targets dived confirm this, there are differences (see Appendix VIII). LR is the large rock target; SAS is the Single Anchor Site; DAS is the Double Anchor Site; and EWS is the Elmina Wreck Site; each of these is discussed below.**

surveyed in one year or the other. [260] In addition, significant areas of sand and ripples were consistently visible further offshore in both data sets. It is interesting to note here that the most distinct ripple area nearshore is located between the mouth of the Benya and the sandbar resulting from the Elmina peninsula.[261] Patterns of mixed sediments were harder to detect, and as a result, were identified more often in the 2009 data, which, because of calmer conditions, tended to be clearer.

Many of the sedimentary and geomorphological features noted in Figure 5.2 and by divers can be attributed to the relatively consistent interactions of various oceanographic processes with features such as the Elmina peninsula,[262] but not all are so easily explained. There appear to be what can be considered “micro-environments” within the Elmina seascape as well, although these are less visible in the geomorphological interpretation and are instead noted primarily from diver observations. For instance, the pockets of mud of various sizes scattered across the seafloor do not have any apparent pattern, and their origins in this particular environment are unclear.[263] In addition, there does not appear to be any consistent pattern in terms of whether mud or sand or both are associated with rock features. This may change over time, which may explain differences in the side scan sonar data over a six year period, but as we have only a limited number of targets that were dived both in 2007 and 2009, this is difficult to assess. One final example of the (apparent) unpredictability of sediment patterning is the

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[260] Note that because we were not able to synthesize the data we were collecting in 2009 with that collected in 2003 while we were in the field, there was some variation in side scan coverage. For the most part, however, the 2003 survey area was almost completely covered with various combinations of side scan and magnetometer surveys (the magnetometer tracklines are not currently available for display).

[261] Note that the Single Anchor Site is located within this zone.

[262] Or other underwater features (i.e. Cacchione et al. 1984:1280).

[263] The mechanisms responsible for these mud patches on continental shelves across the world are only beginning to be understood (Hill et al. 2009; Ogston et al. 2005); no research concerning this has been conducted on the inner continental shelf in Ghana.

different sediments noted at both the Double Anchor Site[264] and the Elmina Wreck site in 2007 and 2009: in 2007 the Double Anchor Site was completely covered in mud, but in 2009 it was sand and shell, and the wreck site was mostly covered in mud in 2007, but only in sand in 2009. What can cause these sediments at widely different locations to change in such a short period of time needs to be further investigated, but at present it must be sufficient to attribute the changes to the highly dynamic environment of coastal Ghana (see Appendix II). Finally, as can be seen in Figure 5.2 and are discussed below, the cultural features currently known on the Elmina seafloor are located in very distinct sedimentary environments.

Formation Agents of the Sea

As noted above, sediments play several key roles in terms of both being *affected by* formation processes, as indicated by those forces that serve to manipulate and transport them, and in *acting as* formation processes, such as covering sites or abrading artifacts. Because sediments do not move of their own accord, and because the various components of the ocean are powerful formation processes in terms of their effects on cultural material in addition to being sediment movers, it is useful here to provide a brief summary of these agents. It needs to be noted, however, that while there are some data available in terms of sediment types specifically related to coastal Ghana, there is very little data concerning many of the specific oceanographic processes active in the region. As such, interpretations and assessments are made primarily based on general patterns and characteristics as noted in the literature (Appendix II), remote sensing data, and by diver observation. In the future it is hoped that more in-depth oceanographic research will

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[264] Although it was not identified as such until 2009, the feature was first discovered by divers in 2007.

be carried out in this area of the world; this will make investigating and interpreting physical formation processes exponentially more effective, accurate, and efficient.

Chapter 3 discusses the historical and cultural formation processes that lead to international trade along the Ghanaian coast, and introduced the concept that these processes are effective at a range of scales. Similarly, the oceanic processes at work in coastal Ghana are active on a range of scales, from sediment transport along and across the coast, to the effects of seawater on small beads found at the Elmina Wreck site. And yet, although they have effects on a range of scales, the processes themselves tend to be consistent in scope and influence.[265]

Three primary features should be highlighted: currents, upwellings/downwellings, and storm surge. The coast of Ghana is characterized by high (often exceeding one meter) waves (Amlolo 2006) and powerful currents. The primary current along the coast is the Guinea Current (Figure 5.3), which travels from west to east, approximately parallel with the coast and varying in speed from less than one knot to more than three (White 1989:160); driven by offshore winds and the Guinea Current, waves strike the coast at an oblique angle, thus producing the longshore drift. The action of the longshore and littoral drift in coastal Ghana are responsible for the predominate and most powerful movement of sediments from west to east, parallel with the coast near Elmina.[266] A minor current, the Ivoirian undercurrent, is a slow, westward-flowing current that is present as a bottom current flowing under the Guinea Current and may be present only at certain times of year, in association with the Guinea upwelling. It is not at present known how much of an

[265] Because detailed descriptions of currents and various ocean processes active in coastal Ghana is provided in Appendix II, it is only necessary to provide a short summary here.
[266] This can be seen, for example, in the creation of the sandbar to the east of the Elmina peninsula, and in the coverage of the Elmina Wreck site from west to east (discussed in Chapter 6).

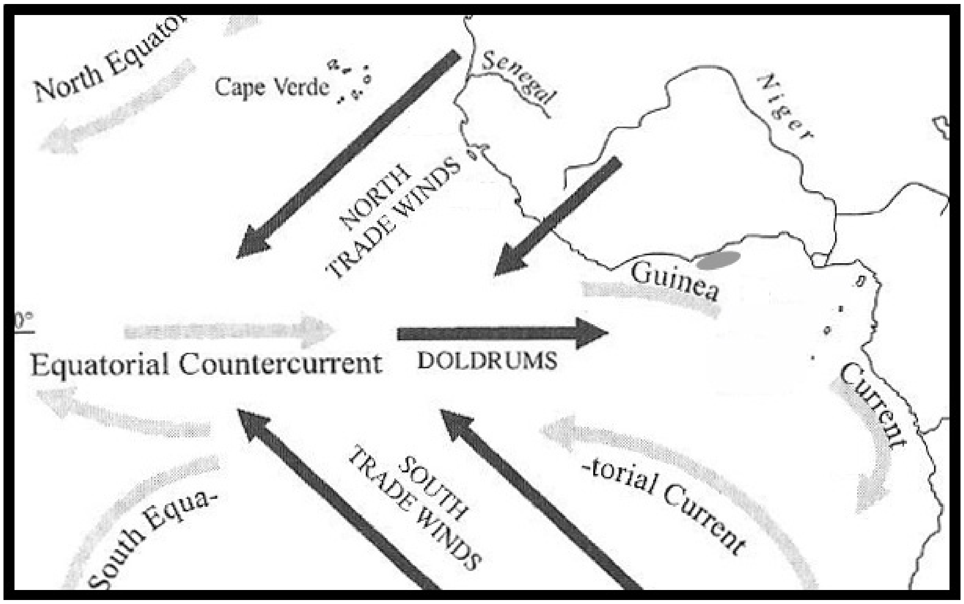

Figure 5.3. The major forcing factors at work in the Gulf of Guinea and along the Ghanaian coast are illustrated here. The small ellipse adjacent to the Ghana coastline represents the approximate location of the Guinea upwelling. The narrow Ivorian Undercurrent runs from east to west directly adjacent to the coast, but is very minor and not constant throughout the year (modified from Mitchell 2005:180).

impact, if any, this current has on sediment movement along the coast. The continental shelf varies in width between 13 and 80 kilometers, with the widest point being just to the west of Elmina, near Cape Three Points (Koranteng 2001:1-2).

The Guinea upwelling is a mass of cold, clear water that surfaces near the coast for several weeks in July and August; the upwelling drops the surface temperature of the water by several degrees during the time it is presenting. After a period of several weeks, it once again drops below the Guinea current and moves further offshore. It is possible, although this has not been tested and confirmed, that the downwelling phase of this phenomenon is responsible for moving some artifacts offshore, along with the sediments it is known to transport. A somewhat more likely candidate for this, however, is storm surge.

Strength, intensity, numbers, and duration of storms along the coast change over the course of the rainy season.[267] Storms tend to encounter the coast from the southeast, and their power has been known by sailors along the coast of Ghana for centuries. During storm events the storm surge and wave heights dramatically increase, and currents run dramatically faster (up to three knots). The effects of storms on currents and coastal processes are immensely important in terms of the building and erosion of the coast,[268] as well as the destruction and preservation of submerged cultural resources (White 1989:160). The returning or seaward downwelling of storm surge can also be a significant mover of sediment across the shelf, both in seaward and shoreward directions (Niedoroda 2005:868) and is likely a key player in the distribution of cultural material across the submerged Elmina landscape.

Although there are many more factors at work as formation processes along the coast, these three likely have the most dramatic (in the case of storm surge) and also the most consistent (currents) effects on the characteristics and morphology of the seafloor and of the cultural material contained in it. In terms of an overarching understanding of the Elmina seascape, it is also useful to remember that these same forces played tangible roles in navigation, anchoring, and trading practices in historical maritime interactions along the coast, and they remain integral to the use and understanding of the sea today, including the interpretation of submerged sites. One example of how an understanding of these processes is also integral to the interpretation of archaeological formation processes

[267] Typically from June or July through October or November.
[268] And are likely key factors in the rapid changes is seafloor characteristics.

relates to some of the cultural material in sediment cores. It has been observed that things as charcoal,[269] wood fragments, palm kernel shells,[270] peanut shells, plastic, fishing line, and, in sites closer to shore, what appears to be roadtop or asphalt[271] are essentially ubiquitous in coastal Ghana. Artifacts such as these hold the potential to be diagnostic if collected from unique contexts of strata or sites, but if, as in the case of coastal Ghana, they are present at every level across a site and no longer appear to have any primary context, they are no longer valuable in terms of being diagnostic in and of themselves. Precisely because they are so common across the survey area, and likely across the entire coast, they may, however, be useful in terms of tracing physical formation processes such as current and sediment movements: the amounts and conditions of the materials in different sediment types, different regions, and different depths within the cores may serve to indicate the extent to which this dynamic environment is transporting and modifying cultural materials.[272] Some patterns relating to this are already evident, but more research is needed before these materials and the forces affecting them are fully understood, and may be utilized in archaeological interpretation.

Interpreting the Submerged Seascape

Elmina's place is at the boundary of land and sea, historically a key juncture in the meeting and straddling of worlds, and a place now poised to offer insights into the

[269] The charcoal is usually burned wood, but sometimes it's also burned palm kernel shell or other various organics.
[270] The observed charcoal/wood/palm kernel shells are fairly distinctive, but once in a while a) it is difficult to tell them apart; b) they may be partially burned, making differentiation more difficult; or c) the staining is such that it makes it difficult to tell. The majority of the time this is insignificant, but it does play into an understanding of site formation processes and as such is useful to note.
[271] It is not at all common at sites in deeper water such as the Double Anchor Site or the Elmina Wreck site.
[272] It should be noted here that the depths represented in the cores vary significantly, and the longest core is only 130 cm, which, while nearly doubling the depth of the deepest excavation unit at the shipwreck site (Chapters 4 and 6), is likely not the deepest depth at which cultural material will be found in this environment.

intricacies of maritime relationships, navigation within the complex seascape, and the varying scales of history and archaeology. Steinberg (2001:109) suggests that the sea during the time of the Atlantic trade "was fought over not as a space to be possessed, but to be controlled, a special space within world-society but outside the territorial states that comprised its paradigmatic partial structure."[273] The nations that met, traded on and competed for control of the sea and historical seascape understood that they could never control the sea herself, however, and remained in awe and fear of her power. Remains of their actions and attempts to control nature in coastal Ghana are still in the grip of that power, entombed in the sediments of the Elmina seafloor landscape. Those remains that have been found provide clues both to the history on the seascape, and to the subsequent site formation processes at the level of the seafloor. Data collected across a broad region provide comparisons for sites and a larger picture of the submerged environment of trade.[274] The previous chapter (Chapter 4) is a discussion of the methodologies employed in site survey and investigation, as well as descriptions of what was discovered. As a means of tying together the widely differing scales of individual sites and the region, the remainder of this chapter examines several examples of submerged sites (one natural and three cultural) and the formation processes that likely created them and still affect them;

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[273] In other words, the sea itself constituted a real space that was recognized as an entity in and of itself, one which could only ever partially be considered part of the fabric or structure of the nations that sought to control it.

[274] One simple example and parallel in the literature can serve to highlight the importance of comparison over space and over time: at the time of Cook's original survey in 2003, several targets seen in the side scan sonar data must have been at least partially exposed, but four years later, in 2007, they were no longer visible, having been covered up by the significant amounts of sediments being transported along and across the continental shelf. Jones et al. (2005:190) report a parallel example involving the wreck site of the *Bellona* off the coast of Devon: divers were unable to detect any surface or near-surface evidence of the wreck, but through the use of remote sensing they were able to identify specific anomalies to use in their search. The authors also use this example as a means of suggesting that perhaps individual survey equipment may not provide the answers we are looking for, but in tandem they provide a powerful suite of investigative tools.

the sites are then contextualized within the larger Elmina seascape and the processes at work across the region.

Remote sensing data were collected in 2003 and 2009, but diving on most targets[275] was not conducted until 2007 and 2009; as such, the different data sets provide essentially three different perspectives on those particular locations on the seafloor. Table 5.1 lists all of the targets that were dived in the 2007 and 2009 field seasons, along with descriptions of the seafloor and cultural materials, and a record of whether or not cores were collected at the sites.[276] Because no significant historical cultural material was identified at most of the targets dived in 2007 and a number of those dived in 2009, these locations on the seascape are considered informative in terms of the wider submerged landscape, the processes affecting it, and interpretation of remote sensing data, but are less directly useful in terms of understanding cultural uses of the seascape.[277] As such, only four examples are presented here (see Figure 5.2 above); three of them relate to submerged cultural sites, and the fourth is an example of a rock feature that in the side scan sonar data provided the best possible target comparison to the Elmina Wreck site, and therefore was considered to be the most likely candidate for a shipwreck site. Although only a limited number of targets is expressly discussed here, interpretations of the formation processes affecting them are informed by the processes observed across the region (Appendix VIII). Table 5.1 (below and continued to p.194) illustrates the wide variety of locations investigated on the seafloor, including at the selected sites. Interpretation of some events at these sites is presented, both in terms of natural and

[275] With the exception of the Elmina Wreck site, the topic of the next chapter.
[276] Full details of all cores collected in both seasons are presented in Appendix I; discussions here focus on several examples chosen from these.
[277] Details of a number of representative examples of these sites are presented in Appendix VIII.

cultural events, and the archaeology of the event is highlighted. Where possible, comparative side scan sonar images are presented to highlight targets and changes in local environments.[278]

Table 5.1

Target	Year	Seafloor	Cultural	Core Data
Elmina Wreck Site	2003, 2005, 2007, 2009	varying - sand and shell (2003, 2005, 2007, 2009); mud (2009); scoured areas (2007, 2009)	shipwreck	yes
05-016 R-B	2007	sand with undulations	no	no
05-016 R-A	2007	sand with undulations	no	no
05-056 R	2007	large rock	no	no
10-13 R	2007, 2009	muddy (2007); sand and shell (2009)	Identified in 2009 as the Double Anchor Site	yes
07-40 R-B	2007	large flat rock and mud	no	no
06-53 L	2007	sand with low (possibly linear) rocks	modern trash	no
07-28 R	2007	mud	no	no
07-39 R	2007	large rocks and mud	yellow brick	no
04-45 L	2007	mud	no	no
08-47 L	2007	not recorded	no	no
10-57 R	2007	sand with undulations, some shell	no	no
04-13 L	2007	mud	no	no
04-30 R	2007	patches of sand; patches of mud	no	no
05-04 R	2007	large rock, sand	fishing net, modern debris	no
07-27 R	2007	rocks and sand	no	no
07-26 L	2007	mud, depressions once in a while	no	no
06-32 R	2007	mud near Pasum Accra Reefs	no	no
06-36 R	2007	rocks with soft coral; sand and shell	no	no
06-24 L	2007	large rocks with soft coral; sand with shell and undulations	no	no
06-41 R	2007	mud/silt	no	no
07-40 R-A	2007	rocks with sand; silt/mud	no	no
08-56 R	2007	mud/silt	modern debris	no
08-68 L	2007	mud/silt	no	no
12-23 R	2007	rock with sand; silt/mud	no	no

[278] Exact sizes of targets are not provided, but the scale of each image in the same, as each target image is shown on a 50 meter-wide swath of side scan data.

11-36 R	2007	mud	no	no
08-22 R	2007	silt/mud with shells	no	no
11-29 L	2007	sand with large undulations; some areas mud	no	no
08-12 R	2007	silt/mud	no	no
10-15 L	2007	mud/silt	no	no
11-46 L	2007	sand with undulations; one quarter of the search area was mud	modern concrete with rebar in it	no
10-40 L	2007	silt/mud	no	no
05-52 R	2007	silt/mud	no	no
11-01 R	2007	mud/silt	no	no
11-01 L	2007	mud/silt	no	no
12-04 L-B	2007	not recorded	large cylindrical object standing 1 m above sediments at 45° angle	no
06-35 L	2007	rock and sand	no	no
C1	2007	mud	no	yes
C2	2007	silt/mud	no	yes
Waypoint **46**	2009	hard-packed fine sand	no	yes
Waypoint **303**	2009	sand with scours	no	yes
Waypoint **394**	2009	sand with scours	no	no
Waypoint **397**	2009	sticky mud with scours	no	yes
Waypoint **395**	2009	rock, sand and mud	no	no
Waypoint **398**	2009	rock and sand	no	no
Waypoint **322**	2009	sand	nothing on surface - hit something with core	yes
Waypoint **338**	2009	undulating sand over black silt	no	yes
Waypoint **538: Near Single Anchor**	2009	sand	no	yes
Waypoint **539**	2009	mud	no	yes
Waypoint **253**	2009	sand and silt	no	yes
Waypoint **555**	2009	rock reef and sand	large chain	no
Waypoint **541: Single Anchor Site**	2009	sand	single anchor fluke	yes
Waypoint **411**	2009	sand	no	yes

Table 5.1. The variety of seafloor characteristics across the Elmina seascape is clearly seen when comparing the different targets that were dived. Note that the rocky areas are reported with the surrounding sediments as well. The targets discussed below are highlighted; the Elmina Wreck site is discussed in the following chapter.

It should be noted that the targets displayed in Table 5.1 are listed in the order in which they were investigated; this reflects in part the target ranking done in 2007 (Chapter 1), but also reflects the conditions present along the coast. For example, on extremely rough days it was impossible to dive the reef targets, so other, perhaps not as highly-ranked targets were investigated instead. The 2009 targets were dived as they were identified in the remote sensing data, and as time permitted.[279] As shown in Table 5.1, more than 50 targets have been investigated in the Elmina seascape to date; as many of the sites share similar physical characteristics, and only four[280] of the targets have produced significant historical material, it is not necessary to discuss all of them here (see Appendix VIII for additional examples). The targets and sites discussed here were selected for three specific reasons: 1) they represent a range of seafloor environments; 2) they illustrate both research methodologies and the varying scales at which this research is interpreted; and 3) three of them reflect cultural practices in the seascape.

Large Rock (07_40R-B)

This target was identified in the 2003 side scan sonar data and investigated by divers in 2007; it was re-surveyed using both side scan sonar and the echo-sounder in 2009, but was not re-dived. It is easy to see, particularly in the 2003 side scan sonar data (Figure 5.4), why this was an attractive target to investigate: it has clear elevation, is more than 30 meters long, has scouring along at least one edge of it, and has various features/distinct objects within and near it. In addition, its side scan sonar signature

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[279] It should also be noted that all the 2007 targets were identified based on Cook's side scan data collected in 2003; the targets dived in 2009 were based on Cook's data and on side scan and magnetometer targets from data collected in 2009.
[280] To date there are five known submerged cultural sites in the Elmina seascape, but the Benya Lagoon site was discovered by dredgers and not dived on, so it is not considered a target here.

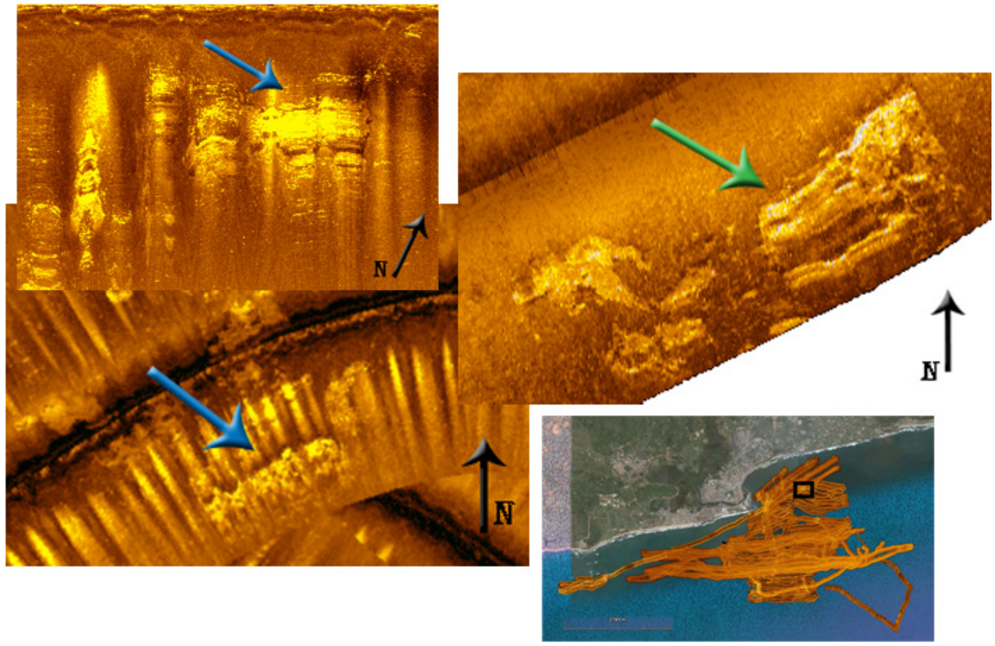

Figure 5.4. **The blue arrows indicate the target in the 2003 side scan sonar data: the upper image is in the raw data, while the lower image is in the corrected form. The green arrow indicates the same target in the 2009 corrected side scan sonar data. The feature is approximately 30 meters long.**

closely resembled that of the Elmina Wreck site identified in 2003, and it was thus considered an attractive target. Finally, it was an area recognized by Papa Kofi Arhin as being a net snag, although he believed it was a grouping of large rocks, which was in fact the case upon diver observation.

In 2007 the site consisted of one very large rock with varying topography sitting one to one and a half meters above the surface of the seafloor, surrounded by a series of smaller ones and mud. Cclearly the rock features at this target have remained constant, but it is uncertain from the 2009 side scan sonar data what changes, if any, have taken place in the composition or quantities of sediments at the site. Because this area of rocks is located in the shallow, shoreward side of the bay, they are subject to a battery of formation processes on a regular basis, particularly to storm surge during the rainy season, but also to the longshore drift throughout the year. As a result, it is likely that the sediments surrounding the rocks will vary over time, as seen at other sites across the region, but this has not yet been verified.

On one dive a small yellowish brick that may have been of Dutch origin was found,[281] but it was not recovered and was not relocated on subsequent dives, and no other cultural material was identified on or near the target. No cores were collected at this location and the target was not revisited in 2009. All dives made at this place were conducted in rough conditions with near-zero visibility, so while there is little indication of cultural material at present, the site should be visited in calmer and clearer conditions to verify that there is in fact no additional historical material there.

One final note relates to this target and to numerous others across the submerged landscape. Reef and rock structures are of interest because of their obviously historical significance as shipping hazards. They are also interesting in terms of this research for their potential roles in terms of indicating formation processes (in terms of cycles of exposure and cover-up, and the sediments that are concentrated with them), and in terms of being potential traps for submerged material loose on the seafloor. The naturally-rough water associated with these features (at the surface, anyway) makes remote sensing near them very difficult, resulting in unclear data. Because conditions have been consistently rough along the coast during field research, these areas have been only minimally investigated. It is hoped that future field seasons in calmer conditions will be more

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[281] Note that the target at which it was found was several meters away from the target number noted here, but, as is visible in Figure 5.3, this is a large rock, and both targets were in fact located on it, just in different places.

conducive to exploring these potentially very informative features both with remote sensing instruments and diver investigations.

Chain Site

The Chain Site was discovered in a magnetometer survey in 2009, in an area not previously surveyed. It is located in the Kassi reefs, approximately ten kilometers west of Elmina (Figure 5.5). Illustrative of the mariner's relationship with rocks and reefs is Nathan's (1904b:15) quote describing this large reef as "running straight towards d'el Mina, mostly by the land, so that mariners have nothing to fear" if traveling past the region. Half a century later the US Navy Hydrographic Office (1951:52) described the same area in the following manner:

> Ampeni Point, is a low sandy point 3 miles eastward of Kommenda Point… A ledge of rocks extends about 300 yards eastward from Ampeni Point. Kassi Reefs which extend 1½ miles eastwards are separated from the ledge off Ampeni Point by a 2-fathom channel available for boats. A depth of 3½ fathoms is found close to the outer edge of the reefs, and the surf at times breaks over them in high rollers. There is a passage inside Kassi Reefs, but the depths, from 2 to 4 fathoms, are very irregular.

At some point prior the availability of such a detailed description of the area, it appears that a very large vessel encountered the reefs at Ampeni Point, but the fate of the vessel remains a strange mystery.[282]

The Chain Site is located on the lee side of the reef in fewer than five meters' water depth, with rocks breaking the surface and visible just below the surface, depending on the tides. The chain itself is concreted to the seafloor in a position suggesting that the anchor was shoreward of the snapped end (also suggested by the ring

[282] A possible alternative explanation is provided below.

at the shoreward end), and the reefs, which lay less than two meters from the snapped or cut end, played a role in the severing of the chain. It is estimated that the chain is of 19th century construction, but it is difficult to date chain, and it is unknown when it was actually deposited.

Figure 5.5. **The Chain Site is indicated here by the diamond in the left side; unfortunately GoogleEarth image coverage has not yet expanded to this region. The site is located approximately ten kilometers west of the Elmina Castle. Because of its distance from the survey area, it is not indicated on the geomorphological analysis (Figure 5.2).**

Although not part of the immediate survey area around the Elmina Castle, the Chain Site relates to a number of features that are associated with it. First, it is likely an example of a historical interaction of a vessel with the dangers of a reef system. The chain (and therefore the extent of the site, as it is presently understood) itself is dwarfed by the size of the reef – more than one kilometer long – and yet its size in comparison to other (anchor) chains, is large (Pering 1819:96-98), suggesting that the vessel that carried it was relatively large and equipped to handle such a large piece of equipment. Regardless of the size of the vessel, however, the broken or snapped chain is possible evidence that the encounter with and event at the reef was at the least problematic for the vessel involved.[283] An alternative possibility, noted in Chapter 4, is that it is also possible that the chain was deposited in such a location as a result of some activity other than a vessel's navigation, such as having part of a marker buoy. While this is possible, the chain's location on the lee side of the reef makes this a less likely explanation. Whatever the explanation, it is an interesting part of the seascape of coastal Ghana, and represents events of the past that have yet to be explained. Secondly, the high rates of sedimentation[284] observed at the Chain Site can be compared to those seen at the Single Anchor Site;[285] at a slower rate, they are also comparable at the Elmina Wreck site.

In terms of methodologies, it is important to note that the site was discovered with the magnetometer, as, if it had been surveyed only with the side scan, it is likely that the high sediment covering and extensive rock field and rough waters near the reef[286] would have prevented the chain from being recognized (see Figure 4.10 in Chapter 4).[287] A comparative survey on the windward (seaward) side of the reef system did not produce any magnetometer signatures, although, because of rough conditions, it was not possible to survey as close to the reefs on this side as would have been ideal. A full description of the chain and of this site may be found in Chapter 4. No sediment cores were collected

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[283] As discussed below, the evidence at the Single Anchor Site also suggests that a vessel was in far too close proximity to a rock feature, but, equally interesting, it is unknown at present what happened to this vessel either.

[284] Most of the chain was buried by approximately 30 centimeters of sediment; when this was hand-fanned away in order to map it, divers had to keep a hand on the chain because literally within seconds it was covered again by sand. This meant that if a physical connection was not maintained with it, there was no trace of it on the surface, and it would be necessary to return to the exposed portion and begin the uncovering process again.

[285] Rates are somewhat slower at this site, but 20-30 centimeters of sediment were observed to have covered the anchor fluke within a single week during the 2009 season.

[286] Causing distortions in the side scan data.

[287] This is a significant factor to consider when approaching any reef system with remote sensing equipment. We surveyed the Pasum Accra reefs, located just one kilometer west of the castle and previously surveyed with the side scan by Cook in 2003 (see Appendix VIII), and did not detect any targets. It should be noted, however, that because of the rough and shallow water, neither Cook's survey nor the 2009 survey were able to access the lee side of the reefs; in addition, as with the reefs in which the Chain Site is located, rough conditions prevented a close survey of the seaward side.

here due to the sand stone substrate to which the chain was concreted. This site should certainly be returned to in the future.

Single Anchor Site

As noted in Chapter 4, the Single Anchor Site is located just to the lee side of the natural sandbar southeast of the Elmina peninsula (Figure 5.6). The target was identified in the 2003 side scan sonar data by the deep scours in ripple beds; the site was dived in 2007, although nothing was found at the time. The target was re-dived in 2009 as a result of a target being identified in the 2009 side scan sonar survey. The 2009 side scan sonar signature is significantly different than that in the 2003 data, including a shift in the location of ripple patches and less indication of scouring (Figure 5.5). Diver observations in both 2007 and 2009 noted that the entire seafloor surrounding the area was covered in large sediment undulations/ripples. The seafloor is sand, a high percentage of which is carbonate detritus (Short 2005a:822).[288] No other features, whether cultural or natural,[289] were noted on the seafloor near this site.

Two cores were collected at or near this site; the first (#**17_09**, 135 centimeters) was collected at the original target location[290] which proved to be approximately 25 meters south of the actual anchor where the second core (#**6_09**, 108 centimeters) was taken. These two cores were the longest cores collected, likely as a result of the combination of sediment characteristics and density in the area;[291] the types and qualities

[288] There were carbonate sands/detritus in other locations, including Waypoint **46**, but the extreme rounding of both the shell fragments and sand was most evident at the Single Anchor Site.
[289] Such as rocks.
[290] The coordinates were taken from the target identified in the 2003 side scan data and which was dived in 2007; the 2009 signature is used as a comparison here but was not used in the field to identify the site.
[291] Although the sediments were far less dense or compact than at Waypoint **46**, which, although only slightly closer to shore than the **SAS**, is located directly in the surf zone.

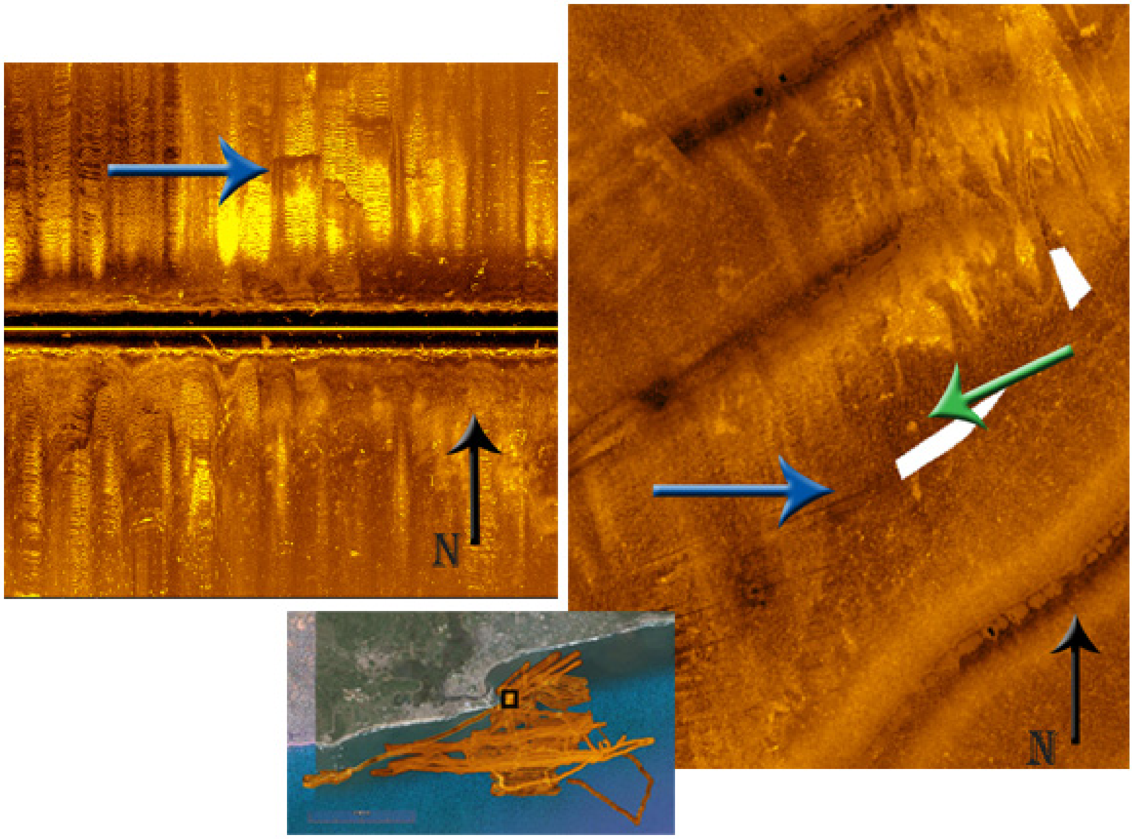

Figure 5.6. **The blue arrows indicate the location of the target dived in 2007, and the green indicates the location where the anchor was actually identified in 2009. The image at the left is raw data collected in 2003, which presents a slightly distorted version of the target; the image on the right is processed data collected in 2009. Note that the ripple patterns have clearly shifted location and shape in the span of six years.**

of cultural material present may also have played a role in securing the sediments inside the tube. Sediments in the upper parts of the cores tended to be angular or have some indications of rounding, but those towards the middle and bottom of the cores were well-rounded, indicating not only the high-energy character of the coast and the area within the coast, but also the effects of those sediments having spent more time in this particular high-energy area. As noted in the previous chapter, the dynamism of this area is highlighted by the fact that over a period of one week there was a 25 centimeter difference in the levels of sediment at the site. This may have been a significant factor in the site not having been identified in 2007, although search methods and rough, zero-visibility conditions also may have played a role.

A brief revisiting of the geography and navigational history of the area adjacent to the Castle is helpful in interpreting the Single Anchor Site. The US Navy Hydrographic Office (1951:52-53) once again provides a succinct description and instructions for navigating it:

> The rocks off Elmina Point shelter the landing place at the mouth of the Beya [*sic*] River. The water is, however, very shoal and ordinary boats should only land on the beach at high water. Landing may be effected in ships boats at high water in the Beya River during the dry season when the surf is not very high, but it is not safe at or near low water. In making for the river give the rocks off Elmina Point a wide berth and steer out into the bay until the river is well open. Around Elmina Bay the current follows the course of the shore from west to east; there is an indraft to Beya River on the flood.

As discussed in Chapter 3, accounts as to the navigational and anchoring practices near the Castle vary, but what is consistently noted is that there was no access to the Castle from the south for either friend or foe, as the rocks and waves off the peninsula did not allow access to it (Hair 1994a:17, 78; Lawrence 1963:103; Vogt 1979:25-26). It was not only the rocks that were a problem, as in high seas or foul weather the rollers could break as far out as 550 meters from shore (US Navy Hydrographic Office 1951:52), threatening any vessel caught in them with being thrown on the rocks. In addition to the rocks, the geological form of the end of the peninsula on which the castle was built means that sediments carried on the prevailing west-east currents and the longshore current are dropped after encountering the rocks forming a sandbar;[292] this feature would have been a constant threat to any vessel that for whatever reason found itself close to the south or southeast side of the castle.

As with the Chain Site, and as noted in Chapter 4, it is possible that this site is not actually directly related to the navigation or an incidence of a single vessel; it too, may be evidence of, for instance, a navigational buoy.[293] That being said, however, its location on the lee side of the rocks and sandbar, as opposed to the seaward side, makes it less likely that it is the anchor for a navigational buoy, as it would have been useless to the navigator. It is also possible that it represents some other event related to the Castle, but it is difficult to imagine what that would be. As a result, and until other data become available to support different interpretations, discussions here are focused on the likely navigational associations of the anchor, and on the implications in terms of historical navigation within the Elmina seascape.

While very little of the anchor was visible above the sediments, very rough estimates as to its size may be made based on the size and construction of the visible fluke. The fluke of the anchor most closely approximates the British Admiralty anchor of the 18th or possibly early 19th century (Cotsell 1858:14-17; Curryer 1999:49; Rubin 1971:237) in terms of its form and size. The size of the fluke also denotes that the shank is likely approximately four meters long, and possibly longer, indicating that it would clearly have been a bow anchor, and could have fit a vessel of 625 tons or more

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[292] DeCorse (2001:48-55) details the changes made through time on the Elmina peninsula, including modifications to the mouth of the Benya. While these changes would certainly have had an effect on navigational practices at the mouth of the river, the sandbar to the southeast of the peninsula would have been a relatively permanent feature, although it could have varies somewhat seasonally.

[293] A less likely suggestion is that that the anchor was lost or simply cut away if trapped on something. Its position so near the Elmina peninsula, however, makes it an extremely unlikely location for a vessel to anchor and therefore to subsequently lose an anchor, suggesting that this is not the most probable explanation.

(Sutherland 1717:22).[294] It is not possible to offer more than these general conclusions at present, but future investigations hold the potential to provide a great deal more data. Probing around the anchor provided information on the direction in which the anchor is lying, but it offered no indications of additional material.

The Single Anchor Site provides a good case study for examining some of the historical and navigational practices associated with maritime trade at Elmina. The position of the Single Anchor Site just meters to the north or lee side of the sandbar is intriguing. It is located in approximately five meters of water, less than 400 meters from the present shoreline[295] and the rocks at the southeast tip of the peninsula. Because of this, it is difficult to imagine not only why a vessel would have ventured not only so close to the peninsula, where rough or unpredictable winds, currents or storms could have easily smashed it against the rocks, but also so close to the potentially disastrous sandbar, the presence of which had to have been common knowledge to sailors.[296] The fate of grounding on a sandbar was often similar to that of hitting rocks: at best, if the vessel was floated free, it usually meant damage to the hull, and at worst it meant complete loss of the vessel (i.e. Lusardi 2000; Marsden 1972; McNinch et al. 2001). Because it is absurd that a vessel of such a size[297] would have intentionally ventured to such a location and anchored there, another explanation must be in order.[298]

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[294] Anchor sizes and weights were contingent on the size and weight of the vessel using them (Pering 1819:20-23), and changed over time and with different nations (Jobling 1993:126), so this estimate, as well as those provided in reference to the Double Anchor Site, are presented with caution and as a range, rather than as an exact estimate.

[295] Although it may have been up to 500 meters from the historical shoreline just north of the rocks at the end of the peninsula.

[296] This would be the case regardless of whether the vessel was under its own sail power or, for some reason such as intended careening (also unlikely in this environment for such a large vessel), was under tow at the time it came so close to the shore.

[297] It is interesting to compare the possible sizes of vessels represented archaeologically near the Benya and nearshore areas of the Bay. Pietruszka (2011) estimates that the Benya Lagoon ship measured

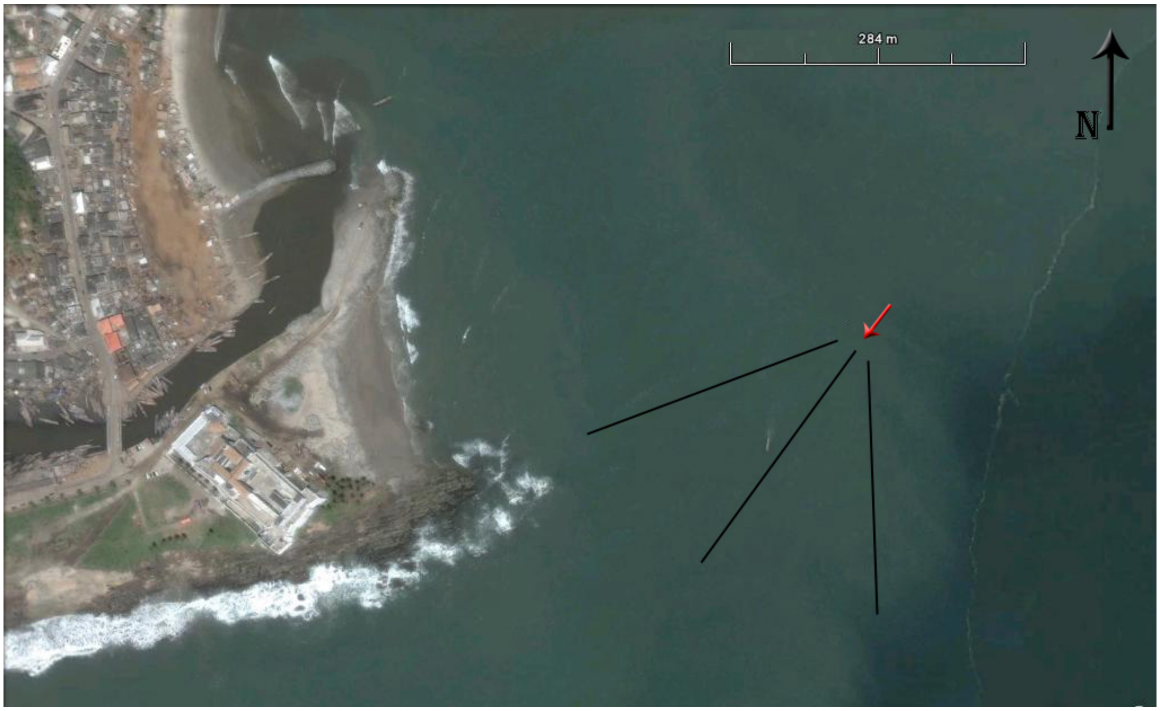

Figure 5.7. **While clearly not to scale, the red arrow in the GoogleEarth image above indicates the direction in which the shank of the anchor is pointing, in turn indicating the direction that a vessel utilizing it would be positioned. The black lines indicate the approximate range of positions a vessel could be in to successfully utilize an anchor at this angle. Keeping in mind that there would have had to be some scope on the line to assist in maneuvering, it is obvious from the illustration that any vessel needing to use the anchor as it is set was in trouble. That being said, there does not appear to be a vessel there, which may indicate that the maneuver worked, or possibly, that another explanation is need.**

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approximately 36 meters in length; this estimate would put it in the range of vessel tonnages from a large bark to a frigate, possibly carrying 400 tons or more (Chapman 1775). The vessel associated with the Single Anchor Site could have been as large as 625 tons. As noted in Chapter 3, a shallow-draft vessel of 300 tons could draw three meters, and a higher tonnage vessel would have drawn more; it is most likely that because of its location so far up the Benya, the Benya Lagoon vessel was towed (using a kedge or warping technique) and moored there, so as long as the draft was just shallower than the Benya, it could be drawn up the river without concern for having to turn such a large vessel around or extract it again from the Lagoon. The vessel responsible for carrying the single anchor was, at the time, a functional vessel, possibly much larger than the Benya hulk; because of a deeper draft and larger size, unless it too was stripped down for mooring, it is highly unlikely that it was destined for the Benya for any purpose.

[298] It is also possible that a vessel was already (unintentionally) caught on the sandbar or further offshore, and the anchor was carried out and set using smaller boats in an effort to provide a means of pulling the vessel off of the sandbar or from its troubled location. However, the large size of the anchor (weighing over 900 kilos and four meters long) most likely precludes this, as it would have been impossible to carry such a large anchor any distance in small boats and to launch it without potentially destroying the smaller vessel; in this circumstance a much smaller kedge anchor would have been used for that purpose (Rubin 1971:233; Steffy 1994:266-267).

The angle at which the anchor is lying (Figure 5.7) indicates that whatever the circumstances in which it was dropped there – whether to save the vessel on which it was used, another vessel, or even to try to salvage an already wrecked vessel – the vessel to which it belonged would have been dangerously close to the rocks of peninsula. In this situation it may have been preferable to drop a large bow anchor and ground the vessel on the sandbar than to lose it on the rocks, assuming it could be controlled in such a dynamic location. If this hypothetical maneuver was successful, the vessel may have been refloated in calmer weather and this may explain why there were no visible[299] shipwreck remains near the Single Anchor Site.[300] If the vessel was, in fact, refloated, it would have to have been pulled to sea in order to free it, possibly damaging it further in the process[301] and requiring that it be transported somewhere else for repairs. That being said, however, it is also equally possible that there was actually a wreck and the site is simply so deeply buried that there is no additional material visible on the surface.[302]

Site formation processes active at this site are indicated both by surface features and the materials collected in the sediment cores. As noted earlier, sedimentation rates vary remarkably quickly,[303] at some points scouring out the fluke of the anchor and at

[299] This includes "visibility" in terms of remote sensing instruments, particularly the magnetometer.
[300] The only potential target within a radius that could reasonably be expected to contain shipwreck remains associated with this anchor was located more than 200 meters to the east, which is an unlikely location. The target was indentified with the magnetometer and we did not have time to dive on the target.
[301] If this is indeed the scenario that created this site, there may not have been any choice at the time about the direction in which the vessel was towed, even though pulling a vessel backwards ran the risk of causing even more damage to the rudder and stern. It is also possible that though the anchor appears to be set now, it may not actually be lying as the users intended it to be, and may not have served a useful purpose there at all; that possibility, however, brings us back to the question of why, and more importantly, how, the vessel got there in the first place.
[302] See Laures (1987) for a brief discussion of other single anchors that have been interpreted as vessels escaping wrecking.
[303] Because it has not been possible to quantitatively measure sedimentation rates in this region, these observations must be presented in terms of qualitative data. For example, sedimentation rates of greater than half a meter were observed (but were not quantitatively measured) at the mouth of Benya during the months of September and October, 2007. Sedimentation at the Single Anchor Site (located approximately

others filling in the scour and substantially covering the fluke. Modern debris[304] is regularly caught under and around the exposed part of the anchor; the continuous nature of these processes is evident also in the core material (see Appendix I for more details on the cores). One striking feature of the materials in core #**6_09**, which was taken next to the anchor,[305] is the extreme rounding of the coal, charcoal, and palm kernel shells[306] in it. The most unique item recovered in this core was a number of small black seeds resembling pepper corns, found in levels throughout the core. None of these seeds were collected in any other core across the entire region, so their presence in several strata of the same core is intriguing. Further research will need to be carried out before any conclusions can be drawn from them.

The strata in both cores collected in this region tended to be differentiated based primarily on sediment colors and characteristics; in both cores, however, there were also distinct lenses that consisted primarily of palm kernel shells. In core #**6_09**, **S3** is comprised almost entirely of palm kernel shells, and all of the strata deeper than **S7** had high proportions of them, most more than 20% of the coarse fraction. Core #**17_09**, collected 25 meters south of the anchor, also had a distinct layer of palm kernel shells in its deepest stratum, **S8**. Nearly every other strata in both cores contained palm kernel shells, but the extreme concentration of the shells in specific strata suggests that these particular strata are the result of storms or other short-term morphological events (Wright 1995:171) in association also with high concentrations of the material being present on

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400 meters south (upcurrent) of the mouth of the Benya), was observed in the time frame of a week, when there was a measured 20-25 centimeter difference in the amount of the fluke that was exposed. Future work needs to include more quantitave assessments of sedimentation rates and other forces in this region.

[304] Including modern bottles and glass fragments, tomato paste cans, a wire lantern, a D battery, coconut shells, sea shells, modern lead fishing weights, fishing line and plastic fragments (see Appendix VI).

[305] This core was collected half a meter NE of the fluke, where it was certain that the core would not strike any part of the anchor itself.

[306] Although the rounding typically was more prevalent on burned than unburned palm kernels.

the seafloor.[307] Strangely, while the surface of the seafloor in and near the scour/anchor fluke was covered in coconut shells, only one fragment of coconut shell was identified in the cores.

Core #**17_09** has a similar artifactual and sedimentary signature to core #**6_09** in terms of the types, quantities, and conditions of (generally modern) materials in it. It is interesting to note, however, that there was significantly less rounding in both the sediments and the artifacts in core #**17_09** than in #**6_09**, and a completely unique feature of palm kernel shells in this core (found in the deepest strata, **S8**) is that many of them appear to be covered in sulphur or a sulphur-looking material. The reason(s) for this is unclear, but one possibility is that it is a combination of the chemistry of the environment in which the artifacts were located, including any other objects they may have been associated with, and the process of drying after removal from the saltwater environment. It should be noted here that the deepest core recovered to date has been 135 centimeters, which, while clearly providing significant data, likely does not reach the depths to which cultural material can be found in this region, leaving open the question of what else may be present and how deeply it is buried under the sediments.

Double Anchor Site

This target was identified in the 2003 side scan sonar data, dived in 2007, identified in magnetometer data and dived in 2009. As noted in Chapter 4, the Double

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[307] Palm kernel shells unfortunately cannot be considered diagnostic, as they float and therefore can be transported easily long directions, and because they have been continuously used. The meat of the palm kernel is used for food, and the shell itself is used to make small, intense fires, such as for blacksmithing. While it can probably be safely assumed that palm kernels were utilized well before European contact, there is no current evidence for this (DeCorse 2001:104), so at present, and without the use of precise dating techniques, it is not possible to know what dates these strata may represent. Because this is such a dynamic region, unfortunately even the depth at which they are buried is not a reliable indicator of age.

Anchor Site was actually discovered in 2007 based on the 2003 side scan sonar data (Figure 5.8), but the metal objects at the site were not identified as anchors until the site was re-dived in 2009. Interestingly, the sea bottom conditions in 2007 were noted as muddy, while in 2009 they were consistently sand with considerable amounts of shell; this can be seen in the geomorphological interpretation (Figure 5.2), as the site appears to be located just west of a large area of different sediments, which *may* indicate the shifting of the mud seafloor over the period of two years.[308] As is discussed below, these changes in sea bottom conditions may be a key factor in the preservation of the anchors in a standing position.

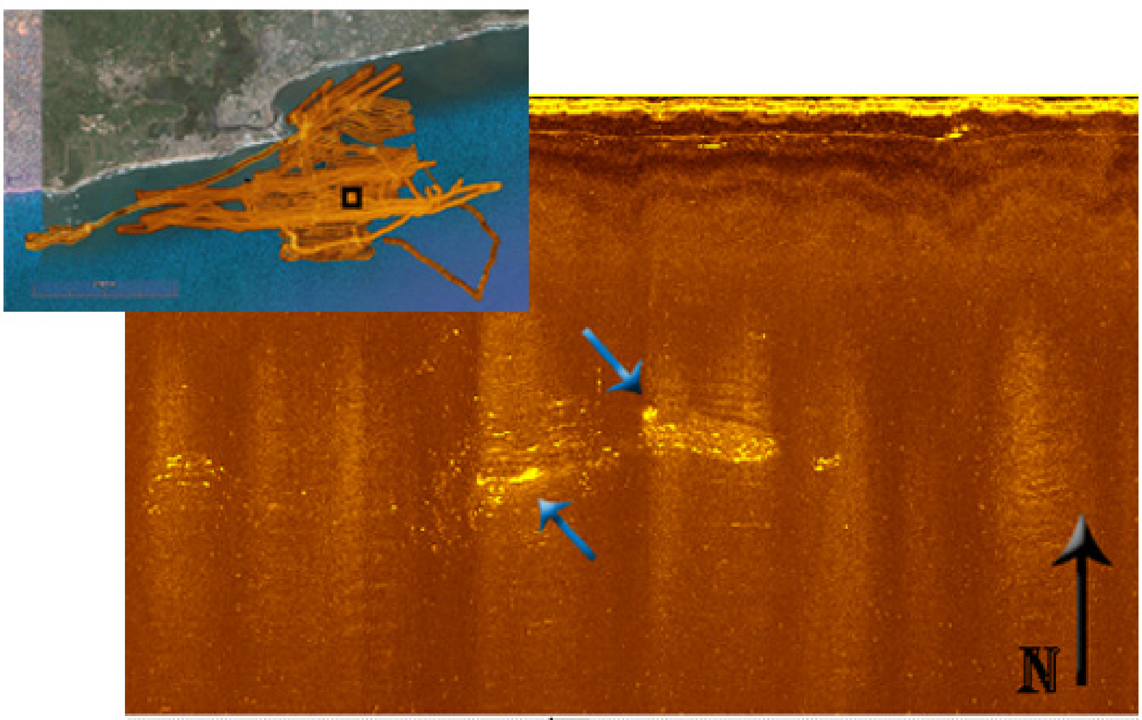

Figure 5.8. In retrospect, it is clear that the two round, bright spots indicated by the arrows in this side scan sonar image collected in 2003 are the anchors. Some sediment scouring is visible, particularly to the east of the anchors.

[308] It is not possible to say this with complete certainty, as the side scan data from 2003 either did not indicate a different sediment due either to a lack of discrete signature or difficulties in reading the data.

The site is located in 12 meters of water, and it was remarkable that on the only exceptionally clear day we experienced, the very end of the large anchor, standing more than two meters above the seafloor could be seen from the surface of the water using a mask. The clarity of the water is a confirmation that apparently at select times of the year there is enough sunlight to allow for the growth of some floral marine life, as was observed elsewhere as well,[309] including at the Elmina Wreck site. The site was used as a test/comparative data set for correlating magnetometer data to side scan sonar data, and interestingly, it was possible to tell the anchors apart with the magnetometer by differences in their magnetic signature due to differences in their size.

In addition to the changes in sedimentation,[310] a number of site formation processes are visible on and around the anchors. The first concerns indications of exposure and reburial of cultural material in this environment and is based on observations of barnacles at both the Elmina Wreck[311] and the Double Anchor Site. It appears that barnacles are the first marine fauna to colonize exposed objects on the seafloor, and, as is often the case, as the material is broken down, it generally is covered up and the barnacles die. However, as is the case with anchors at this site, since they have never been fully covered, the barnacles have retained colonization rights, and very few other fauna, with the exception of some crabs that live in the eyes of the anchors (see Figure 4.11 in Chapter 4), have succeeded in colonizing them. The relatively large size of the barnacles, comparable to the largest found anywhere in this region, indicates that the anchors have been continuously exposed for long periods of time. This indication of

[309] It was also seen at the reef site (**06_024R**) discussed in Appendix VIII.
[310] These changes are also evident at the Elmina Wreck site, discussed in detail in Chapter 6.
[311] This is discussed more fully in Chapter 6, but it is important to note here that the observations have been made on multiple sites.

exposure is a crude but useful means of estimating the amount of time an object was initially exposed, and perhaps can even be used to identify periods of re-exposure.

The second and third indications of site formation are related and concern episodes of accretion and depletion of sediments at the site. Current action and scouring are clearly having significant impacts on the anchors in at least two distinct ways. First, the scouring (depletion of sediments) destabilizes the bases of the anchors, and is likely primarily responsible for the angles at which both anchors lean, clearly influenced by both the destabilization process and the predominant direction of the current, with which they lean. The second concerns the modern fishing line and net caught around the base of the anchors. While it is less apparent on the smaller anchor, the base of the larger anchor is being worn down by the continuous action of scouring and currents rubbing the line, nets and weights against the anchor. Because of how quickly the anchors became less stable with any sort of digging at their bases it was not possible to determine the depth to which this process is affecting their structures, but it is something that should be monitored in this future.

Finally, episodes of sedimentation accretion and depletion have apparently considerably changed the surface of this site numerous times in the past. As noted above, within the short period of two years the entire surface of the site changed from being mud to sand. The complete coverage of the site by two dramatically different sediment types is complicated and what triggers the change is at this point unknown.[312] Regardless of the

[312] Niedoroda (2005:867) provides a simple explanation that can help to understand the general processes at work that maintain each different sediment type in a region, but does not provide insights into why sediments change. He writes, “bottom sediments may be granular or cohesive. Granular sediments are stabilized in their “at-rest” positions only by gravity. As a general rule, sediments with less than 10-15% clay particles exhibit granular behavior… Sediments with higher concentrations of clay particles, or significant amounts of organic material, tend to resist entrainment because of binding effects.”

mechanism of change, core data indicate that while the surface sediments presently are sandy, there are multiple strata below the sand and shell that were a very soft, highly sticky mud, very much like what was observed at Waypoint **397** (discussed in detail in Appendix VIII);[313] which may have served to trap the anchors and support them in the vertical position. Secured in the mud, subsequent sediment changes served to gradually build up the sediments around the anchors which, despite periods of depletion, have served to keep them in their relatively upright positions.

Several tentative conclusions may be made based on the accessible dimensions of the anchors. The first of these is that the anchors represent two bower anchors, the larger of which would have been on the starboard side of the vessel (Elkin et al. 2007:41; Pering 1819:63-64; Rubin 1971:233; Tinniswood 1945:87; Upham 2001:13). This indicates that when the anchors were dropped, the vessel was facing NNE and traveling east along the predominant current. Interpretations based on the sizes of the anchors are more tentative, but it is possible to say that the shank of the larger of the two anchors is close to four meters in length, as nearly three meters is visible above the surface and thus more than one meter must be below the sediments to be supporting it. A possible similarity in size may be found in the bower anchor recovered from Captain Cook's vessel *Endeavour*, which was determined to be 3.9 meters in length and originally weighing 908 kilograms, or approximately 17 cwt (Callegari 1994:85).[314] Similarly, then, to the anchor at the

[313] Waypoint **397**, located more than two kilometers from the Double Anchor Site, is an area of deep, soft sticky mud that is visible at the surface of the sediments. If surface conditions were comparable to this, it is not impossible that the anchors would have found enough support in the mud to remain vertical, and have gradually been leaning with the predominant current over time.

[314] Weights were measured by cwt. (count weight), for simplicity this can be thought of as 100 count weight, although it varied with the country of use; this means, for example, that a 24 cwt. anchor weighed approximately 2400 pounds (Rubin 1971:232).

Single Anchor Site, the larger of these anchors can be reasonably placed on a vessel of up to 625 tons. The smaller anchor clearly has a much lower cwt.[315]

Apart from the anchors themselves, the only cultural material noted at the site was fishing line, net and lead weights, all clearly modern. No cultural material other than the fishing-related material was observed in either of the small test holes that were dug. There is some interesting material that was collected in the cores, however, which merits discussion. Six cores[316] were collected, three (#**5_09**, #**10_09** and #**13_09**) of which show almost identical patterns consisting of basically no cultural material in the top 20 – 30 centimeters, and the most and most varied material at the base of the cores. Core #**18_09**, however, was collected one meter east of the small anchor and had significant amounts of cultural material in all the strata. The presence of modern plastic and filaments in the lower strata of several cores indicates that there is some vertical traveling between the strata, but the consistent pattern of most of the non-modern artifacts being in the lower strata consisting of sand and shell indicates that there is also some stability at the site.[317] The most intriguing material discovered in the cores is what appears to be the same melted material observed predominantly on the shipwreck site, but also observed in **C2**.[318] Proportionately, the Double Anchor Site has the largest sized-fragments of melted

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[315] While combined the anchors at the Single and Double Anchor sites only offer a sample size of two, they can form the base for future comparisons of the sizes of vessels active in the Elmina seascape.

[316] #**5_09** (56 centimeters), #**10_09** (70 centimeters), #**12_09** (25 centimeters), #**13_09** (56 centimeters), #**15_09** (34 centimeters) and #**18_09** (63 centimeters).

[317] Modern and intrusive materials, such as individual pieces of plastic, in the cores are not a result of the coring process, but rather of the natural movements of objects in fluid-filled sediments. While this does indicate that there is some mixing of the sediments at the site, the concentrations of the melted material in particular in specific strata indicate that it is most likely associated with the site, and not the result of random mixing of materials that are carried on currents or waves and eventually find themselves intermixing with sediments across the region.

[318] Pieces of melted metal in the sediments of maritime shipping regions, particularly those that experienced steamship traffic, is a common phenomenon around the world (Baker and Bett 2001:86-87; Lewis et al. 2000:309; Scholz, personal communication 2011). It is very possible that some of the single or isolated examples of the melted material in the Elmina region are also the results of steamships or other processes

material, as well as the most clearly melted material of any core collected, including those collected at the Elmina Wreck site,[319] indicating that it is likely original to the anchors.

Why are the anchors there, and how are they still standing up? It is possible that they were put in place as mooring anchors, but their close proximity to each other, shared orientation and the fact that they could be easily loosened suggests that this is not a viable explanation. Another less likely explanation is that the anchors were intentionally dumped as trash offshore, but as iron was and still is an expensive and highly-sought after commodity, this is extremely unlikely, and still fails to explain their formation and vertical stances.[320] As unlikely as it may sound, perhaps the most probable scenario is that the anchors were for some reason dropped essentially simultaneously, possibly in an attempt to avoid sinking or in some other emergency-related event. The presence of the melted material provides a potentially significant clue, suggesting that fire may have burned the (likely hemp) cables holding the anchors in place at the bow and allowing them to drop essentially simultaneously; the mud that happened to be present on the seafloor would have held the crowns and arms of the anchors, preventing them from tipping over as they were designed to do (Brande and Cauvin 1842:49-50).

It is an intriguing idea to potentially relate this and a site such as the Elmina Wreck site, which is the remains of a vessel that burned and could easily have drifted 700

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producing clinker or slag (or, alternatively, materials transported off of archaeological sites such as shipwrecks), but the concentrations of the melted materials at both the Double Anchor Site and the Elmina Wreck site suggest that this is not the case in these particular examples. It is more likely that in these cases, the melted material is related to the original archaeological site.

[319] The Double Anchor Site is located 700 meters southwest (bearing 245°) of the Elmina Wreck site, indicating that the melted material is original to each site, respectively.

[320] A similar critique may be made here concerning the suggestion that the anchors were trapped or cut away from a vessel in a storm or other emergency situation.

meters with the current after having lost its bower anchors.[321] While this is scenario is presented cautiously and is admittedly based on only a handful of clues, at present it is the most plausible explanation that takes into account artifact (anchor) positioning, sedimentary contexts, and micro clues recovered from the surrounding matrix. At present there is no known parallel to this site in the maritime world; clearly more research should be conducted at this site.

Contextualizing Submerged Sites

The "whole site formation" approach introduced at the beginning of the chapter focuses on context, and as such, includes the physical environment and site matrixes, historical and natural events, the seascape as a whole, and an incorporation of varying scales: particularly scales of space and geographical extent, and of time. Related to this, one of the key components of my research was the investigation of the Elmina seascape and seafloor both in terms of cultural and natural features and processes. To accomplish this, data from the 2007 investigation of targets identified in Cook's 2003 side scan sonar data and from the intensive investigation of the Elmina Wreck site have been evaluated; a comprehensive survey using both side scan sonar and a magnetometer was conducted in 2009 over the area originally surveyed by Cook; additional targets were investigated, resulting in the discovery of three sites related to historical maritime trade; and data from micro-sampling and sediment cores, as well as environmental literature, have been assessed. The examples discussed above are illustrative of the different methodologies

[321] This is touched on again briefly in Chapter 6. It is interesting to note here that if this is the case, the actual process of the event of wrecking likely took place over a larger area than simply the location in which the remains exist today, providing an additional perspective of scale to the event itself. The natural transport of materials, such as shipwrecks, by water is known to have been effective over far larger scales than those represented in the Elmina seascape (i.e. Rönnby 1995:157; Tuttle 2010:62), but it is the perspective of the *event* of wrecking taking place over a larger area that is of most interest here.

employed, of both the theoretical and methodological approaches to formation processes at a range of scales, and of unique events related to historical maritime trade that are now preserved in the archaeological record on the seafloor.

In each of the discussions of cultural sites, the formation processes that contributed to the creation of the site are discussed in terms of site interpretation and the possible scenarios that may explain them, including the overarching formation process of the historical maritime trade and navigation in the Elmina seascape. Post-depositional processes are highlighted in terms of the current processes affecting the sites, and those that are assumed to have affected the cultural materials since their deposition. While each of the known cultural sites, including the hulk[322] in the Benya and the Elmina Wreck site, represents a unique historical event, they are related by their common foundation in the submerged seascape of Elmina and by the environmental site formation processes that affected and affect each of them. They are also related to non-cultural features[323] of the seafloor both through their historical significance (such as rocks or reefs) and through the methodologies used to investigate and interpret the submerged landscape.

Interpreting the Region and Historical Cultural Uses of the Sea

The use of remote sensing instruments in a region so little-studied provides, and has demonstrated the utility of, a means of both investigating large areas and identifying such unique and particular artifacts as a single anchor standing above the seafloor. In concert with this, it is a testament to the utility of the micro-sampling and coring

[322] This term is used here is used for a non-functioning vessel – likely stripped down before being transferred into the lagoon.

[323] This includes the Large Rock Site as well as sites described in Table 5.1 and in Appendix VIII, all of which provide unique insights into the submerged landscape and the formation processes at work there, regardless of whether or not the sites have been identified as being culturally significant.

technique that such miniscule items as tiny fragments of melted material and single beads have been recovered from a two-inch sediment core collected in the vast expanse of the ocean floor. It also speaks to its application as a means of sampling a region when diagnostic items recovered from cores can be related, however tentatively, to sites other than the location in which they were found.[324] Clearly the environmental processes at work in this region are responsible for a great deal of movement of materials around it. The comprehensive approach utilized here to investigate the Elmina seascape presents a framework that provides a systematic basis for evaluating the relationships of submerged resources with each other, with historical navigational practices and events, with the natural environment, and with site formation processes across the region.

For the most part, environmental patterns seen in the sites across the submerged Elmina seascape can be explained through the environmental agents most active in the area: the dynamic nature of the coast appears to ensure that a suite of non-diagnostic artifacts has a nearly ubiquitous presence across the region as objects are dispersed on currents, winds, storms, and up- and downwellings; nearly every site demonstrates evidence of the constant cycle of exposure and reburial due to seasonal cycles; and ripple patterns shift and migrate, at times highlighting differences in the seafloor and at other times disguising them based on the interaction of currents with coastal geological formation. But there are also differences in patterns that serve to highlight unique events such as storms, and the movement of artifacts in directions not anticipated by the predominant currents[325] and related forces demonstrates the complexity of the region.

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[324] This is particularly in reference to some of the modern cultural material identified in sediment cores from locations across the seascape (Appendix I).

[325] This statement is made based primarily on data discussed in Appendixes I and II, but it is relevant to an understanding of the seascape and submerged landscape as a whole.

The integration of historical maritime practices and physical environmental processes allows for particular cultural remains to be interpreted as the remains of specific events in history, and even provides a means of conjecture for defining just what those events may have been. At a microhistorical level, each cultural site presently known in the submerged Elmina seascape represents a unique event and set of interactions with the navigational landscape, and of necessity, with other people related to the seascape, as each event was part of the interrelated environment of historical maritime trade.[326] Although we have a relatively small sample size of unique sites and events, within the sample we have represented events that occurred in the 17th century (the Elmina Wreck), in the early 18th century (the Benya hulk), and sometime likely in the later 18th or early 19th centuries (the Single Anchor Site).[327] If, as has been suggested as a possibility, the Double Anchor Site represents an association with the Elmina Wreck, the anchors may be confidently assigned to the 17th century; it is also possible, however, that they date from any time between the 17th and the 19th centuries, making it difficult to assign a date based solely on the anchors.[328] While the date of the chain at the Chain site is also more ambiguous, it likely represents an event from the 19th century, when large chains, made without studs, were in more common usage.[329] The locations of each of

[326] While we cannot know, purely from the archaeological record, the roles that individuals played in the events represented, historical accounts, such as that of the *Groningen* (Furley Collection Notebook 1646-1647 pages 162-164) and personal accounts at the coast (such as Barbot's – see Hair et al. 1992) provide ample evidence for stating that the events that occurred on the seascape did not occur in a vacuum. Rather, they affected a range of people, from the sailors themselves to those posted at the Castle, to the local peoples.

[327] See Cotsell (1858:14-17); Curryer (1999:49); Rubin (1971:237).

[328] It is possible to assign a date more confidently to the anchor and the Single Anchor Site because the fluke, which tends to ba more diagnostic part than the shank of the anchor, was visible. Because it was not possible to access the arms and flukes of the anchors at the Double Anchor Site without disturbing or destroying the site, the anchors alone have to be assigned a more general date range. The intriguingly similar melted material on it and the Elmina Wreck site, however, *may* provide a significant clue that can be used in dating the site by association, rather than strictly by the notoriously difficult dating of anchors.

[329] See Pering (1819:77-78).

these sites within the historical seascape speak to navigational hazards (the Chain Site and the Single Anchor Site), intentional use of the Benya Lagoon drainage (the Benya hulk), and possibly anchoring strategies, as well as the ever-present danger of sinking (the Double Anchor Site and the Elmina Wreck site). Within several of these sites are also provided insights concerning micro-artifacts and formation processes, and what they can inform concerning the unique events related to the sites, as well as the macro-processes affecting the region.

At a more macro-level, even the expanses of the submerged Elmina seascape that appear to be devoid of cultural material present us with information concerning possible activity patterns in the historical seascape related to maritime activities. Interpreting both positive and negative data patterns necessitates transitioning between scales of large spaces and of individual sites as a means of delineating areas of probable historical maritime activity and those less likely to have been hubs of activity. Viewing the region from a bird's eye perspective suggests that while there is clearly archaeological evidence of significant activity that took place along the littoral margin, or the boundary between sea and land, the data are more sparse concerning the more seaward regions. The absence of data to the south and southwest of the Castle may indicate that these areas were not often utilized for anchoring, something that also appears to be consistent with documentary sources. Alternatively, and more likely in the case of the lack of cultural material offshore to the southeast of the Castle,[330] it is more likely a factor of survey methodologies, which, for safety and time reasons, have been necessarily restricted to the

[330] It is possible that there is simply less in terms of cultural material further offshore or that anchorages were in fact in a different location, but this is in direct contradiction to the historical record in terms of the Elmina roadstead and the extensive activity that took place there. It also contradicts the present anchoring strategies employed by large vessels off the Elmina coast, which, like the common practice recorded in historical documents, anchor more than two miles offshore (see Chapter 3).

regions shallower than the 20 meter-depth contour, approximately three miles offshore. In the event that future investigations are able to survey beyond this limit, it is anticipated that these patterns will change. The data presented here add to the foundation upon which maritime research in coastal West Africa is being built, and while the sample size may be relatively limited, the application of the techniques and interpretations developed from them is far from limited.

As outlined in the next chapter, the primary evidence currently available for activity further from shore indicates that the *intentional* activities in which the vessel involved was engaged took place somewhere other than the current location of the wreck site, highlighting the powerful role of formation processes even during the course of a sinking event. The following chapter is presented as a case study that focuses on the interpretation of the extensive regional and local site formation processes on a specific submerged site: the wreck of a 17th century merchantman known as the Elmina Wreck.

Chapter 6
A Case Study of an Unfortunate Merchantman

> [T]ime is irreversible, in the sense that…an event, once experienced, cannot be obliterated. It is lodged in the memory of those whom it affects and therefore irrevocably alters the situation in which it occurs (Sewell 2005:6-7).

> Answers revealed by shipwrecks add to history by rediscovering what was lost, forgotten, misrepresented or perhaps never written down (Delgado 1988:7).

Historical archives are filled with fascinating tales of maritime adventures and woe, and it is a fortunate researcher indeed who can with certainty relate such a tale to archaeological remains discovered in some corner of the sea. Historical accounts give life to these inanimate remains, and provide a means of relating a far-distant past with the tangibles of the present; they connect people across the ages by relating human experience. Historical accounts are not necessary for interpreting an archaeological site or telling a story; they are, however, often useful in providing a more nuanced interpretation of the past, helping to ask questions perhaps not otherwise thought of, and as useful measures against which to compare the archaeological record. Perhaps most importantly, whether they can be directly associated with archaeological remains or not, accounts that are unquestionably part of the same historical seascape in which archaeological remains are found highlight the common eventscape that touches all of the past and present. An account of the *Groningen*,[331] which sank off the coast of Elmina, serves as an excellent illustration:

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[331] As noted earlier, the name of the vessel is used interchangeably in historical documents as the *Nieuw Groningen* and simply the *Groningen*.

> For that Factor reported to me that the ship *Groeningen*, having anchored on the last day of February before Del Myna, wished to fire 5 salute shots, as is customary, had caught fire from the last cannon, which had burst… throwing the shot into the Constable's (gunner's) room. The hatch of the orlop flw overboard; but the worst of all was that the blow took its chief force downwards, breaking the orlop in piece which fell into the hold where it made a fearful fire…The descending fire progressing so strongly caused the crew, through sheer amazement to get into perplexity. For such combustion… some, to save their lives, went off by boat and "schuyt", whereby the others, seeing themselves past help through the fire getting the upper hand, each worked for his own life... Nevertheless, 11 seamen and eight soldiers perished in the fire and water, which number could have been greater if the factor Coymans had not quickly sent out some canoes for salvage…[332]

For those who survived the explosion and burning on the *Groningen*, the visions of those events had to have been seared into their memories, perhaps haunting them for the rest of their lives. Somewhere off the coast of Elmina lie the remains of the *Groningen*, possibly represented by the site now known as the Elmina Wreck. The memories of the events surrounding her sinking, whether represented by the remains of the Elmina Wreck or not, remain shrouded in mystery, alive in just a handful of researchers' minds and imaginations. Regardless of its unique historical identity, the Elmina Wreck is an integral part of the narrative of the eventscape of historical coastal Ghana, and the stories embedded within it tell of its life, of the event of its demise and of its life at the bottom of the sea.

The previous chapter discussed site formation processes and effects on submerged cultural resources and the underwater landscape in coastal Elmina as a means of creating an understanding of the submerged archaeological environment of historical trade across

[332] This reference is from the Furley Collection Notebook 1646-1647 pages 162-164, transcribed by C. R. DeCorse, August 2010. Translation comments are removed for presentation here, but the account may be found in its full extent in Appendix IV. Transcription details are presented as originally provided by C.R. DeCorse.

the region. In continuation of the discussions of the previous chapter, and using essentially the same sources of data, this chapter is a case study, an exploration of the archaeological history of an unfortunate merchantman that burned and sank in the waters off Elmina Castle. Detailed discussions of the material culture present at the wreck site are discussed by other researchers (Cook n.d.; Pietruzska 2011). The discussion here is an in-depth investigation into both the specific event of sinking and the effects of regional and local site formation processes on a particular and unique site.

The primary goals of this investigation are twofold: it is foremost an opportunity to follow different avenues of inquiry as a means of telling the story of this particular site within its physical and historical context in coastal Elmina; secondly it is intended to serve as a foundational, baseline, and comparative study for future investigations of submerged cultural remains in coastal West Africa. A third goal is related to the second and is concerned with the processes of exploration implemented in this project. As noted throughout the dissertation, for the most part, the individual component parts of the research have been explored and modeled by others; what is singular about this project, however, is that it is a comprehensive, innovative, and explicit synthesis of inter- and intradisciplinary methodologies, theories, techniques, and interpretations. No other maritime archaeological research to date has incorporated such disparate scales, data sets and ideas in a truly holistic approach to anthropological and historical maritime archaeology. It is hoped that this dissertation as a whole, and this chapter in particular, will serve as a model for future studies that are concerned with fully investigating and understanding the contexts, environments, and archaeologies of historical events.

The complex and intersecting processes that shaped the historical Elmina seascape include such factors as the Atlantic trade; the international relations between Africans and Europeans trading at the coast; the permanent presence of the Europeans in Elmina Castle; the resources of the Benya Lagoon; common sailing, navigational and anchoring practices for European vessels; the central location of Elmina both in terms of the Ghanaian coast and in terms of the trade along the West African coast as a whole; and the weather and oceanographic patterns that dictated the seasons of trade. The formation processes that dictated the creation, destruction, and preservation of submerged cultural resources included all these factors; it was and is, however, the power of the sea that ultimately determined where archaeological sites are located and the conditions we find them in today. The disparate forces that affected historical sailors now affect the tangible remains of their presence across the submerged landscape. The Elmina Wreck, like the region as a whole, is the intersection of all of these processes. Understanding the complexities of all of these processes as they are presented in the wreck provides a way to interrogate and transition between scales of history and events, region and site, and micro and macro, and in the process creates a richer understanding of both the submerged archaeological record and the maritime history of the Atlantic trade in coastal Ghana.

The primary discussions in this chapter include the physical and historical environment of the wreck site; methodologies of investigation, particularly micro-sampling; various factors of formation processes; the micro- and macro-evidence from the wreck site; and interpretations of the site, including events and post-depositional processes as they relate to the site and the region. The following section is a brief description of the Elmina Wreck site and its environs.

The Elmina Wreck Site and Its Environs

The Elmina Wreck site is located approximately two kilometers southeast of the Elmina peninsula (Figure 6.1) and is in 11-12 meters of water in a highly dynamic ocean environment (Anthony and Blivi 1999:165). Discovery of the Elmina Wreck was through a side scan sonar remote sensing survey conducted in 2003 (Cook and Spiers 2004), and additional remote sensing investigations of the site in 2009 provided insights concerning the seafloor environment in which it lies (Figure 6.2) and into the extent of its

Figure 6.1. The location of the Elmina Wreck site is shown in this GoogleEarth image as it relates to the rest of the Elmina seascape, particularly its relation to the Castle and to the morphology of the coastline, which affected navigation and anchoring practices. The site is located in the region historically considered to be the Elmina roadstead, an area that, while deeper than the Elmina Bay, is still in a dynamic zone that is a significant factor in formation processes.

preservation in the sediments (Klein 1997a:384-385; Quinn et al. 2002:415; Quinn et al. 2007).[333] As can be seen in Figure 6.2, the site is a prominent feature in scan sonar images from both 2003 and 2009;

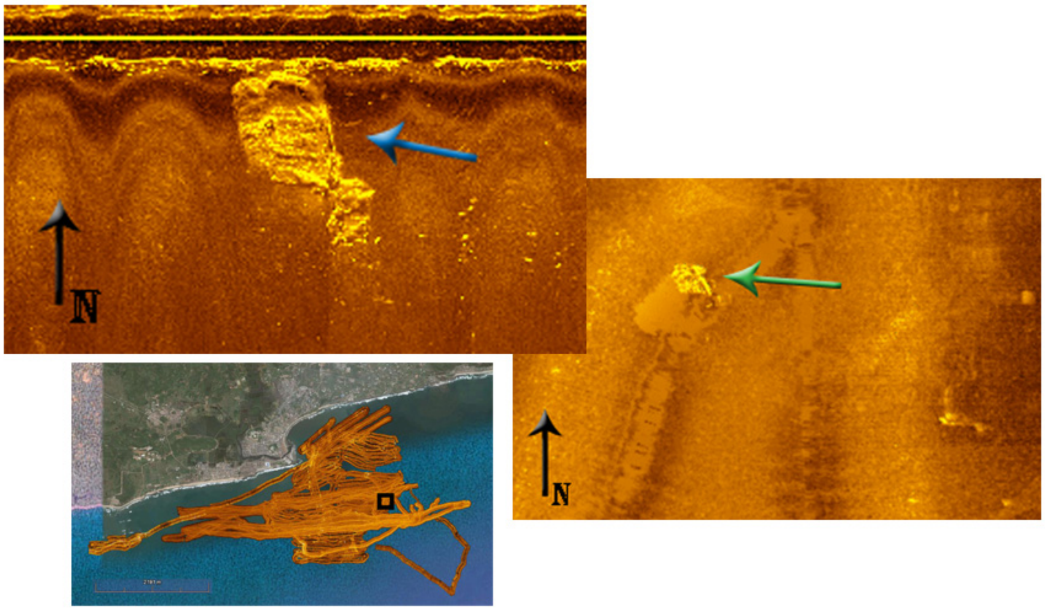


Figure 6.2. Although, as is discussed below, the surface of the wreck site was significantly different in 2009 than in 2005 or 2007, the side scan sonar signature is remarkably similar in the data (left) and the 2009 data (right). This is most likely the result of shallow penetration of sonar waves through the relatively unconsolidated sediments covering the site. The bright yellow spots south of the 2003 *may* indicate debris associated with the wreck, but this is not clear in the side scan sonar data and was not reported in any diver observations.

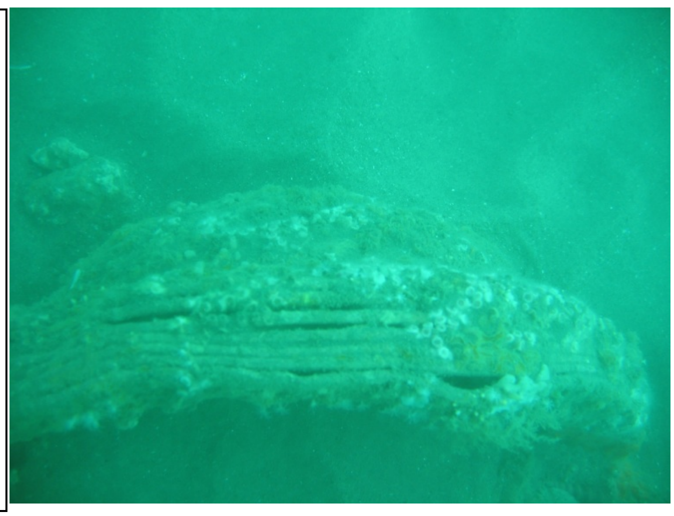
some texture and relief is visible in both the data sets, although it is clearer in the 2003 data. It is interesting to note that the relatively consistent shape of the wreck site as depicted in images from both 2003 and 2009 bears almost no resemblance to diver observations concerning its shape (see the site plan in Figure 6.20 below). This is likely the result of some sonar penetration of the sediments, representing an interesting

[333] See Figure 6.4 below.

conundrum in terms of correlating what is observed on the seafloor with what is seen in the remote sensing data.

As depicted in the side scan sonar data, the seafloor is a relatively uniform matrix – sand or mud or both, but no ripples and only light indications of scouring are visible. Some evidence for scouring, although it is poorly defined, is visible on the northeast side of the wreck in both the 2003 and the 2009 data; extensive scouring in the northeastern region of the site was observed in 2009. In addition, there is very little indication of ripples at the site in the side scan sonar data, but ripples were clearly observed outside of the wreck in 2007[334] and both inside and out in 2009 (Figure 6.3); the lack of visibility of

Figure 6.3. **Light ripple marks are visible behind this concreted stack of small basins inside the shipwreck site. Rarely more than 1cm high, it is not surprising that the side scan images do not depict them. It is interesting, however, to compare these smaller ripples with the larger ripples/ undulations reported elsewhere in the region, and which were depicted in the side scan images (photo R. Horlings, 2007).**



ripples near the wreck site is likely the result of the smaller scales or sizes of the ripples compared to other sites across the region.[335] Significant geomorphological changes have occurred in the six years that the site has been observed by divers. These observed changes, as well as those indicated in sediment core records, can safely be assumed to be

[334] It is possible that the ripples were also inside the wreck in 2007, but zero-visibility conditions prevented us from seeing them; the ripples outside the wreck were observed while taking sediment cores in six-inch visibility.
[335] See, for instance, the ripples clearly visible in the Single Anchor Site side scan images (Chapter 5), and in several examples in Appendix VIII.

indicators of the cycles and patterns of change (formation processes) across the site and across the region in the centuries since the beginning of the Atlantic trade along the coast.

It should be noted that with only a few exceptions, most of the observations made at the shipwreck site and elsewhere within the survey area were made in minimal or, more commonly, zero-visibility, high-energy water. This being the case, it is at times difficult to gauge subtle changes or differences observed by divers, and thus, of necessity a general description of the sedimentary changes at the site must be presented here. When Cook first identified the shipwreck site in 2003, he noted that the seafloor was primarily sand and shell; observations in 2005 indicated a similar make up, although there were pockets of mud throughout the site (Cook personal communication 2007; Pietruszka, field notes 2005). In addition, Cook observed that there was a cloud or concentration of sediment that surrounded the site and covered it up to two meters in the water column[336] (Cook personal communication 2007). In a significant shift from the primarily sand sediments observed earlier, in 2007 the majority of the site was a thick layer of mud that was loose and unconsolidated at the top, but which became denser at its base, approximately 30 centimeters below the surface. In this case as well there was a suspended cloud of sediments that enveloped the site. Sand and shell were prevalent in the regions which had been scoured out, particularly under some of the larger objects,

[336] The most likely explanation for this phenomenon is that as mud is transported in suspension, the topography of the wreck site traps it, but due to its fine nature, it is kept in suspension (Stride et al. 1982:97-98). This can occur in both low- and high-energy environments (Niedoroda 2005:868). As soon as there is no protuberance to trap the sediments, they continue to move with the current, thus often substantially improving visibility as one moves further away from the site. This is singularly unfortunate for archaeological investigations, and the ability to see decreases chances for accidents and improves the quality of data, but conversely, the deposition of these sediments likely help to preserve submerged sites.

such as cannon.[337] In 2009 the site was once again completely sand and shell, and, while conditions were generally calmer, the same cloud of sediment was not observed.[338] The northeastern edge of the wreck was heavily scoured, and consisted of sand and shell; the area around the shipwreck site consisted of nearly sand, completely featureless except for a few shells and some ripples.

Shifting Sands

Chapter 4 discusses the sedimentation of the Elmina Wreck site as was observed between 2005 and 2009; while it appears that the process affected the site more dramatically between 2007 and 2009, the sedimentation process was clearly active before this (see Figure 4.15 in Chapter 4).[339] Comparisons between the 2005 site plan and diver observations in 2007 indicated that less of the southwestern edge of the wreck site was visible in 2007 than in 2005. Measurements in this region indicated that up to 40 centimeters of sediment had accumulated, but relatively little of the site overall was obscured. In 2009 nearly two-thirds of the site was buried under nearly a meter of sediment. Burial of shipwreck sites after periods of exposure is relatively common (i.e. Green 1986:95; Quinn et al. 2007:1457-1458; Reedy 1991:54) but typically it is storm events that are responsible for burying or exposing sites located in relatively shallow water. While storms and currents have an indisputably significant role in formation processes of this shipwreck site (i.e. Quinn et al. 1998:133), it is not possible at present to pinpoint the unique effects of each of these processes. That being said, the artifact

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[337] It was hypothesized that some of this mud may have been the result of our excavations disturbing the sediments; while this may have contributed to it, the sheer volume of mud makes this unlikely as the primary explanation.
[338] Although several dives were still conducted in gray-out conditions.
[339] Note that these same processes have been observed across the region, for example at the Chain and Single Anchor sites.

assemblage from the site supports the assessment that episodes of burial and exposure have occurred repeatedly in the site's history.

Sediment is being deposited across the site in an approximately west-east direction, clearly in relation to the predominant current direction. Because the wreck is lying nearly perpendicular to the prevailing current, this means that the sand is building up on its southwest side and moving across the wreck towards the northeast side. As the current drops sediments and they accumulate on the southwestern side of the wreck, the current is also scouring out the northeast side. If, as is likely, the present trend continues, the wreck will be completely covered in less than two years,[340] eventually filling in even the areas that are presently deeply scoured.[341] While shipwrecks and their surrounding environments tend to reach a period of stability at some point after wrecking (Brown et al. 1988; Murphy 1983:78), this stability is interrupted by dramatic events such as extensive exposure caused by storms. On the other hand, the sediments now covering the site will serve to protect cultural material from most mechanical forces that serve to break it down.

As was highlighted in 2009, it is not possible to judge the extent of the wreck site based on surface signatures alone (i.e. Baker 1978). Two particular tools – sediment cores and the echo-sounder – are useful as means of exploring the buried extent that would

[340] From the time the observations were made, sometime in late 2011 or early 2012.
[341] It is not possible at this point to predict what all of the potential implications of this are for other sites in the region. That being said, however, it is a fair assumption that this is also going on in other areas and therefore it is very likely that other wreck sites and other cultural materials are also undergoing this cycle of exposure and deposition. This is likely at least part of the reason that there were features indicated in the 2003 data that were not visible on the surface in 2007, and the reverse can also be assumed for data collected in 2009. The rapid sand deposition over the Single Anchor Site is also testament to this. It will take significantly more research over periods of years to get a handle on how long these cycles are, how they affect the visibility of sites, and how they help to preserve or conversely affect submerged cultural resources.

otherwise only be possible with full excavation.[342] In 2007 the horizontal[343] extent of the wreck site below the sediments was determined through the micro-sampling technique, and was determined to be at least 15 meters longer than previously thought based on surface indications (see the locations of cores 13 and 20 in Figure 6.23 below).[344] In 2009, the site was investigated with an echo-sounder both as a means of exploring its subsurface extent, and also as a means of testing the echo-sounder in this environment (Figure 6.4). The echo-sounder data indicate that remains extend more than one meter into the substrate, something confirmed by sediment cores collected in 2007; it also indicates that there are discrete objects located below the surface that have yet to be identified.

All of the sedimentary changes observed at the Elmina Wreck site are indicative of the physical and environmental formation processes active in the region (see Appendix II), the effects of which are also seen at other sites in the submerged Elmina seascape (Chapter 5 and Appendix VIII). These processes, as well as a suite of others, are also active at a more micro scale within the wreck site itself, but tend to be less obvious to the observer, particularly in black-out conditions. The primary means of accessing this

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[342] The following excerpt from Carroll's (1872:73) "The Walrus and the Carpenter" is clearly silly, but the image it portrays of copious amounts of sand is comparable to that discovered at the shipwreck site and raises questions concerning future investigations of a site that will soon have no surface signature.

The sea was wet as wet could be,
The sand was dry as dry.
You could not see a could, because
No cloud was in the sky;
No birds were flying overhead –
There were no birds to fly.

The Walrus and the Carpenter
Were walking close at hand;
They wept like anything to see
Such quantities of sand:
"If this were only cleared away,"
They said, "it would be grand!"

"If seven maids with seven mops
Swept it for half a year.
Do you suppose," the Walrus said
That they could get it clear?"
"I doubt it," said the Carpenter,
And shed a bitter tear.

[343] Similarly, Quinn et al. (1998:137) write that without the use of geophysical remote sensing data it was difficult to quantify the true extents of the *Invincible* and *Mary Rose* wreck sites. In both of these cases it was diver investigations and excavations that provided most of this information.

[344] Although it is more difficult to define the depths to which cultural material extended using this technique (see Jones et al. 2005:187).

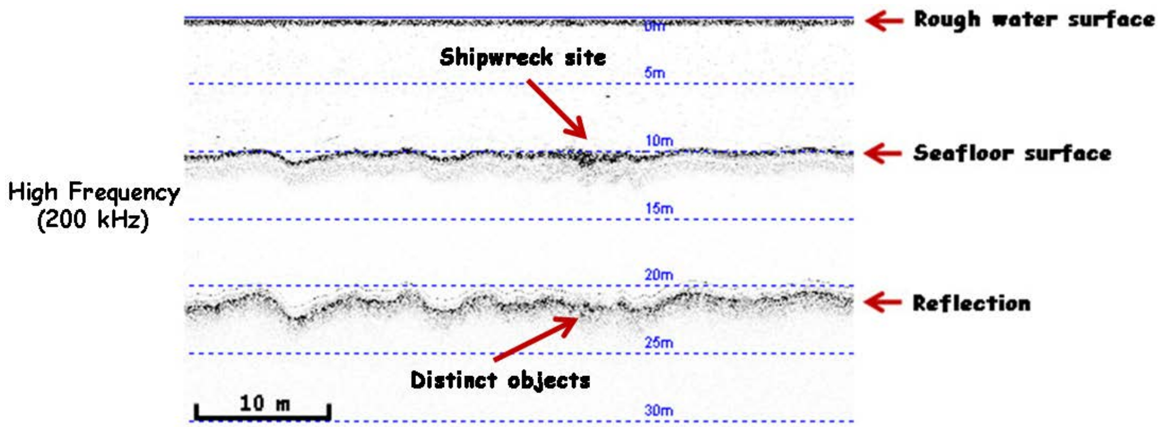

Figure 6.4. **The potential of using geophysical instruments such as the sub-bottom profiler or the echo-sounder has been well-documented, although, due to their expense and the fact that results vary depending on the substrate,[345] this technique is applied less often than others. The efficacy of the echo-sounder is demonstrated here in the information it provides concerning the depth of defined material below the seafloor, and even in its ability to identify individual objects, as is shown in the less dense reflection.**

elusive data was the collection of sediment cores (through micro-sampling) in and around the shipwreck site in 2007 and 2009; much of the following discussion makes use of these data (see Chapter 4 and Appendix I). Data were also collected on the wreck site through surface collection and excavation, and these provide an excellent data set that provides unique information and with which to compare the information collected in sediment cores. The varying avenues of inquiry, from macro-survey to micro-sampling and across the spectrum of formation processes, engage with a multi-scalar approach to the investigation of the maritime past in coastal Ghana. Survey has already been addressed; a brief introduction to the applicability of micro-sampling in investigating site formation processes follows.

[345] See Dix (2007:18), Els (2009); Grelowska and Kozaczka (2010) for additional discussions on this.

Investigating Site Formation

As has been discussed throughout this research, formation processes[346] here are understood as the larger, historical circumstances of coastal maritime trade in the Atlantic era, as well as those processes which served specifically to sink the vessel and have subsequently played roles in its destruction, preservation, and stabilization. Historical formation processes frame the interpretation of the wreck site in terms of its relation to historical trade and to explain its location (in the Elmina roadstead). Both historical and physical formation processes are used to interpret its sinking event and subsequent deterioration. Investigation and interpretation of the distinct signatures of both of these processes (Veth 2006:23) tie the story of the shipwreck together, crossing numerous scales and bridging the past and the present.[347] The approaches utilized are contextualized through the microhistorical investigation of archaeology of the event and within the physical and temporal context of the historical maritime seascape, telling a story of part of the historical maritime past of coastal Ghana and demonstrating a holistic approach to its investigation.

The integration of vastly differing scales of investigation has been central throughout this research, and the focus of this case study; the Elmina Wreck continues

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[346] There is a subtle but important distinction between *formation* processes and *post-depositional* processes that can most easily be explained in terms of their extent of influence and their distinct chronological aspects; while they are necessarily interrelated, formation processes *include* post-depositional processes, but the reverse is not true, as post-depositional factors, by definition, can only occur after the site has been created. Formation processes include why the wreck is located where it is, how it wrecked, whether or what type of salvage was carried out at the site, and all of the factors that have affected the condition of the site since deposition. Post-depositional processes can be considered to include salvage (whether historical or modern) and other cultural factors such as the effects of fishing nets and anchors on the sites, but are more heavily determined by natural or physical environmental factors, and are typically the determining key to the destruction or preservation of submerged sites.

[347] I suspect that one of the reasons formation processes are so often ignored or relegated only to interpreting the physical condition of submerged sites is that this distinction is not necessarily noted and one aspect or the other is often overlooked, thus presenting an incomplete picture of both the physical remains and their larger physical, historical, social, and environmental contexts.

this emphasis of addressing and grappling with a range of scales. For example, the wreck itself is decidedly macro in comparison to the small beads and other micro objects recovered from it in sediment cores, and the event(s) that it represents was catastrophic for some and incidental in the lives of others. For purposes of this discussion, the wreck itself is considered to be the main or macro event; keys to interpreting this macro event have been found in the micro remains recovered in the cores. As noted earlier, the strength of this research lies in its explicit incorporation of this range of scales within the expansive framework of formation processes and the archaeology of the event (Richards 2006; Dellino-Musgrave 2006; Elkin et al. 2007), and is accomplished primarily through the micro-sampling coring technique. [348] The power of micro-sampling through the collection of sediment cores is as a tool for navigating between and across these different scales. [349]

The utility of sediment cores was touched on in the above discussion of the extent of the site; a number of other applications are also useful to highlight. Core data have provided insights concerning the destruction and preservation of the site; concerning formation processes both within and outside the wreck site; concerning artifact distribution and conditions; and have even provided a glimpse into vessel construction. Micro-sampling was also germane to the dating of the site, as the wood collected in sediment cores established the date of vessel itself. In addition, used as a non-random sampling technique (Hocker 2000a:393), micro-sampling has provided a representative

[348] In addition, micro-sampling is minimally-destructive and is aimed at maximizing data returns while minimizing risk, financial and time costs (Bower 1986:26).

[349] It should be noted here that the concept of micro and macro scales is actually a continuum that should be approached in relative terms. For example, at the scale of the region or an era in history, a single shipwreck or the event represented by, for instance, the Single Anchor Site is considered micro – just a single occurrence or object that in the grand scheme of things is minute and relatively unimportant.

sample of data about the subsurface materials and conditions of the Elmina Wreck site on which both specific and general interpretations can be confidently based. Finally, sediment cores provide both environmental and cultural information that have been used to investigate multiple types of data and processes across the site.[350]

Environmental data from the site are recorded in the complicated stratigraphy seen across it, and the strata provide context for the cultural material collected in the cores (Banning 2000:258; Courty et al. 1989:139; Gladfelter 1977:520; Harris 1979:86).[351] The stratigraphic distribution of the wreck site provides chronological markers as well as data the vertical and horizontal relationships of sediments, ecofacts, and artifacts (Dincauze 2000:96; Rapp and Hill 2006:135; Rönnby 1995:159), but there is copious evidence that the sediments at the site are far from static. In addition, even though the sedimentary strata may after a time be fixed or set, there is clearly movement of artifacts across sediment boundaries, which complicates interpretation of "original" contexts and stratigraphic integrity (Dincauze 2000:98).[352] Analysis of the site formation processes recorded in the stratigraphy inside and outside of a wreck site has provided information concerning the effects of local sedimentation and the degradation and stabilization of the shipwreck, as well as episodes of exposure and reburial. It has also

[350] It should be noted here that the interpretation of micro-sampling data is necessarily interdisciplinary (Murphy 1997c:386) and relies on an understanding of the physical environment and processes at work in it, as well as on the artifacts themselves.
[351] See core # **06_09** from the Single Anchor Site for an excellent illustration of all of these (Appendix I).
[352] These factors, coupled with the difficulties in keeping fluid sand in place, for instance, in excavation unit walls, have led many researchers working in underwater contexts to place little emphasis on stratigraphy underwater; in fact, it is rarely discussed in any detail in the literature (see Elkin et al. (2007); Gifford (1982:7); and Marsden (2003:44, 144) for some of the few exceptions to this). In order to map stratigraphy underwater (see Hocker 2000b:643), however, it is necessary to have a modicum of visibility, something that was rarely the case in coastal Ghana. As a result, the stratigraphic data preserved in the sediment cores is invaluable in providing the same information across the wreck site and elsewhere.

provided baseline data against which to measure intrusive material that has accumulated on the site after the actual ship wreck event (Rönnby 1995:159).

Destruction and Preservation of a Shipwreck Site

The investigation of formation processes is viewed in this research as both a theory and a method; this has been touched on throughout the dissertation and highlighted in Chapter 5. While the exposure and deposition cycles obviously occurring at the Elmina Wreck site are perhaps the most dramatic example of formation processes at work, there are in fact many more processes that also must be understood in order to present a comprehensive discussion concerning the history of the site. Ward et al. (1998:110) provide a succinct summation of these complex processes and their relationships to each other and submerged sites in the following quote:

> Physical, biological and chemical parameters act together in wreck disintegration. Currents are a primary control upon the removal or accumulation of sediments at a wreck, and with changes in the elevation of the seabed, upper levels of the sediments are likely to have their redox[353] conditions altered, along with the concentration and nature of the infauna.[354] Currents also affect the supply of oxygen and nutrients. Positive and negative feedbacks will operate between processes in the water, sediments and the wreck, and it is important to understand the dynamics of these interactions as part of wreck formation.

In other words, the complex systems that interact to destroy and preserve submerged cultural material are all related, and it is only in understanding these complex relationships and dynamics affecting preservation that the cultural aspects of submerged

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[353] "A chemical reaction between two substances in which one substance is oxidized and the other reduced" (www.dictionary.reference.com).

[354] Aquatic animals, many of which bore into the substrate.

sites can be accurately interpreted (Ward and Larcombe 2003:1223). The effects of regional formation processes have been touched on in the above description of the Elmina Wreck site, but there are other processes also at work that at times have equally dramatic effects on the material of the wreck site. The following discussion highlights some of these that are particularly relevant and provides examples illustrating them from the Elmina Wreck site. As will become apparent, the results of some factors are easier to identify than others; interpretations of their different effects are offered at the end of the chapter.

Site Formation Processes

The Human Factor

The overarching historical formation processes such as international trade and Elmina's prominent place in West African commerce were discussed earlier in the dissertation and form the larger setting within which submerged remains are investigated. The investigation of formation processes can easily focus so much on the more obvious environmental and physical that the human factor is often ignored; this factor is clearly apparent in several aspects of the Elmina wreck site, so it should be noted.

As Oxley (1998a:48) explains, archaeological evidence "results from two processes – initial human behaviour (i.e. the phenomenon of a shipwreck which is a culturally-derived event) and subsequent transformational actions (effect of natural processes and subsequent human activities)." The presence of Elmina's 25,000 plus population[355] living near the coast is having a significant and visible effect on submerged

[355] Tageo.com 2010; www.wolframalpha.com (2010).

sites across the seascape in several ways.[356] First, the obvious effects of the large population in Elmina (both historical and modern), as well as of populations along the coast, can be seen in the extraordinary quantities of trash and debris in the water and along the coast. These items, particularly those modern items made of plastic such as bags and bottles, float easily on the currents at the surface or along the seafloor and become entrapped in submerged sites (see Appendix VI); because this is a major feature of the Elmina Wreck site, it is discussed in more detail below. The second major human factor is the (generally) unintentional modification of the submerged environment by those engaging in maritime activities. As there is little to no modern shipping on the coast of Elmina (Cook and Spiers 2004:18), the major modern human factor affecting submerged sites, including the Elmina Wreck, is fishing. This results in the introduction of new material such as nets, lines, and weights to the site[357] and the movement and disruption of artifacts on the seafloor by nets and lines moving across the site (Stewart 1999:577);[358] there is also clear evidence of these activities at the site. Related to this is the possible and recorded damage anchors can do to sites. As noted in Chapter 4, the rebar grid left at the Elmina Wreck site had been caught by an anchor and bent backwards; while there was no other obvious indication of damage to the wreck site

[356] This is particularly relevant in terms of near-shore geomorphological, biogeomorphological, ecological and contamination issues (Ansa-Asare et al. 2008; Awosika et al. 1993:35; Milliman and Meade 1983:19; Viles and Spencer 1995; Nixon et al. 2007; Nunoo et al. 2009; Otchere 2003), and affects every area of the ecosystem, from the sea itself to fish populations, to the people who rely on them and live near the shores.
[357] The most serious ramification of this is the monofilament that becomes entangled on the sites, posing serious diving hazards to the investigators.
[358] It has also been observed that fishing activities such as trawling (such as is done by the Chinese and Koreans along the Ghanaian coast) has had impacts on the seaward transport of sediments (Nittrouer and Wright 1994:100). While it is likely that other factors have had a greater direct impact on the Elmina Wreck and other sites, it is possible that this has also been a recent influence on both sediment movements and on the movements of mobile materials, such as, for example, bottles, across the continental shelf.

itself, this is illustrative of the potential issues that may be caused by anchors and anchoring. [359]

A third human formation process – historical salvage and attempted salvage – is usually far less obvious to detect and interpret than the presence of modern intrusive material. Salvage and attempted salvage of materials from shipwrecks was common historically, and in the case of the location of the Elmina Wreck, the relatively shallow water (11 meters) would have meant that, depending on weather conditions, and on the condition of the vessel when she sank, there could have been relatively easy access to at least some of the goods in the wrecked vessel. As noted in the records of the *Groningen* (Furley Collection Notebook 1646-1647 pages 162-164), there were several successful and attempted salvage events. It is likely that this was the case with the vessel of the Elmina Wreck, but here it is sufficient to note that there is some evidence that the vessel settled on a relatively even keel,[360] meaning that the masts may visible above the surface of the water, and there would have been some access to the decks, as indications are that they would have been sitting in a relatively upright position. This position so close to the surface (the upper deck would have been less than two meters below the surface) would have provided the opportunity to try to salvage goods from within the hull.

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[359] Other factors such as the dragging of large anchors across sites can wreak havoc on submerged sites. For example, in 2007 we witnessed two foreign fishing vessels cabled to each other trying to use a single anchor to fight against the up to three knot current, resulting in the anchor dragging very quickly along the bottom; without our intervention the vessels would have dragged anchor directly over the shipwreck site. While this is a serious issue for the preservation of cultural resources, the vessels anchoring in the same roadstead that has been used for centuries by foreign vessels is a confirmation of the navigation and anchoring protocols or traditions along the coast noted in historical documents, as they are still being followed.

[360] Meaning that, while the vessel did not necessarily end up sitting exactly straight up on the bottom, she would have been sitting so that the weight would have been relatively evenly distributed on either side of her keel, keeping the vessel from tipping over too far to one side or the other.

Sediments

Details of sediments and sediment movement along the coast are discussed elsewhere, but as sediment movement is clearly an active process at the Elmina Wreck site, several things should be highlighted here. The two most important functions of sedimentation[361] are the preservation or disintegration of submerged cultural material and their contexts, which is seen in the mixing of cultural material throughout the site (Allen and Oxley 2005:513; Banning 2000:235; Dincauze 2000:259; Hopwood 2009:42; Jones 2003:15; Muckelroy 1977:115; Murray and Thieler 2004; Murray et al. 2003; Quinn2006; Quinn et al. 1997:15; Quinn et al. 2002:422; Robinson 1981; Ward et al. 1999a:565), and its key role in obstructing submerged sites from view and in the process, in protecting them (see McNinch et al. 2001) (Figure 6.5).

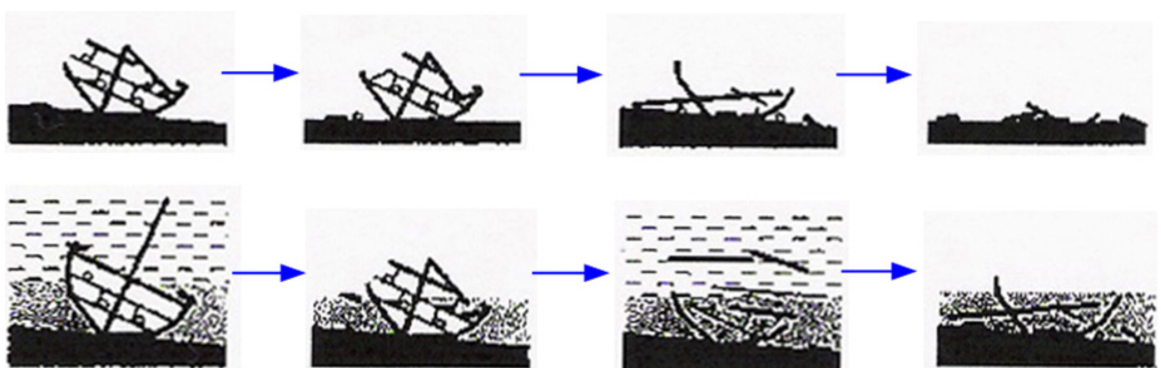

Figure 6.5. **The top sequence in this image illustrates the deterioration of a shipwreck on a hard sea bottom with little sediment; the result of the extreme exposure of the wreck is that it disintegrates rapidly and completely. In contrast, the lower sequence illustrates the protective action of sediment that covers the organic (wooden) components of the wreck and serves to protect them from many destructive processes and forces. The lower illustration appears to best represent the condition of the Elmina Wreck (modified from Ward et al. 1999b)**.

[361] At least for present purposes in investigating formation processes of the wreck site.

Biota

The same currents, storms, and up- and downwellings that serve as movers of sediments also affect the temperature, salinity and clarity of seawater, which in turn affects the biota that colonize the site. The most significant bio-active organisms on shipwreck and other submerged sites are, as a whole, anaerobic bacteria, marine fungi, wood- and stone-boring animals and fouling organisms, and are known as the biofouling community (Bastida et al. 2008:175-177; Brown et al. 1988:143; Florian 1987:14; Guthrie et al. 1994; Hamilton 1989:53; Jones 2003:16; Jones and Eltringham 1968; Wheeler 2002:1150). Three particular observations related to the biofouling community on the Elmina Wreck site merit brief discussion here.

The first observation relates to the order in which organisms colonize submerged sites (Bastida et al. 2008:175-177). As noted on the Double Anchor Site, barnacles completely cover the exposed portions of the anchors, not allowing room for other species. Interestingly, while barnacles were noted in sediment cores collected at the wreck site, no live barnacles had been observed there until 2009, when it was observed that the exposed portions of the rebar grid we left at the site in 2007 were covered in barnacles (Figure 6.6). Comparisons between the sites and the data from cores, it appears that barnacles are one of the first species to colonize submerged objects in this environment,[362] but, as indicated by the small size of the barnacles found in the cores and the lack of barnacles across the wreck site, as soon as the object is covered, the barnacles

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[362] A number of studies have been conducted on this and related questions (i.e. Broadwater et al. 1985:312; MacLeod and Killingley 1982), which also suggest that barnacles are typically early colonizers of submerged structures and that they are a fast-growing species (Bruijs 2006; see also Miron et al. 1999). The rate and succession of colonizers on any site is, of course, dependent on proximity to shore, water depth, light, salinity, temperature, and a range of other conditions (Bruijs 2006:14); these exact parameters are not presently known for coastal Ghana.

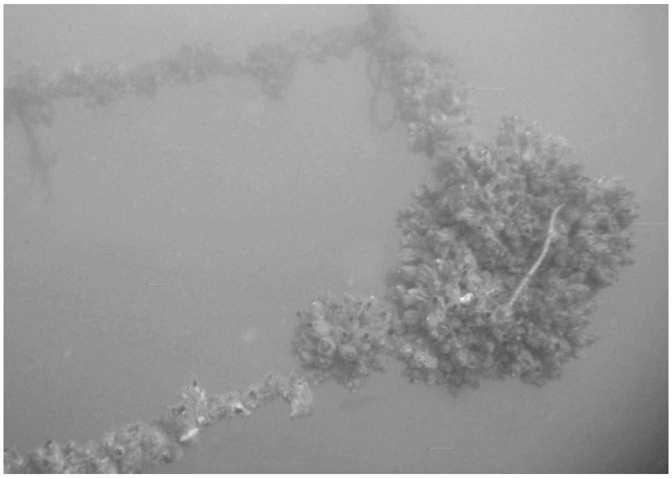

Figure 6.6. The rebar grid, which was likely pulled from its original location by an anchor catching on it, is shown here with the masses of barnacles that have colonized it. Their large size relative to the small size of those in the cores likely indicates periods of exposure (photo R. Horlings, 2009).

die and are replaced. This clearly needs to be tested further, but it appears to be a promising indication of formation processes (MacLeod and Killingly 1982; see also Kenchington et al. 1989:116).

The second observation relates to wood collected in sediment cores. No wood was visible on the surface of the wreck site during any of the field investigations, but, as is indicated in Figure 4.2 in Chapter 4, there is ample evidence that wood from the hull of the vessel is preserved under the sediments.[363] The wood that was collected in the cores however, was in varying conditions, from completely intact to fragmentary as a result of attacks by marine boring organisms, likely the *Teredo navalis* worm,[364] of the mollusc Teredinidae (the ship-worm) family (Robinson 1981:12-14), when the wood was exposed on the seafloor (Figure 6.7). This is touched on later in the chapter, but it is important here to highlight the destructive nature of these organisms not only on organic material on the seafloor, but also on the vessels themselves, as historical mariners were constantly on their guards against the effects of these warm-water organisms that could so weaken

[363] As noted earlier, it provided the key evidence for dating the Elmina Wreck.
[364] Which is in fact a bi-valve.

the hull of a vessel as to cause it to sink (Jones 2003:19; see also Florian 1987:15; Hickin 1968).

Figure 6.7. **The holes in this dug-out canoe base which washed on shore near Elmina were likely drilled by molluscs such as the *Teredo*: there is clearly a weakening in the structure of the wood as a result of all of the borings. Because wood-boring organisms thrive in warm waters (Pournou et al 2001), the risk of severe damage by these organisms increased with the amount of time a wooden sailing vessel remained in the tropics. Wood in similar condition was collected in sediment cores (see Core GW#2 in Appendix I) from the shipwreck site, indicating that it was exposed for a period before collapsing and being covered up (photo R. Horlings, 2007).**

The final observation concerns the much larger species such as eels, lobsters, fish and cuttlefish (see Appendix III for a more complete list) that inhabit the Elmina Wreck site.[365] These creatures' activities within the site and the sediments of the site form a part

[365] It should be noted here that although a significant number of species has been observed at the wreck site, the marine life off the coast of Ghana has been severely depleted due to overfishing and commercial fishing

of the mechanical aspects of benthic bioturbation (Easton 1997:60), and likely contribute to the mixed nature of the sediments and artifacts at the site, such as, for instance, a likely relative of the scorpionfish family that has burrowed out a home under a large unidentified object (see Appendix III).[366]

Artifacts

Throughout this dissertation the premise has been that understanding the past through the dynamics of archaeological assemblages is a matter of understanding the relationships between artifacts and each other and between them and their contexts (Gowlett 1997:152). The historical and environmental contexts of the Elmina Wreck site have already been presented; what remains is the cultural material itself, investigated through the lens of site formation processes and their results. The basic formation processes and their effects discussed above can be related to the entire shipwreck site, or on a much smaller scale to artifacts within the site. As a means of illustrating some of the effects of these processes, this discussion touches on some of the small-scale artifacts collected in sediment cores, as well as on several examples of larger objects.[367] Because of their uniqueness, several examples of wood from the site are also presented. It should be noted here that what can be learned from these data sources at different levels or scales can be similar, but can also be dramatically different.

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practices (Nunoo et al. 2009; Papa Kofi Arhin, personal communication, 2007). As a result, there are likely far fewer individuals present at the site now than were present before overfishing.

[366] Some research is available on the biological mechanisms on submerged sites (Ferrari and Adams 1990; Stewart 1999), but more research needs to be conducted in this environment and on this site to provide other examples and to assess the mechanical damage or disruption caused to the material culture as a result of these organisms.

[367] Only a selected few artifacts are presented here; a general list of artifact categories found at the shipwreck site, including a comparison of artifacts found during surface survey and excavation and those recovered in sediment cores, may be found in Appendix IV.

Concretions

One of the most common descriptions of material from shipwreck sites is that it is "concreted." Most of the objects on the Elmina Wreck site display some form of

Figure 6.8. A grapnel anchor recovered from the shipwreck site is shown in the top image in its concreted form, and in the bottom after concretions have been carefully removed. Note that in this case there is a clear indication, even in its concreted form, of what the object is; this is always not the case, and many concretions no longer contain original material. It is unknown whether the anchor is original or intrusive (photos R. Horlings, 2007).

concretion, although it varies with the composition of the object.[368] For instance, there is far less concretion on the brass basins than on the lead rolls, and there is far more concretion on the cannon and anchor than on either the basins or lead rolls. While there are different kinds of concretion, the basic description of a concretion is that it is a mass of hard, mineral matter that forms by precipitation from aqueous solution and can form on almost any (primarily inorganic) matter. Concretions are either concentrations of some cementing material, such as iron oxide, silica, calcite, or gypsum (Rapp 2000:242-243), or a conglomerate formed of sediments or some other material with the cementing substances (Courty et al. 1989:18; Rapp and Hill 2006:28). Reactions of various materials, particularly metals such as iron, with seawater produce different compositions of concretion. In addition, the proximity of various materials to each other within the

[368] This includes objects that have been visible on the surface as well as those that were collected from subsurface contexts. There is also a great deal of and variety of concretion present in the sediment cores.

seawater and sediment environment can serve to create chemical micro-environments that affect materials differently (Brown et al. 1988:143; Hocker 2000b:643; MacLeod 1985:10, 1997:112) and therefore create different compositions of concretion.

In many instances concretion envelops an object to the point that it is beyond recognition. Reactions of materials such as iron with seawater work to degrade and break down materials, but the subsequent formation of concretion can serve to actually protect it from further decay (Callegari 1971:43) (Figure 6.8). In addition to the mineralized concretions that form on objects, surface accretions, primarily made up of calcium-depositing organisms, are common (Florian 1987:12). In addition, other organisms such as flora colonize objects and create essentially an organic concretion on objects (Figure 6.9). These organisms form part of the biota of the site, and can also serve as protectors or destroyers of submerged material (Wheeler 2002:1151).

Figure 6.9. **The marine flora growing on this concretion is forming a biological concretion over the mineral one. Turquoise fishing line caught in the wreck is visible wrapped around the plant (photo R. Horlings, 2007).**

One final concretion feature of the Elmina Wreck site is worth highlighting here. Excavations through the middle of the wreck site (see Figure 4.2) revealed that there is what appears to be a solid concretion across almost the entire site, located approximately 30 centimeters below the surface sediments, but varying depending on the region of the site.[369] From appearances, both by feel in the 2007 excavations and visual confirmation in 2009, this is a metal – likely iron – based concretion. The most logical explanation for its presence is that it is the result of complex chemical interactions between metals and seawater (Brown et al. 1988; Hamilton 1989:52; North 1984; Wheeler 2002:1151). As MacLeod (1997:112) explains, on shipwreck sites proximity corrosion occurs between dissimilar metals that may not necessarily be direct contact with each other, for instance, when iron and copper alloys are near each other, as is the case on this shipwreck. It is possible that if there was an iron-based cargo[370] located below the copper-based basins, the ionic interactions between it and other objects have created this unique “floor” throughout the site.[371] The extent of the concretion was inadvertently discovered when attempting to collect sediment cores inside the wreck site, resulting in the PVC cores shattering on the concretion (see images in Appendix I). As discussed in Chapter 4, both the limitations and the efficacy of the micro-sampling technique and coring have been demonstrated, among other things, as a result of the presence of this concretion.

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[369] McBride et al. (1972:136) report a similar concretion below the natural single matrix of a 17th century merchant shipwreck site near Cornwall, but this concretion was such that objects could be dug out of it. Similarly, artifacts were “cemented” to the hardpan of the Molasses Reef site, but this was a natural oceanic concretion (Keith and Simmons 1985:412). The concretion on the Elmina wreck site is iron-based and solid, so no objects can be removed.

[370] Such as iron bars, which were a common trade item in the 17th century (DeCorse 2001:124-125; see also Moore (1997) and Moore and Malcom (2008) on the *Henrietta Marie* site); however, since it was not possible to feel any definition in the concretion that suggested this, and some of the concretion was clearly formed to objects, such as the curved, cradle-like depression below one of the cannon, it is difficult to even guess what the source material is.

[371] It is also possible that it is the result of the large iron cannon interacting with the basins, but this is less likely, as the concreted base is below both of them, not between them, even where the cannon are in close proximity to the basins.

Metals and Melted Materials

Two primary formation processes are identifiable in the metals collected in sediment core samples from the wreck site: the first is corroded metal in the form of iron rust, iron concretions, and eroded pieces of metal artifacts such as basins, and the second is melted material, likely as a result of an intense fire on the vessel. In terms of corrosion and erosion, metal artifacts at the sediment/water line tend to show accelerated corrosion at the water/sediment interface (Jones 2003:15), but deterioration is prevalent across all exposed metals. As noted above, the presence of multiple kinds of metals and alloys on a shipwreck site complicates this process (MacLeod 1982, 1997:111-112; Scott 2000:362). The effects of corrosion on iron are the most easily identified, as exposed iron tends to rust and break off in pieces (Figure 6.10), or else form a mass as demonstrated in Figure 6.8 above.

Figure 6.10. The flake depicted here is typical of deteriorated iron and is found throughout the wreck site and across the region (photo R. Horlings, 2008).

One of the most intriguing discoveries made based on artifacts collected in sediment cores was a range of burned and melted material. As discussed in Chapter 5, charcoal is relatively ubiquitous across the site and the region (see Appendix IV), so, while it is interesting, it is less diagnostic than the melted material. PXRF testing indicates that there is a large range of material that is burned and melted, including iron-based, copper-based, silica-based (probably glass) objects (Figure 6.11), as well as objects that appear to contain several different materials (Figure 6.12). Several discussions below and Appendix I contain more details on these materials, but it is

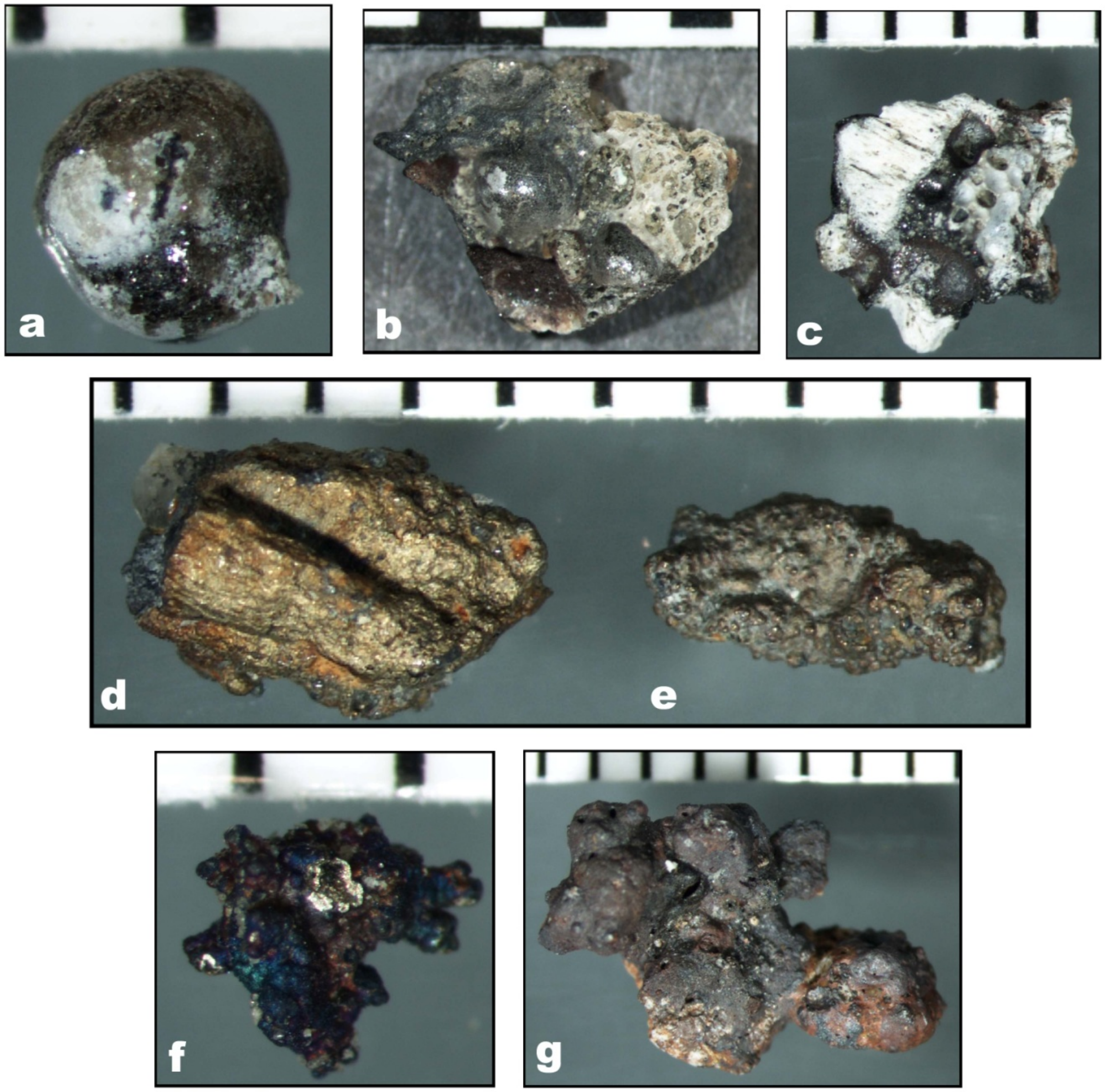

Figure 6.11. **All of these melted objects were collected in sediment cores and are clearly melted, as indicated by the bubbles and rounded nodules on each of them. Images a, b and c are not metallic-based materials, and b in particular is reminiscent of vitrification of ceramic glaze; images d, e and f are all copper-based, and image g is unidentified, although it is likely iron-based (all scales are millimeters, and all photos were taken on a Nikon SMZ800 macroscope by R. Horlings, 2008).**

important to note that there appears to be very little post-depositional change on the materials apart from breakage, which suggests that the burning and melting process in some way has served to protect the materials from reacting chemically to the seawater environment and other materials in close proximity to them. A great deal more research needs to be conducted on these materials.

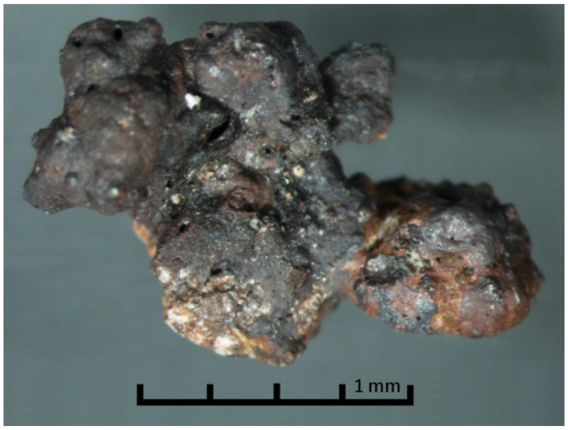

Figure 6.12. This object shows indications of melting on the outside, but is a different texture on the inside. It appears to represent a conglomerate of material, as sediment grains as well as what appears to be metal fragments are clearly visible in the melted parts. (scale in millimeters; macroscope photo by R. Horlings, 2008).

Beads and Cowry Shells

Small trade beads were discovered concreted to other items, free on the site, and inside artifacts such as bottles that were collected in the 2005 field season (Hopwood 2009). The prevalence of both small trade beads and cowry shells throughout the wreck site was noted in the 2007 season through test excavations and sediment cores (see Appendix I), but the lack of visibility prevented visual estimates across the site as a whole. Only two cowry shells were observed on the site's surface in 2009,[372] and no beads were noted, likely as a result of their small size blending with the shell and coarse sediments. The scattered nature of most of the beads and cowry shells that were observed indicates that they are in secondary contexts; however, a number of large concreted bead conglomerates were recorded (Figure 6.13) that indicate at least the original association

[372] It should also be remembered, however, that less than one third of the site was still exposed in 2009, meaning that there was significantly less area in which they could have been found.

of the beads with each other in some form of container.[373] While no beads were retained from excavations in 2007, at least ten of the 16 types identified by Hopwood were collected in sediment cores.[374]

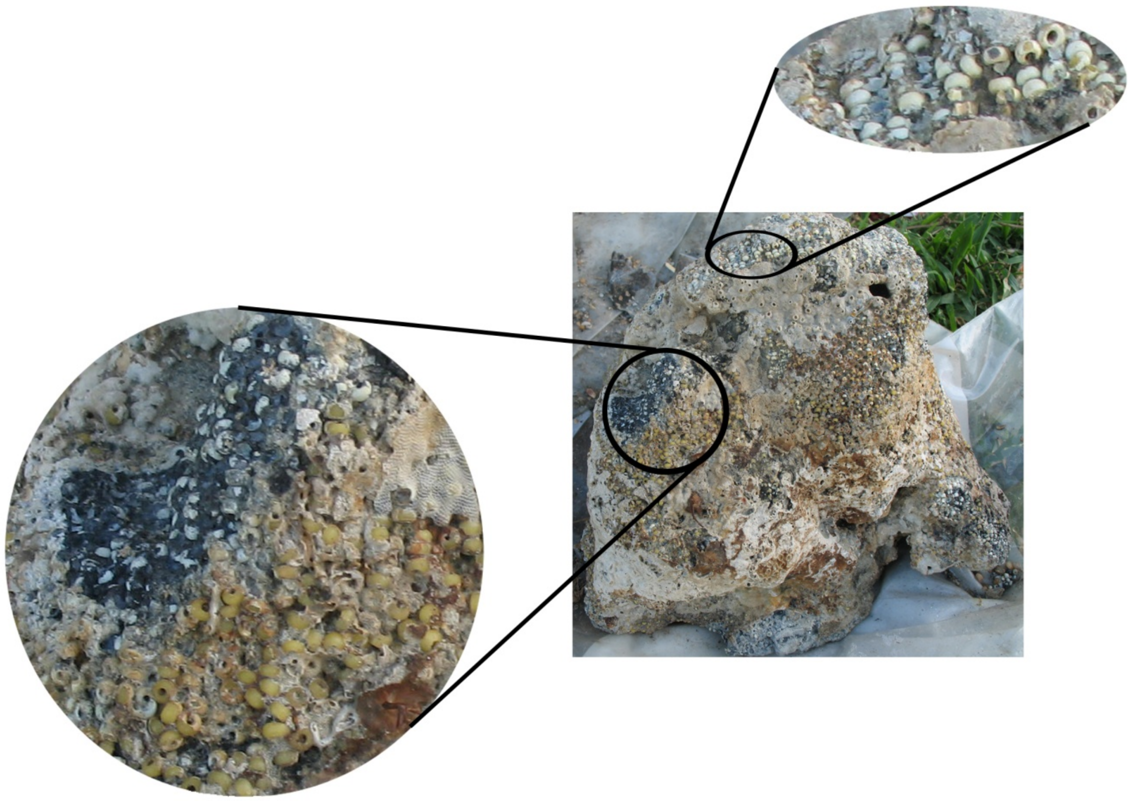

Figure 6.13. The original packing configuration of these beads is indicated by the differently-colored beads clearly stacked on each other, likely originally strung on thread of some kind; while the original cask is gone, concretion has served to keep the beads in their original arrangement. The dark-colored material visible between beads appears to be a residue, likely the result of different degradation processes of different beads (original photo by A. Horlings,[375] 2007).

[373] This is similar to discoveries on other shipwreck sites as well, for instance, the "mass of bead-laden concretion" (Moore and Malcom 2008:29) found on the *Henrietta Marie* site.
[374] This is a low estimate, however, because it is very difficult to categorize many of the beads from the cores due to their varying levels of deterioration and high variability that may or may not fit with Hopwood's analysis.
[375] My father, Andy Horlings.

Small trade beads and cowry shells made up the largest component of artifacts collected in sediment cores,[376] and as a result, these objects provide the largest comparative data set for analyzing post-depositional effects on micro-artifacts. The most noticeable degradation of these artifacts was in some surface wear and staining on cowry shells (Figure 6.14), and in mechanical abrasion and pitting of beads (Figure

Figure 6.14. **The cowry shells in this image are shown as they were found, in a concreted stack of small brass basins from an excavation unit; while they are *in situ* in terms of their present association with the basins, they are clearly in secondary context with respect to their original holding container. Some staining is visible on the cowry shell at the base of the green arrow, which is in fact pointing to the bead visible in the sediments. The gray, sandy and shelly sediments are typical of the shipwreck site (photo R. Horlings, 2007).**

[376] Appendix IV contains more details of artifact categories; while there were more than 35 categories of artifact recovered, beads and cowry shells were numerically the highest represented.

Figure 6.15. **The selection of beads shown here presents a number of different results of the beads' tenure on the seafloor, as well as the wide variation in size. The blue bead in the top left show some pitting, but is in relatively good condition. The bead next to it, however, is in extremely poor condition, likely a result of both chemical and mechanical stresses. The green beads (middle) demonstrate a different kind of reaction to the chemical environment, while the bead on the bottom left appears more resistant. The bottom right bead shows more pitting (scale in millimeters; original macroscope images by R. Broda-Blake, 2010).**

6.15). There are inconsistencies within artifact types in terms of the types and degree of degradation, likely relating to the materials and manufacture (in the case of the beads), the micro-environments in which they are located, and the length of time they have been exposed. The "Micro-environments" section below discusses these effects and patterns in relation to different areas within the wreck site.

Other Materials

As noted earlier, there are many more artifact categories represented in the cultural material collected from the site during excavation and in the sediment cores than can be easily discussed here. In addition to those already presented, several more bear a brief mention, as they illustrate different formation processes at work. The first of these is the charcoal found throughout the site. Because, as will be discussed shortly, there is very strong evidence that the vessel burned before sinking, charcoal, in theory, would be an excellent indicator of this; however, as was noted a multiple sites in Chapter 5, it is difficult to determine its significance in terms of this wreck site.[377] That being said, however, the exceptional amounts of charcoal found throughout the site indicate that much of it is most likely associated; it is discussed more below and in Appendix IV.

One specific observation concerning charcoal should be noted: while at present there does not appear to be a distinct pattern within the wreck site itself, scattered through site there are pieces of charcoal that have clearly been rounded or abraded to the point of appearing almost polished; a similar process was also noted in some of the coal pieces. Interestingly, this same process was observed at the Single Anchor Site and is clearly the result of a dynamic environment (i.e. Stein 1987:362), suggesting that there may be

[377] This is a similar to Hall's (1996:234-235) assessment of charcoal on the Monte Christi pipe wreck, where he suggests that other evidence, namely melted beads, makes a stronger case for burning.

micro-environments or localized processes within the wreck site itself that may be affecting these objects in very specific locations, such as, for instance, if they were trapped near a larger object and the currents kept rolling them against it (Banning 2000:236-243). Alternatively, they may be intrusive to the site, but as this is noted only in a few other areas within the submerged seascape, a more logical explanation is that the process is occurring within the wreck site itself.

Perhaps the most unusual, and even dramatic discovery in the sediment core material was what appears to be gunpowder (Figure 6.16).[378] This was discovered in stratum **3** of core **GW#5**, collected in 2007, and consisted of bits of sulphur, a white material, and black material in association with each other. This material was so delicate that if it was handled too much or too roughly, the crystals disintegrated and the material essentially became pulverized. The fact that gunpowder is present on a shipwreck is not

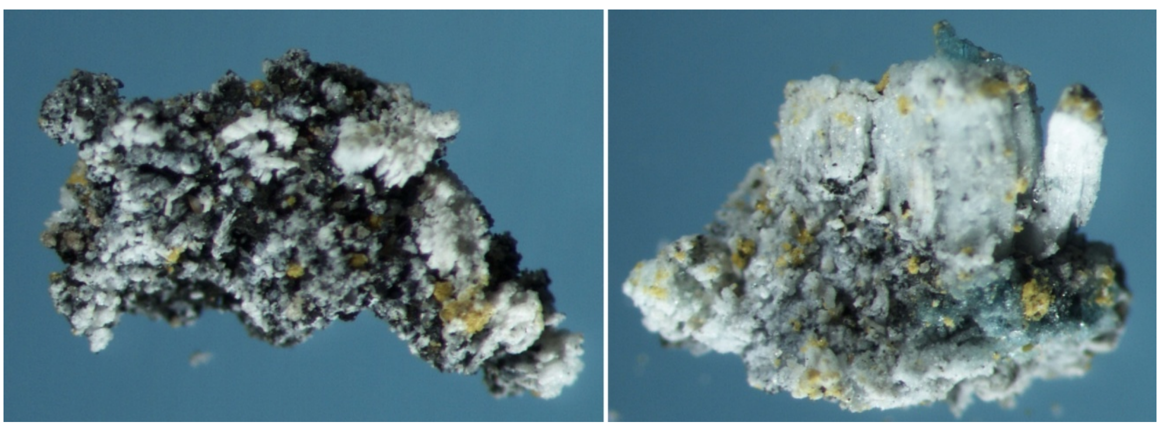

Figure 6.16. **The three component parts of sulphur (yellow), charcoal (black) and saltpeter/potassium-nitrate crystals (white), as well as an unknown blue crystal are all visible in these macroscope images (objects about five millimeters across; photos R. Horlings, 2008).**

[378] I first found a strange substance made up of sulphur, a white material, and a black material while doing microscope analysis. Dr. Christopher DeCorse suggested that it may be gunpowder, which subsequent tests confirmed is likely the case (personal communication Jack Irion, graduate student in Syracuse University's Department of Earth Science).

what is most unique about this, but rather, that it was preserved to the extent that, even after having been processed in the field,[379] it was still identifiable by its component parts.[380] Because it was found in such a concentrated location, it likely means that either the core punched through a bag or other holding container; alternatively, there may be a great deal more present in the sediments, but it is not preserved in other cores. Because it was not found in direct association with a cannon or some other direct indicator, it is not possible to say with complete certainty that this material is gunpowder. That being said, however, separate tests conducted on a JOEL 8600 electron micro-probe[381] and with a Bruker pXRF indicate that the separate components of the clearly associate sulphur, carbon-based material (charcoal) and a potassium nitrate compound (saltpeter) together make up the essential components of gunpowder (Cocroft 2000:2-6).[382] The presence of this pocket of gunpowder indicates that, while there may be many dynamic processes occurring on the shipwreck site, it is also possible that incredibly fragile and or organic materials have still been preserved.

Wood

Two more items should be briefly discussed here, as they attest to the preservation of organic materials: what appears to be the remains of a complete birch tree, suggesting it was alive while on the vessel and discovered during excavation, and remains of the hull

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[379] See Appendix I for a complete discussion of field-processing techniques.

[380] Identifying gunpowder from shipwreck can be difficult to do because of the various processes that can mask or destroy it (Callegari 1971:67); however, because the component parts here are so well preserved, this assessment is presented as the most likely interpretation.

[381] I am grateful to Jack Irion for his assistance with this and making it possible.

[382] The electron micro-probe test was conducted in the Department of Earth Sciences at Syracuse University, and the pXRF test was conducted by Dr. Bruce Kaiser of Bruker AXS. These results have also been independently confirmed by Dr. Donald Siegal of Syracuse University's Earth Sciences department. A raw spectrum of the gun powder compared to a number of other samples is presented in Figure IV.1 in Appendix IV. Unfortunately the electron micro-probe results were recorded only in notes during the testing session, so no formal data are available for them.

collected in sediment core samples. The birch tree remains were found in unit **J11** (see Figure 4.1 in Chapter 4) and included a trunk between 15 and 20 centimeters in diameter connected to branches which still had leaves attached to them;[383] much of it was located underneath a large concretion. It should be noted here that shipwrecks tend to trap material that is being carried near the seafloor by currents, and it is not unusual to have entire trees caught on shipwrecks. What makes this tree so unusual is that it is intact; if it had been rolling or carried along the seafloor for any distance or amount of time, the small branches and leaves would have been torn off, but they were not. In addition, at least part of the tree was trapped below a large concretion in the center of the wreck site. The tree was identified as birch by Dr. Stefanie Kahlheber.[384] While likely, the tree cannot be confirmed as associated with this particular shipwreck until it can be dated, but its association is probable, as birch trees do not grow in Africa.[385] While it is not possible to know the exact purpose of the tree on the coast of Ghana, one idea is worth suggesting. Staniforth (2009:96; see also 2003) argues that archaeologists should interpret material culture in terms of the society for which it was intended, and while it is possible that it was intended for trade, a more likely explanation is that it was intended for the garden of a fort (Lawrence 1964:165), perhaps to remind the Europeans stationed there of home. It is hoped that future archival research may shed light on this intriguing “passenger” on a merchant vessel on the west coast of Africa.

[383] Unfortunately, because of the lack of visibility it was not possible to photograph the tree in situ, and I was not able to photograph the pieces before they were sent for analysis.
[384] Of Johann Wolfgang Goethe University in Frankfurt, Germany.
[385] It has been suggested by one researcher that the tree was intended for firewood, as European woods have been found on the shipwreck of the Fredensborg in Sweden (Svalesen 2000:178-179). While this is possible, it is unlikely, as firewood is not stored with branches and leaves intact, as it would have unnecessarily taken up the already-small space on a vessel.

The final item that should be discussed is wood from the hull that was collected in sediment cores from the shipwreck site (Figure 6.17). Wood was noted in many of the cores collected, but six cores in particular had wood in significant amounts (see Figure 4.2 in Chapter 4 and Appendixes I and IV); the majority of the wood was identified as Northern White Oak independently by Dr. Amy Mitchell-Cook and Dr. Stefanie Kahlheber. [386] Apart from the wood clearly having non-African origins, its presence is intriguing because of what it indicates concerning the formation processes of the site, particularly in terms of sedimentation in the region. The combination of a high energy environment, warm water and "voracious shipworms," all of which are present in coastal Ghana, means that there is typically nothing left of the wood from wrecked vessels *on the surface* (Souza 1998:38). However, as was illustrated in Figure 6.5 above, if a portion of the hull is instantly covered by sediments and remains covered, it is likely that the covered part will be preserved. As is illustrated by the dating of the wood from the cores, the presence of well-preserved wood opens up numerous avenues of inquiry in the future, possibly including the investigation of a hull of a European merchantman sent to the dangerous coasts of West Africa.

Figure 6.17. Collected in core #GW2, this is the most intact wood sample, but those from other cores were also both recognizable and datable (shown actual size; photo R. Horlings, 2008).

[386] Respectively of the University of West Florida and Johann Wolfgang Goethe University.

In addition to clues to the vessel's origins, another piece of evidence has been provided by the wood collected in the sediment cores: the wood in core **#GW13** also provides insights into ship construction: two wood species, a White Oak and a Red Pine,[387] were present, with a coarse fiber caulking between them. All of the other wood in the cores was identified as White Oak, suggesting that the Red Pine is likely an outer or sacrificial sheathing put in place literally to be sacrificed to the wood-boring organisms discussed previously.[388] Additionally, we were able to have the wood dated through

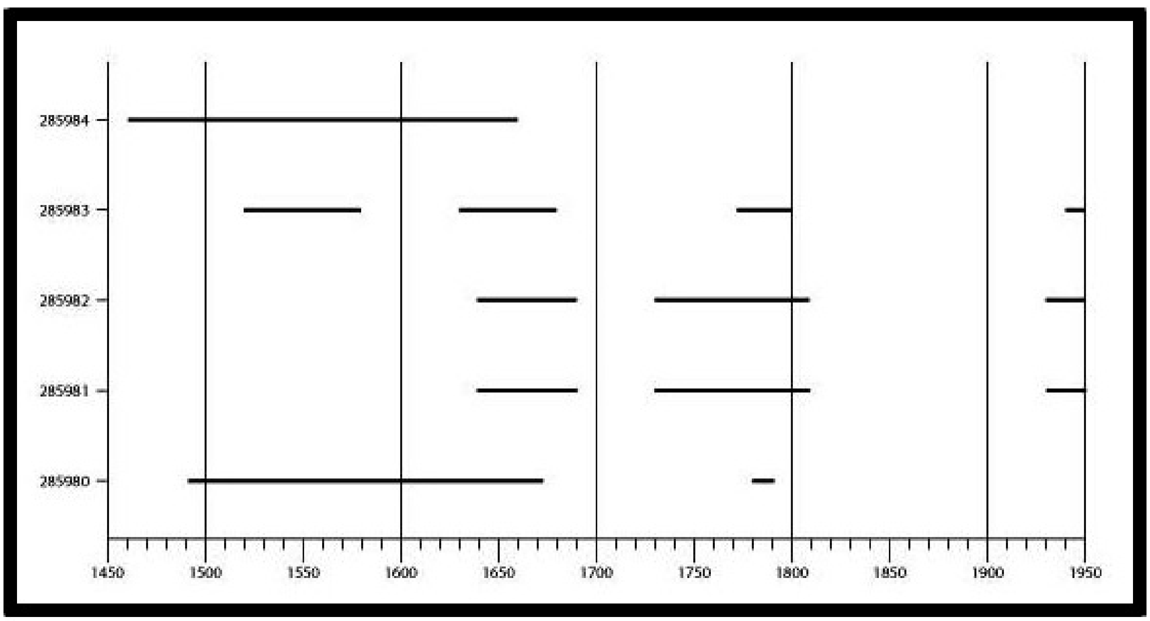

Figure 6.18. This image is a plot of the radiometric dates taken from each of five wood samples from the Elmina Wreck, based on 2 Sigma Calibrations. Additional calibration data may be found in Figures IV.2 and IV.3 in Appendix IV. Radiocarbon tests were run by Beta Analytic, Inc., in Miami, Florida.

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387 These woods were also found in structural elements on the probable wreck site of the *Queen Anne's Revenge* (Newsom and Miller 2009:5; Wilde-Ramsing 2006:172-173), and are also common on other historical vessels, including many of Dutch construction (L'Hour et al. 1990:64; Parthesius 2005:229).

388 Alternatively, as was the case with the so-called Pepper Wreck, the pine may also be hull planking (Castro 2003:12), in which case the core perforated the hull at the location where the pine was attached to an inner member (likely a frame) made of oak.

accelerator mass spectrometry (AMS), providing a date for the vessel[389] of between AD 1642 and 1664, with a 2 Sigma calibration error (Figure 6.18).[390] While this does not solve the problem of the vessel's identity, it provides a very tight context within which to conduct future investigations, including archival work. One final clue was also discovered from the wood in a core: partially burned White Oak wood, which provides conclusive proof of a fire being associated with the vessel itself. This is discussed in more detail below.

Each of the examples presented above illustrates different formation processes and effects within the Elmina Wreck site and its environs, and most of these processes are at work at various scales and affect a range of materials and objects. Transitioning to patterns within the wreck site based on the processes evident there, rather than on particular artifact categories, provides a means of contextualizing the materials from within the wreck site within the larger history and story of the wrecked vessel.

Micro-Environments within the Wreck Site

In 2007 the team noticed that there were far more cowry shells[391] and small beads[392] in the northern parts of the wreck site.[393] Beads and cowry shells recovered in sediment cores corroborate these observations and, along with other lines of evidence,

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[389] Note that this is the date of wood from the vessel; it provides an approximate date for its construction and use, but not the date of sinking.
[390] Funding for this was provided for by the Archaeology Institute, University of West Florida.
[391] It should be noted, however, that while the cowry shells were in somewhat more concentrated areas within the site than the beads were, there were still more in the northern area of the site.
[392] This also correlates with Hopwood's (2009:71-75) assessment that there were distinct areas in the northern part of the site that contained the small beads.
[393] Some bias was present here, as most observations were made based on excavations, which were in the middle and the northern part of the site, but there was clearly a difference in the numbers observed in the southernmost areas versus the northern.

suggest that there may be micro-environments discernible within the site.[394] For purposes here, micro-environments are considered to be localized areas within the wreck site as a whole that for any number of reasons tend to vary in their composition and the processes acting in/on them, resulting then in slightly different effects on the materials within them. Differences in micro-environments may be due to chemical composition and reactions of the artifacts within them; obstructions to current flow, resulting in differences in sediment composition; different biological/benthic activity; or a combination of any of these, as well as additional factors. The topography, and even the micro-topography (Gould 2000:59) within the shipwreck site, is also a significant factor in the development of micro-environments. A simple illustration of this is in the areas of scour within the site in 2009: after the currents deposited sediments on the south side of the wreck site, they in effect “tripped” over the higher elevation objects still exposed on the north side, in the process scouring them out at their bases. Like this example, some micro-environments are clearly visible, but it is likely that future research, including chemical analyses, will indicate a great deal more micro-environments.

More research as a whole needs to be conducted on assessing the micro-environments of shipwreck sites, including the Elmina Wreck site.[395] Included in this needs to be a quantifiable way to identify, measure, and describe both long and short time scales. For example, while it is possible from the core data to tell individual episodes and even cycles (Marsden 2003:84), at present it is not possible to assign any time-depth to

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[394] It is possible that the distributions of beads and cowry shells are also related to size sorting, but even if this is a contributing factor, the patterns appear to also be caused by other factors.

[395] A limited amount of research, including work done on the *Mary Rose* (Marsden 2003:76-86), has investigated localized processes and their effects through shipwreck sites (MacLeod 1982; Muckelroy 1977:1117), but the nature of the macro data typically collected from underwater sites tends to make this assessment difficult.

the individual strata. That being said, however, it may be possible to assess the *cumulative* time of deposits by correlating the depths of individual strata and the total depth of deposits with the known date of sinking.[396] The dates for the Elmina Wreck, measured from wood samples collected at known depths, place the wreck between 1640 and 1664 AD, suggesting that it may be possible to correlate the depths of deposits with time. As noted earlier, the clear cyclical nature of exposure and deposition in this environment will make this difficult. An intriguing part of this is that while a micro-environment may have certain characteristics at one point in time, as the materials, chemical compositions, and ocean movements changed, the micro-environments would also have taken on different characteristics.[397] Some of these changes and processes are visible in the sediment cores collected thus far, but future research should include cores taken with the express purpose of identifying these changes.

The importance of identifying and delineating micro-environments within the wreck site lies in its potential to inform not only about the macro-physical processes at work across the site, but also concerning the micro-processes that have affected the site as a whole and the cultural material contained in it. One means of correlating data across the site is through comparisons of sediment matrixes as recovered in cores through micro-sampling. Related to this, one of the goals of micro-sampling the site was to assess patterns within and across it as a whole through an investigation of the micromorphology

[396] Hamilton (1989:52) suggests that small (size not qualified) iron objects buried in aggressive site environments will corrode completely in less than 200 years, although larger artifacts will remain longer. While clearly not truly quantitative, this may be a very tentative and basic way of estimating time frames of sites for which the dates are not known. Ward, Veth and Larcombe (1999) have proposed a quantitative and predictive model of site deterioration as a function of physical, biological and chemical disintegration in relation to sedimentation rates; while this is a more quantitative means of determining site deterioration, until it is possible to scientifically measure these factors in Ghana, this model cannot be applied to submerged sites there.

[397] These changes may be caused by a range of factors, including the cycles of sediment deposition and exposure (Ward et al. 1999a; Wheeler 2002:1152-1153).

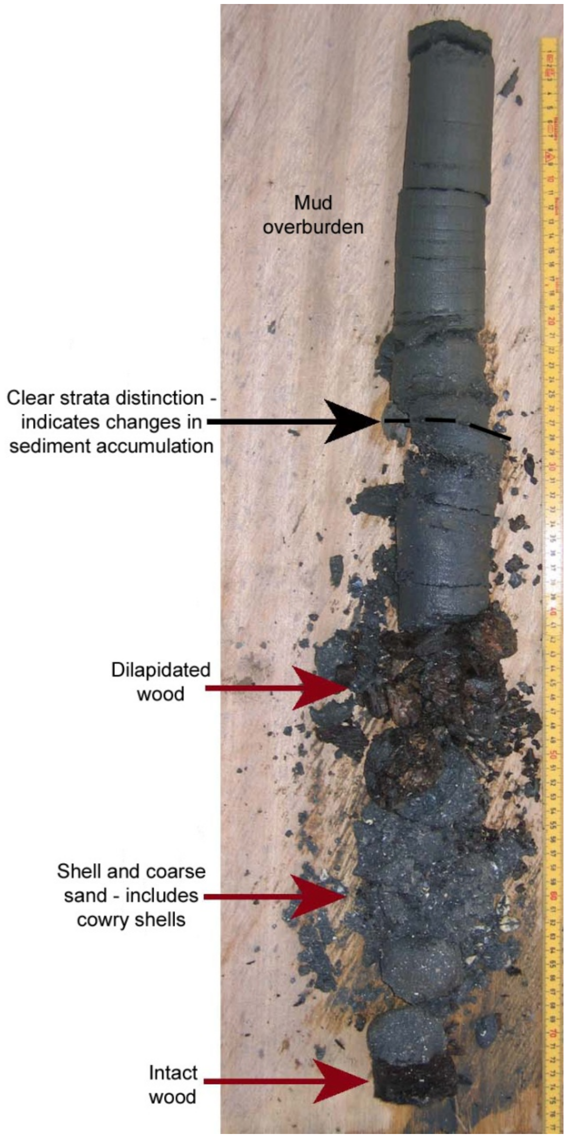

Figure 6.19. **This image of core #GW2 illustrates a number of different aspects of cores and the environment, but most importantly it shows the dilapidated wood positioned over the artifact-bearing coarse sand and shell layer, which in turn sits on top of the intact wood. The core is shown here in its original orientation (photo R. Horlings, 2007).**

represented in sediment cores.[398] Results of these analyses suggest that there are similarities in some of the sediment patterns across the site,[399] but there are also differences. For instance, there is a coarse sand layer that often contains shell and wreck artifacts located between approximately 60 and 100 centimeters below the surface in many of the cores;[400] the layer is never thicker than approximately 30 centimeters, but it is consistently present in many of the cores that reach that length. This same sediment

[398] A similar assessment was made in cores collected across the region; in this case there were also what appeared to be consistencies over large areas, but more data need to be collected before this can be confirmed.
[399] In a similar experiment, Gifford (1982:7) reports that a series of cores was taken using a diver-operated corer similar to the one used in this research on the Yassi Ada 4th century shipwreck site and resulted in the observation that there were consistent and easily-defined strata across the entire site. The primary difference between the Yassi Ada site and the Elmina Wreck site is that Yassi Ada is a very low energy environment, which allows for continual and consistent development of strata, while the high-energy Elmina environment means that strata will likely be more interrupted.
[400] A thick layer (sometimes more than 30 centimeters) of mud was present across most of the wreck site in 2007, and consequently was also present in the sediment cores. However, because the corer works by

composition in more shallow strata rarely contains the amount of cultural material represented deeper, suggesting that the lower sand strata may represent the original in-filling of the hull after the vessel settled on the seafloor.[401] This assertion is also supported by core **#GW2** (Figure 6.19), in which intact wood was present near 100 centimeters' depth, above which was coarse sand with cowry shells and other artifacts, above which was dilapidated wood, above which were finer-grained sediments and muds. The presence of the dilapidated wood separated from intact wood by sediments suggests that this part of the vessel was exposed for a period of time, allowing wood-boring organisms to deteriorate the wood to the point that it collapsed on top of the original in-filled material. While this sand and artifact stratum is the most dramatic sedimentary feature across the site, there are many more strata that are very distinct in cores collected within five meters of each other, suggesting that there are indeed micro-environments within the wreck site that may differ vertically and horizontally across space from other areas, and which may also contain differently-processed artifactual material. The one thing that is consistent across almost the entire site, however, was a wide range of intrusive material.

Mixing and Intrusive material

Intrusive material is defined here as any material found within the shipwreck context that was not original to the wrecked vessel. Typically these materials are single

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making use of a one-way valve (see Appendix &), some of these finer sediments were lost through the top of the corer during collection. This likely accounts for some of the discrepancies in the lengths of the cores, and explains why the mud layer at the top of each varies so dramatically.

[401] Perhaps in a similar event or series of events as occurred when the hull was in-filled, these upper strata most likely represent periods of exposure on the site. This is corroborated by observations of the differences in sediments during the different field seasons: in 2005 there was both mud and sand represented at the site; in 2007 most of the site, with the exception of several scoured-out areas, was covered in a thick layer of mud; in 2009 all of the exposed parts of the site were characterized by coarse sand with shell.

objects that can be easily moved by natural forces; they also include such objects as fishing nets and lines that have become entangled in the objects of the site as a direct result of fishing activities near it. The presence of intrusive materials on the wreck site is an indication of the dynamic physical forces at work in the region, as well as possibly reflecting cultural practices or activities in the region (see Table 6.1 and the discussion below).

The only sediment core successfully collected in the sediments covering the southwestern side of the wreck in 2009[402] contained virtually no artifacts. Of those recovered, only a few small pieces of burned material bore any resemblance to other artifacts recovered in cores from the wreck site. As discussed in Chapter 5, these are fairly ubiquitous in the waters of coastal Elmina, and therefore should be assigned association with caution. In other words, there was no material in the covering sediments to indicate that material from the wreck site was being cycled up into the covering substrate. This is an important point to consider concerning the mixed nature of the deposits in the wreck site as a whole.

It should be noted at the beginning of this discussion that the frustrating lack of specific and quantifiable data concerning the oceanographic processes in coastal Ghana, and indeed in all of West Africa, in addition to the fact that we have not yet been able to collect such specific data at submerged sites along the coast, makes specific analyses in terms of attributing evidence to particular formation processes difficult. As a result, some of the specific interpretations relating to intrusive material at the site are presented here in

[402] Another core hit something and shattered, so there was no material retrieved in it.

general terms; a more concrete interpretation cannot be made until more environmental data, whether analogous or specific to the coast, is available.[403]

As clearly demonstrated by the sediment covering the shipwreck site when just two years before it was not, there is ample evidence of at least one episode of exposure and deposition affecting the site. The excavation data, as well as evidence in the cores also indicates episodes, and therefore we can reasonably assume that this is not the first, and likely not the last time that the cycle will occur.[404] The primary processes creating these cycles appear to be the predominant west-east current and seasonal storm surge, although there are quite certainly other processes at work as well. The results of these episodes in terms of site and artifact preservation have already been mentioned, but one of the most perplexing features of the site has yet to be discussed.

The tendency of shipwreck sites to trap material travelling along the seafloor is well documented, and the site of the Elmina Wreck is no exception to this as it contains significant amounts of this intrusive material. What is perplexing about this site, however, is the extreme temporal range of the material represented on it. As illustrated in Figure 4.3 (in Chapter 4), the range of cultural material[405] on the shipwreck site spans the 15th century through the present day, with more than half of the diagnostic historical artifacts collected having been assigned to the 19th century or later (Cook n.d.; Pietruszka 2011). As the age of the site has been confirmed through AMS dating to be mid-17th century, this range of nearly 500 years is troubling. While archiving or reuse of items such as bottles may explain a limited range in dates (i.e. Tuttle 2010:51), this extreme

[403] See Appendix II for the most comprehensive discussion and literature review available on this topic.
[404] The lack of barnacles growing at the site also indicates that it is not consistently exposed.
[405] A more complete listing of categories is presented in Appendix VI, but several examples may be noted here, including a range of different wine bottles, smoking pipes, and modern glassware and plastic materials.

range can only be explained through physical formation processes active in the region. Several possible explanations for the source(s) of the intrusive material are explored in Table 6.1.

As Table 6.1 indicates, none of these sources seems to definitively account for either the temporal range or quantity of intrusive material at the site, and there is little evidence at present to support any single one of them as the primary source. It should be noted, however, that the Elmina anchorage has been actively used by local and foreign vessels for over 500 years. In that time, all of the events listed in the table, including the random dropping of items, jettisoning, and capsizing, likely happened on numerous occasions, possibly contributing to the accumulation of intrusive material to the site.

Possibilities	Explanations/Refutations/Comments
random events of dropping items/items falling out of boats and/or canoes	- possible, but difficult to account for sheer amount of intrusive material; - also unlikely that so many random droppings would occur over exactly the same spot
jettisoning events	- possible, but unlikely to explain the range and amounts of material
canoe(s) capsizing	- possible, but unlikely to explain the range and amounts of material
items dropped as off-loaded from large trading vessels	- possible, but here also, unlikely to have been repeated over the same spot, or even multiple times in the very proximate region in order to account for quantity and diversity of material
shiptrap/multiple wrecks	- no structural or other indications of multiple vessels - wreck site too organized to be multiple wrecks - there is neither geological nor oceanographic cause for the sinking of multiple vessels on this spot
multiple wrecking events near it	- possible, as there are several magnetic (and possible side scan sonar) targets to the north and northeast, but it is likely that this amount of material would have traveled this far against prevailing currents and surge - possible if wreck is located upcurrent, but no evidence at present for this - cannot be sole source because of the range of intrusive material present
Benya dredge spoil	- unlikely to have been deposited over the wreck site, but if material was deposited offshore, a number of processes may have worked to transport it generally across the wreck site location
loose/ambient material	- certainly contributes, but volume is uncertain

Table 6.1. Possible sources of intrusive material on the Elmina Wreck site. It is likely that multiple factors, including any combination of those mentioned in this table, explain the intrusive material at the Elmina Wreck site.

The town of Elmina, located in such close proximity to the shipwreck site (Figure 6.20), is likely a major contributing source for intrusive material on the wreck site. Explaining its direct role as a source is challenging, however, in terms of the relative positions of Elmina and the shipwreck site in relation to predominant oceanographic processes.[406] The position of the wreck site in relation to Elmina is such that any material coming directly from Elmina via the mouth of the Benya Lagoon would have had to travel directly perpendicularly to the predominant and powerful Guinea Current, which runs along this part of the West African coast in a west to east direction throughout the year. It would also have to have crossed the weak Ivoirian undercurrent which runs east

Figure 6.20. Note in this image adapted from GoogleEarth how the sediment plumes are being pushed towards shore and to the northeast, following the direction of the longshore current and predominant onshore wind.

[406] Because the Castle and the mouth of the Benya and the lagoon area immediately adjacent to it had been used for ferrying and transferring goods for centuries, and because of common waste disposal practices into bodies of water in this region and in harbors around the world (Tuttle 2010; Riccardi 1987), numerous modern and historical artifacts have been deposited, intentionally or not, into the waters around the Elmina Castle. Modern refuse is ubiquitous in the water and on the beaches in Elmina, and broken historical artifacts are often found washed up on shore in the vicinity. In addition, a number of historical artifacts were recovered by the dredge team, some of which we were able to view in 2007.

to west underneath the Guinea Current for parts of the year. If material was lost or deposited on the south side of the peninsula on which Elmina Castle is built, or even if it was deposited further to the west in other locations, such as Bantama or Komenda, the longshore current and waves would have moved it shorewards and northeast along the shore, not ESE as would be required for it to reach the shipwreck site from that location. It is possible that surface wind currents moving offshore could have transported floating material offshore, but realistically this cannot account for most of the material on the site.

As noted in Table 6.1, it is likely that some materials were lost or deposited at sea or along the shore miles upcurrent and were transported either by rolling along the sea bottom or suspended until they became trapped on the wreck site, but again, as the wreck site is a relatively very small, single location on the bottom of a very large sea, it is unlikely that this process alone can account for all the material. Furthermore, although trash and modern materials are present in massive quantities along the shore and floating on the sea today, historically there was far less in terms of the sheer quantities of intrusive material in the sea, making it even less likely that large quantities of material would become trapped in an isolated and relatively small site. An analogy may be made here with the Single Anchor Site: the site is located in much closer proximity to Elmina and the Benya, and there is a great deal of intrusive material trapped around it, but all of it is of modern origin. The anchor is clearly historical, indicating that there has been ample time for similar kinds of historical materials to become trapped on it as well. Of course, regardless of the source, in no way does the material travel in straight "bee-lines" to the wreck site or any other location, but rather, it is subjected to a plethora of factors that may move it in any number of directions before it is finally caught by the material at the wreck site. Finally, it should be noted that during the “covered-up” phase of the deposition/exposure cycle, as is the case now, there would have been nothing to trap the materials. As we do not know the lengths of times in the major cycles, we cannot therefore say how much time the site would and would not have been trapping materials, but we can say that the site has not been constantly trapping since it was created.[407]

None of these arguments can prove or disprove what the source(s) of intrusive materials are, but they are all factors that need to be considered, and, as noted earlier, it is likely that a range of factors has contributed. It is entirely reasonable to assume that Elmina is, directly or indirectly, the major source of and causal factor in the presence of intrusive material at the wreck site, as is evidenced today by the excessive amounts of modern debris that it deposited in the sea along the Elmina shoreline and by fishermen. As it was a major center of historical international trading activities, a town with a population reaching up to 20,000 people (DeCorse 2001:32), and in more recent times a major hub for local fishermen, there is no doubt that the activities of so many would have contributed significant amounts of cultural material into the sea environment in the past as well as the present. The question remains, however, how those materials transitioned from being associated with Elmina to being trapped on the Elmina Wreck site.

All of the preceding discussion has been focused on possible explanations for the presence of intrusive material at the Elmina Wreck site, but has not offered a truly plausible mechanism for the transport of those materials, particularly if, as seems to be logical, a majority of the objects entered the sea in or near Elmina. One observation of the

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[407] A perhaps tangential argument is the fact that there is extremely little in terms of material culture scattered across the seafloor at present. While this was difficult to discern reliably in 2007 due to the total lack of visibility, in 2009 there were several days of visibility, but no comparable objects to the intrusive material were seen being transported along the seafloor. In both years, however, large amounts of materials were observed floating in various directions on the surface, depending on winds and currents.

distribution of artifacts within the wreck site may provide support for another possible transport mechanism: a large portion of the intrusive material (post mid-17th century)[408] collected in surface surveys and excavations was recovered from the northeastern area of the site (see Figure 6.21 and Appendix IV) (Cook n.d.; Pietruszka 2011). Taking into

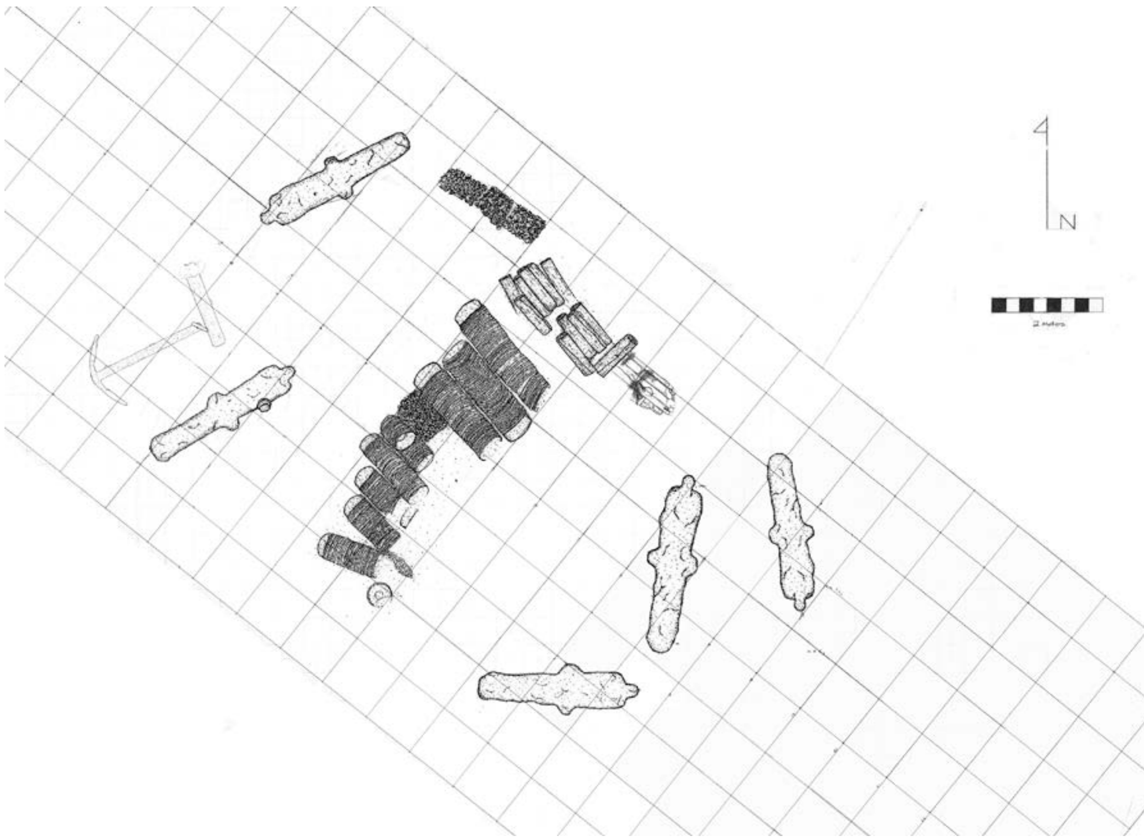

Figure 6.21. The wreck site is depicted here in its 2007 iteration; note that the southernmost basins visible in 2005 are absent, and the small cannon, anchor and unknown object are visible.

account the biases in terms of excavation trench locations, this still indicates that it is possible that for some reason the northern part of the site is trapping more intrusive

[408] This was confirmed by the AMS dating of the wood, and also by the presence of diagnostic pewter basins that date to this period (Pietrusza 2011).

material;[409] this indicates that much of it is likely reaching the site via cross-shelf mechanisms, as opposed to along-shelf mechanisms,[410] and is then being deposited on the northern, most shoreward side of the site. Two different processes may be suggested as the driving mechanisms; they are storm surge[411] and the subsequent downwelling after an upwelling. Both of these processes are known to move materials in cross-shelf directions,[412] and while net transport from storms and upwellings appears to be shoreward, there is evidence that the return storm surge and downwelling movement of water do transport materials seaward (Gelfenbaum 2005:259; Healy 2005:312; Nittrouer and Wright 1994:105).[413] A great deal more research must be conducted in order to confirm that these are indeed the predominant transport mechanisms, but with the

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[409] As with the sediments that are now covering the site, if materials were being transported primarily by the currents, they would more likely be concentrated on the west side of the site. While it is possible that a significant number of intrusive artifacts are in fact present on that side, it was not observed in surface collection, and sediment cores indicate that there is less cultural material on the west and south sides of the site than on the north and east.

[410] Cross-shelf refers to the perpendicular (in reference to the shoreline) movement of material either seaward from the coast or shoreward, across the continental shelf and therefore also across the predominant currents; along-shelf refers to movements parallel to the shore.

[411] While the idea of storms playing a role in the deposition of materials at the wreck site had been mentioned earlier, the actual mechanism (downwelling) by which this could have taken place, considering Elmina as the primary source for materials, was originally proposed by coastal geomorphologist Dr. Andrew Ashton of Woods Hole Oceanographic Institute (personal communication, 2010), who also has experience working in coastal Ghana.

[412] This is generally transported as bedload (Gutierrez et al. 2005:81).

[413] As discussed by Healy (2005:312): "*Downwelling* and *upwelling* in the coastal zone are largely wind-driven processes… These processes have marked, but often overlooked, influence on the diabenthic (cross-shore) sediment transport. For the case of significant onshore wind blowing for some hours, surface waters are forced up against the beach and dunes, raising the still water level at the beach. As a requirement of continuity, the onshore surface current in turn generates a bottom return current (downwelling). Thus sandy sediment grains initially eroded off the beach in a storm, which uplifted by the bottom orbital motion of the waves, are acted upon by the downwelling current as they fall back to the seafloor, and thus become transported offshore, typically to "closure depth." Conversely, with consistent offshore winds, wind stress on the sea surface forces the water out to sea, and lowers the still water level. This generates an onshore-directed bottom return current (upwelling), and as the longer period (non-storm) swell waves uplift the bottom sediment, it is transported onshore to the beach, facilitating beach face accretion… Of the two processes, the latter likely transports bottom sandy sediment at a greater rate because the longer period waves have greater bottom orbital velocities which uplift more sediment. It is often observed that beach recovery at the end of a storm (when winds reduce in strength and change to an offshore direction) is more rapid than the loss of sand from the beach during the erosion phase (emphasis original)". See Appendix II for more details concerning these processes.

information currently available for this study, it is at present the most plausible explanation that can be offered for the quantities and temporal ranges present in intrusive material at the Elmina Wreck site.[414]

As noted earlier, cultural material both at the wreck site and across the entire coastal Elmina region are mixed both temporally and contextually. At the wreck site in particular, it is clear that loose objects are no longer in their original lading, and that they are also vertically displaced. This contextual confusion is problematic for then interpreting the integrity of the shipwreck site, and in determining which materials or objects may be original to the wrecked vessel and which are intrusive, as they are often found in the same sedimentary context. The process of objects becoming intermixed through the sediment column is relatively simple, and is not surprising to find in such a dynamic environment as coastal Ghana.[415] As is illustrated in Figure 6.22, the objects themselves create a disturbance in water flow, resulting in small scouring occurring around the object. Over time, the scours create depressions deep enough for the object to settle into, until sediments begin to cover up the depression and its enveloped object (Inman and Jenkins 2005). In this way, individual objects can settle through the sediments without any massive disturbance having happened across an entire site (see also Hamilton 2006:135-147). The cyclical nature of exposures and depositions does apply across the entire site, but this explanation concerning the intermixing of objects on

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[414] It is worthwhile mentioning here that these same processes that are responsible for transporting intrusive material to the wreck site are also responsible for transporting original materials away from the site. It is impossible to quantify how much and what materials may have been moved, but this has to some degree created a bias in the material culture that has been identified from the site. Understanding the effects of these different processes in terms of the composition of the site and its interpretation is a key aspect of formation process research.

[415] This is a common occurrence in shipwreck sites that are located in high-energy or dynamic environments; for examples see Hamilton 2006:136; McBride et al. (1972:138) and Muckelroy (1978:176-177).

an individual basis suggests that the presence of intermixed materials does not necessarily or in every case fully negate the integrity of the stratigraphy of a site (e.g. Parker 1981).[416]

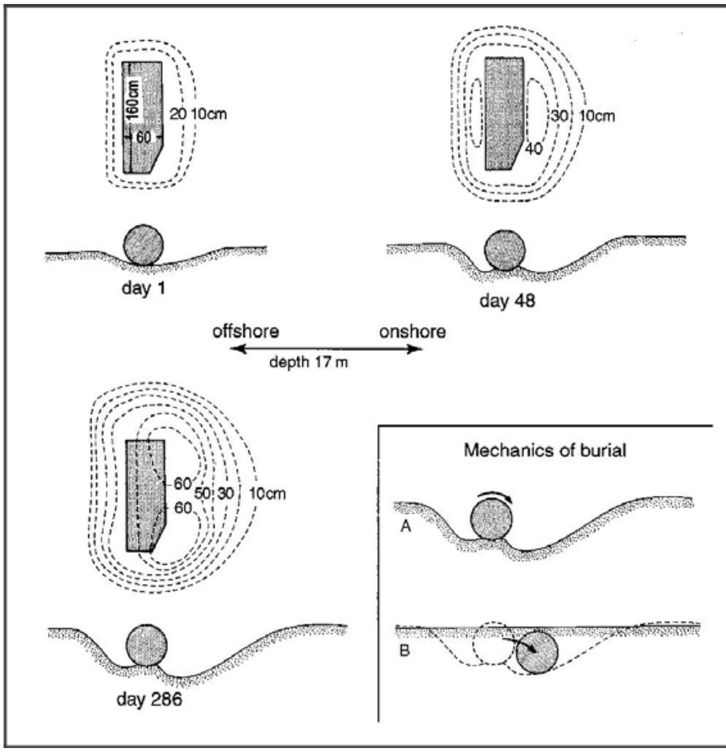

Figure 6.22. In this simple illustration from Inman and Jenkins (2005:828), a cylindrical mine is shown as it is scoured out and settles through the sediments. Note that this process occurs with objects of nearly any size that are in sedimentary environments. An excellent example of this may be found in the suspected site of the *Queen Anne's Revenge*, located in the sandy environment of the intercoastal waterways of North Carolina (Lusardi 2000; McNinch et al. 2006).

One final point concerning intermixing on the Elmina Wreck site should also be presented. The large concretion that apparently covers the majority of the site forms essentially the floor of a very large, coarse mixing bowl. Because this concretion is located relatively close to the surface, any loose objects that become trapped in the site are in effect caught in the bottom of a bowl and rolled around on it, in the processes becoming increasingly abraded and intermixed. While this clearly contributes to the

[416] Stein et al. (2003) experimented with identifying the accumulation rates of materials in terrestrial archaeological sites as a means of delineating time frames associated with them. One of the possible utilities of the micro-sampling approach applied here is that it could provide a means of testing this, but more work needs to be done in order to make this an effective application of the technique.

mixed nature of the materials recovered from above this concretion, it may also be a significant contributor to the distinct wear patterns observed on many of the collected artifacts; as such, wear patterns on artifacts may not be a reliable single indicator of the processes which contributed to the intrusive material being on the wreck site in the first place.

Formation process analysis of the contexts and artifacts of the Elmina Wreck site has not only revealed details concerning the history of the vessel and wreck site, but has also reinforced the assertion that a great deal of valuable information may be garnered regardless of whether a shipwreck site is relatively intact or apparently dispersed and incomplete (Adams 2001:297; Hall 1970:121; O'Shea 2002:212, 2004:1537; Oxley 1998b:523-524; Quinn et al. 2000:295; Redknap and Besly 1997).[417] It has also demonstrated that all sites need to be systematically investigated and recorded individually and as components of the much larger seascape within which they operated. As Adams (2001:297) writes, "[t]hrough analysis of formation processes, the relationships between component objects, assemblages and structures and their varying qualities of contemporaneity and selection can be recovered…on even the most dynamic of sites." Formation theory is therefore a methodological and theoretical tool that can be effectively applied to all kinds of shipwreck archaeology. The inter-disciplinary nature of site formation research lies primarily in the investigation of the role that the environment plays, as environmental (cultural and natural) factors affect every part of the site, acting as the formation processes that serve to break down and yet stabilize the wreck (Ward et al. 1999a:566; Wheeler 2002:1150), but it also applies to the interpretation of the cultural

[417] An excellent example of this may be found in the work done on the very rough and scattered site of the slave ship *Whydah* (Hamilton 2006:157; Reedy 1991; see also Keith and Simmons 1985; Martin 2005).

material and history of the site. The following section discusses some of the interpretations of the Elmina wreck site based on the archaeological investigation of formation processes within the framework of the archaeology of the event.

Evidence for the Event(s)

The historic African trade was notorious for its uncertainty, both in terms of profits and the very real possibility that those involved in the trade would never return from Africa due to mismanagement, illness, warfare, piracy, shipwreck and any number of other mishaps (Eltis et al. 1999; Fage 1969; Hopkins 1973:92; Inikori 1996:58; Mancke 2004; Williams 1994 [1944]:38). The Elmina Wreck site discussed in this chapter is evidence of one of those unfortunate merchantmen. Investigation of this site within its larger historical and physical contexts provides the opportunity to study a unique wrecking event in the past as well as general formation processes that affect this and other submerged sites in the region. Its interpretation within the larger seascape context of coastal Elmina provides insights into the historical and physical environment of historical maritime trade along the coast. The final discussion of this chapter centers around the description and interpretation of some of the assessments of specific micro and macro evidence at the site, and presents a story, based on archaeological evidence, of an event that occurred over 350 years ago on the coast of West Africa.

Several things can be stated about the vessel in question before any in-depth archaeological observations are even considered: she was a merchantman (as evidenced by the large cargo of trade materials); as a merchantman she was part of a series of larger systems of international politics, economics and trade; her sinking represents a single event on the eventscape of history; and the remains of the vessel and its cargo are now part of the international underwater heritage of coastal Ghana. An investigation into the processes that created the wreck site and which have affected it since provides an opportunity to learn not only what has happened to this particular vessel, but also about the maritime world in which she was, and is still, a part.

Micro- and Macro-Evidence

All the water in the world cannot sink a ship unless it gets inside.
Chinese fortune cookie.

While there is very little evidence on the surface of the wreck site to indicate why she sank, there are some clues that provide insights into the sinking event and what has happened since. [418] As there is no superstructure or hull of the vessel visible above the sediments, it is necessary to look at the artifacts that make up the site, as well as below the surface to ascertain what may have happened. Several pieces of (macro) evidence can provide insights into the sinking event and the hours and days immediately following it, and they are highlighted in the following discussion. In terms of the events that occurred during the sinking, one relatively inconspicuous clue may be found in a stack of large basins intended as trade items: the surface of the entire stack has been flattened (Figure 6.23). This unremarkable observation provides direct evidence as to at least one structural event that occurred while the vessel was still on the surface, and likely as a result of the same event that sank the vessel. It is not naturally possible to create enough force

[418] Cook (personal communication 2007) observed charcoal on the surface of the wreck site, which suggested that perhaps the vessel burned; while this is almost certainly the cause of sinking, because charcoal has been found to be relatively ubiquitous in the underwater landscape of coastal Ghana, this by itself is not sufficient information on which to base that interpretation. This is in contrast to other locations or sites where the presence of charcoal can more reasonably be interpreted as direct evidence of burning (i.e. Dethlefsen et al. 1977; Flecker 1992).

underwater to flatten an entire stack of metal, regardless of its malleability; therefore, the flattening had to have occurred while the vessel was still afloat, and was likely caused by

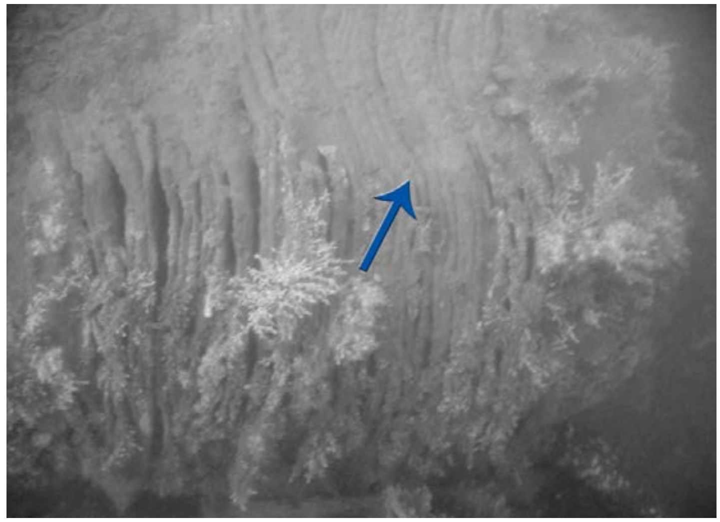

Figure 6.23. **The image on the left was taken in the Elmina fish market and illustrates modern aluminium basins that are very similar to those found on the wreck site; while it is easy to dent and mis-shape a single basin, it would clearly take a great deal of force to flatten an entire stack of them. The image on the right was taken from video footage of the wreck site; the blue arrow points to the squared corner created in the otherwise round basins by the flattening (photo on left by A. Horlings, 2007; photo on right by R. Horlings, 2009).**

a very large, heavy object with at least one side; there is no material currently on top of the stacks, suggesting that the heavy object was likely a wooden beam that has long-since disintegrated. Whatever created enough force to dislodge a heavy structural beam[419] was clearly enough to sink a vessel.

Two additional observations can provide probably evidence for what happened as the vessel was sinking and lodging in the seafloor. The first of these is in regard to the

[419] The basins are lying along the long axis of the vessel, and the flattened portion of the basins is also oriented this way, suggesting that the beam was a longitudinal structural piece, likely supporting one of the upper decks.

position of the cannon: four of the six cannon on the site are still facing outwards;[420] one cannon (the middle southern cannon in Figure 6.21) appears to be facing inside the vessel, but I propose that it is likely that its cables broke and it slid backwards as, or after, the vessel settled, thus placing it in the middle of the wreck and making it appear that it is no longer in its ship-board position; and one cannon, the smallest (the northernmost cannon in Figure 6.20), is clearly facing inwards. This general patterning of the cannon, spread out across the site and still facing outwards, regardless of their positions, suggests that the vessel likely sank and settled on a relatively even keel.[421] If this is the case,[422] it is safe to assume that the masts of the vessel, and possibly even some superstructure,[423] were visible above the waterline for at least a short period of time after sinking, which would have easily facilitated salvage attempts, as the deck would have been within meters of the water surface, and hatches would have also been accessible. It is unknown from the remaining evidence what other material, including the possibility of smaller cannon on the deck, may have been successfully salvaged.[424]

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[420] Similar positions of cannon have been noted on other wreck sites as well, for instance, the likely wreck of the HMS *Sapphire* sunk in 1696 near Newfoundland (Barber 1977:308) and the 1668 wreck of the Sacramento off Brazil (de Mello 1979:213).

[421] A contrast to this can be seen in the Molasses Reef wreck site in the British West Indies, where the 16th century vessel sank on her side and was dragged along the bottom for some time before grounding (Keith and Simmons 1985).

[422] Even if the hull was not on an even keel it is likely that parts of the masts were still visible above the surface, albeit at a greater angle than if the vessel was on an even keel.

[423] Of course, how much was visible would have depended on the vessel type and how much burned before it sank.

[424] An interesting question that may be related to this is the question of lading of the vessel. As indicated by the site plan (Figure 6.20), basins are neatly stacked in the center of the vessel, and barrels of manilas were distributed relatively evenly, as were the cannon, but there are also a massive stack of lead rolls and a very large iron object located to the side of the wreck site. Because there was a slight list to the wreck it is possible that there is some other material to the starboard of these heavy items, but not likely a lot, as historical vessels were not built widely. This begs the question, then, what was on the port side of the vessel to balance out this incredibly heavy load on the starboard? No materials recorded on the port side of the wreck site could have been heavy enough to counterbalance the lead and iron object. Does this indicate that whatever this material was, it was successfully salvaged after the wreck? Were there simply more guns on the port side that were used to counterbalance this weight, and then were salvaged from the accessible

The other observation that appears to indicate an even settling is in the anchor, located in the northwestern part of the site (Figure 6.21).[425] The ring of the anchor is sitting *on top* of the small cannon, suggesting that there was hull structure to keep it vertical for a time; when the hull structure collapsed, the anchor settled with its ring on top of a cannon that was either on the gun deck or stowed. This process may have taken weeks or months, but the anchor is positioned as it would have been had it been hanging from the bow of the vessel, perhaps in preparation to be set.[426] All of these pieces of evidence provide indications of what likely happened during and after the wrecking event, but there is a great deal more to the story.

What evidence to we have as to what actually sank the vessel? There are no geological hazards in the region of the site, making it unlikely that the ship ran aground.[427] In addition, the cargo appear to be relatively intact: the basins remain in neat, orderly rows, the lead rolls are still stacked, and almost all the cannon face outwards, as though still in position on the deck. All of this indicates that it was also likely not a storm or other vigorous or violent act that sank her. It is possible that ship rot or biofouling organisms caused major leaks in the hull, but in that case the imminent danger would have been apparent to even the most untrained crew and she would have been towed to

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deck? If this was the case, why were the other guns not salvaged? These questions may never be answered, but perhaps future investigations will be able to shed some light on them.

[425] An interesting side observation merits noting with regard to the anchor. The shape of the anchor is very similar to that of the anchor from the Portuguese vessel *San Antonio*, which was built in 1680 and wrecked near Fort Jesus, Mombasa in 1697 (image of the anchor in Curryer 1999:40). This is a mere 20-40 years after the building of the vessel at the Elmina Wreck site, and provides a nice comparison to the likely Dutch anchor associated with the vessel.

[426] It is possible, although unlikely, that the anchor is also intrusive. Anchors were relatively easily lost or simply cut away if trapped in something, but the fact that it is not caught on anything and is lying flat on the sediments with its ring on top of a cannon but no evidence of any struggle with it suggests that this is not the case in this instance.

[427] It is possible, but also unlikely, that the vessel encountered rocks or a sandbank upcurrent and drifted downcurrent until she sank. This is unlikely, as there is no evidence of tumultuous actions (the cargo are still neatly arranged), and in such a situation some effort would have been made to transport or tow her to shore.

shallower water where she could have been more easily salvaged. She may have been sunk by pirates or enemy fire, but there is very little evidence for any subsequent looting of the vessel as would have been the right of the victors, suggesting that this is also not the reason. There is also no surface evidence of a widespread fire as none of the visible artifacts – including the stacks of brass basins – show any indication of intense heat, and apart from a few pieces of charcoal, there is no other indication of a fire on its surface. What is below the surface, however, tells a different story.

As noted above in the discussion on micro-artifacts, there was a great deal of melted material recovered in sediment cores from the wreck site. PXRF analysis of these materials indicates that there are silica-based (likely glass), copper-based (likely the brass basins), lead, and iron-based melted artifacts. The range of melted material indicates that the fire had to have been intense enough to melt even iron, something that is rarely observed in natural fires (Cote and Linville 1997:4-188). In addition, a piece of partially burned wood, identified as White Oak by Dr. Mitchell-Cook, was collected from core **#GW22**; as White Oak is the wood from which the hull was constructed, this suggests that it was not a partially burned piece of wood from the galley,[428] but rather a part of the vessel's structure. It is almost certain that this fire was responsible for the demise of the vessel, but the evidence for the intensity of the fire must be considered in light of the other evidence from the wreck site.

[428] There is also coal throughout cores collected on the wreck site, indicating that coal was likely burned in the galley; while this is likely, due to its size and ubiquity on the site, there is also some coal in cores collected across the region, likely deposited in the water from other vessels that visited (or wrecked near) Elmina over the course of the Atlantic trade. Regardless of whether wood was burned as well, as White Oak does not grow in Africa, it clearly would not have been the fuel used in the galley weeks, if not months, after the vessel left its home port in Europe (see Cook (n.d.) and Pietruzska (2011) for analyses as to the vessel's origins).

As already mentioned, the cannon are facing outwards, meaning that they would have been in this position as the vessel settled into the sea bottom. [429] Accepting that there has been little change in the cannon positions, it would mean that the fire could not have consumed and destroyed the entire upper works of the vessel, but instead had to have occurred, or at least been most intense, somewhere lower in the hull. In this scenario, the vessel would have sunk rather quickly, before the fire could spread to the upper decks; this would have almost certainly been the case had the fire been low in the hull and burned through enough of the wood to allow water pressure from outside to perforate the hull and fill the inside, thus sinking the vessel.

The anchor, located on the northwest side, of the site offers several additional clues to the interpretation of the wrecking and subsequent wreck site. Most historical vessels carried between five and eight anchors, depending on the size of the vessel. Two or three of the largest anchors were reserved for the bow (McCulloch 1844:42), while the remaining anchors were stored on the deck of or off the sides of the stern or, in the case of the largest, called the sheet anchor, most commonly in the hold (Rubin 1971:233; Tinniswood 1945:89).[430] The anchor on the site is more than two meters long,[431] and most likely a most likely a bow anchor.[432] If this is the case, the anchor on the wreck site

[429] In contrast, for instance, on the *Mary Rose* the cannon were clearly shifted to the starboard side, as she listed heavily and lay almost fully on her starboard side (Allen and Oxley 2005:509)

[430] While there were certainly variations in this, depending on the vessel type, nationality and time period, there appear to be fairly consistent trends in terms of numbers and types across time, vessel and nation to indicate that this, or a slight variation on this, was the norm for several hundred years of recent maritime history (Blanckley 1750:1-2; Jobling 1993:69-73, 123).

[431] Based on very rough estimates, likely a 5 to 7 cwt. (Pering 1819:92; Tinniswood 1945:91; see also Curryer 1999:60). Anchor capacities were actually determined based on weight ratios to vessel size; this in turn affected their sizes (McCulloch 1844:42; Rubin 1971:232; Smith 1993:124). Several bow anchors described on the 16th century Highborn Cay wreck appear to be a similar size to this one (Smith et al. 1985:69).

[432] It must be made clear here that the descriptor of “large” (referring to both size and weight) is completely relative: this size anchor is large enough to be a bow anchor on a merchant vessel of anywhere from 100 to 350 tons (Sutherland 1717:22; Tinniswood 1945:89). Merchant vessels from this time period varied in size

is the port bow anchor (as it is located on the left outside of the wreckage concentration), indicating that the vessel listed somewhat to starboard as she settled. Her position lying on the sea bottom almost perpendicular to the main west-east current suggests one of two things: either she was not anchored at all when the accident happened; or she was originally at a single point anchor using her main starboard bower anchor and the cable parted, causing her to drift with her bow facing the Castle and her broadside to the current. It is also possible that the current was partially responsible for her list to starboard; exactly the direction that would be expected with a current applying pressure to her broadside.

The listing of the vessel away from the anchor (to starboard) is also consistent with evidence from the cores that most of the melted material is located in the northeastern region of the wreck site (Figure 6.24; see also Appendix IV).[433] The concentration of this material suggests that the fire was most severe somewhere on the starboard side, perhaps in the starboard bow; this, therefore, would have been where

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from less than 100 tons to larger than 1700 tons (Baker 1955; Castro 2003:19; Thomson 1902:1412), making it extremely difficult to estimate vessel size with any modicum of certainty based purely on anchor dimensions. Thomson (1902:1412) provides some general insights into this issue when he writes that during the days of wooden sailing vessels "the rough rule was 1 cwt. for every 20 tons of a merchant-ship's burthen… Up to the beginning of the seventeenth century the largest anchors in use must have been very light, for we read in "Derrick's Memoirs of the Royal Navy" that the capstan for weighing anchors was first invented in 1610. In 1637, however, the "Sovereign of the Seas [a Royal Navy ship-of-the-line]," a vessel of over 1600 tons burthen, carried eleven anchors of about 2 tons each." There was a lack of standardization both within countries and between them in terms of vessel types and their equipment, including anchors, through the 18th and into the 19th century (Pering 1819:59; Tinniswood 1945:88). It is highly unlikely that that vessel represented by the Elmina Wreck was larger than 500 tons, and more likely even less than 300, judging from the size of the wreck site and the amounts of cargo present and typical merchant vessel sizes for the 17th century. Keeping all of these factors in mind, the anchor's position on the port side of the vessel suggests that it probably was not the largest or the best anchor, which would have been on the opposite, starboard side (Pering 1819:63-64; Rubin 1971:233; Tinniswood 1945:87; Upham 2001:13). If the vessel was anchored when she caught fire, this anchor is likely lost somewhere in the submerged Elmina seascape; alternatively, if she was not at anchor, this anchor may still be buried under the wreck site.

[433] It is possible that there is some bias here due to the currents carrying materials from the west to the east side if the site, but as there is so little evidence of melted material on the left (port) side, this is unlikely in this case. Similarly, there is burned material all over the wreck, including the west side, indicating that while the fire may not have been as intense in these regions, it did affect much of the vessel.

water would have entered first, causing the list while still on the surface, and the eventual sinking. The fact that all of the intact wood fragments or pieces from the wreck, including

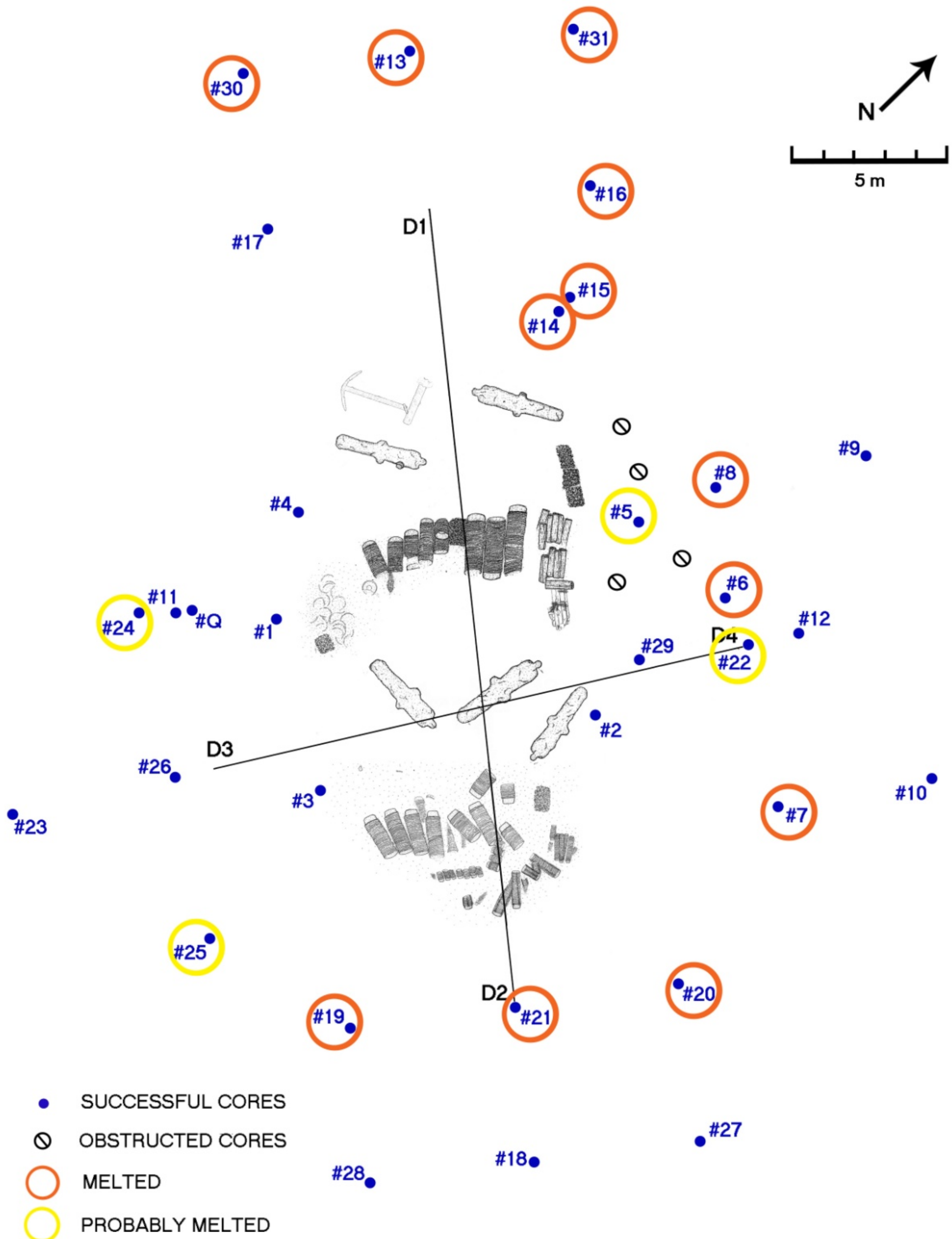

Figure 6.24. A simple presence/absence schematic showing the locations of burned material throughout the wreck site serves to highlight the concentration on the starboard side of the wreck. More details, including the depths at which the melted materials are found, are presented in Appendix I.

the partially burned wood, were collected in the east (starboard) side also indicates that the vessel listed to this side, burying a portion of the hull in the sediments that was then preserved. The cannon that appears to have shifted to the east also suggests that the vessel listed to starboard, as it would have been facing out from the port side and would simply have slipped backwards (to the east) down a minor slope as or after the vessel settled.

The partially-burned wood mentioned above, along with evidence of barnacle-growth on burned wood, is significant in interpreting events that occurred as the vessel disintegrated. That the hull of the vessel did not disintegrate completely immediately after sinking is evidenced by two small, yet vital observations. The first of these is that in the partially burned wood there is evidence of *teredo* damage on the unburned wood, but

Figure 6.25. This image shows three different pieces of partially burned wood collected in core #GW22. The top row shows the unburned parts of the wood, including the *teredo* casing clearly visible in the middle of the piece at the far left. The bottom row shows the burned and hardened side through which the *teredos* were not able to burrow (scale in centimeters; photos R. Horlings, 2009).

not on the burned portions (Figure 6.25). This is significant because it confirms that portions of the hull were a) not completely burned, and b) did not disintegrate or were not covered immediately, leaving the relatively softer, unburned wood, available for *teredo* colonization. A second piece of evidence is found in the tiny barnacles and other shells growing on clearly charred wood (Figure 6.26). Barnacles are apparently one of the earliest species to colonize submerged sites, and so they would have been early visitors to

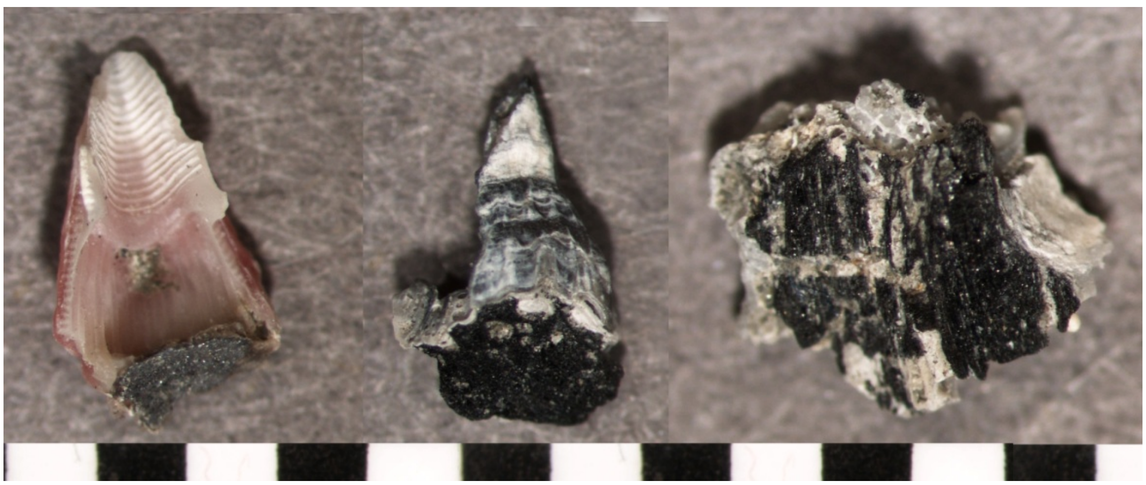

Figure 6.26. **The three tiny pieces of shell, the left two barnacles, the right an unidentified shell, all show distinct evidence of having been attached to burned wood. As barnacles need a solid and fixed object on which to live, the burned wood here can be directly associated with vessel structure still somewhat intact (scale in millimeters; macroscope images R. Horlings, 2010).**

the exposed wood of the wrecked vessel. As indicated by the lack of *teredo* damage, the burned area was likely more resilient to degradation by marine forces, ensuring its survival over a longer time of being exposed, and therefore providing a platform for the barnacles; essentially creating an artificial reef. The small size of the barnacles, however, suggests that even the burned portions of the hull collapsed[434] relatively soon and were buried, thus killing the barnacles.

A final clue to both the season/time of year in which the vessel sank and the processes of hull deflation may be found in the concentrations of seagrass recovered in association with wood in several cores collected at the site (see Appendix IV). The presence of seagrass in direct association with hull structure but not throughout the site suggests that it was growing on the hull after the vessel sank. Very little seagrass grows in the sediments on the coast of Ghana because the sediment-filled water prevents sunlight from reaching the seafloor for most of the year (McLachlan 2005:6-7); the presence of the seagrass on the hull indicates that it had to grow during the short time when there was enough sunlight to penetrate to the level of the wreck on the seafloor, essentially between December and April.[435] An alternative explanation may be that while much of the hull was intact, it created a platform close enough to the surface to allow it to grow for a time, and then when the vessel collapsed, there was no longer enough light to support it; however, this scenario is also contingent on light being able to penetrate through the water, so would also indicate that the vessel sank during this narrow window. Once the hull structure on which it was growing collapsed and there was less light available, the seagrass, like the barnacles, likely died and were eventually covered up with the rest of the remains of the hull.

[434] Likely due to the unburned portions of the hull below them collapsing and eroding their structural support.
[435] The dry season in West Africa.

In Summary

A basic recap of the evidence and its interpretation is helpful as an entrée into a discussion of the investigation of a shipwreck site within the framework of the archaeology of the event and the formation processes that created it:

> Sometime in a dry season of the mid-17th century, a European trading vessel made its way to West Africa. Perhaps intended as its final destination, or perhaps only a stop along the way, the vessel found herself in the roadstead of the trading entrepôt of Elmina. An event occurred there, within the Elmina seascape, that proved fatal for the vessel, and perhaps for some of those on board: some place low in the belly of the vessel caught fire and burned so intensely that it melted metal and freed a massive support beam that crashed down on a stack of basins and partially crushed them; and then it perforated the hull, allowing water to flood inside and sink her. As sinkings go, it was relatively calm and did not disturb the lading of much of the cargo; most of the cannon were held in place by their lashings, but one broke free and slid down the minor slope to starboard. The large port bow anchor was hanging when she sank, and rested along the side of the hull after she settled. She settled on a relatively even keel, with her decks just below the surface of the then-clear water, and she was thus accessible enough that at least some goods were likely salvaged; eventually however, most of the cargo, particularly the bulky and heavy metalwares, had to be abandoned and she was forgotten. As time went by, the hull was colonized by various biota, at the same time being viciously attacked by the motions of the sea and by marine organisms such *teredo* worms. Eventually her structure was too compromised and she accordianed into herself, preserving still the original lading, even as the exposed wood of her hull disintegrated. After she was deflated the anchor resting along the port bow came to rest with its ring on a smaller bow cannon. As time went on the remains of the hull and cargo were covered with sediments, some of which were then removed, and then more added in cyclical patterns of indeterminate lengths of time. In the times when the sediment was gone, her cargo sat proud of the seabed and trapped passing materials, creating a cornucopia of cultural material that spanned at least four centuries. She attracted sealife of all descriptions, eventually also attracting local fishermen who unwilling left fishing gear in her grasp. In 2003 she appeared on a side scan sonar image as a strange

> anomaly, and then Greg Cook found her and she was once again part of the known seascape of coastal Elmina.

So why is the investigation and interpretation of a single merchantman[436] in the midst of a sea of wreckage and history important? How can it inform us of anything other than itself, regardless of how fascinating a tale can be told about it? How can it be used to cross the scales of space and history so as to touch the globe and yet single beads within it, or to transition between single events and those processes at work over the centuries?

The marine environment is capable of creating problems of interpretation not normally encountered in terrestrial contexts (Marsden 2003:76), creating complications both in data acquisition and in its interpretation; the extremely difficult environment of coastal Ghana provides an excellent opportunity to tackle many of these issues. On a pragmatic level, single sites, particularly that of the Elmina Wreck, have been proving grounds for innovative theoretical and methodological approaches to the investigation of submerged Atlantic history. The concept of interpreting objects in relation to contexts has been appropriated in this research across the different scales involved with maritime archaeology, from relating micro objects from sediment cores to their positions in the wreck site; to relating the cores to each other and to the wreck as a whole; to relating specific submerged sites to others; and to relating submerged sites to the larger historical and environmental seascape of which they are a part. It is with the "explicit consideration of the theoretical appropriateness of asking broad-scale questions of micro-scale techniques" (Haslam 2006:404) [437] that this research is concerned, and it is through

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[436] Or any other submerged cultural material from the past, for that matter.

[437] His article plays on Staniforth's conceptualization of the archaeology of the event, but focuses on the residues present on artifacts – truly a micro- or minute-scale approach, but one that also offers answers to larger questions.

micro-sampling of shipwreck sites and their environment, in relation to the greater historical and theoretical frameworks, that this is accomplished. In an approach rarely applied by others (see Souza 1998 for an exception), I employ a micro-scale, micro-sampling technique not only to sample at the miniscule scale, but also to investigate and the scale of an entire region.[438]

Additional practical applications have provided a means for collecting extensive and meaningful data within an incredibly difficult and dynamic underwater environment, and proved methodologies that can be effectively used for answering a range of questions concerning scale, methods, culture, processes, stratigraphy, environment, stories, and events. Post-processing techniques including microscopic and pXRF analysis of sediment core contents have offered insights into these micro-artifacts and provided ways of asking questions previously unaddressed, presenting both methodological and theoretical implications for the use of the micro-sampling technique. All of these data, interpreted in conjunction with data collected through other avenues of inquiry such as limited excavation and surface collection/observation, have revealed details of events in history that would otherwise have remained hidden until perhaps the entire site could have been excavated.

Delgado (1988:3) once made this remark: “Not every shipwreck is old, not every old shipwreck is historic, not every shipwreck is significant.” In all likelihood, this historical shipwreck in coastal Elmina was never famous and was significant only to those who were directly affected by it. But, just as its discovery has once again placed it as an active part of Elmina’s seascape, and quite apart from its intrinsic cultural and historical value, this site, along with others in the region, has been significant in

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[438] Essentially a microhistorical approach.

demonstrating the potential for shipwreck and submerged cultural resource studies in Africa (Werz 1993b:254). It has also proved important for illustrating the value of innovative theoretical and methodological approaches to maritime archaeological research. The application of the site formation processes framework to the methodologies of investigation has provided details concerning the physical remains and their tenure on the seafloor. Its application as a theoretical framework has situated those remains and the processes affecting them within the theoretical framework of larger formation processes, shedding light on the historical contexts of the past and the events that created and still affect the shipwreck site. Whether this wreck site represents the remains of the *Groningen* or not is still unknown, and perhaps will never be known, but it illustrates an event in the dramatic historical eventscape of coastal Elmina, and presents intriguing possibilities for the investigation and interpretation of the Elmina Wreck site.

This case study has also demonstrated the ability to move through multiple scales of analysis (DeCorse 2008:90) as a means of providing information across the spectrum of

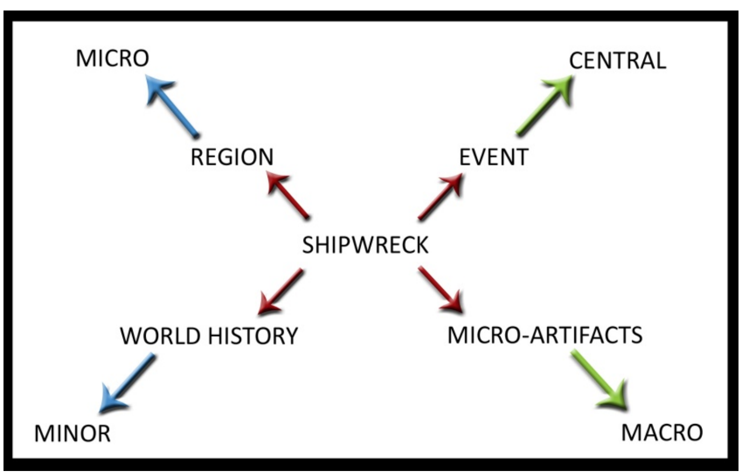

Figure 6.27. **A simple schematic can demonstrate the multiple roles that a shipwreck plays in the interpretation of history; it is not until all of those different roles are examined that it is possible to confidently present an accurate historical interpretation based on archaeological evidence.**

archaeological data and interpretation. Interpreted through the larger contexts and frameworks of regional trade, navigational and anchoring practices in coastal Ghana, formation processes across a region, macro artifacts at the site, and micro-artifacts at the site, the shipwreck itself changes in scale and perspective depending on which lens one is looking through (Figure 6.27).[439] It is not until submerged sites are considered within all of these nested frameworks and contexts that full interpretations can be made of them.

The concluding chapter of this dissertation briefly engages once more with the interpretation of the submerged archaeology of coastal Ghana with its varied theoretical frameworks.

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[439] To reiterate, this can be applied to any submerged site, but the example here is of a particular shipwreck.

Chapter 7
Of His Bones are Coral Made

Full fathom five thy father lies;
Of his bones are coral made;
Those are pearls that were his eyes;
Nothing of him that doth fade,
But doth suffer a sea-change
Into something rich and strange.

Shakespeare – *The Tempest*

I suspect that in his description of the dramatic transformational power of the sea Shakespeare never actually intended for the playful words of his spirit Ariel to so exquisitely depict the effects of formation processes on submerged objects, whether human or otherwise. Although acknowledging the sea's mysteriousness, his words also show an understanding of the nature of the sea even by those who were not sailors or directly connected to it, indicating the understanding that historical sailors must have had of the underwater world above which they sailed, and of their fate should they not remain firmly in control of their ventures. Although it never fully lost its mystery, perceptions of the sea changed over time as people became more comfortable with it and with its role as a connector of worlds and a highway of trade. During the seventeenth century, the nature of the sea gradually became more commonly viewed as benign, and increasingly, "the sea shifted from being a space of mysterious danger to being a space without nature, unpossessable, but also unremarkable" (Steinberg 2001:105). It became an accepted part of people's everyday lives, and as such, was relegated primarily to being the stage on which the events of maritime trade took place. The remains from some of those events studied here have provided insights into that historical worldview and the seascape of international trade in coastal Ghana.

This dissertation began with the following quote: “Recognizing the importance of formation processes apparently presents archaeologists with the impossible requirement of knowing what is unknown in order to ever have a chance of knowing it” (Staski 2000:44). Through the systematic investigation of formation processes across the range of scales, the dissertation has not only demonstrated that it is possible to know much of the unknown, but also to then study and interpret it. Viewed through the lens of the archaeology of the event and historical formation processes, it has also established that material remains from the past can truly be used as a source of information about human and natural history that is both independent of historical written records and complementary to them, asserting that the maritime archaeological undertaking is not the tautological endeavor some claim it to be (Dellino-Musgrave 2006:20).[440] An innovative research tool, micro-sampling through collection and analysis of sediment cores, has been developed and tested throughout this research, providing insights concerning submerged cultural resources and their environments that would otherwise have gone undiscovered. Finally, this research has also expanded from and added to the work of the Central Region project in Ghana, and built on Cook’s pioneering work of starting the first maritime archaeological investigations in sub-Saharan West Africa.

Frameworks

The nature of archaeological material evidence is that it is inherently generated through a series of timescales; it is built from a single event, such as a shipwreck or

[440] Note that Dellino-Musgrave also argues *against* it being a tautological argument. This is discussed again at the end of this chapter.

losing an anchor, and from the results of processes that occur and build up over centuries and millennia, such as the development of trade forts and evidence of the navigational practices associated with them, through a complex combination of human and natural factors (Gosden and Kirsanow 2006:30). In a helpful critique of the ways in which this evidence and these timescales have been investigated, Flatman (2003:144) suggests that there has in maritime archaeology been an unnecessary and artificial disconnect between those who have worked on the methodological advances necessary to allow effective fieldwork, and those who have focused on theoretical critique. Similarly, Oxley (1998a:13) suggests that researchers have tended to focus so much on the minutia that few objective data useful for comparing one site against another have been published.

The original and unique research presented throughout this dissertation has centered on bridging these disconnects and providing a comprehensive, holistic approach to maritime archaeological research that focuses on the investigation of formation processes across a range of scales and their interpretation through the historical eventscape and the archaeology of the event. Essentially, research goals were related to the formulation of multidisciplinary, multitemporal, and multiscalar (Marquardt and Crumley 1987:3) methods and theories for investigating the maritime past of coastal Ghana. Results have provided answers to questions concerning historical maritime trade in West Africa and the environment in which it is found, and offered a means of asking new theoretical, historical, and methodological – archaeological – questions concerning formation processes and the investigation of historical maritime trade that can be applied to a range of sites in any area of the world.

As a means of physically and historically situating this research, it was framed within the "profoundly contextual" (van Dommelen 1999:283) seascape of historical coastal Elmina, articulating with what Preucel and Meskell (2009:216) call the "politics of location and the social construction of space and place" as it relates to the overarching historical formation processes of the region. The concept of scale was used to navigate between human and environmental relations (Marquardt and Crumley 1987:7), and the integration of the seascape, archaeological remains, and varying scales (Breen and Lane 2003:469) was facilitated by the innovative approach of micro-sampling and application of interdisciplinary concepts, including goarchaeological principles (Rapp and Hill 2006:274). Formation process research is presented throughout as both a theoretical and a methodological means of investigating the physical remains of the past and their environments, and the archaeology of the event provides a means of interpreting submerged cultural remains and asking the simple question: How did it get to be like that?

For purposes of this research, the archaeology of the event has been defined as the multi-disciplinary investigation of archaeological sites such as shipwrecks[441] that represent events unique in time and space, although created within complex contexts, investigated through a multi-scalar perspective that encompasses the contexts and events leading up to, and those resulting from, the creation of an archaeological site. The archaeology of the event has been used as a framework within which to situate formation processes of submerged cultural resources, their effects on the associated material culture

[441] While a significant portion of the discussion in this dissertation has focused on the Elmina Wreck site and the event(s) associated with it because it is an ideal starting point for research, it should also be emphasized that this research also includes discussions of submerged cultural sites that are not, in fact, shipwrecks, as well as investigations of events across the historical seascape.

and the larger contexts within which those involved in maritime trade were operating (Gawronski et al. 1992:18). The case study of the investigation of the Elmina Wreck site has been used to highlight the efficacy of the micro-sampling technique and the application of interpretations made based both on the archaeology of the event and site formation processes.

Site formation processes have been investigated and interpreted as the historical, physical, chemical, and biological processes which create and transform archaeological sites through time – in this case, such things as currents, sedimentation, storms, benthic organisms, the events that occurred which wrecked the vessel, and any attempts to salvage or interact with it after wrecking. Inherent in this definition is also an incorporation of the overarching historical formation processes, such as the Atlantic trade itself, which played decisive roles in the creation of the historical eventscape within which trade took place. Formation process investigations have been used here to examine the relationship between long-term archaeological and environmental trends, both at the macro- and micro-level, as demonstrated by the discussions in Chapter 5 of different sites across the region. Finally, the use of formation processes as both a methodological and as a theoretical framework has been used to try to identify the biases inherent in the creation of archaeological sites and to compensate for them in their interpretation, for example, by investigating the copious intrusive material on the Elmina Wreck site.

Research on submerged cultural resource site formation necessarily intersects both cultural and natural processes (Adams 2001; Gibbins and Adams 2001; Martin 2001; Murphy 1983, 1990; Oxley 1998). Investigation of all formation processes requires examination of cultural factors such as sailing, navigation and anchoring practices, trading customs, ship lading, and cargo salvaging; natural factors such as storms, reefs or shoals; and post-depositional dynamics such as currents and sediment loads. While it is virtually impossible to account for all of these factors individually or in combination (Ward and Larcombe 2003:1233), characterizing site formation processes and their effects is an invaluable archaeological tool for understanding the dynamic and subtle processes that convert submerged remains from articulated entities into dispersed sites. It is also useful in interpreting consequent modifications by these processes and how they affect extant cultural information, including indicators of contemporaneity, remaining in the site (see Adams 2001, Baker 1978). The example of a single shipwreck site is useful in framing one of the larger questions of formation processes across the region as a whole: “does this wreck and the processes responsible for its exposure and earlier preservation give insight into the fate of other wrecks in similar settings” (McNinch et al. 2001:19-21)?

Events across a Region

The almost cavalier manner in which da Mota and Hair (1988:6-8) discuss competing nations intentionally sinking several different vessels on the Ghanaian (Gold) coast within a period of only weeks clearly indicates that there are more shipwrecks and maritime-related trade sites located along the coast than the few sites that have been discovered to date. Added to that, the frequency with which historical vessels in general burned, were captured, sunk in storms, and suffered other mishaps, considered over a span of the nearly four hundred years that Elmina was a major trading entrepôt and stop along the coast, makes it virtually impossible that there are no additional shipwreck sites located in coastal Ghana, and coastal Elmina in particular. Remote sensing data also suggests that there are significant submerged features that have yet to be identified, but which have not been either because it has not been possible to investigate them, or because they are covered over with sand and thus not visible to divers. Finally, the discovery of three additional sites in the 2009 field season also confirms that there is a great deal of history still to be discovered in the seascape of Elmina.

What is even more intriguing than the identification of individual sites is investigating the possible connections that they may have to each other. Take, for example, the Double Anchor Site. It is an entirely unique feature as far as submerged cultural resources go: two anchor shanks standing vertically out of the sediments with evidence of melted material, possibly metal, between them, but nothing else. What could possibly have contributed to the creation of this site? What if, hypothetically, a vessel located upcurrent (west) of the castle caught fire in the bow, causing the hemp cables holding the two bow anchors in place to burn and then to drop into mud as the vessel continued to drift downcurrent? Equally hypothetically, what if the historical records on the *Groningen* were slightly off in their details, and she was not in fact anchored, but rather preparing to anchor, so the bow anchors were free? When she caught fire the anchor cables would have parted and she would have been left to drift another half mile downcurrent to where she eventually sank. Alternatively, perhaps the historical documents are accurate, and the vessel represented in the Elmina Wreck is not, in fact the *Groningen*, but strangely suffered the same fate, losing two anchors along the way?

What about any number of other sites across the region that may or may not be related? The investigations that have been conducted to date have only begun to scratch the surface of history. Future research into the events that occurred on this historically rich seascape holds the potential to offer insights into the historical maritime past that have yet to even be considered, and will undoubtedly impact future interpretations of history. As Murphy (1983:69) asserts, the archaeological investigation of shipwrecks and other submerged cultural resources should be "not merely the embellishment of the maritime historical record, but the elucidation of otherwise unattainable aspects of human behavior." I propose that the approaches and methodologies utilized in this research have indeed provided insights into these otherwise unattainable aspects of both human behavior and the environment in which evidence of that behavior remains. As with all other research, it has only been possible to present in this dissertation a selection of the most interesting and pertinent data and interpretations, but through them, the efficacy of these approaches has been demonstrated.

Maritime Archaeology

> The final question, rudely put, is of course, so what? Who cares if a bit of planking is less rotten than one might have thought after a couple of [hundred or] thousand years underwater? What difference does it make to our tired planet, other than giving pleasure to a few harmless eccentrics who might otherwise be developing the pitless peach or observing waterfowl? The answer, equally rudely put, is, probably not much. Archaeology is, after all, only the raw material of history. And for all the good the study of history has done in terms of preventing Man's foolishness, we had just as well burn the libraries down. And yet Man still craves knowledge of his own past. Few would condemn archaeology as useless. And if the archaeology is justifiable, then the study of ships and their cargoes, the sea paths they sailed and the men who sailed them is surely worthwhile (Throckmorton 1970:32).

Shipwrecks are nearly universal in their appeal, conjuring images of adventures and events in exotic places and worlds that most people can only imagine. But while we as maritime archaeologists can investigate and tell these fascinating stories, we do have to be cognizant of why we do what we do, and also be able to answer those who demand that we justify the expenses of working in the underwater world when there is so much yet to learn on shore. Although Throckmorton is clearly being facetious in this quote, he does touch on these questions that are relevant to every maritime archaeologist. As noted above, the discipline of maritime archaeology is expensive and time consuming, even condemned by some as tautological or "an expensive way of telling us what we already know" (quoted in Green 2004:1). If the questions researchers ask and the means by which they seek to answer them are not framed to provide new information about the past and make them pertinent to a wide audience, this is perhaps a justified critique.

In answer to this critique, I have argued throughout this dissertation that if shipwrecks and other submerged cultural materials are considered within the framework of the whole (including the historical and contemporary seascape, environment, site formation processes, history, and archaeology in terms of interdisciplinary techniques and theories), there is a great deal of applicability in terms of wider implications to the maritime history of Ghana; to the anthropological academic community; to the public in general; to related disciplines; and even to the local people with whom we work. People do indeed crave knowledge of their past, but the coastal Ghanaian seascape of today also includes people who cannot afford to eat every day and ecosystems that are rapidly being destroyed. Part of what is viewed here as a holistic approach to this anthropological research includes a responsibility to use archaeology as a vehicle for the elucidation of the past and an opportunity to influence the concerns of the present. The inherently interdisciplinary nature of this research offers ample opportunity for including such researchers as biologists and geologists who may be able to be part of addressing the environmental destruction and resulting economic problems of the coast; opportunities to work with educators in the country hold the potential for making the coastal research relevant to those in very different places in society (Figure 7.1).[442] Obviously these are complex goals for social and environmental responsibility, but they are also crucial if we

Figure 7.1. To this fisherman the Elmina seascape represents a source of life, but for him, as for so many others, there is little time for the history at the bottom of the sea (photo R. Horlings, 2007).

[442] It is important to note that the intent here is not to create a form of scientific colonialism. The problems outlined are very real, and at present the majority of those who are directly affected by them (in terms of the environmental issues) and those whose past they touch (in terms of cultural and historical issues) are not in positions to affect or change them. Until they are, and before they are destroyed, I believe it is important for those who can make a difference or an impact to do so, with the understanding of working with and alongside the people whose past and future are at stake.

are to continue to invest so much in the study of the past in a place where both the past and the present have a nebulous future (Hassan 2004:319).

Future

I consider this research to be foundational and fundamental to the investigation of submerged cultural resources in Ghana, but also potentially in many other areas of West Africa. Part of Africa's more recent but fascinating history is the international maritime trade that took place between numerous coastal African peoples and various (primarily) European nations, and this research in coastal Ghana is but a step in terms of investigating it. Even though the area around coastal Elmina has yet to be fully explored, I also hope to expand to different areas of coastal Ghana to be able to find, record, and investigate a range of submerged cultural material there. Eventually I envision this research expanding to other countries; to the Calabar region of Nigeria, for instance, and to the island nations of São Tomé and Grand Popo. Intrinsic in all of this research, however, will be an exploration of the historical seascape and a concerted effort to bring more to these regions than I take away in information; to help to protect submerged cultural resources, and to use anthropological archaeology as an avenue for the greater benefit of those who are touched by it and of the environments in which they live.

David and Thomas (2008:33) discuss significant sites and landscapes (seascapes) as "cultural resource catchments," and discuss the need for the assessment of them in terms of cultural resource management (see also Ash 2007:6; Jameson and Scott-Ireton 2007:2). Both Elmina Castle and Cape Coast Castle have been designated as World Heritage sites, and, in accordance with the above-mentioned sentiments, the World Heritage status awarded to these monuments should now also include the wider contexts in which they operated historically – the seascape and landscapes specifically associated with international maritime trade – as part of their heritage.[443] Vrana and Stoep outline several specific criteria that constitute a cultural resource, or as suggested here, specifically a cultural heritage seascape. They write that a "cultural resource must have important historical, architectural, cultural, scientific, or technological associations to be significant. Associations are ties or relationships between a resource and its social-cultural context. A cultural resource has integrity if it retains material attributes representing these associations…" (Vrana and Vander Stoep 2003:21). Clearly encompassed in this definition would be the submerged cultural resources in Ghana that, at least for the moment, remain hidden and protected by the natural environment.

Underwater archaeological sites in Ghana are, for the present, exclusive in nature because very few people in Ghana have the means and technology to explore or otherwise affect them. The most direct influence people have on submerged sites such as

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[443] In a somewhat odd article printed in the *Journal of the Royal African Society*, a compilation of letters from the years 1753 to 1756 between the governors of the then-Dutch and British forts of Elmina and Cape Coast respectively is summarized. Several direct quotes (written by the 1904 governor/author Sir Matthew Nathan and his assistant, Mr. W.W. Woods) from the article are as follow:
"It is curious to note the little correspondence that appears to have existed between Cape Coast and Elmina. Though the settlements, only eight miles apart, had been occupied for the best part of one hundred years [apparently in his reckoning, only the British occupation period counted], no one at Cape Coast knew one syllable of Dutch… Van Voorst [the Dutch governor at Elmina] in seven years had never visited his English colleagues, and beyond Melvil's [presumably the British governor of Cape Coast] short visit to Gietere at the end of 1754, the only interchanges of amenities in four years appear to have been loans of salt beef…, offers to dispatch letters by home-going ships, and the exchange of European news received by arriving vessels" (Nathan 1904a:326-327).
(As written by W. W. Woods): "The correspondence summarized [in the article] contributes practically nothing to our knowledge of the history of the Gold Coast during the few years over which it extends. At the same time it illustrates in an interesting manner the relations between the representatives of two European nations that had settled in the country at places almost within sight of each other, and shows very clearly the impossibility of such a condition becoming permanent. The relations between the English and the Dutch, so far as they alone were concerned, were distinctly cordial, but both found themselves obliged, much against their will, to adopt the quarrels of the native populations around them" (Nathan 1904a:328-329). While this little vignette would clearly never be a major interpretive aspect of a heritage seascape, it is an interesting additional perspective on historical coastal relations.

the Elmina Wreck site is in the fishing nets and lines that are often snagged on the sites, but those who are responsible for the nets and lines are not, in any significant ways, intentionally affecting the sites. It is possible, however, that in the relatively future, as Ghana is more and more a part of the global world including its diving technologies, this scene will change. This is particularly relevant to the large tourist interest in coastal Ghana, which could possibly move into the realm of visiting underwater sites related to the Atlantic, or more specifically, possibly to the slave trade. If this does happen, there need to be management plans in place to guide these tourists and monitor the sites. Naturally, this also opens up the possibility for local people to obtain the means for diving on sites, and, unless a great deal of educational, preservational and preventative work is done now, the combination of tourists and local influences on submerged sites will almost certainly result in the wear and tear, looting and destruction of sites (Wilde-Ramsing and Hermley 2007:130), as has been the case in nearly every other location on earth. While any conceptualization of underwater tourism or heritage viewing in most of West Africa is unrealistic for the moment (see Jameson and Scott-Ireton 2007; Spirek and Scott-Ireton 2003; J. Webster 2008:9), what is possible is to begin to create and put in place legislation that will preserve these sites for the time when this is less of a remote and distant possibility and very much a reality. What is a more immediate threat is the people who do have access to underwater equipment; namely, people who are related to the offshore gas and oil industries who not only have the interest and equipment, they also have the time and the means of remotely finding these sites.

Related to the possibility of a greater public beginning to be interested in submerged sites in Ghana is the problem of the unfortunate lack of education among people in general concerning the differences between treasure hunting and archaeological investigation (Marsden 2003:143). The most serious challenge to underwater archaeology today the world over is counteracting the effects of treasure hunting and looting (Gould 2000:316), and when the equipment becomes generally available, the case in Ghana will be no different. As Scott-Ireton (2007:19) writes, the "most effective way to protect archaeological sites, whether on land or underwater, is to instill in the public the concept that these places and objects have value. Not the intrinsic value of treasure hunter propaganda, but cultural and historical value as precious pieces of our past." While this is a laudable goal and viable in many areas of the world, it is less practicable in places where history and its resultant artifacts are less intrinsically valued, as is the case in much of West Africa. Particularly the case in small coastal villages, for the most part people are understandably concerned with the basics of life, and therefore do not have the time, resources, or interest to spend on relics of the past that have no direct relation to their everyday lives. It will take a very different approach to become effective stewards of submerged cultural history in West Africa, particularly after it becomes more and more accessible for people to visit sites (such as shipwrecks) that have for centuries been out of reach (see, for example, Gould 2000:23; Oxley 2007:88).

Touched on throughout the dissertation and in the discussion above is the concept of environmental stewardship[444] and awareness, specifically as it relates to submerged cultural resources, but more importantly, how it relates to the general conditions in which they exist. Seascapes are becoming more commonly incorporated into environmental and heritage management plans, a reflection of both a greater emphasis in environmentalism

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[444] "Stewardship can be defined as a long-term commitment to protecting and managing cultural values and their associated physical and non-physical aspects and integrities" (Jameson 2007:10).

and for heritage in general. Interest in the seas has also increased worldwide following the *United Nations Convention on the Law of the Sea* 1982 and more recently on the *UNESCO Convention for the Protection of Underwater Cultural Heritage* 2001 (McNiven 2008:150). As noted by McNiven (2008:150), "[a]lthough none of these conventions mentions "seascapes," various government agencies around the world have incorporated the term into heritage management discourse" (McNiven 2008:150; see also Hill et al. 2001).

An engagement with both environmental and heritage discourse and research in coastal Ghana could provide an immensely influential opportunity to conserve submerged cultural resources and to work towards the slowing of the rapid environmental degradation currently occurring. One avenue for accomplishing this may be in fully developing the interdisciplinary nature of my research by incorporating marine biologists, geographers, geologists, oceanographers, and others who can provide insights into the cultural and natural formation processes of the region, but also who can help to research and monitor the environment (e.g. Church et al. 2009). Data collected through these avenues can then be used to inform environmental and cultural conservation efforts, and, working with the government, may ultimately play a role in environmental stewardship and social welfare. As Vrana and Vander Stoep (2003:27) write, "the concept of maritime cultural landscape provides an opportunity to integrate research and resource management…These concepts also provide areas of common ground where different disciplines and fields may collaborate to reinvent the practice of resource management."

One final note that has also been indirectly addressed above concerns the ethics of "opening up" a new research area, particularly in a region with limited means for managing historical cultural resources (Cook, personal communication 2005; see also Bass 2003; Coroneos 2006; Harris 2006; Mather and Watts 2002). Submerged cultural resources in Ghana have been protected up to now because there are very few in the region with the technology to access them. The fact that we are now researching there has broken that protective seal, and it is a serious responsibility for the researcher to do whatever possible to protect those remains. Unfortunately, though, the reality is that much of what will happen is, and will likely remain, completely out of the researcher's hands. On the other hand, responsible and meticulous theoretical frameworks and investigative techniques can provide not only valuable insights into historical maritime trade, but also hold immense potential for creating (in conjunction with Ghanaian authorities) a framework of maritime cultural heritage management legislation for Ghana. One of the primary goals of this project has been to lay the foundation on which to conduct future investigations; related to this is a platform on which to build management plans for these cultural resources (see Coroneos 2006:113-114; Grenier et al. 2006; UNESCO 2001). This foundational investigation of submerged cultural resources is hopefully only the beginning of what can surely be a beneficial endeavor to study and protect the past, and in doing so, to also protect the seascape, the environment, and the future.

Appendix I
Cores: Micro-Sampling across a Region

This appendix 1) describes the methods of collecting, processing and analyzing cores, and how these methods may or may not have affected the data and hence any interpretations built on them; and 2) provides detailed descriptions of each core and its contents. Since one of the goals of this investigation was to develop and to build methodologies, the process in which the coring was carried out and the cores subsequently processed and analyzed is vital to understanding the data they produced.[445] The catalogue provides the reader with the most pertinent information concerning each of the cores collected. The larger contexts from which the cores were collected are discussed in Chapters 5 and 6.

The purpose of collecting sediment cores in Ghana was to develop a practical tool for collecting data concerning cultural remains and site formation processes at the local (site-specific) and regional levels. While the relatively simple sediment core was the primary tool used in data collection, the theoretical and methodological frameworks behind it are more complex and primarily drawn from geoarchaeology (Butzer 1980; Davidson 1985; Gorham and Bryant 2001; Holliday 2004; Quine 1995; Stein and Farrand 1985; Wheeler 2002; Wilkinson 2004). Geoarchaeology is “the application of concepts and methods of the geosciences to archaeological research” (Waters 1992:3). It is concerned with physical, environmental (sedimentary) context and is useful in investigating the temporal, spatial, landscape, regional, and environmental contexts of

[445] The data used as the foundation for interpretations in Chapter 6, as well as in Chapter 5, come primarily from the information collected in sediment cores from the known shipwreck site, control areas, and from the various other sites investigated in 2009.

archaeological sites at the varying scales at which they exist and are studied (Dalan 1993; Denham 2008:474; French 2003; Gladfelter 1977; Herz and Garrison 1998; Kvamme 2003; Quine 1995; Quinn et al. 2002; Rapp and Hill 2006:1-2; Stein 1993; Waters 1992:12). The principles, foundations and tools of geoarchaeology can aid in the investigation of relationships between culture and the environment of, for instance, shipwrecks, and are applied here as a “means to understand and manage scalar issues of time and place” Denham (2008:476) with regard to submerged cultural resources and the seascape of coastal Ghana.

Collection and analysis of sediment cores provides not only a “comprehensive, albeit incomplete, barometer of formation processes,” but also provides “a sensitive, fine-tuning index for evaluation of site perimeters and subsurface complexity” (Schuldenrein 1991:133). The relatively undisturbed subsurface stratigraphy that a core can bring to light also provides a “fundamental data source for information on seabed character, depositional history and environmental change” (Rothwell and Rack 2006:1). Pragmatically, coring is also generally relatively quick, minimally destructive, and cost-effective (Rapp and Hill 2006:125). While neither geoarchaeology nor coring itself are perfect in and of themselves, nor can they be perfectly applied, they have proved invaluable in the investigation of submerged maritime history in coastal Ghana.

The next section of the appendix briefly describes the collection, processing and analysis of the cores, as well as the rationale for the locations of collection. The final section of the appendix is comprised of the catalogue of each core. It should be noted here that the cores presented here are only the successful ones – ones where there was actually material in the core upon retrieval – there were numerous cores that were attempted but for various reasons were not successful. Some of the unsuccessful ones are indicated on the shipwreck site plan (Figure I.4).

Core Collection

Locations of Collection

Cores were collected at three different locations, the known shipwreck site and two experimental control areas (see Chapters 4 and 5) in 2007; they were collected at sites across the region in 2009, including the known shipwreck site that was sampled in 2007 (see Chapters 5 and 6). We collected a total of 32 successful cores[446] on the known shipwreck site (Figure I.4 below) in an effort to secure a representative sample of the sediments both close to it and surrounding it. However, as noted in Chapter 6, it was not possible to core inside the wreck due to the massive underlying concretion that appears to cover the majority of the site. The intentions behind this were as follows: a) to get an idea of the different sediments that were collecting at the site, as well as where they were collecting in relation to the material of the wreck itself, b) to use the data from the cores to investigate both local and regional site formation processes, c) to see how representative a sample of artifacts could be collected using the sediment coring tool, and d) to supplement the data collected through surface collection and excavation at the site.

Cores collected at the control areas were intended to a) investigate the control areas themselves, b) provide data concerning local processes (storms, sedimentation) across the region, and c) to provide baseline data concerning the cultural material that was ambient in the environment in this region, as things such as charcoal and plastics

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[446] At least 40 were attempted but either were not successfully collected or were lost in transit. Time was the most significant factor in determining how many cores we were able to collect.

were known to be ubiquitous in the waters. During the 2009 season cores were collected at every location on which we dived, conditions permitting, primarily as a means of collecting more baseline data across the region. Furthermore, the cores were used as an additional means of testing potential target areas as a complement to the remote sensing and diver investigations.

The Process of Collection

Cores were collected with a diver-operated coring device that was employed directly on the seafloor; this was a particularly important feature because it allowed the diver to be very precise in the placement of each core. The corer design was modified from a design intended for lacustrine environments (Cawley and Parker 2001; Horlings 2009), and was a simple construction including a galvaized steel pipe, a one-way valve in a PVC coupling, and unlined PVC tubes used to collect the cores; hand-made lead weights[447] were used to drive the corer into the sediments (Figure I.1). Due to a number of factors, cores were usually collected by a single diver.

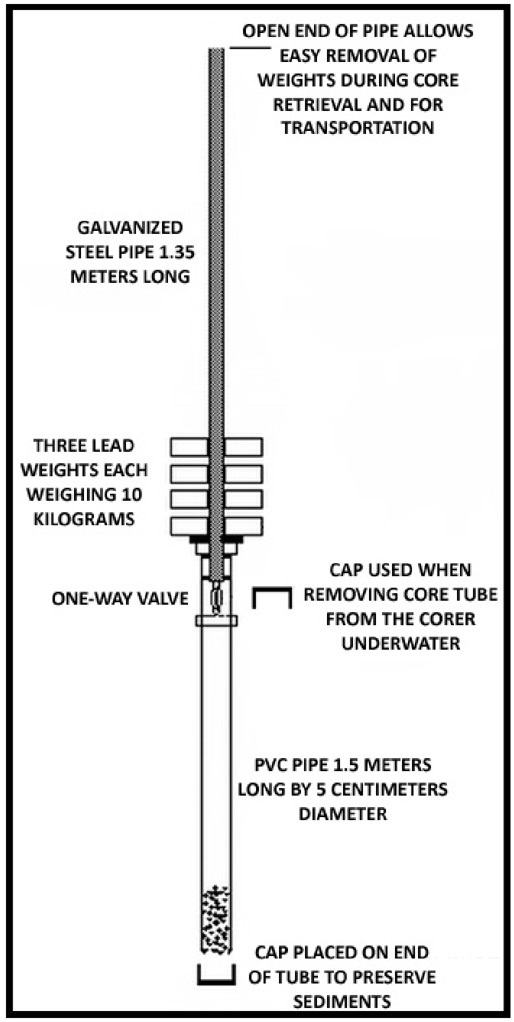

Figure I.1. The simplicity of the corer is ideal for rough working conditions (figure by R. Horlings).

[447] Made by Papa Kofi Arhin.

Samples were extruded upon returning to the project headquarters.

Collecting cores in 2007 was particularly challenging as conditions were typically zero-visibility and high energy, making it difficult to remain in one place on the seafloor. As is briefly discussed in Chapter 4, five meter and ten meter tethers were used at the shipwreck site as well as **C2** to ensure that each core was collected the correct distance from the datum point. This physical tethering served not only as a back-up safety measure, but also alleviated the need to measure distances in addition to moving the coring weights (also tethered to a known location), carrying the corer, and determining the direction to go to the chosen location. Once it was determined where the core was to be collected, for instance, five meters north of Datum 2, the diver(s) would move the weights and corer to the location and prepare to take the core. Because of the incredibly difficult sea bottom, surge and current conditions, it was not possible to simply lay an item on the seafloor as one worked on something else. Because the weights weighed more than 30 kilograms (65 pounds), it was easiest to move tools in stages, generally starting with the weights first because they did not need to be secured apart from the tether, and they could in turn be used to secure other items.

In order to force the PVC into the sediments it was necessary that the weights be placed on the coring device, and this was generally most easily accomplished on ones' knees. After the weights were put on the corer (and the weight tether line attached to the diver to prevent it being lost), it was necessary to time standing up with the surge so that the additional weight of the cores and length of the corer (more than 7 feet) did not throw one off balance. As soon as the diver was vertical it was crucial to immediately plant the corer and start pounding it in using the weights, as the surge could (and often did) snap the PVC pipe, wasting a core and a dive. This process *could* be easier with two people, but the surge easily knocked over two people as well. Once the core was pounded in the full length (approximately 1.5 meters (5 feet), unless it hit something), the weights were removed and placed back on their tether and set aside (this then also served as the guideline for going back to the wreck site or anchor weights and to the anchor line up to the dive vessel). At this point the upper part of the coring device was unscrewed from the PVC and the PVC immediately capped to prevent contamination. The top of the corer was generally placed under the weights to prevent it from being swept away or buried, and then the core could be pulled up by the diver standing or kneeling on the sea bottom. Depending on the sediments, some cores were easy to retrieve, but others required that the sediments surrounding them be dug away to provide a grip lower down. If possible, the diver reached into hole around the core and placed the bottom end cap on while it was still in the sediments; if this was not possible, the bottom was capped as soon as the core broke the surface of the sediments. The diver was responsible for maintaining the correct attitude of the core (with respect to the sediments) as she or he carried it back to the dive vessel, where it was immediately marked and stored vertically.

The process described above was the culmination of testing different techniques for the best way to collect the core.[448] One of the major problems was creating and maintaining enough of a seal in the core to hold the sediments in as it was retrieved. This problem was eventually solved by finding caps that fit more solidly on the PVC piping, but the character of the sediments also clearly plays a major role in whether or not they are retained in the core. Most of the these lessons were learned by the 2009 field season

[448] These are the same problems researchers have had with diver-operated coring devices for decades (Sanders 1968).

and this, combined with the generally better diving conditions later in the year, ensured that core collection was a generally smoother operation. Despite the incredibly difficult conditions in which the cores were collected in 2007, the coring device certainly proved a very effective tool for site sampling (Horlings 2009) both in 2007 and in 2009. One final note: in an ideal situation the cores would have been frozen immediately and brought back to the US for processing in controlled laboratory conditions, but circumstances, particularly finances, did not permit that. As a result, they were processed initially in the field and subjected to an in-depth analysis upon return to the United States.

Field Processing

Although all the members of the diving teams participated in core collection, I was solely responsible for the post-processing of every core. While the goal was to process the cores on the days they were collected to provide immediate feedback data on the site in question, this was often not practical, as other tasks demanded more immediate attention. Additionally, since it was necessary to photograph the cores in the most natural light possible (for both consistency and ease of identifying strata delineations), there was often not enough daylight remaining after a day of diving to accomplish this (see Nederbragt et al. 2006).[449] Because of this, the majority of cores were processed either on days on which we did not dive, or after the diving season was over.

Cores were processed in the order in which they were collected when possible, although damaged cores (such as had cracked PVC pipes) or cores that felt (by weight)

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[449] If a core took a particularly long time to process, there was also the risk of the sediments starting to dry out. This risk was minimized by immediately marking and dividing all the strata and photographing the core. In situations where it was apparent that the core would take additional time to process I also tried to describe all the strata immediately so that there would be consistency in description for the entire core, regardless of whether there was some drying or not.

that they may have been in poorer condition were processed first. This had the effect of making the location-number correlation somewhat random, but means nothing more than that in either field season. In the event that cores had to be stored for a time before being processed, they were stored vertically (with both endcaps on) in a large bucket of water to prevent them drying out. This was an effective means of preserving the moisture (and therefore the integrity) of the cores (Weaver and Schultheiss 1990:97; see also Nederbragt et al. 2006).[450]

Through several experimental methods I determined that using a tamping device[451] was the most efficient means of extruding the core from the PVC, although it was recognized that there may be some compression from the process (Stein 1986), and a minimal amount of sediment from the top strata (usually some of the ubiquitous silt) was lost. Cores were extruded onto a simple wooden plank.[452] The core was immediately photographed in its entirety, and any notable features were specifically documented as well. After initial photographs, all the cores were split and photographed again. In some instances the different strata of the core were visible in its complete condition, but for most it was necessary to split the core down the middle to see the differences; this was done for consistency and ease of processing for all the cores. When possible, photographs at each stage were taken in both broad daylight and in the shade to provide as accurate a photographic record as possible. All photo documentation was done using a Cannon Powershot A95 hand-held camera.

[450] Most cores had some water remaining at the top of the core before it could be removed from the PVC, but in several cases there was none. This may have been a factor of storage, but as several of the cores collected in 2009 and processed immediately after collection also did not have water in them, it may also simply be a factor of the types of sediments that made up the core.
[451] Which I designed and that was made by the local blacksmith.
[452] In the future a more refined surface is advised, but this was all that was available for the 2007 and 2009 seasons.

An expandable ruler was laid out next to the core at the beginning of the process and remained until it was completed. After splitting the core, the different strata were delineated using color, texture and compositional differences (Gladfelter 1977; Stein 1987:347). Post-field analysis has revealed that this process was quite consistent and effective. Notes were taken at every step of the process, and included visual and tactile descriptions of the sediment matrix[453], as well as descriptions of any obvious content.[454] Once all of the strata had been delineated, they were physically cut apart and photographed. Following this, each strata, taken from the corresponding halves, was individually washed through a $^{1}/_{16}{}^{th}$ inch screen fabric in fresh water in a bucket. The material that remained in the screen after washing was covered with another screen or fabric, labeled, and left to dry. The fine fraction was then disposed of and the bucket washed and filled with clean water in preparation for and to prevent contamination of the next sample (Figure I.2). This process was repeated for all the strata of each core. The exception to this was when large pieces of wood were recovered, in which case they were kept wet in fresh water until returned to the US. After the sediments had dried they were stored in individually labeled bags and also transported to the US. All materials from the cores were carried to the US with the full permission of the Ghana Museums and Monuments Board.

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[453] It is interesting to note that the appearance of the sediments did not always correlate either to what was felt during washing or to the material that remained after it was washed. This may be a factor of several things, but is most likely related to the masking effect of silt, as even a little bit of it may make a sediment appear more or less smooth than it really is.

[454] As noted previously, it is important to describe and photograph the cores immediately after extrusion and before any deterioration of the sediment surface (such as drying) occurs (Weaver and Schultheiss 1990:97; see also Nederbragt et al. 2006)

Figure I.2. The simple tools used for processing cores in the field proved to be surprisingly effective (photo A. Schnabel, 2007).

Laboratory Analysis

Each step of the process of collection, field processing, and laboratory analysis of the cores was an opportunity for development and improvement. Some techniques, such as the field processing of the cores, were effectively established near the beginning of fieldwork and remained relatively consistent throughout. For others, as was the case with the laboratory analysis, there were more iterations in terms of developing the methods; these included identifying the most pertinent data to be collected from the processing and analysis, and building methodologies that could be consistent, effective and flexible. Because sediment cores provided the essential immediate context for both artifacts and understanding site formation processes across the region, accurate laboratory analysis was a crucial facet to their interpretation and as such is discussed in some detail here. Procedures used followed the general principles outlined by various authors (i.e.:

Garrison 2003; Quine 1995), but were modified as necessary to best suit the conditions and goals of this research.

Drawing Core Profiles

Upon immediate return to the US after both the 2007 and 2009 seasons, more formal core profiles of each of the cores were drawn based on field notes and sketches taken during post-processing and on the photos of the cores. Surfer was used to transcribe the cores from photographs to the drawn profiles, and Adobe Photoshop was used to finalize the images. Almost all the cores were drawn on the half-profile from photos of the core after it was split and the strata delineated on both sides.[455] Measurements, sediment descriptions and artifacts noted in the field were included in the drawings. As is discussed below, while the profile drawings are useful in studying the cores, it would perhaps have been better to wait until the microscope analysis was completed to draw them, as there are significant changes to the initial interpretations of some that are not evident in their profiles.

Microscopic Analysis

The material collected in the cores was analyzed with a Bausch & Lomb 0.7-3x magnification laboratory microscope with dual 10x oculars; a GE 150 W dual gooseneck halogen microscope illuminator was used for lighting. Before analysis the coarse fraction[456] of each strata was weighed as a simple means of recording the approximate amount of material present for each. Weights of the strata differed by the material present

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[455] While there is some room for distortion and error using this technique, it was the most accurate means of depicting the strata of the cores.

[456] None of the fine fraction was intentionally preserved, although some remained caught in the large shells that were collected in the cores.

in them, providing an indication of the character of each sediment type that could then be compared to the visual description made in the field. Depending on the type of sediment and material in the strata, there was often less than 10% of the total amount of matter remaining after washing; this was particularly the case in the strata predominantly made up of silt.

Because only the coarse fraction was retained from the cores, the amounts of material remaining in each stratum sample after washing were weighed, but little emphasis was placed on the weights themselves.[457] What was considered more relevant were the types or characteristics of the sediments represented and the types and amounts of cultural material present. In their simplest forms, the quantities of natural versus cultural material in the strata are not remotely related, nor should they necessarily be linked in subsequent analyses and interpretations. However, while there is not a 100% correlation, there is a definite association between types and positions (relative to other strata in the environment) of sediment matrixes and the artifacts that are found within them.[458] This is most clearly seen in cores collected from the shipwreck site (see also Chapter 6), but there are also correlations in cores taken from sites not related to the shipwreck. While these data have played a role in subsequent interpretations,[459] they have not been included in the core catalogue, as without presenting the exact quantities of each

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[457] For purposes of this research, the *types* of sediments and relative amounts (prior to washing) are the most significant factor in the investigation of site formation processes (partially following Rapp and Hill 2006). The strata were washed for two primary purposes: 1) to provide a way to take the "core" data from each of the strata and 2) to expose any cultural material present. While it is entirely possible that some miniscule bits of cultural material were also lost in the washing process, for purposes of presence/absence, which was the central aim, what remains after washing must be considered adequate.

[458] For example, there is what appears to be a major sand deposition episode that is visible in cores across the wreck site; when this is encountered, there is usually much more sediment than in any other strata, and it usually contains small round beads and cowry shells.

[459]For instance, the roundedness of sediments and artifacts in a number of strata from cores across the region have been compared in Chapters 5 and 6.

cultural or intrusive material along with sediment weights and proportion assessments, those data are superfluous.

Analysis of the materials in each stratum included an assessment and description of sediments, organic or biogenic materials, and cultural materials.[460] The assessment included a description of the sediments in terms of minerogenic and organic components (i.e.: approximate ratios of shell versus sand content), approximate shell sizes, grain shape,[461] natural inclusions such as marine flora, any identifiable marine faunal parts, and shell types where identifiable.[462] Any unusual aspects or features were also noted, including extreme differences in angularity or sphericity. After the matrix was described, any cultural material was identified or described, removed, weighed and bagged separately. Modern or intrusive material was also noted, and depending on the size and type was sometimes bagged separately. Both the sediments and the artifacts in each stratum were weighed and the ratio of artifacts weights or amounts of artifacts to the sediment itself was noted, but unless it was dramatically different than what was seen in other cores, it was not recorded. It should be noted that most of the material in the cores, with the general exception of shells and some wood pieces, was very small (almost all < 5 mm in size, and most < 2 mm). That being the case, the *condition* of the artifacts relative to each other and to the matrix in which they were found were considered more important factors in understanding environmental site formation processes and the effects of the environment on the artifacts (discussed in more detail in Chapter 6). Detailed notes

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[460] Typical core analysis also includes chemical analyses, but this was not a viable option here due both to funding restraints and the fact that the sediments were washed from the cores in the field and thus were not available for further analysis.

[461] Also determined based on the Kent State University field guide for sediment size and angularity analysis.

[462] See Garrison (2003:85-122) and Stein (1985:9) for similar analytical criteria.

on analysis were kept throughout the process, and, with the exception of two cores, which I supervised, I completed the analysis of all the cores myself.

General Observations

While each stratum of each core was analyzed separately, throughout this process was a continuous comparison of strata and cores in an effort to build a comparative database of the environment and site formation processes across the shipwreck site and the region. These comparisons were used to build Chapters 5 and 6, and are fundamental to a general understanding of the submarine environment near Elmina. A few general observations can be made here.

Sediments

The vast majority of the actual sand particles are made up of quartz grains, with some sandstone lithic fragments, mica and other grain types mixed in. In addition, there are micro-fossils in the shapes of leaves that are in many of the sediment matrixes, but not all. In the future a more detailed study of these micro-fossils may indicate sediment sourcing and travel paths, but they have not at present been studied in detail. For some of the cores located closer to the shore[463] there is also a significant amount of hard coral, which is intriguing because there is little to no hard coral growing visibly on any of the sites at which we dived.[464] For purposes of this research, material was called "sand" if it was a coarse fabric (see Table I.1 below) with no macro or identifiable shells in it; anything larger than 2 mm was called a pebble (gravel). As noted earlier, a continuing

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[463] For some reason the frequency of florescent purple sea urchin spines is also much greater in cores located closer to shore.

[464] While several species of coral are present there (Edinger and Risk 1995:204-205), for the most part coral is rare anywhere along the coast of West Africa (Boughey 1957:674; John et al. 1977:498; Perry 2007:303).

Descriptor	Grain Size*	Comments
clay	<$^1/_{256}$ mm	in most cases what was termed as clay were extremely smooth, fine and sticky inclusions, most often associated with silt matrixes
very fine silt	<$^1/_{128}$ mm	often this had a very high water content, and could be very sticky; also included in this category were the black, organic inclusions
fine silt	<$^1/_{64}$ mm	extremely common in the overburden material that covered the shipwreck site, but was also prevalent in other locations; silt lenses were most often visible in this sediment type; more coarse in texture
silt	<$^1/_{32}$ mm	extremely common in the overburden material of the shipwreck site as well as other areas; a small percentage of silt was almost ubiquitous in the sediments of every strata, although in differing quantities; more coarse
coarse silt	<$^1/_{16}$ mm	this was most commonly associated or near a sand deposit, and may be a factor of its proximity; the descriptors of "coarse silt" and "fine sand" are essentially interchangeable
fine sand	<$^1/_4$ mm	often associated with or near sand deposits, fine sand could also be in the form of a pocket or inclusion in either more coarse or more fine material
sand/ coarse sand	< ½ mm – 2mm	this material appeared in several forms - in some cases it made up entire strata, and in others formed pockets in layers of other material; it was often associate with shell of various sizes; in some cases what appeared to be sand during field processing was in fact made up primarily of broken shell material - in these cases the ration of sand:shell varied tremendously; strata made up primarily of sand were found across the shipwreck site as well as in some other locations across the region
shell	<$^1/_{16}$ mm – 4 cm+	there were very few strata that consisted of only shell - it was found primarily in association with sand; individual shells of differing sizes were found in each type of sediment, although there are patterns for which were the most common
wood	various size fragments	this descriptor was reserved for strata made up of more than 50% wood or wood fragments and has only been seen on the shipwreck site

*Sizes in the field were based on comparisons to other sediments, tactile and visual indicators.

Table I.1. The descriptions presented here are based on more rigorous definitions (Gladfelter 1977; Rapp and Hill 2006; Shackley 1975), but for purposes here they are simplified.

theme throughout this analysis was the correlation of what looked like sand (to the naked eye) in the core during field processing with the material that was actually in it, which in many cases was made up of a higher percentage of clearly broken and abraded shell fragments than minerogenic sand particles, for instance in cores collected at the Single Anchor Site.

The basic descriptions and explanations of the terms used for sediments in the analysis are displayed in Table I.1. Note that sediment descriptions were made in the field by visual and tactile inference, and are not as precise and the measurements described by the Wentworth Grain-Size Classification for Sediments (Waters 1992:20-21). One example of this, which has been implemented in the post-processing, is that because it is difficult to visually and tactilely differentiate between the varying size grades of clays and silts, all of these terms have been converted to the term “mud” in the sediment core descriptions below. For purposes here, mud is defined as a “sticky fine-grained sediment (silt, clay, sometimes with organic matter)” (Bird 2005:1178; see also Rapp and Hill 2006:34). That being said, however, differences in texture and color were noted and will be useful measures for future assessments. Working out a means of more accurately and consistently indentifying and describing sediments throughout the field and laboratory stages of research will be an important factor in future investigations.

Artifacts

All the material considered to be artifactual was <30mm in size, and most was <5mm; it was identified foremost by whether or not it could be considered a “natural” part of the environment or not. This is an important distinction for materials such as charcoal, for example, which seem ubiquitous in the region. The most likely source for the majority of the charcoal is from intentional human use in terms of cooking and other fires, but it is also possible that some of it is "naturally" integrated into the maritime system by fires set in the brush inland and along the coast, or by burning other refuse, including wood. Similarly, other items such as palm kernel shells occur naturally along the coast, but the seeds are also a source of feed, and the shells are burned for fuel. In this case, burned palm kernel shells are *likely* of intentional human origin, but this is not necessarily always the case. A final example may be found in the modern or obviously intrusive material that is also nearly everywhere in the environment. While the bits of plastic and fishing line were clearly not intentionally deposited on the shipwreck site, for instance, they were at one point intentionally made and used by humans. Their introduction into the marine environment is in most cases the result of refuse disposal, the presence of this material deep in sediment cores indicates a number of things about how other material may be moved through the environment and introduced onto maritime sites, and perhaps may be used as a tentative measure for interpreting other, non-related (to specific sites) cultural material. As a foundation for beginning to investigate the cultural aspects of submerged sites in this region, the primary concern was the presence/absence of clearly historical cultural material, and this was determined by noting and/or separating out all of the material that may have cultural origins. A list and discussion of the categories of artifacts may be found in Appendix IV.

One category of "artifact" that was created from necessity was that of UID, or unidentified material. In the majority of cases these materials were far too small or non-diagnostic to identify, but they had characteristics that either suggested cultural origin or indicated the presence of a natural material that I could not identify. For purposes of this dissertation, the UID category is noted but is not further discussed.

Challenges

As with any research investigation there were associated challenges to this analysis. Several of these have been noted throughout this discussion, but two in particular should be discussed in slightly more detail.

Color Analysis

One of the most significant aspects of sediment analysis has to do with its color (Garrison 2003:96-97; Lyle 1983; Nederbragt et al. 2006; Shackley 1975:13-14), but this proved to be one of the most exasperating problems of sediment core analysis on this project. The most considerable issue revolved around determining the color of wet sediment, as it was processed out in the field and needed to be immediately recorded. While the *Munsell Soil Color Charts* do have a GLEY option that can be used for marine sediments, it does not solve the problem of determining color on wet sediments.[465] Sediment colors were described during field processing in both 2007 and 2009, which are useful measures for comparison, but the lack of a consistent standard by which to determine them remains an issue. [466] Profiles of the cores collected in 2007 are shown with color coding, but those from 2009 are not after it was determined that this was not a

[465] One possible solution to this is to follow the steps of processing up to the point of starting to wash the sediments, and instead of working with them while they are still wet, allowing them to dry so that Munsell descriptions can be made on dry materials. The problem with this is that it was significantly extend the amount of time necessary to process each core, making it impractical on a tight field schedule. Alternatively, a small sample could be collected from each strata, from which color descriptions could be made at a later time, however, the time constraint problem is still present in this scenario. Finally, experience suggests that either of these suggestions is still problematic, as the distinctions between colors tend to be blurred or completely lost when the sediments are dried.

[466] In addition, I did not have access to a Munsell book for the 2007 field season.

consistent enough measure or descriptions of the sediments. One logical solution is to use the color descriptors that are generally completed on wet material (i.e. Hassan 1978:200-201; Herz and Garrison 1998:43), and another is to not use color for analysis purposes (it may be used descriptively), and instead focusing only on textures (Courty et al. 1989:35; see also Goldberg and Macphail 2006:13-18). Some combination of these may also be used, but this is an issue that should be resolved before further field work is conducted.

Benthic and Botanical Analysis

I am not trained in botanical or marine floral or faunal analysis, and funding constraints precluded contracting the job to another researcher. While I was able to identify certain patterns in terms of the zones of habitation for different benthic species were visible and did provide some data concerning the interpretation of sites and strata, these data are used sparingly in interpretation to avoid making assumptions that may not be accurate. Future investigations would do well to involve a marine biologist who is better able to contribute to this discussion. A list and brief discussion of the observed fauna on the shipwreck site may be found in Appendix III.

Methodological Refinements

As this appendix is predominantly concerned with the cores and the data presented in them, one particular refinement to the analysis and display aspects of cores is necessary to highlight.

It was necessary to document and profile the cores as they were observed in the field, however, this presented problems in terms of correlating field observations with later laboratory observations. In the future a strategy needs to be developed for one of the following options: a) presenting the profiles “raw” from in-field observations, as was done in this case, b) presenting the data only after thorough processing and microscope analysis, which in some cases significantly altered the interpretation of sediments and other contents, or c) finding some way to present both data sets (which are not contradictory, but also may not completely match). Working with a geologist will likely alleviate some of these issues, but the problem of analyzing geological material for anthropological ends is not necessarily easily resolved. Until this problem is satisfactorily resolved, it is recommended that color descriptors not be used in profile drawings. While they are useful for general and comparative descriptions of raw sediments, they are a hindrance in later creation and interpretation of profile drawings. The final section before the core catalogue is a guide to their interpretation.

Keys to the Cores

As was already touched on, one of the most frustrating aspects of core analysis was trying to be consistent with descriptions in terms of sediment color. Related to this was the problem of displaying the information concerning the strata in the core profiles. As may be observed from the core catalogue, there were significant differences in the appearance of the cores from 2007 depending on how the chosen color interfaced with the texture descriptors, resulting in inconsistent visual portrayals of core data. It was decided for the 2009 cores to use only texture and sediment type descriptors in the profiles to minimize the confusion with colors, but this has created an inconsistency in the way the data are displayed. This problem has continued to plague even the creation of this appendix, as there are now so many variants in the *appearance* of the cores that a useful key or legend is essentially pointless. For this reason, the written descriptions of the sediment matrixes are the most useful key to interpreting the profiles of the cores. Future core profiles should be created, particularly if there are multiple software packages involved, using only the lowest common denominator descriptor of the programs, which is color (i.e.: red-orange = very fine silt). All the cores have been converted to a grayscale/black and white format for display purposes here, but a more consistent methodology for displaying the cores needs to be outlined and implemented in the future. Figure I.3 is the key for interpreting the presence or absence of certain materials in the cores collected in 2007, but as they are presented in grayscale, some of the identifiers are more difficult to see than they were in their original colored format. Figure I.4 is the key to the textures

Figure I.3. The objects depicted in the 2007 core profiles are based solely on field observations of objects in the strata and are thus often incomplete, as microscope analysis revealed a great deal more than was initially visible. For this reason, none of these symbols appear in the cores collected in 2009.

used to depict the different sediment types in all of the cores, both those collected in 2007 and those from 2009.

A list format is perhaps the best way to point out the most important features of the core appendix and how to use it.

Figure I.4. The textures illustrated here provide the key for cores all of the cores in the collection.

- Every core is depicted in the same proportion as every other one for ease of comparison between them.
- The total length of the core indicated in the profile is the length it was when it came out of the PVC pipe. Lengths differed depending on the matrix in which the core was collected, the method in which the core was recovered, and whether or not something was encountered or hit in such a manner that it broke the PVC and therefore lost the seal.
- Note that each section on the scale on the side represents 15 cm.
- Strata are delineated by lines but their corresponding descriptions do not necessarily line up with them, depending on how much there is to say and the size of the stratum.

- Note that just because strata are described as having the same matrix, such as sand/silt/shell, they may have different characteristics or be in different proportions, which was the reason they were separated in the field.

- Strata that are described as “with” something, such as “sand with shell” indicate that the primary component was the first-mentioned material, and the added material was secondary, for instance in the form of a pocket or discrete concentration of shell.

- Strata with the descriptor of “mottled” have organic silt inclusions.

- Strata with the descriptor of “in lenses” have minute lenses of differently-colored or textured silt that are so fine that they could not be separated out.

- Only the most pertinent data is noted in these summaries.

- The site plan and map of the region display the locations of each core.

- The * denotes that the microscope analysis indicated that the sediment description should differ from what was originally determined during initial post-processing of the cores in field. Unless it is a truly significant difference, nothing else is done with this other than to note it.

- Materials such as artifacts that are clearly not “natural” or part of the natural environment (shells, etc.) are shown in **bold lettering.**

- All artifacts other than the beads and cowry shells are fragmentary unless otherwise noted.

- Artifacts are merely noted as present and do not necessarily indicate “original” association with the site from which the core was collected.

- The term “roadtop” refers to material that looks like it could be tar or pavement. It is often relatively soft with sediment grains in it, but at other times hardened like asphalt.

- The term “filament” describes any clearly modern fiber or string, usually in a tangle.

- No botanicals or fauna are noted in the cores, as they are discussed elsewhere.

The core catalogue begins with cores collected at the known shipwreck site in 2007 and 2009 and displays a total of 33 cores. Following this are seven control area cores. Next are the nine cores collected at various dive targets across the region. Following this are the two cores from near the Single Anchor site. The final six cores displayed were collected at the Double Anchor Site. The cores are summarized in Table I.2, and there is no further introduction to any of the cores.

Collection Date	Core	Length (cm)	Location	Water Depth (m)	Remarks
14-Sep-07	**1**	29	NW quad - sw	11	
15-Sep-07	**2**	75	30 cm S of Cannon 3 (mooring)	11	intact wood - AMS dated to 1642-1664 (2 ∑ error)
17-Sep-07	**3**	70	1.5 m S of E-W baseline	11	
17-Sep-07	**4**	63	NW quad - 1.5-2 m N of Cannon1	11	core hit an obastacle about 130 cm down - tore PVC and likely caused loss of sediments
25-Sep-07	**5**	44	NE quad - 2 m E of manila barrel concentration	11	3rd attempt in this region - hit something 80 cm down and split core
25-Sep-07	**6**	53	NE quad - 5 m E of lead rolls	11	mostly intact wood
27-Sep-07	**7**	68	SE quad - 5 m S of Datum 4	11	
2-Oct-07	**8**	78	SE quad - 5 m NE of B2 stake Datum 4	11	lots of dilapidated wood - AMS dated to 1642-1664 (2 ∑ error)
2-Oct-07	**9**	32	5 m N of 5 m extension E of Datum 4	11	
6-Oct-07	**10**	58	B2 Datum 4 extension - 5 m SE	11	
6-Oct-07	**11**	13	5 m NW B2 Datum 3	11	shortness appears to be a problem with the corer not sealing

Collection Date	Core	Length (cm)	Location	Water Depth (m)	Remarks
26-Oct-07	**12**	28	5 m E Unit E15	11	
28-Oct-07	**13**	43	5 m N Datum 1	11	intact wood and caulking - appeared to be paint on the wood; also appears to have hit a metal fastener in the wood - twisted the PVC - AMS dated to 1642-1664 (2 ∑ error)
28-Oct-07	**14**	52	5 m SE Datum 1	11	
28-Oct-07	**15**	35	5 m SE Datum 1 (2nd core here)	11	core hit something and shattered the end; used it to experiement with cutting the PVC in half to examine sample
28-Oct-07	**16**	85	5 m E Datum 1	11	
28-Oct-07	**17**	34	5 m W Datum 1	11	
28-Oct-07	**18**	55	5 m S Datum 2	11	
29-Oct-07	**19**	50	5 m W Datum 2	11	
29-Oct-07	**20**	87	5 m E Datum 2	11	dilapidated wood chunks - AMS dated to 1642-1664 (2 ∑ error)
20-Oct-07	**21**	74	Datum 2	11	
30-Oct-07	**22**	80	Datum 4	11	partially-burned wood - AMS dated to 1642-1664 (2 ∑ error)
30-Oct-07	**23**	63	5 m W of 10 M W of grid	11	
30-Oct-07	**24**	48	5 m N 10 m W B1 side grid	11	
30-Oct-07	**25**	62	5 m S 10 m W grid	11	
30-Oct-07	**26**	29	10 m W grid	11	
30-Oct-07	**27**	71	5 m E 5 m S Datum 2	11	
30-Oct-07	**28**	43	5 m W 5 m S Datum 2	11	
10/30-31/2007	**29**	27	Unit U15	11	broken off in wood in unit
31-Oct-07	**30**	85	5 m W 5 m N Datum 1	11	
31-Oct-07	**31**	39	5 m E 5 m N Datum 1	11	
6-Oct-07	**Q**	-	5 m NW B2 Datum 3	11	core hit something and shattered PVC - came up with a chunk of yellow brick in it
5-Dec-09	**7_09**	37	10 m SSW of Cannon 2	11	
27-Aug-07	**C1 - 1**	31	at **C1** rebar	12	1st core collected with the corer; only core at C1

Collection Date	Core	Length (cm)	Location	Water Depth (m)	Remarks
24-Aug-07	**C2-1**	50	NW of control box	7.5	experimental methodology
31-Oct-07	**C2-2**	51	N (inshore) of rebar	7.5	
31-Oct-07	**C2-3**	48	10 m E rebar	7.5	
31-Oct-07	**C2-4**	36	10 m N rebar	7.5	has a preserved ripple in it
31-Oct-07	**C2-5**	56	10 m W rebar	7.5	
31-Oct-07	**C2-6**	34	10 m S rebar	7.5	
10-Nov-09	**1_09**	43	Waypoint **46**	3.9	just outside harbor mouth - incredibly difficult to take, retrieve and extrude
10-Nov-09	**2_09**	83	Waypoint **46**	3.9	just outside harbor mouth - incredibly difficult to take, retrieve and extrude; very strange core
25-Nov-09	**3_09**	55	Waypoint **322**	10	magnetometer target site; hit something at 85 cm; possibly related to shipwreck site
21-Nov-09	**4_09**	24	Waypoint **397**	12	"mud site;" side scan target
8-Dec	**8_09**	44	Waypoint **411**	11	
25-Nov-09	**9_09**	93	Waypoint **338**	9.3	very little cultural material
26-Nov-09	**11_09**	65	Waypoint **539**	7.6	a lot of organic material in it
20-Nov-09	**14_09**	85	Waypoint **303/394**	10.5	
27-Nov-09	**16_09**	63	Waypoint **253**	9.6	
26-Nov-09	**17_09**	135	25 m S **SAS**	6	longest core collected
4-Dec-09	**6_09**	108	**SAS**	6	lots of coconut on surface, almost none in core
28-Nov-09	**5_09**	56	**DAS** - 5 m at 160° from center	10	
21-Nov-09	**10_09**	70	**DAS** - 1.5 m SW big anchor	10	possible processing contamination
26-Nov-09	**12_09**	25	**DAS** - in test hole between anchors	10	
26-Nov-09	**13_09**	56	**DAS** - 1 m S waypoint	10	taken before site was actually identified

Collection Date	Core	Length (cm)	Location	Water Depth (m)	Remarks
28-Nov-09	**15_09**	34	**DAS** - middle between anchors	10	
26-Nov-09	**18_09**	63	**DAS** - 1 m E small anchor	10	most melted material ever found in a core

Table I.2. The cores are presented in the table above in terms of location/category, so some of them may appear to be out of order. More details concerning each core may be found in the individual summaries below.

The following two images display the locations and corresponding numbers of cores collected at the known shipwreck site (Figure I.5) and at sites across the region near Elmina (Figure I.6). The final image before the catalog (Figure I.7) is a composite of two different bathymetric maps that display sea bottom sediment conditions and contour lines for the environment in which the cores were collected.

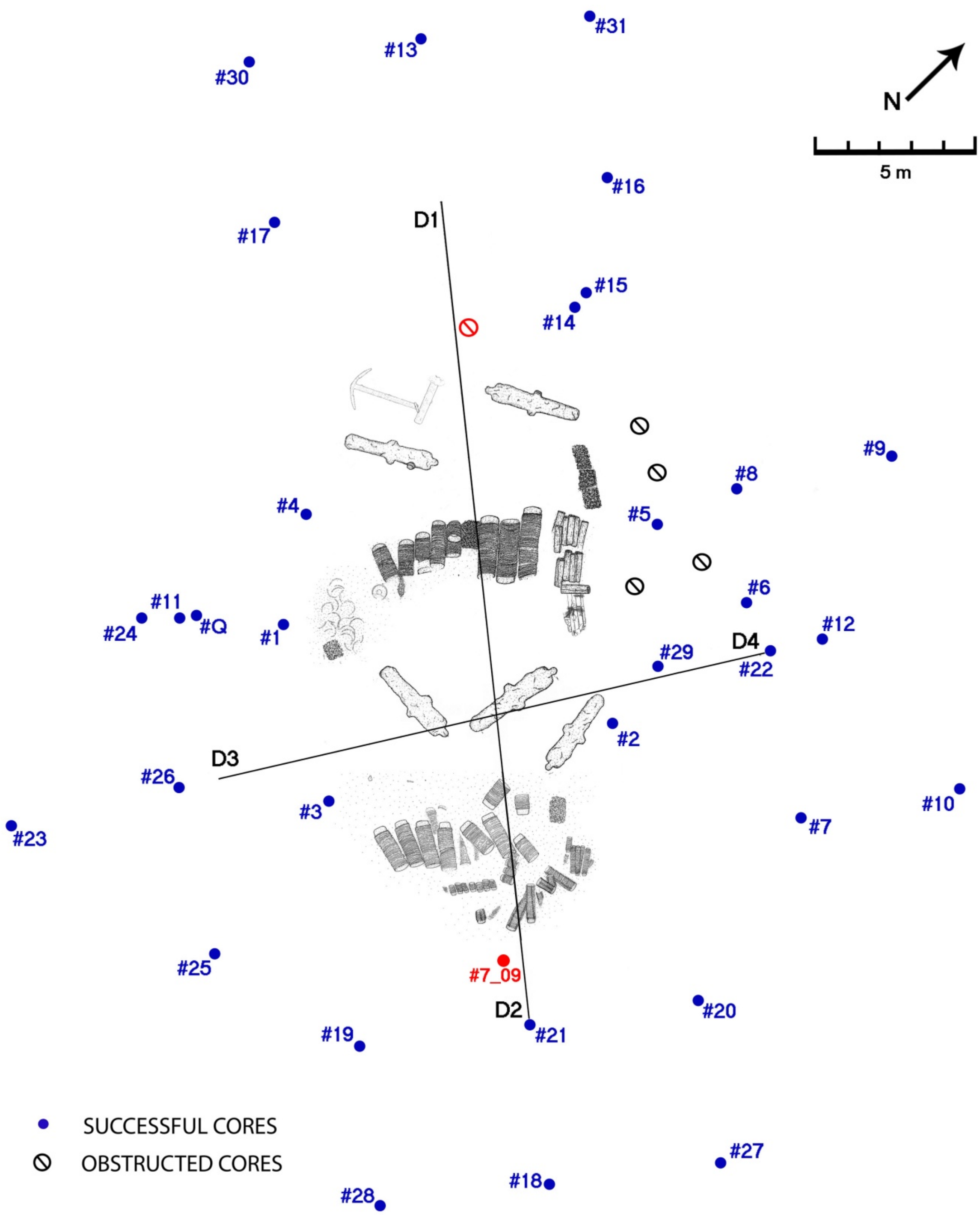


Figure I.5. **The 31 successful cores collected in the 2007 season are indicated here in blue; the single successful core collected in the 2009 season is indicated in red, as is the 2009 attempted core.**

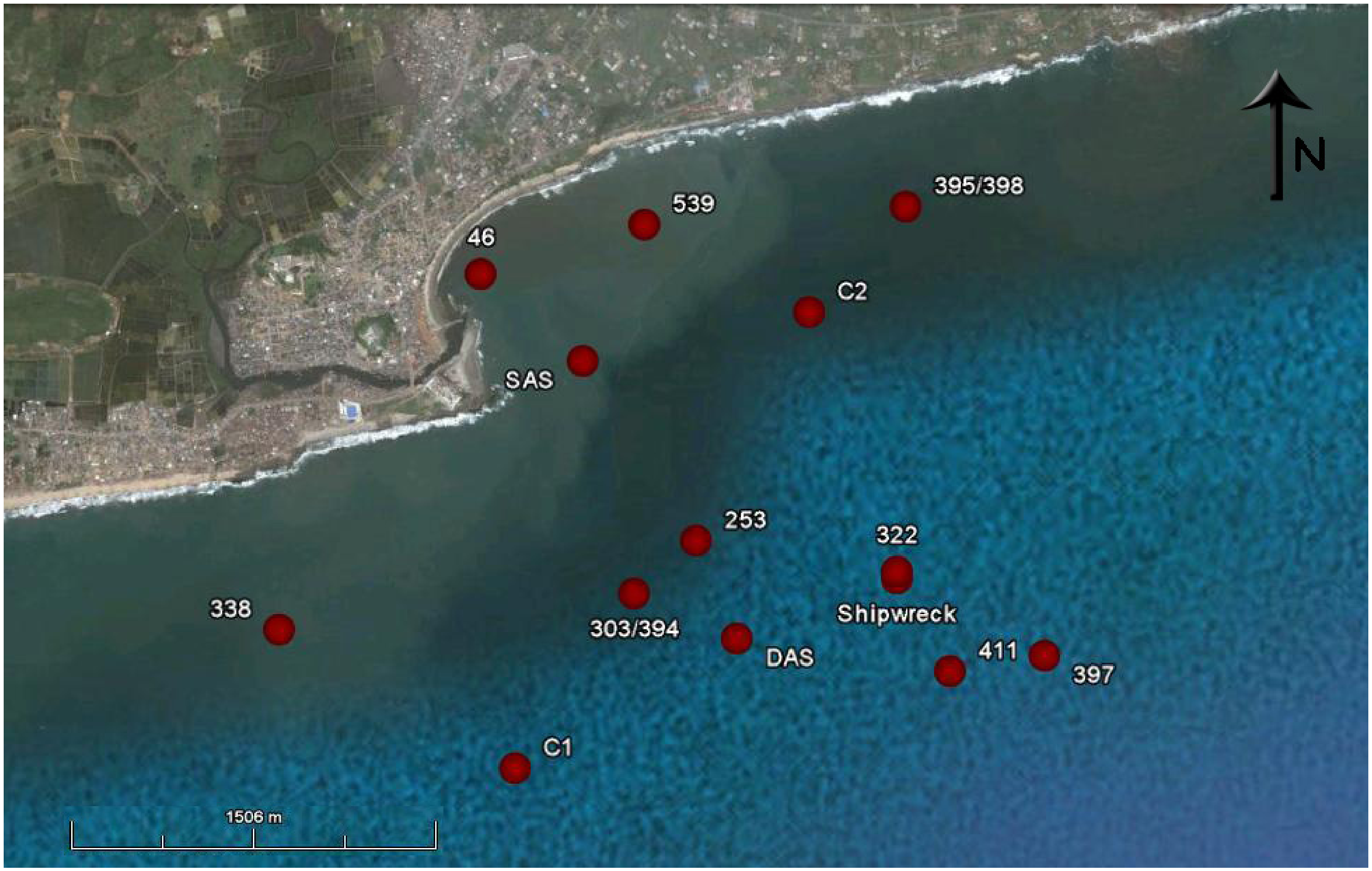


Figure I.6. **"DAS" and "SAS" represent the Double Anchor Site and Single Anchor Site, respectively, in this image. Also included are the locations for the control areas, C1 and C2, which were implemented in the 2007 field season. Sites too close together to display at this resolution are named together (i.e.: 303/394), but in reality there are at least 50 m between each of these sites.**

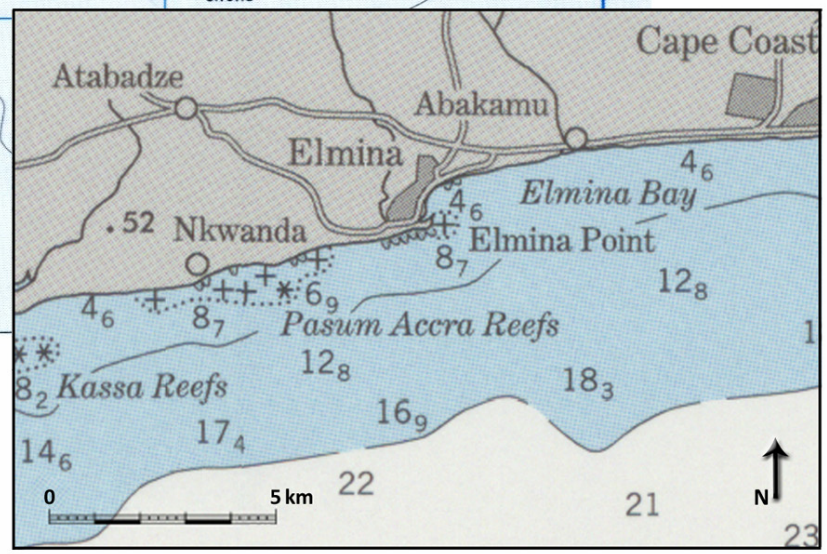


Figure I.7. These bathymetric maps are taken from two different nautical charts: the larger, background image is a 1963 US Army Map Service chart and describes sediment types along the coast; the inset is a 1996 British Admiralty chart and illustrates the bathymetric contours (in meters). Note that the contour lines are consistent between the maps, but the depths are incorrect on the 1963 version.

Shipwreck Core #1 - NW Quad

Total Length: 29 cm

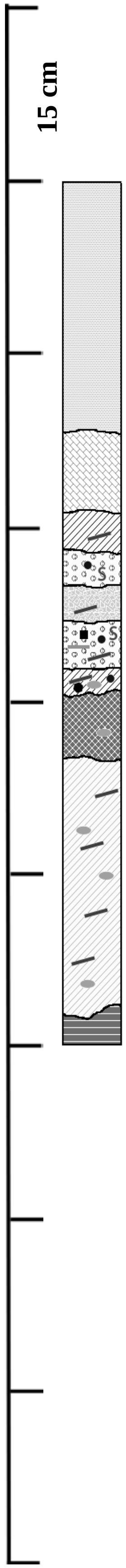
S1 - mud

S2 - mud/sand/shell

S3 - mud, but some sand and shell*

S4 - mud/sand/large shell*; **coal, wood**

S5 - mud/sand/shell - mostly sand and large shell*; **wood, coal, charcoal, 1 blackened small bead; palm kernel shells**



<u>Shipwreck Core #2 - 30 cm S of Cannon 3 (mooring)</u>

Total Length: 75 cm

S1 - mud

S2 - mud/sand/shell

S3 - sand and shell; **tiny bits of charcoal, coal, concretion, wood; possible turquoise glass**

S4 - mud/sand/shell; **2 small beads, possible metal fragment, ant**

S5 - mud and shell; tiny charcoal fragments

S6 - mud/sand/shell; **wood, 3½ small beads, plastic, twine, 2 ants and 1 insect**

S7 - shell/sand**/wood; bits of coal and charcoal, polypro twine/ plastic string, 6 cowry shells, 2 small beads, UIDs**

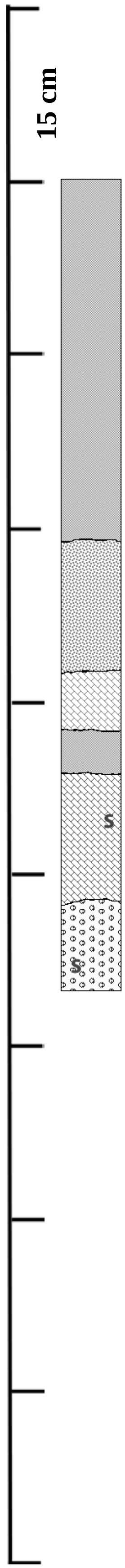
S8 - dilapidated wood, some sand and shell; 1 cowry shell

S9 - sand and shell; **wood, charcoal, coal, 14 cowry shells, insect parts, plastic filament**

S10 - intact wood chunks with caulking between them

Note: The images below show the wood as it came directly out of the core. The image on the left is the intact hull structure, and on the right is the dilapidated wood that appears to have collapsed later on the already in-filled hull.



<u>Shipwreck Core #3 – 1 m S of E-W Baseline</u>

Total Length: 70 cm

S1 - mud

S2 - mud and clay

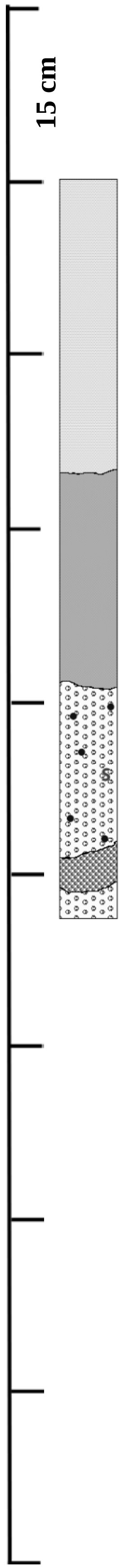
S3 - mud and shell*, little bit sand

S4 - mud/shell/sand*; **charcoal, coal, burned/melted material**

S5 - mud and shell*; **wood, charcoal, coal, burned/melted material, palm kernel shell**

S6 - mud/sand/shell; **wood, concretion, charcoal, 1 small bead, tiny brass/copper pieces**

Note: Many of the artifacts and shells had what appears to be iron-staining on them.



<u>Shipwreck Core #4 – NW Quad (about 1.5-2m N of Cannon 1)</u>

Total Length: 63 cm

S1 - very fine mud; **small wood and charcoal fragments**

S2 - mud and shell*; **small charcoal, coal and wood bits, 2 small bead fragments**

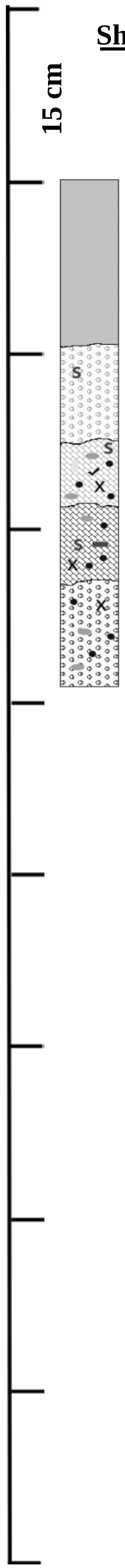
S3 - mud/sand/shell; **tiny coal and (possibly burned?) glass fragments, 7 complete, 3 partial small beads**

S4 - sand and mud, some shell*; **tiny wood and charcoal fragments**

S5 - sand/mud/shell; **minute wood and charcoal fragments**

Note: The core was driven in about 130 cm before hitting something, which dented/tore the base of the PVC and probably caused a loss of sediments due to lack of vacuum in the tube.

Shipwreck Core #5 – NE Quad (about 2m E of manila barrel concentration)



Total Length: 44 cm

S1 - mud; **plastic, UID**

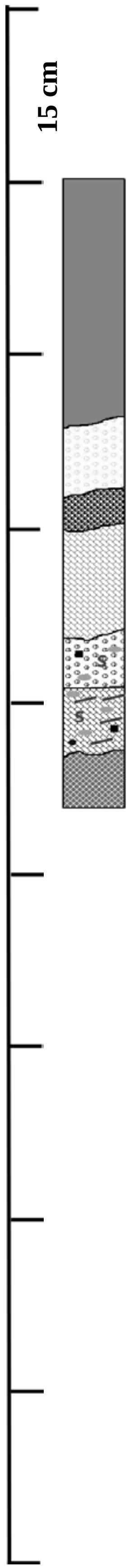
S2 - sand/mud/shell; **8+ small beads, coal, charcoal, concretion, burned/melted material, plastic, UID**

S3 - sand and mud, with shell*; **3$^1/_3$ cowry shells, burned/melted material, 21+ small beads; gunpowder, metal fragment (probably brass), concretion, palm kernel shell, plastic, UIDs**

S4 - sand/mud/shell*; **1 cowry shell, 18+ small beads, many of which *look* burned, concretion, coal, charcoal, very few wood fragments**

S5 - sand/mud/shell; **very little bit of wood and charcoal, 2 cowry shells, burned/melted material, 10+ small beads (some *look* burned), UIDs**

Note: This core was the 3rd attempt in this region – broke the first two in the surge and hitting something ~40-50 cm deep. This core I hit something ~80 cm deep, which split the core about 20 cm up the pipe (see images below). There was clearly a loss of material in the core due to the crack. Some shells in this core have iron staining.



Shipwreck Core #6 – NE Quad (about 5 m E of lead rolls)

Total Length: 53 cm

S1 - mud*

S2 - mud/sand/shell

S3 - coarse mud, with shell*; **tiny bits of wood and metal concretion, UID**

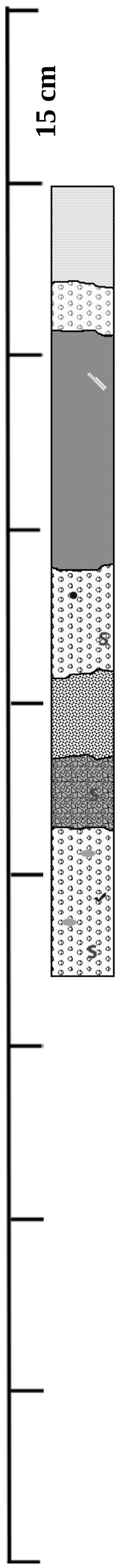
S4 - mud and sand; **1½ small beads, charcoal, very small bits of wood, burned/melted material, concretion**

S5 - sand/mud/shell; **4+ small beads, 2 cowry shells, melted material, coal, charcoal, concretion**

S6 - sand and shell; **wood fragments, 3+ small beads, 21 cowry shells, coal and charcoal, burned/melted material, glass that *looks* melted, concretion**

S7 - wood chunks, some charcoal

Note: Possibly because of the angle at which the wood is under the sediments the wood in this core is not a solid plug like in Core #2, but there are clearly relatively large chunks of solid wood.



Shipwreck Core #7 – SE Quad (about 5 m S of Datum 4)

Total Length: 68 cm

S1 - mud and shells*; **tiny wood fragments, ant, UID**

S2 - sand/mud/shell; **wood (some appears to be partially burned), charcoal, coal, filaments**

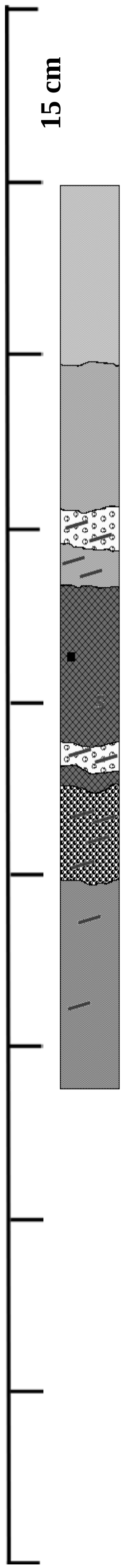
S3 - very fine mud and shell*; **melted material, coal, charcoal, wood, ant, plastic, filaments**

S4 - sand/shell/mud; **1 small bead, melted material (some lead), wood, concretion, charcoal and coal, pink string, UID**

S5 - fine mud, with shell*; **metal fragments**

S6 - mud and shell, some sand*; **wood, concretion, coal, brick - all tiny fragments**

S7 - mud/sand/shell; **1 cowry shell, tiny ceramic sherds and brick, coal, charcoal, concretion, palm kernel shell**



<u>**Shipwreck Core #8 – SE Quad (5m NE of B2 stake Datum 4)**</u>

Total Length: 78 cm

S1 - mud and clay with shell*; **charcoal, concretion, small wood fragments**

S2 - mud and shell*; **concretion, tiny charcoal, burned/melted material and wood fragments**

S3 - mud and shell with sand*; **wood, charcoal, concretion**

S4 - mud with shell*; **burned/melted material, coal, charcoal, concretion**

S5 - large wood fragments with evidence of *teredo* damage, 2 small beads, large concretion/burned object, coal, charcoal

S6 - mud/sand/shell; **lots of wood fragments, iron concretion, tiny charcoal pieces**

S7 - dilapidated wood, iron concretion, melted material

S8 - mud and sand with shell*; **wood, small charcoal bits, concretion, possible pitch**

S9 – mud with sand and shell*; **concretion, charcoal, possible brick and UID – all tiny, wood fragments**

Note: Much of the wood in this stratum has iron-staining on it, although no fasteners were found.

Shipwreck Core #9 – 5m N of 5m extension E of Datum 4

Total Length: 32 cm

S1 - mud; **palm kernel shell**

S2 - mud with shell*

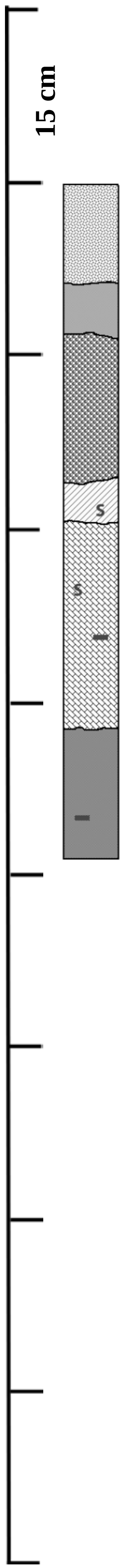
S3 - fine mud

S4 - very fine mud; **2 bits charcoal, 1 bit wood**

S5 - mud

S6 - mud and shell with sand; **1 bit either wood or palm kernel shell**

S7 – mud; **3 tiny wood fragments**



Shipwreck Core #10 – B2 Datum 4 extension – 5m SE

Total Length: 58 cm

S1 - fine mud with shell*

S2 - mud

S3 - coarse mud with shell*

S4 - sand and shell; **charcoal, UID, possible wood – all tiny**

S5 - sand and mud with shell*; **brick, charcoal, burned material, possible tiny wood fragments**

S6 – mud and shell*; **brick, charcoal – all tiny**

Shipwreck Core #11 – 5m NW B2 Datum 3

Total Length: 13 cm

S1 - fine mud

S2 – mud

Note: This is clearly just the mud overburden and does not contain sediments associated with the wreck. The short length of the core probably has to do with a problem sealing the corer, although it may also have to do with the type of sediments which were being cored – mud is very difficult to retain in the corer.

Shipwreck Core #12 – 5m E Unit U15

Total Length: 28 cm

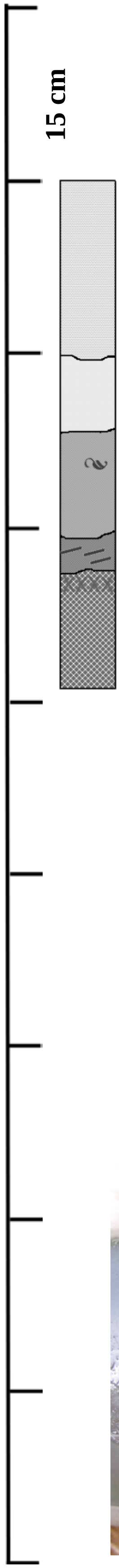
S1 - very fine mud

S2 - fine mud

S3 - mud and shell with sand*

S4 - fine mud with shell*; **wood fragments, concretion, string/fiber, brick fragment, charcoal – all tiny, part of an ant**

S5 - fine mud with shell*; **wood, charcoal – tiny, part of an ant**



Shipwreck Core #13 – 5m N Datum 1

Total Length: 43 cm

S1 - very fine mud with shell*; **probable caulking, charcoal, small bit of concretion or melted material, insect skeleton – resembles a weevil**

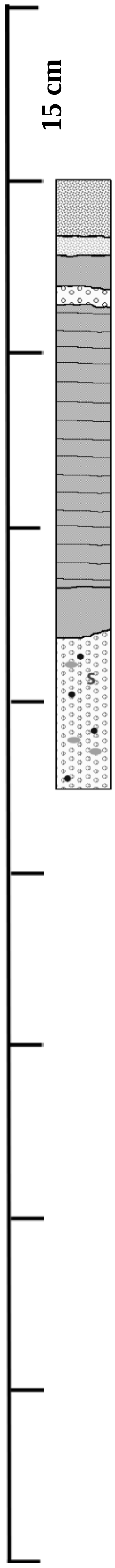
S2 - mud; **probable caulking, charcoal, concretion, melted material, probable copper bit, probable blue glass, filaments**

S3 - mud with sand and shell*; **probable caulking, charcoal, concretion, melted material**

S4 - mud with sand and shell*; **partial cowry shell, melted material, metal bits, possibly burned seed, charcoal, caulking, concretion, UID, tiny string**

S5 - solid and fragmentary wood, caulking, part of an insect

Note: There appeared to be gold-colored paint on the wood upon immediate removal from the core, but it very quickly disappeared. The core appears to have hit some sort of metal fastener in the wood (as seen in the image on the left below), as is evidenced by the way the PVC is wrapped on itself in the midst of the wood. It is possible that the wood was in better condition but the pressure from the core hitting the solid object fragmented some of it. The caulking may be seen on some of the wood in the image on the right.



<u>Shipwreck Core #14 – 5m SE Datum 1</u>

Total Length: 52 cm

S1 - fine mud

S2 - fine mud with sand

S3 - mud

S4 - sand; **tiny bits of wood and concretion**

S5 - mud with sand and shell (in lenses)*; **melted material, concretion, small bits of wood**

S6 - mud; **wood, concretion, charcoal – all tiny**

S7 - mud/sand/shell; **2½ cowry shells, ½ blue tube bead, 55+ small beads (5 of which *look* burned), 2 bead cores/centers, melted material, burned material, charcoal, metal/rust fragments, small bits of wood, probable brass basin fragment, possible pitch, concretion, probable sulphur, UID**

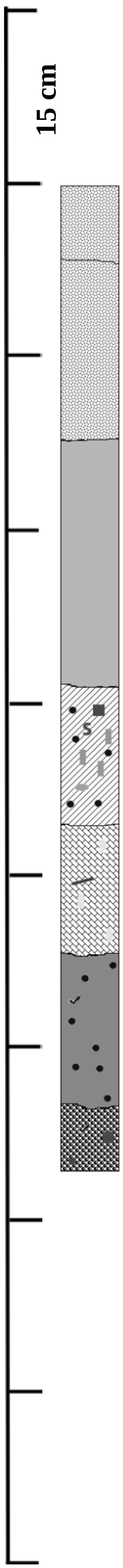
Shipwreck Core #15 – 5m SE Datum 1 - 2nd core taken here

Total Length: 35 cm

S1 - mud with shell*; **2 cowry shells, basin fragment, 1 small bead, concretion, charcoal, burned material, small wood fragments, paint chips (modern), ant**

S2 - mud/sand/shell; **5+ cowry shells, 20+ small beads, probably sulphur, melted material, burned material, concretion, UID**

Note: This core also hit something, shattering the end. As a result, it was transported to the surface upside-down to preserve the sediment in it, which may have resulted in some mixing, although it does not look like a lot. Because the core was already damaged, we experimented with sawing it open as opposed to extracting it, but this was a dismal failure, as the amount of plastic filings or "swarf" (Weaver and Schultheiss 1990:96) was excessive and the cutting may have disrupted the profiles of the core. There were solid chunks of the local purple sandstone in this core, which I rarely see in off-shore environments. The image immediately below shows the shattered core, and the image below that shows the sawn-open core with the PVC filings obviously visible on the edges.



Shipwreck Core #16 – 5m E Datum 1

Total Length: 85 cm

S1 - fine mud; **modern paint chip, metallic concretions, insect parts, wood bits**

S2 - fine mud with sand and shell*; **charcoal, melted material, wood**

S3 - mud with shell and sand*; **1 small bead, charcoal, burned material, concretion**

S4 - sand and shell; **19 small beads, 1 cowry shell, glass, UID material that looks like slate, UID material that may be gunpowder, burned material, coal, charcoal, melted material, UID – one bit may be ceramic**

S5 - mud and sand; **7+ small beads, coal, burned material, melted material, concretion, wood, UID**

S6 - mud with shell and sand*; **10 small beads, charcoal, burned material, concretion, UIDs**

S7 - coarse mud with sand and shell; **1 small bead, concretion, wood**

Note: Some of the shell has iron-staining on it. The length of this core would make it seem that the strata should be more complex, but they were not.

Shipwreck Core #17 – 5m W Datum 1

Total Length: 34 cm

S1 - mud (in lenses) with shell*

S2 - mud and shell*; **palm kernel shell, possible plastic**

S3 - mud/sand/shell

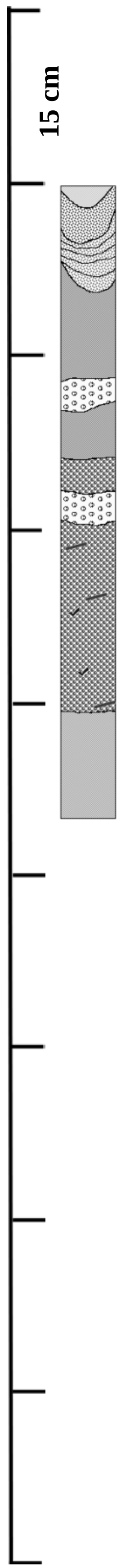
S4 - mud with sand and shell*

S5 - sand and mud with shell*

S6 - sand/mud/shell

S7 – mud and sand with shell; **possible wood**

Note: This core is from the west side of the wreck where there is typically little to no cultural material. It is possible that it is buried, but it is more likely that there is simply less cultural material there, as it would have been moved to the east by the current (predominantly). Compare this core to **#16**, which is more on the eastern side of the wreck site.



<u>Shipwreck Core #18 – 5m S Datum 2</u>

Total Length: 55 cm

S1 - mud with shell*

S2 - fine mud

S3 - fine mud with shell*

S4 - mud with shell*

S5 - mud/shell/sand

S6 - mud with shell*

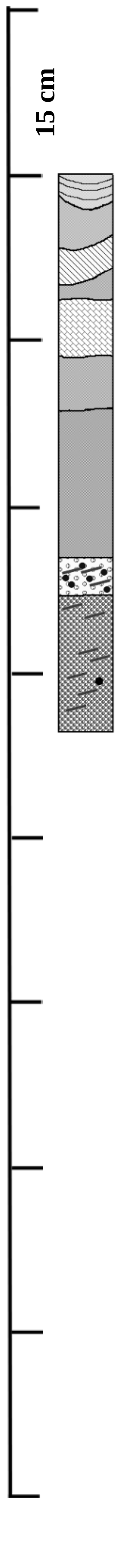
S7 - coarse mud with shell*

S8 - mud/sand/shell; **wood fragments**

S9 - coarse mud with sand and shell*; **wood fragments, coal, charcoal, palm kernel shell, melted material, concretion**

S10 - mud and shell*; **charcoal, wood fragments**

Note: The curvature that can be seen in the top strata is likely due to compression from core extrusion. It is not clear why this happens to some cores and not others. As can be seen in the profiles, strata are not generally straight across, but the extreme curvature displayed here is more defined than that normally contributed to natural layering scenarios. Normally the top 4 strata (as seen in this core) would be processed as a single stratum of overburden, but because there are distinct enough differences in the colors and textures (although they are all mud) I decided to try to process them separately to see if any more information could be collected in that way.



Shipwreck Core #19 – 5m W Datum 2

Total Length: 50 cm

S1 - mud

S2 - very fine mud

S3 - sand and shell

S4 - mud with shell*; **tiny bits of charcoal, coal and melted material**

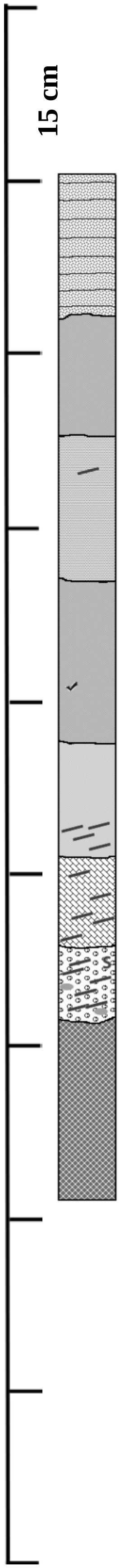
S5 - mud and sand with shell*; **melted material, charcoal, coal, concretion**

S6 - mud and sand with shell*; **1 small seed, burned/melted material, charcoal, coal**

S7 - mud with sand and shell*; **1 small bead, ceramic flake (possibly Delft), burned material, charcoal, wood fragments**

S8 - sand/mud/shell; **1 small bead, burned/melted material, charcoal, wood fragments**

S9 - coarse mud; **wood fragments, charcoal, wood fragments**



Shipwreck Core #20 – 5m E Datum 2

Total Length: 87 cm

S1 - fine mud (in lenses)

S2 - fine mud; small **wood chunk**

S3 - extremely fine, sticky, gooey mud (mostly organic); **small wood chunk**

S4 - mud with fine mud and shell*; **palm kernel shell, charcoal, wood fragment**

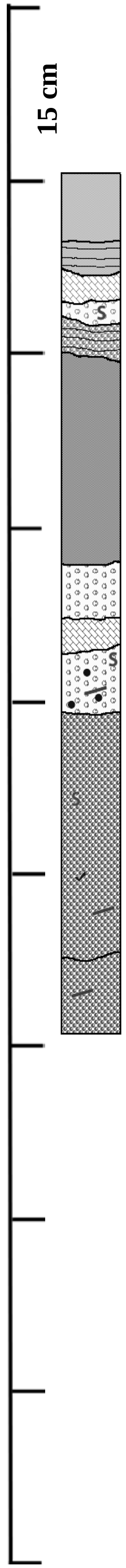
S5 - mud with sand and shell*; **1 small bead, coal, charcoal, wood fragments**

S6 - mud/sand/shell*; **melted material, burned material, charcoal, coal, insect, wood fragments**

S7 - sand/mud/shell (including barnacles); **2 cowry shells, wood fragments, charcoal, burned material**

S8 - **wood – some fairly large chunks, but clear evidence of *teredo* damage, some wood with likely iron-staining; possible sulphur, probably caulking, concretion, 1 bit charcoal, mosquito, fruit fly**

Note: A lot of marine growth and larger barnacle shells in **S7** may indicate that the hull in this area was exposed for some time on the seafloor. The image below shows the wood from the core.



<u>**Shipwreck Core #21 –Datum 2**</u>

Total Length: 74 cm

S1 - mud

S2 - fine mud (in lenses)

S3 - mud and sand

S4 - mud/sand/shell

S5 - coarse mud with shell*

S6 - mottled mud*; **charcoal, burned/melted material, concretion**

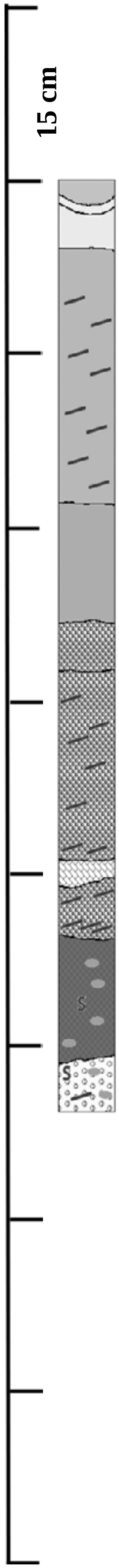
S7 - mud/sand/shell; **charcoal, melted material, coal, concretion**

S8 - sand and mud with shell*; **1 small bead, charcoal, melted material, burned material, concretion, filaments**

S9 - mud/sand/shell; **½ small bead, glass fragments likely from blue tube bead, charcoal, coal, concretion, burned material, melted material, wood fragments**

S10 - coarse mud with sand and shell*; **½ blackened small bead, glass fragments likely from tube beads, charcoal, coal, concretion, wood fragments, plastic fragment**

S11 - coarse mud with sand and shell; **coal, concretion, tiny wood fragments**



<u>Shipwreck Core #22 – Datum 4</u>

Total Length: 80 cm

S1 - mud

S2 - mud

S3 - very fine sticky mud (in lenses)

S4 - mud; **lots of wood fibers, palm kernel shell**

S5 - mottled fine mud; **wood fragments**

S6 - coarse mud with shell*; **charcoal, wood fragments**

S7 - coarse mud with shell*; **coal, burned material, bone, charcoal, wood fragments**

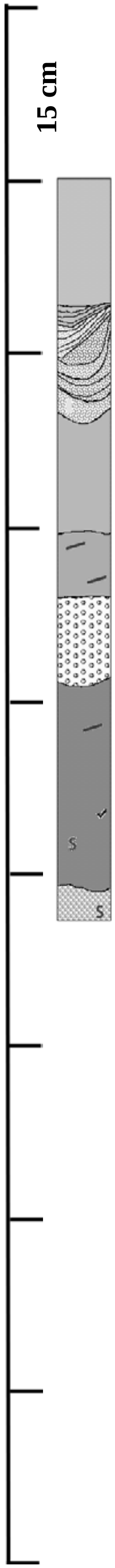
S8 - mud and sand with shell*; **coal, burned material, bone, charcoal, wood fragments**

S9 - coarse mud with shell*; **wood, coal, burned material, melted material, concretion**

S10 - wood chunks (some partially burned), some with evidence of *teredo* damage with coarse sand, mud and barnacles*; **charcoal, UID concretion, melted material**

S11 – mud/sand/shell (including barnacles); **8½ cowry shells, bone, pipe stem fragment, concretion, burned material, wood, filaments**

Note: Some wood is iron-stained. There is seagrass in **S8** and seagrass and barnacles in **S10**, which may indicate exposure for a time on the seafloor. The smaller barnacles in **S11** may indicate that that portion of the hull was exposed for a shorter amount of time. Also includes the partially burned wood.



Shipwreck Core #23 – 5m W of 10m W of grid

Total Length: 63 cm

S1 - mud

S2 - very fine mud (in lenses)

S3 - mud (in lenses) and shell*

S4 - fine mud

S5 - fine mud

S6 - fine mud (mottled)

S7 - fine mud (with lenses)

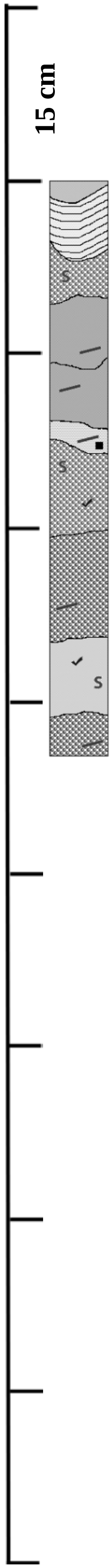
S8 - mud

S9 - mud (mottled) and shell*; **wood fragments and charcoal**

S10 - sand/mud/shell; **coal, burned material, wood fragments, concretion**

S11 - mud with sand and shell*; **palm kernel shell, brick, charcoal, coal concretion, meleted material, wood fragments**

S12 - coarse mud and shell*



Shipwreck Core #24 –5m N 10m W B1 side grid

Total Length: 48 cm

S1 - mud

S2 - very fine mud (in lenses)

S3 - coarse mud with shell*

S4 - mud; **charcoal, coal, wood fragments – all tiny**

S5 - mud with sand and shell*; **plastic fragment**

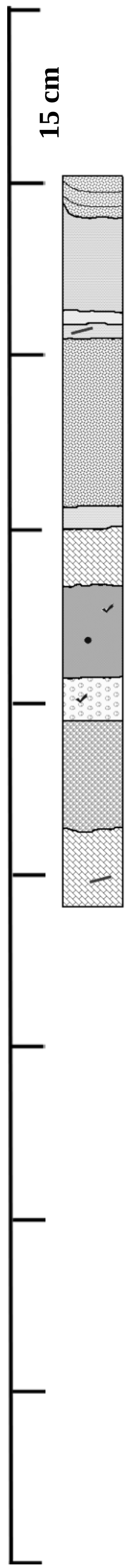
S6 - mud (in lenses) with sand and shell*; **charcoal, UIDs, possible wood fragments**

S7 - coarse mud with sand and shell*; **palm kernel shell, coal, charcoal, bone**

S8 - coarse mud with shell*; **UID, coal, charcoal, burned material, concretion, metal fragments, wood fragments**

S9 - mud with shell and sand*; **1 blackened small bead, melted material, charcoal, concretion**

S10 - coarse mud and sand*; **concretion, wood fragments**



Shipwreck Core #25 –5m S 10m W grid

Total Length: 62 cm

S1 - fine mud (in lenses)

S2 - very fine mud (in lenses and mottled)

S3 - very fine sticky mud

S4 - very fine mud; **wood fragments**

S5 - fine mud; **charcoal, coal, concretion, wood fragments**

S6 - very fine mud with shell*

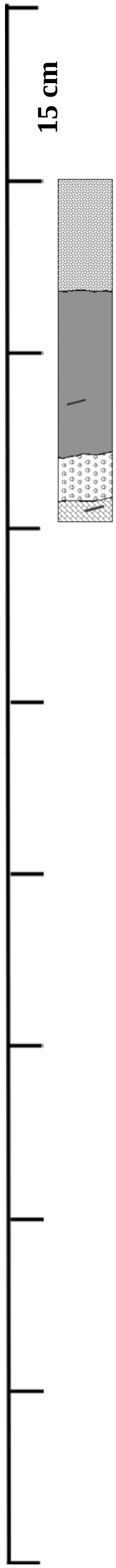
S7 - mud and sand with shell*; **concretion, melted material, metal**

S8 - mud with sand and shell*; **½ small bead, charcoal, concretion, wood fragment, probably palm kernel shell**

S9 - mud/sand/shell; **concretion, charcoal, palm kernel shell, fruit fly**

S10 - coarse mud with shell*; **possible glass bead that looks melted, coal, charcoal, melted material, burned material, UID, wood fragments**

S11 - mud and sand; **coal, melted material, charcoal, concretion, wood fragments (look partially burned)**



<u>Shipwreck Core #26 – 10m W Grid</u>

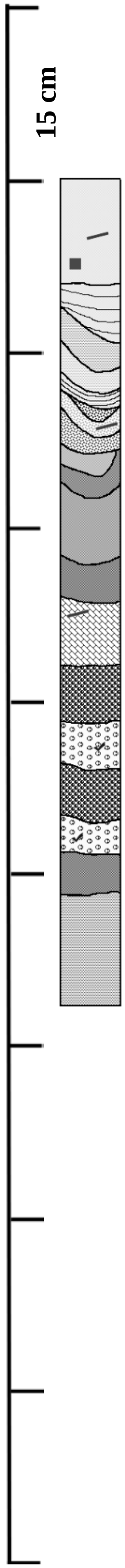
Total Length: 29 cm

S1 - fine mud; charcoal, concretion

S2 - mud with sand and shell*; **charcoal and coal, wood with bark**

S3 - mud/sand/shell; **charcoal, coal, concretion – 1 bit of each**

S4 - mud and sand with shell*; **charcoal, coal, palm kernel shell, partially burned wood**



Shipwreck Core #27 – 5m E 5m S Datum 2

Total Length: 71 cm

S1 - mud; **plastic**

S2 - mud (mottled in lenses); **wood fragments**

S3 - very fine mud

S4 - very fine mud

S5 - very fine mud (in lenses); **charcoal (1 bit), wood fragments**

S6 - fine mud; **concretion, wood fragments**

S7 - fine mud (in lenses); **wood fragments**

S8 - fine mud; **coal (1 bit), wood fragments**

S9 - mud

S10 - mud; **charcoal, wood fragments**

S11 - mud

S12 - mud with shell and sand*; **coal, charcoal, UID**

S13 - mud and sand with shell*; **coal, charcoal, wood fragments**

S14 - coarse mud with shell*

S15 - mud/sand/shell; **coal, burned material, charcoal, UID, palm kernel shell**

S16 - coarse mud; **coal, charcoal, burned material, melted material, wood fragments**

<u>Shipwreck Core #27 continued</u>

S17 - sand/mud/shell; **charcoal, concretion (1 tiny bit), wood fragments, palm kernel shell**

S18 - mud with sand and shell*; **charcoal, palm kernel shell**

S19 - fine mud; **charcoal and wood fragments (all tiny)**

Note: Some of the wood fragments in here appear to be iron-stained.

Shipwreck Core #28 – 5m W 5m S Datum 2

Total Length: 43 cm

S1 - fine mud (in lenses); **charcoal, concretion, wood fragments**

S2 - mud (in lenses) with shell*; **coal, charcoal**

S3 - mud/sand/shell; **charcoal, melted material, concretion, wood fragments**

S4 - sand and mud with shell*; **coal, charcoal, burned material, melted material**

S5 - coarse mud; **possible pitch, melted material, coal, charcoal, concretion, wood fragments, peanut shell**

S6 - sand/mud/shell; **coal, charcoal, burned material, concretion, wood fragments, peanut shells**

S7 - mud and sand; **coal, charcoal, metal fragments, possible wood fragments**

<u>Shipwreck Core #29 – Unit U15</u>

Total Length: 27 cm

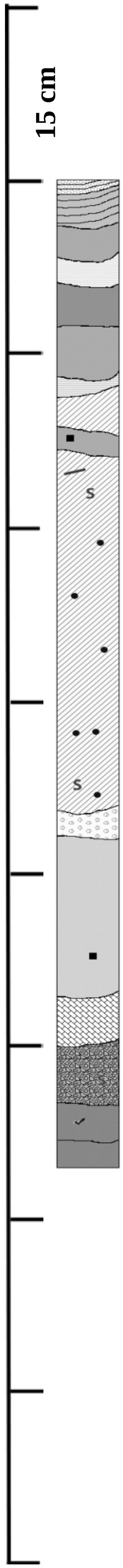
S1 - mud (mottled)

S2 - fine mud (in lenses); **wood fragments**

S3 - mud (in lenses); **charcoal, wood fragments**

S4 - very fine mud

Note: Core broken off in wood in unit.



Shipwreck Core #30 – 5m W 5m N Datum 1

Total Length: 85 cm

S1 - fine mud (in lenses)

S2 - mud with shell (in lenses)*; **charcoal, metal concretion (both tiny), insect head**

S3 - mud with shell*

S4 - very fine mud; **charcoal, wood fragments**

S5 - mud; **burned material, wood fragments (all tiny)**

S6 - mud; **concretion, wood fragments (all tiny)**

S7 - fine mud

S8 - sand and shell; **melted material, coal, charcoal, concretion, metal fragments, possible wood fragments**

S9 - mud with sand and shell*; **melted material, coal, charcoal, UID, possible wood fragments**

S10 - sand and shell; **17+ small beads, melted material, bone, glass, rust flakes, coal, burned material, concretion, charcoal, UIDs, insect, possible wood fragment**

S11 - mud/sand/shell; **coal, charcoal, concretion**

S12 - mud with sand and shell*; **melted material, bone, coal, charcoal, concretion, wood fragments**

S13 - mud and sand with shell*; **burned material, wood fragments**

S14 - mud and shell with sand*; **possible wood fragments**

<u>Shipwreck Core #30 – 5m W 5m N Datum 1 continued</u>

S15 - mud with shell*; **concretion, possible wood fragments, palm kernel shell**

S16 - mud

Note: Many of the artifacts in this core are in very poor condition and appear to have been tumbled significantly for some time.

Shipwreck Core #31 – 5m E 5m N Datum 1

Total Length: 39 cm

S1 - mud with shell*; **wood fragments**

S2 - mud (mottled)

S3 - coarse mud (mottled) with shell*; **burned material, charcoal, possible coal, modern string/filaments, possible wood fragments**

S4 - mud with shell*; **1 blackened small bead, concretion**

S5 - sand/mud/shell; **3+ small beads, melted material, burned material, charcoal, coal, possible wood fragments, UIDs**

S6 - sand and mud with shell*; **2 small beads, ½ tube bead, coal, charcoal, burned material, melted material, bone, concretion, possible wood fragments, UID**

S7 - mud/sand/shell; **1 small bead, coal, burned material, metal fragments/concretions, UID**

S8 - sand and shell with mud*; **1 blackened small bead, coal, melted material, metal/rust fragments, charcoal, UID**

Shipwreck Core Q – 5m NW B2 Datum 3

The PVC pipe clearly hit something as it was being driven in and no sediment was left in the core upon surfacing. However, somehow a 5.5 x 3.5 cm chunk of yellow brick (which may have been what the pipe struck) was somehow retained in the core. The images below are of the piece of yellow brick and the shattered PVC pipe. The designation "Q" was given to designate the brick fragment core from the others.

Shipwreck Core #7-09 – 10m SSW of Cannon #2

Total Length: 37 cm

S1 - fine mud with shell*

S2 - fine mud with shell*; 1 piece charcoal

S3 - sand with shell*; **concretion, metal fragments, peanut shells, possible wood fragments (unlikely association with wreck site)**

S4 - sand and mud; **possible burned material, possible metal fragments, charcoal (1 bit)**

Note: Because the core attempted at the northern end of the wreck site hit something and consequently did not have any material in it, this was the only successful core collected at the shipwreck site in 2009. It was collected SSW of the approximate center of the wreck, although because so much of the southern half of the wreck (including the 3 cannon) was covered, it was difficult position it exactly. The core was collected in the sediment known to be covering the stacks of basins at the southern end of the wreck site.

Control Area 1 Core #1

Total Length: 31 cm

S1 - mud; **modern plastic**

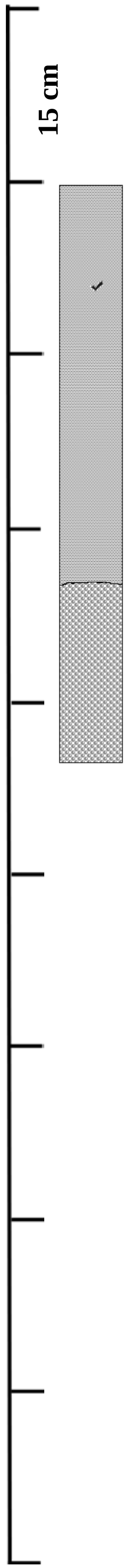
S2 - very fine mud

S3 - mud and sand

S4 - mud and sand (in lenses); **1 bit charcoal, insect**

S5 - mud/sand/shell

Note: This is the first core collected with the coring device, and was the basis for the development of the in-field processing of the cores. It is the only core collected at C1 because all of the experimental material disappeared from the site and we did not return after that discovery.



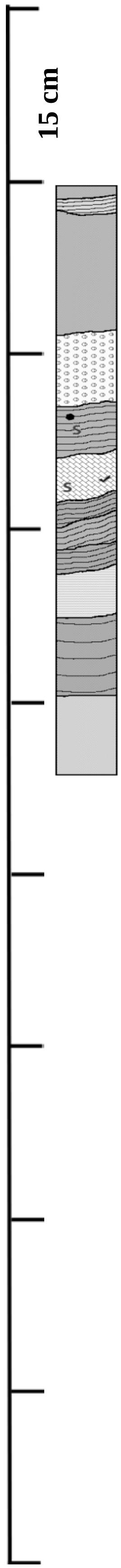
Control Area 2 Core #1 – NW of the control box

Total Length: 50 cm

S1 - mud with shell and sandstone*; **charcoal, possible coal, possible wood fragments (likely modern), palm kernel shell**

S2 - coarse mud; **wood fragments (likely modern), bone, plastic, UIDs**

Note: This core was one of the first cores we collected and it was done in the experimental phase of collection. It was collected using a re-taped PVC pipe – the pipe was split intentionally, as it was hoped that by splitting it we wouldn't have to keep buying more pipe for every core we collected (c.f. Reddering 1981). While there was clearly a fair amount of material remaining in the core, it took several tries to even get that much and there were problems with the suction, so this technique was abandoned in favor of the tamping technique for removal.



Control Area 2 Core #2 – just N (in-shore) of datum/rebar

Total Length: 51 cm

S1 - mud (in lenses)*

S2 - mud (in lenses)

S3 - mud

S4 - sand/mud/shell; **melted material (1 tiny bit), possible concretion, UID, plastic**

S5 - mud (in lenses); **coal, charcoal, burned material**

S6 - sand/mud/shell*; **coal, charcoal, burned material, palm kernel shell, bone**

S7 - mud (in lenses)

S8 - fine sticky mud (in lenses)*; **possible wood fragment**

S9 - mud (in lenses)

S10 - very fine sticky mud; **burned material (1 tiny bit); insect**

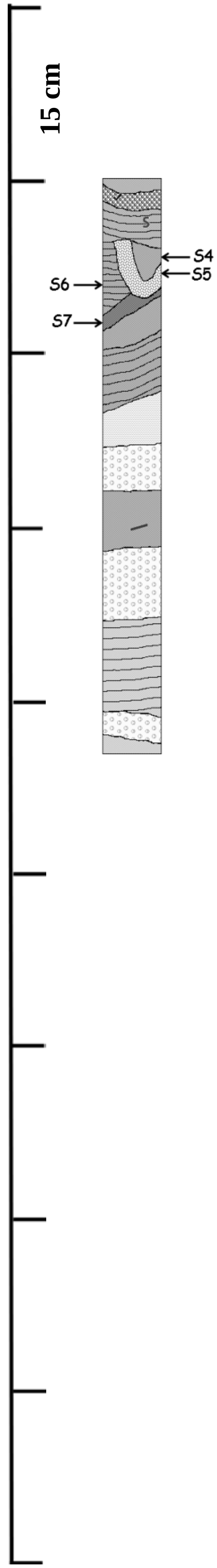
S11 - mud (in lenses) with shell*; **charcoal, possible coal (1 tiny bit each), possible wood fragments**

S12 - mud; **melted material, burned material, coal, charcoal, metal flakes/fragments, string/fiber (modern)**

Note: The mud all through this area is incredibly stiff and made it really hard to pull core out without severe wiggling and manipulation. I'm surprised there's as much in the core as there is. The collection of cultural/non-natural material here is interesting – it is very reminiscent of that on the shipwreck site. It may be a factor of being downcurrent from

Control Area 2 Core #2 continued.

the known shipwreck site, as well as relatively near shore, where things get caught up. One other (likely remote) possibility has to do with the location of the control area, which was intentionally placed approximately 250 m east of a major side scan sonar target in the 2003 data. While nothing was visible on the seafloor at this site in 2007, it is possible that the target was covered between 2003 (data collection) and 2007 (diving on the target) and that there is actually material there. Further research will be necessary to confirm or refute this.



Control Area 2 Core #3 – 10m E rebar

Total Length: 48 cm

S1 - mud

S2 - coarse mud; **palm kernel shell**

S3 - mud (in lenses) with shell; **charcoal, wood fragment (1 bit)**

S4 - coarse mud (mottled)

S5 - fine mud (mottled)

S6 - mud (in lenses); **plastic**

S7 - mud with shell*; **partial insect head**

S8 - mud

S9 - mud (in lenses); **charcoal (1 tiny bit), possible wood fragments**

S10 - very fine mud (mottled); **charcoal**

S11 - mud/sand/shell; **wood fragments, one of which appears to be partially burned**

S12 - mud; **charcoal (1 tiny bit), palm kernel shell, wood fragments**

S13 - mud/sand/shell; **coal, charcoal, wood fragments, UID**

S14 - mud (in lenses) with shell and sand*; **coal, charcoal, wood fragments, possible concretion**

S15 - mud/sand/shell; **melted material (possibly glass), coal, burned material, charcoal**

<u>Control Area 2 Core #3 continued</u>

S16 - mud with shell*; **melted material, burned material (possibly palm kernel shells), leaf, modern fibers/filaments**

Note: The partially burned wood is just as likely to have come from someone’s cooking fire as from something that burned at sea. Without the context of a shipwreck site, it is impossible to assign meaning/importance to it. The context of the control site is such that there are likely multifarious factors contributing to it.

Control Area 2 Core #4 – 10m N rebar

Total Length: 36 cm

S1 - mud (in lenses)

S2 - mud (mottled) with shell*; **charcoal, UID**

S3 - fine mud (mottled); **charcoal, possibly burned material, palm kernel shells, possible wood fragments, filaments/fibers**

S4 - mud (mottled); **charcoal, wood fragments, palm kernel shell**

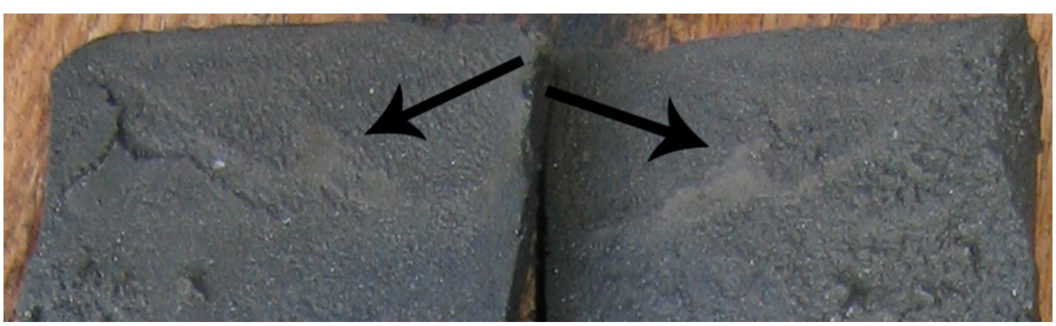
S5 - very fine mud; **possible charcoal (1 tiny bit)**

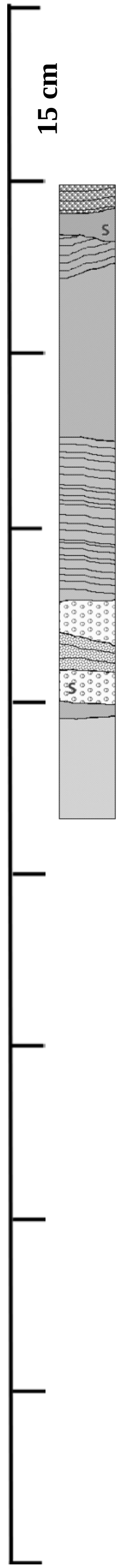
S6 - mud with shell*

S7 - mud/sand/shell; **plastic, palm kernel shell**

S8 - mud; **burned material (1 tiny bit)**

Note: The surface between **S1** and **S2** had a perfectly preserved ripple in the mud that had been protected by the overlaying mud. While it is relatively common to see ripples on the seafloor (both when diving and in side scan sonar), it is unusual to have one so perfectly preserved in a sediment core. The arrows in the image below point to the crest of the split ripple.





Control Area 2 Core #5 – 10m W rebar

Total Length: 56 cm

S1 - coarse mud (in lenses)

S2 - mud with shell*

S3 - mud (mottled)

S4 - mud (some mottling); **coal, charcoal, possible wood fragments, plastic/modern fiber**

S5 - mud (in lenses); **charcoal, burned material**

S6 - sand/mud/shell

S7 - fine mud (in lenses); **charcoal (1 bit)**

S8 - sand/mud/shell; **charcoal**

S9 - mud; **charcoal**

S10 - mud with shell*; **coal, tar (black sticky and viscous material)**

Control Area 2 Core #6 – 10m S rebar

Total Length: 34 cm

S1 - very fine mud; **coal (1 tiny bit)**

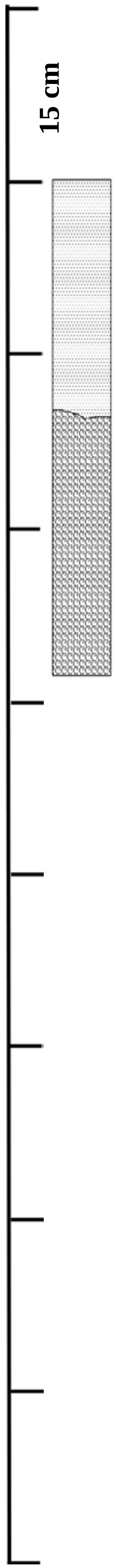
S2 - fine mud with shell and sand*; **charcoal (1 tiny bit)**

S3 - mud/sand/shell; **coal, charcoal (1 tiny bit each)**

S4 - mud (in lenses) with shell*; **coal**

S5 - mud with shell*; **charcoal**

Note: I am quite certain that the differences in length between the cores collected at this site are the result of the retrieval technique – if the core is removed more slowly it is more likely to retain sediments. This particular core is a very different composition from the other cores collected at this site.



<u>Core #1_09</u>

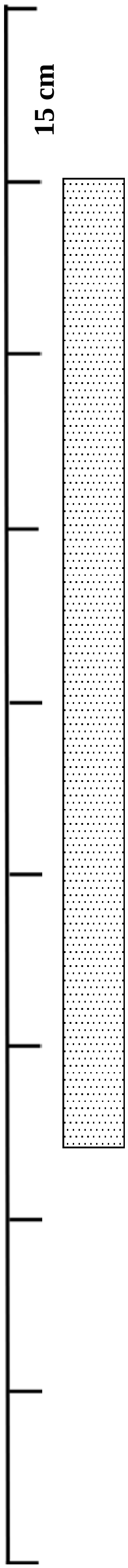
Waypoint **46 -** N05° 05 13.6 W001° 20 48.1

Total Length: 43 cm

S1 - very fine sand with shell*; **charcoal, burned material, iron/rust fragments, UIDs – all tiny**

S2 - fine sandy clay; **coal, probable roadtop/tar material, burned material, wood fragments, paint chips, UID, palm kernel shell**

Note: This core was collected just outside the harbor mouth where fishing vessels still anchor. We dived on this site because it was a large magnetometer hit, but there was nothing visible on the surface – it is possible that the magnetometer hit was a result of modern lost anchors/modern debris, or historical material at the mouth of the lagoon. When taking the cores (**Core 1_09** and **Core 2_09**) the sediments were so compact it felt as though we were hitting wood (although we were not), and it was impossible to drive the core in more than about 75 cm on the first one, and just more than that on the second. I do not know why there is so little in terms of sediment variation in this core and in **Core 2_09**.



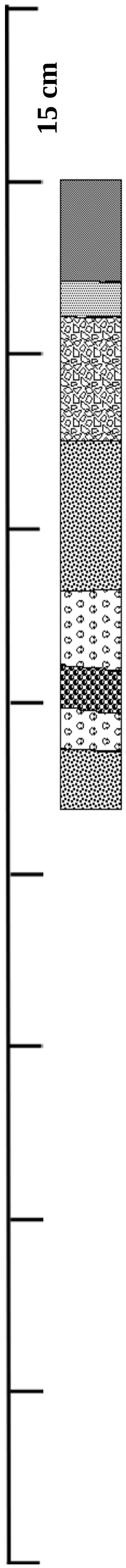
<u>Core #2_09 – 2 m W of Core #1_09</u>

Waypoint **46 -** N05° 05 13.6 W001° 20 48.1

Total Length: 83 cm

S1 - very fine sand (some mottling) with shell*; **lead, rust fragments, probably coal, possible road material/tar, charcoal, wood fragments, palm kernel shells, conglomerate/UID, paint chips**

Note: This is perhaps the strangest core I saw – there was absolutely nothing in it to distinguish strata, and the mottling was not consistent across the core, so it could not be considered a stratum change – so it is considered to be one. There are proportionately far more rust fragments in this core than in **Core 1_09**, which is interesting, considering that they are so close together, and likely means that there is a metal object very near this core that is badly disintegrating. None of the artifacts in this or the previous core is surprising due to the continued use of the area for anchorage, and it is not possible to necessarily distinguish these materials by age, making any inferences from this material speculative until further investigations can be taken on in this area.



Core #3_09

Waypoint **322 -** N05° 04.563 W001° 19.869

Total Length: 55 cm

S1 - sticky fine mud*; **charcoal (1 tiny bit)**

S2 - very fine sticky mud (mottled)*; **charcoal (1 tiny bit)**

S3 - mud and shell; **small bead, possible wood fragments**

S4 - fine mud; **coal, charcoal, UID material – all tiny**

S5 - mud/sand/shell; **melted material, burned material, coal, charcoal**

S6 - coarse mud; **melted material, burned material, charcoal, coal**

S7 - mud/sand/shell; **burned material, melted material, charcoal, UID, plastic line**

S8 - fine mud; **coal, burned material, charcoal, palm kernel shell**

Note: Magnetometer target site. This core went in about 85 cm and then hit something hard. This is the only site in which a bead was recovered apart from the known shipwreck site. There is a high percentage (relatively) of melted material in this core compared to others from sites other than the known shipwreck site (apart from **Core 18_09** on the **Double Anchor Site**), but this is very possibly a factor of the site being located just inshore of the shipwreck site and the material may have been transported there from the shipwreck itself.

<u>Core #4_09 – Mud Site</u>

Waypoint **397 -** N05° 04.376 W001° 19.538

Total Length: 24 cm

S1 - very fine mud (in lenses) with sand and shell*; **charcoal, possible wood fragments, UID**

S2 - fine mud; **lots of UID material that looks like chicken skin (probably marine)**

S3 - very fine mud (in lenses); **fruit fly**

S4 - fine mud; **wood fragments**

S5 - sand and mud; charcoal **(1 tiny bit)**

Note: This was collected at the "Mud site" – a 2009 side scan sonar target that is apparently just a large area with extremely soft and sticky mud extending to at least 1 m below the surface. A full core was collected, but this is all the material that remained in it.

<u>Core #8_09</u>

Waypoint **411 -** N05° 04.341 W001° 19.750

Total Length: 44 cm

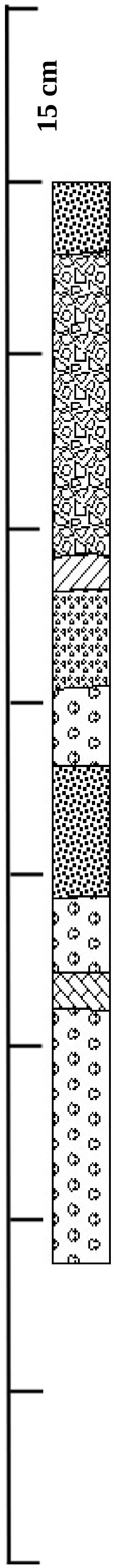
S1 - extremely fine, sticky mud with shell* (mottled)

S2 - very fine mud (mottled) with shell and sand*

S3 - sand/mud/shell; **concretion**

S4 - fine mud with shell and sand*; **charcoal (2 tiny bits)**

S5 - sand with shell*; **charcoal, peanut shells, plastic (may actually be flagging tape from processing)**



Core #9_09

Waypoint **338 -** N05° 04.434 W001° 21.254

Total Length: 93 cm

S1 - fine mud; **filament, plastic/possible paint**

S2 - mud and shell; **insect**

S3 - very fine mud and shell; **charcoal (1 tiny bit)**

S4 - mud with shell

S5 - mud/sand/shell

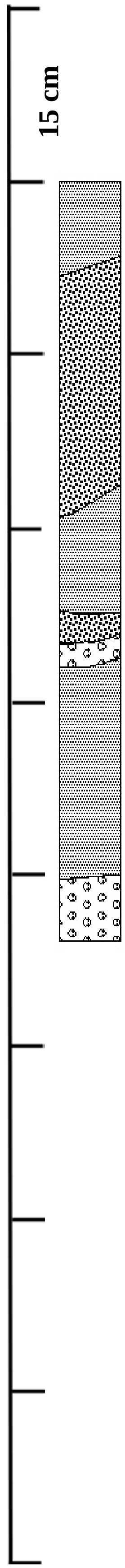
S6 - fine mud with shell*

S7 - mud/sand/shell; **filament**

S8 - sand and mud with shell*; **charcoal (1 tiny bit)**

S9 - mud/sand/shell; **probable concretion, charcoal – both tiny, filament**

Note: The lack of cultural material, whether historical or modern, in this core and several other cores is interesting. It means that perhaps this material may not be as ubiquitous in the region as is perhaps intuitive. The local environment may also play a significant role in this.



<u>Core #11_09</u>

Waypoint **539 -** N05° 05.337 W001° 20.435

Total Length: 65 cm

S1 - very wet sticky fine mud (mottled) with shell*; **charcoal, filaments**

S2 - fine mud (in lenses); **coal, charcoal, palm kernel shells – all small pieces**

S3 - very wet sticky extremely fine mud (mottled); **charcoal, possible wood fragments, plastic, filaments**

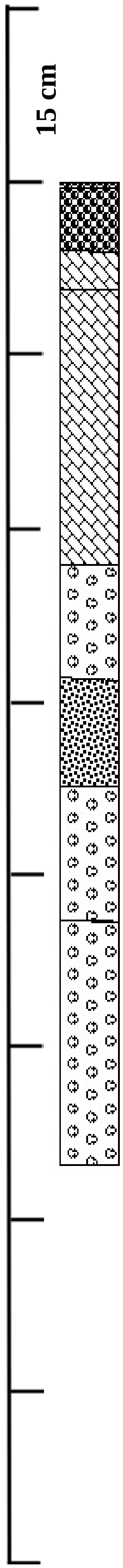
S4 - fine mud

S5 - mud/sand/shell; **UID**

S6 – very wet sticky extremely fine mud (mottled); **melted material, rust flake, coal, charcoal – all very small pieces, peanut shells, palm kernel shells**

S7 - mud/sand/shell; **charcoal, filament**

Note: Smelled particularly awful in post-processing – clearly had a lot of organic material in it.



Core #14_09

Waypoint **303/394 -** N05° 04.514 W001° 20.459

Total Length: 85 cm

S1 - coarse mud with shell*; **rust flake (1 tiny bit)**

S2 - sand and mud; **charcoal (1 tiny bit)**

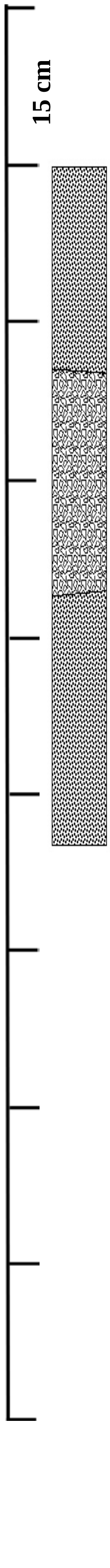
S3 - mud and sand; **melted material, rust flake, charcoal, possible wood fragments**

S4 - mud/sand/shell; **melted material, coal, charcoal, concretion, plastic wrapping**

S5 - fine mud with shell*; **charcoal, palm kernel shell**

S6 - mud/sand/shell; **charcoal (1 tiny bit)**

S7 - mud/sand/shell; **charcoal (including burned palm kernel shell), palm kernel shell**



<u>Core #16_09</u>

Waypoint **253 -** N05° 04.632 W001° 20.319

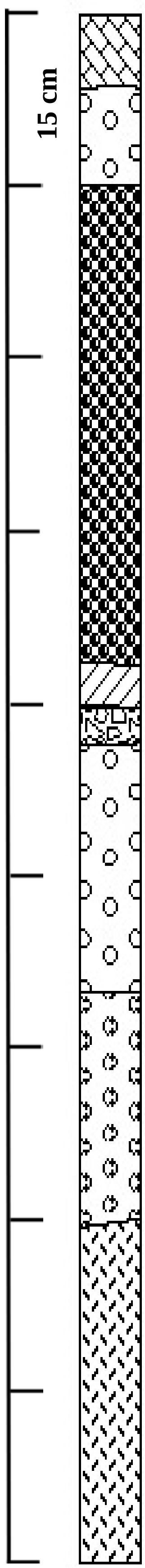
Total Length: 63 cm

S1 - fine mud with shell*; **charcoal (2 tiny bits), filament/string**

S2 - mud and shell; **charcoal (1 tiny bit), filament**

S3 - fine mud

Note: I do not know why there was so little distinction between sediments and thus so few strata.



Core #17_09 – near Single Anchor Site
About 25m South of Anchor

Total Length: 135 cm

S1 - sand and mud with shell*; **rust, burned, material, coal, charcoal, roadtop, plastic**

S2 - sand with shell*; **rust flakes, burned material, coal, charcoal, plastic/paint**

S3 - coarse mud with shell*; **rust flakes, burned material, coal, charcoal, roadtop, wood fragments, palm kernel shells, filament, plastic**

S4 - shell and sand; **rust flakes, burned material, coal, charcoal, roadtop, possible wood fragments, plastic**

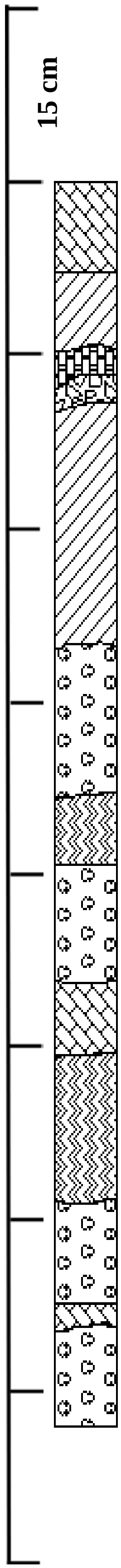
S5 - mud and shell; **coal, charcoal, burned material, UID, palm kernel shells, plastic, filaments**

S6 - sand with shell*; **burned material, coal, charcoal roadtop, wood fragments, UIDs, palm kernel shells, plastic**

S7 - sand/mud/shell; **burned material, coal, charcoal, roadtop, palm kernel shells**

S8 - mud/sand/**palm kernel shell**; **burned material, coal, charcoal, sulphur-covered palm kernel shells (?), wood fragments (some look burned), peanut shells, filament**

Note: This is the longest core ever collected with the sediment corer, and definitely shows its potential as a research tool in diverse environments. Most of the material in this core is likely related to its close proximity to the harbor/lagoon mouth.



<u>Core #6_09 – Single Anchor Site</u>
½ m NE of fluke

Total Length: 108 cm

S1 - mud and sand with shell*; **charcoal, coal, roadtop material, rust flakes, plastic**

S2 - shell and sand; **metal concretions, coal, charcoal, roadtop, palm kernel shell, plastic, filament**

S3 - palm kernel shells with shell*; **possible melted glass, burned material, coal, charcoal, possible peppercorns, possible roadtop, wood fragments, peanut shells**

S4 - shell and mud; **possible glass fragment, charcoal, burned material, probably roadtop, bone, wood fragments, palm kernel shells**

S5 - shell and sand; **coal, possible cement, burned material, possible roadtop, wood fragments, peanut shells, palm kernel shells, plastic**

S6 - mud/sand/shell; **coal, charcoal, burned material, peanut shells, palm kernel shells, plastic, filaments**

S7 - shell/sand/**palm kernel shells**; **coal, charcoal, burned material, concretion, possible peppercorns, bone, peanut shells, filament**

S8 - shell/sand/mud with **palm kernel shells***; **coal, possible concretion, melted material, charcoal, possible wood fragments, peanut shells; filaments, plastic string**

S9 - mud and sand*; **coal, possible cement, burned material, charcoal, wood fragments, palm kernel shells**

S10 - sand/shell/**palm kernel shell**; **coal, burned material, charcoal, possible peppercorns, UIDs, peanut shells, wood fragments, filament**

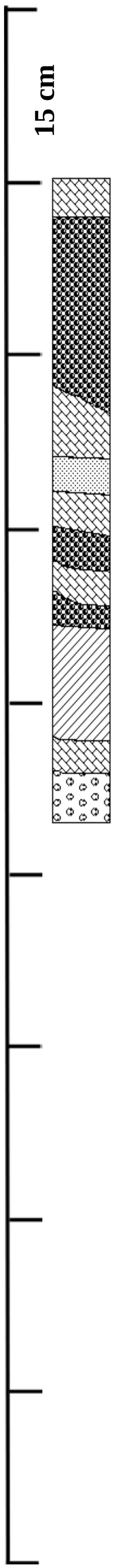
Core #6_09 – continued

S11 - mud/sand/shell; **coal, charcoal, UIDs, possible wood fragments, palm kernel shells**

S12 - fine mud with shell*; **coal, charcoal, palm kernel shell**

S13 - sand/mud/shell; **coal, charcoal, burned material, possible peanut shell, wood fragments, palm kernel shells, filament/string**

Note: This core is located just inshore of a sand barrier/spit, and most of the material in it is extremely rounded, indicating a very dynamic local environment. The quantity and variety of material is consistent with harbor/anchorage areas where vessels have traversed and anchored for at least hundreds of years, as well as an extensive influx of material from the shore around the harbor/lagoon mouth, which probably accounts for the majority of the material. It is interesting that the area immediately surrounding the fluke on the surface had extensive amounts of coconut shell, but there was none in the sub-surface material.



<u>Core #5_09 - Double Anchor Site</u>

5m at 160° from center core (between anchors)

Total Length: 56 cm

S1 - sand and mud with shell*

S2 - coarse mud with shell (mottled)*; **charcoal (1 tiny bit), possible wood fragments, filament**

S3 - sand and mud

S4 - very fine sand

S5 - sand and mud; **UID, possible wood fragments**

S6 - coarse mud

S7 - sand; **melted material**

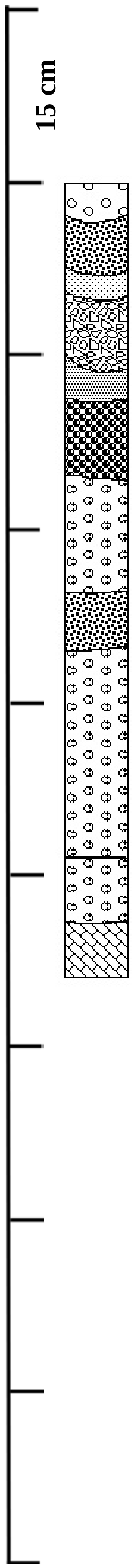
S8 - coarse mud; **coal and charcoal – 1 tiny bit each**

S9 - sand and shell; **rust/iron flake, melted material, charcoal, palm kernel shell**

S10 - sand and mud; **probable melted plastic/glass, charcoal, palm kernel shell**

S11 - mud/sand/shell; **charcoal (1 tiny bit)**

Note: This core was taken because I felt some resistance while probing around the anchors – it was likely a mud/clay deposit/stratum across the site.



<u>**Core #10_09 – Double Anchor Site**</u>

1 1/2m SW of big anchor

Total Length: 70 cm

S1 - sand with shell (in lenses)

S2 - fine mud

S3 - very fine sand

S4 - mud and shell; **charcoal (1 tiny bit)**

S5 - very fine mud; **rust flake (1 tiny bit)**

S6 - coarse mud with shell; **charcoal, wood fragments**

S7 - mud/sand/shell (large barnacle); **possible rust fragments**

S8 - fine mud with shell*; **burned material, filaments**

S9 - mud/sand/shell; **melted material, coal, charcoal, burned material, glass shard, possible brick, palm kernel shells, filaments, plastic (likely flagging tape from post-processing)**

S10 - mud/sand/shell; **charcoal (1 tiny bit)**

S11 - mud and sand with shell*; **plastic**

Note: I had some people assisting me in bagging the strata from this core, and there were some problems with it, particularly with **S7**, as it just seems to have disappeared. While this does not negate the value of the core, I am primarily relying on the notes I took while processing it in the field, rather than the data collected from microscope analysis later, as there may be some contamination/confusion issues.

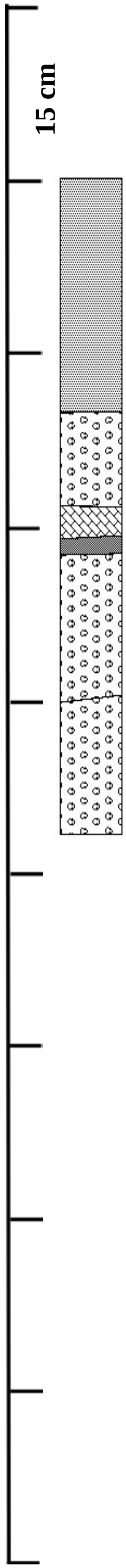
<u>Core #12_09 – Double Anchor Site</u>

Taken in the test hole dug between the two anchors

Total Length: 25 cm

S1 - mud/sand/shell; **melted material, rust flake, charcoal**

Note: This core was difficult to maneuver because it was taken in a hole that was already about 1 meter deep, which may have something to do with why it was so short, but I do not know. It is also somewhat surprising that there is so little cultural material here, as there is usually more in the cores from the Double Anchor Site. That being said, however, the material is similar to what would be expected from the deepest reaches of the core.



<u>Core #13_09 – Double Anchor Site</u>

1st core taken before anchors were found - 1m South of Waypoint

Total Length: 56 cm

S1 - very fine mud (in lenses); **charcoal (2 tiny bits), filament**

S2 - mud/sand/shell; **charcoal (1 tiny bit), filaments**

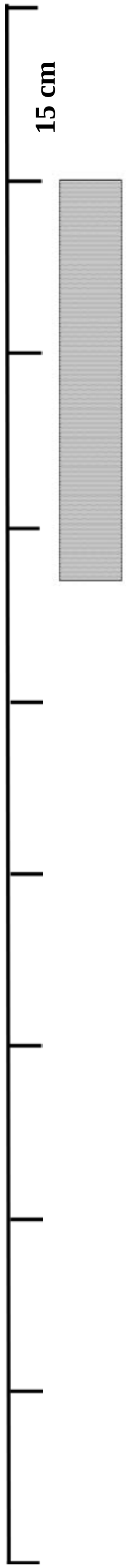
S3 - sand and mud; **filament**

S4 - mud and clay; **filament/string**

S5 - mud/sand/shell; **rust flakes, charcoal, ant, string/fiber**

S6 - mud/sand/shell; **charcoal – both wood and burned palm kernel shells, palm kernel shells**

Note: The mud and clay stratum described in **S4** could be felt around the entire site, and I suspect may have been the surface condition when the anchors were deposited/dropped there, which would have helped to maintain them in an upright attitude.



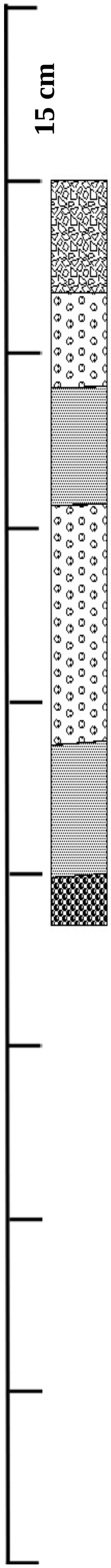
<u>Core #15_09 – Double Anchor Site</u>

Taken in the middle between the anchors

Total Length: 34 cm

S1 - very fine mud (mottled) with shell*; **plastic/net**

Note: This is very strange that there is so little material in this core. It was taken about ½ m from where **Core #12_09** was later taken, and perhaps there was something about the sediments in this area that prevent either one from retaining much in the core, but I am not certain.



Core #18_09 – Double Anchor Site

1 m east of small anchor

Total Length: 63 cm

S1 - mud and shell; **melted material, charcoal, rust, glass shard, palm kernel shells**

S2 - mud/sand/shell; **rust flakes, burned material, melted material, coal, charcoal, UID, wood fragments, palm kernel shells, filaments, plastic**

S3 - very sticky fine mud; **melted material**

S4 - mud/sand/shell; **possible wood fragments, plastic**

S5 - very sticky fine mud (very large barnacles); **melted material, possible rust fragment, charcoal, plastic bag fragment**

S6 - coarse mud; **probable glass shard**

Note: This core has the most melted material I have seen in any core collected to date.

Appendix II
The Environment

> The coastal zone is the area along the margin of a continent where the sea and land meet and there is an interplay between marine and terrestrial processes (Waters 1992:249); the land and sea are constantly at battle (Cunliffe 2001:2).

The coastal maritime environment is a complex web of weather, coastal oceanography, geology, geography, and those who dare to harness the sea in vessels of all descriptions and for an infinite number of reasons. My research is concerned with study of the physical remains of events of historical maritime trade: remains such as shipwrecks that represent, for whatever reason, a failure to successfully coexist with the ocean, or remains of other interactions on or with the sea. The physical environment of trade is studied through the lenses of the archaeology of the event, the seascape, and site formation processes. Site formation process research combines the examination of cultural, coastal geomorphological and oceanographic processes with archaeological techniques of investigation to examine historical submerged sites in coastal Ghana. Integral to the work is a basic cultural resource assessment that involves the determination of presence or absence of submerged sites in the coastal area near the town of Elmina, evaluation of site conditions, and the investigation of factors (site formation processes) that affected the creation and affect the current conditions of these sites.

The primary purpose of site formation process research is to offer insights into the physical processes that contribute to the long-term destruction and/or preservation of invaluable maritime cultural resources. This in turn provides crucial information to the researcher concerning what remains of submerged sites, what questions can be asked of them, and what the best ways/methodologies of investigating them are.[467]

The purpose of this appendix is to provide a detailed discussion of the marine environment of coastal Ghana with an emphasis on the factors at work in site formation[468] and in relation to the factors that affected historical navigation and maritime trade. Cultural formation processes are discussed elsewhere (Chapter 6),[469] so the focus here is primarily on the complex suite of natural post-depositional agents that contribute to or affect the submerged sites and therefore our understanding of them. As articulated by Courty (1989:139),

> post-depositional effects cause specific changes that can be recognised by the kind of features they produce… When sediments have been transformed by only one agent, the resulting features are generally easy to recognize. Complications arise, however, when individual or successive post-depositional processes occur. This results not only in the super- and juxtaposition of features but also in the partial or total erasure of the effects of earlier post-depositional processes.

While Courty's quote is intended for site formation investigations of terrestrial sites, the emphasis on the complexity of processes and their results is even more applicable in the submerged environment, where, for instance, shipwrecks may be visible one year and the next completely nearly obscured by sedimentation (see Figure 4.15 in Chapter 4). Natural formation processes act at the minute, chemical level all the way to the level of an entire

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[467] While I am not a geomorphologist or an oceanographer and this research will clearly in the future benefit from such expertise (Bulliet 1992:131), the research conducted for this project is based on a large literature and observations of the coastal environment in relation to submerged sites.

[468] It is the same factors that work in the short-term, event scale, as work on long-term changes (Wright 1995:174; see also Anthony and Orford 2002), but because this project is so young we clearly are focusing on the (relatively) extremely short term.

[469] However, where particularly pertinent I have included information that directly concerned historical sailing and navigation in this environment, as the relationship of the environment and weather to navigation were directly tied to the success or failure of many endeavors.

region and seascape and include those factors that act to preserve the archaeological record, as well as those that destroy and disperse it (Ward and Larcombe 2003:1223).

A thorough knowledge of the environment surrounding submerged sites is vital to understanding the processes that affect them (Weier 1974:131), and even how sites affect their surroundings.[470] Environmental geological and coastal oceanographic data have been used to investigate site formation processes of a number of shipwreck sites around the world (McNinch et al. 2006; Quinn et al. 1997; Ward et al. 1998). In most cases these data have been applied to specific wreck sites which is also done here (Chapter 6), but the basic concepts are germane to wider applications, such as to archaeological survey and geomorphological analysis of a region (Chapter 5). In summarizing the results from one of their shipwreck site formation investigations, Ward and Larcombe (2003:1232) conclude that "[a]rchaeologists need to draw a clear distinction between description of patterns in the archaeological record and inferences about the processes that created those patterns." An examination of these causal factors provides the general background for site formation research, and provides the pertinent information to begin distinguishing between patterns and processes.

The core of this research is an investigation into the interactions and relationships of the cultural/archaeological seascape with the surrounding physical environmental agents (Parker 1995:89; Wilkinson 2004:352). The two major categories of formation agents most pertinent to maritime archaeology in coastal Ghana are coastal oceanography/geomorphology and climate and weather patterns/meteorology (Orme 2005:11; Wright 1995). Coastal oceanography includes such aspects as tides, currents,

[470] McCarthy (1988) provides an example of how the deteriorating metals on a shipwreck can affect surroundings, but it is also possible to look at a much more macro scale, for instance, if and how the site has formed an artificial reef and what flora and fauna utilize it.

sedimentation rates; weather patterns such as winds, rain and storms are formation agents in their own right, but also affect many of the oceanographic agents.[471] The following discussion touches on each of these different formation processes and the agents that affect them.

The Environment of Coastal Ghana

Coastal Ghana forms part of the northern edge of the Bight of Benin, which is located within the Gulf of Guinea at approximately 5°N. Wave-dominated[472] coastal Ghana spans approximately 600 km, of which slightly more than half is rocky with interspersed sandy beaches and lagoons (Adam 1998:143; Allersma and Tilmans 1993:211; Anthony and Blivi 1999:162; Dei 1985:591; UNEP 1985:31, 111; Webb 1958:308), and in some places sandbars front the coast (Osei and Aryeetey-Attoh 1997:7). As with much of Africa, the coastlines tend to be relatively straight and smooth with few indentations or natural harbors (Anthony and Orford 2002:10; Osei and Aryeetey-Attoh 1997:7). The coast is divided into three general sections according to dominant geomorphological characteristics (Fairbridge 2004; Finkl 2004). Western

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[471] Although slowly growing, at present there exist only sparse and sometimes contradictory data sets for "general geology, hydrodynamics and oceanographic conditions in the Gulf of Guinea" (Awosika and Ibe 1998:26), and particularly near Elmina. This lack of data extends to studies of inner shelf systems world-wide, due to difficulties in accessing it to study (Wright 1995:7), a problem that is exacerbated in West Africa by a lack of resources for such investigations. As a result of this, it is only possible to present a basic model of the coastal and geomorphological processes in this region.

[472] Although there are continuums between coasts described as "wave-" or "tide-dominated", a simple definition describes a wave-dominated coast is defined as a coasts which are relatively straight and smooth, characterized by well-developed beaches, are dominated by wave-energy, and are affected by wave-developed currents; wave-dominated coasts may also include "[p]ocket beaches along bedrock coasts" (Davis and Hayes 1984:324). In addition, they are "characterized by shore-parallel sediment bodies which may span the entire grain size spectrum" (Davis and Hayes 1984:326). A related definition is given as a depositional shore "where consistent, relatively large waves, with their associated strong wave-generated currents, have produced a smoothed shore of sandy sediments… As a generalization, coasts with small tidal ranges (microtidal + <2 m)… are dominated by wave energy, thus most wave-dominated coasts [including coastal Ghana] are microtidal" (Hayes 2005:1053; see also Bird 2005:1189; Davis and Hayes 1984). "[W]ave conditions generally exhibit large variability expressed by irregular, but short-term (order of days to weeks), to seasonal variations in energy and period" (Anthony and Orford 2002:9).

Ghana (west of Cape Three Points) is comprised of rocky features and a narrow continental shelf (approximately 20 km). Central Ghana,[473] between Cape Three Points and the area east of Cape Coast, is generally rocky and the continental shelf widens to between 80 and 100 kilometers but narrows towards the east (Allersma and Tilmans 1993:204; Awosika and Ibe 1998:22; Awosika et al. 1993:27; Ly 1981:231-232; Martin 1971:93; UNEP 1985:143). Eastern Ghana, from Cape Coast area to Benin, is comprised of narrow sandy beaches, generally steep raised beaches and rocky cliffs bordering the water, culminating in the major Volta River basin and the Keta Lagoon (Allersma and Tilmans 1993:200; Awosika and Ibe 1998:21; Blivi et al. 2002:186; Buckle 1978:205, 219; Orme 2005:15; UNEP 1985:111,143). West and east Ghana coastlines are approximately parallel to the equator (John et al. 1977:498), while the rocky coastline of central Ghana lies at an angle approximating WSW-ENE (Allersma and Tilmans 1993:203, 222; Awosika et al. 1993:31; Edmunds and Edmunds 1973:371). This angle is similar to the southerly-westerly angle of the predominant winds in the region (UNEP 1985:143).[474]

While these features of the coast clearly remain relatively stable, it has long been known that the topography of the Ghanain coastal seafloor itself changes constantly, a feature that has made sea travel and navigation along the coast tricky since large vessels began traversing those waters[475] (US Navy Hydrographic Office 1951:10). To complicate

[473] Also called the promontory coast (Boateng 1967:21).
[474] This is an important feature to consider because of how the coast, waves (although these are at slightly different angle than the coast) and wind interact to create one of the highest rates of longshore currents in the world (Anthony and Blivi 1999:162; Blivi et al. 2002:189), a particularly significant factor in shipwreck site formation processes.
[475] By large I am referring to European merchant or military vessels in historical trade and some modern fishing and military vessels; smaller vessels such as ship’s boats and canoes also had their challenges, but their shallower drafts and generally more maneuverable characteristics made travel along an unpredictable coast somewhat less daunting.

navigation, the weather and seasons along the coast tended and still tend to follow *general* patterns, but even these are difficult to predict at times. The following discussions provide some details concerning the climate and weather patterns as formation agents in coastal Ghana. It is important to remember throughout this discussion that each meteorological and oceanographic feature is inseparably connected to many, if not all, of the other features, and each is influenced by and influences the next. Note that the trade winds, the Inter-Tropical Convergence Zone (ITCZ), moisture regimes and temperatures interact with sea surface temperatures, rainfall, monsoon, thermocline, upwellings and downwellings, currents and countercurrents, both in the region of West Africa and across the Atlantic basin. The sketches of each of these provided here offer basic and simplified descriptions that are designed to familiarize the reader with the most pertinent features of these complex systems, particularly those that were relevant to historical maritime trade, and those which are direct actors or agents in the destruction or preservation of submerged archaeological sites. Figure II.1 is a highly simplified illustration that is useful in providing a basic overview of the interactions of some of the major environmental factors in the northern Gulf of Guinea, including the trade winds and most of the major currents affecting the region. Additional currents, as well as features such as the Guinea upwelling are not included, but are discussed in more detail throughout this appendix.

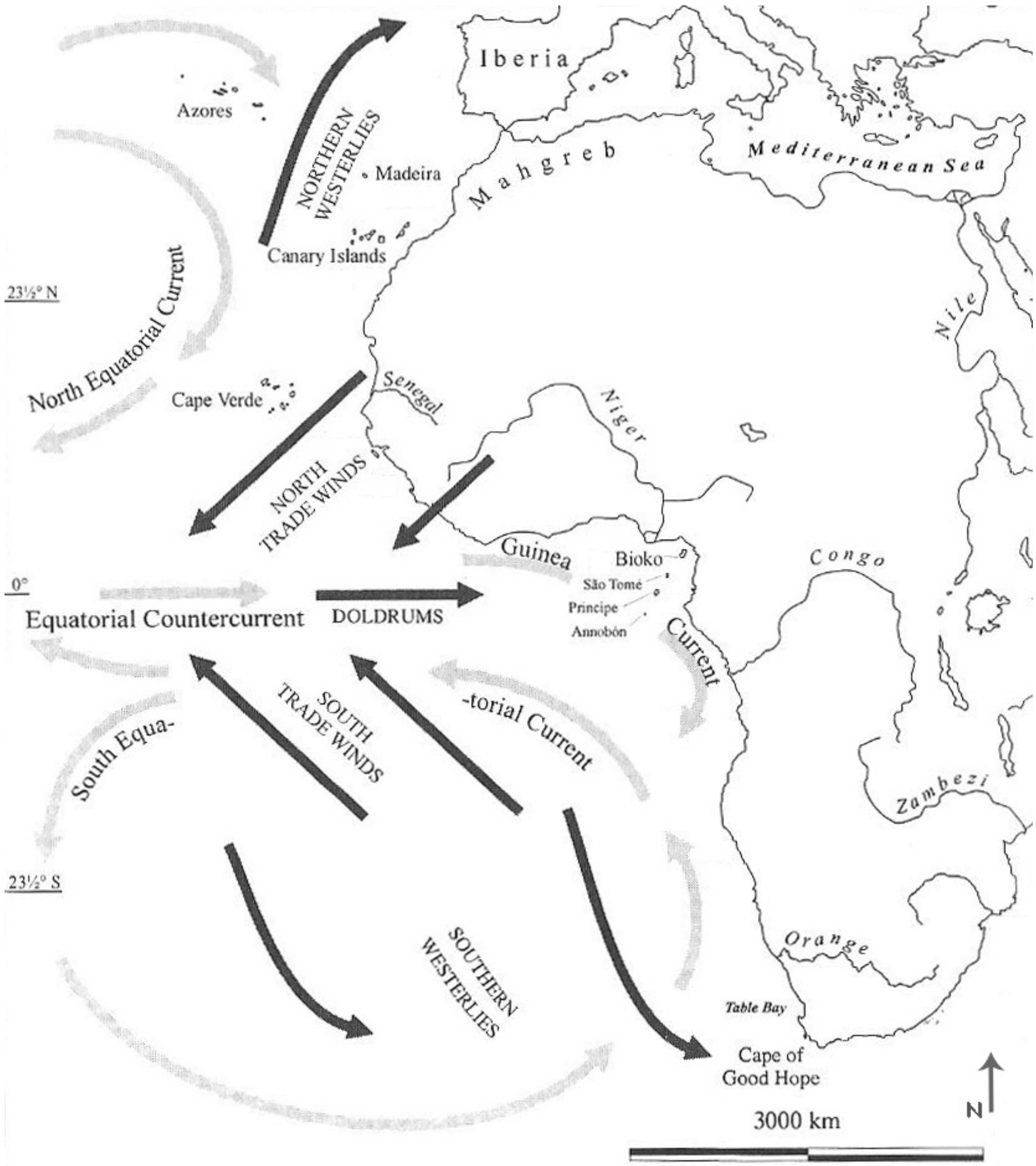

Figure II.1. **The positions of each of factor shown is generalized, as most of them are in various locations throughout the year (modified from Mitchell 2005:180).**

Climate

A number of meteorological (climatic) phenomena relatively unique to this part of the world bear noting, as they were particularly important to historical navigation before the invention of the engine or electronic positioning devices. For instance, during the dry season dust travels on north Harmattan winds[476] from the Sahara Desert (Schwanghart and Schütt 2008) and blankets much of sub-Saharan Africa in a thick, fog-like haze of dust, often rendering visibility less than 0.5 kilometers (0.3 mile).[477] This haze is not constant, but comes in "waves" and may extend up to 24 kilometers (12 or 15 miles) from shore (US Navy Hydrographic Office 1951:16), clearly causing consternation to those navigating visually along the coast. An additional factor in coastal navigation was the "extraordinary refraction produced by the heated atmosphere along the whole coast of western Africa" (US Navy Hydrographic Office 1951:17). This refraction obscured (sometimes to the point of creating a mirage) the true altitudes of the sun, stars and planets and rendered it difficult at best "even for those most experienced on this coast to make a correct estimate of the distance from shore when making a landfall" (US Navy Hydrographic Office 1951:17).

A final unique phenomenon related to weather patterns north of the equator has to do with variations in trade winds[478] and is known as the doldrums. Doldrums are zones of

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[476] Winds coming from the north. Harmattan dust is responsible for reductions not only in visibility, but also in humidity and temperature. Harmattan winds and their entrained dust are part of a complex cycle and interrelationship of the North trade winds, the position of the ITCZ, and pressure systems related to the Mediterranean (Schwanghart and Schütt 2008:425).

[477] Adams (1966 [1823]:166) described the dust as an "impalpable powder in the atmosphere." During the height of the harmattan he suggests that the "sun at noon-day may be looked at with the naked eye, and is seen but dimly, as through a smoked glass" (Adams 1966 [1823]:168).

[478] There are actually two consistent wind patterns in the tropics that affect the climates in most of sub-Saharan Africa. These are the Northeast Trade Winds, which carry harmattan and originate in the north subtropical high pressure systems, and the Southeast Trades, which originate in southern sub-tropical high pressure systems. Dickson and Benneh (1970:26) suggest that the term "trades" or "trade wind" is inaccurate, and the phenomena are more appropriately referred to as the *tropical continental air mass* and the *tropical maritime air mass*. Other authors use these terms, but do not make this clear distinction in terms; regardless of terminology, however, it is accepted that the sources of these regular winds are in the northern and southern hemispheres. The meeting of these winds creates the ITCZ, the position of which, in relation to the wind pressures, is a significant factor in seasonal shifts. When the ITCZ (and therefore the trade winds) are further north, southwesterly winds from the Atlantic bring rain onshore; when it is further south, north winds bring harmattan to the coast (Osei and Aryeetey-Attoh 1997:12-13). Seasonal variations

calms or very light winds that vary in width from 160 kilometers (100 miles) wide in February to 480 kilometers (300 miles) in August, depending on the time of year and position of the trade winds and the ITCZ (US Navy Hydrographic Office 1951:16; see also Binet and Marchal 1993:105; Longhurst 1962:634). Doldrums could prove fatal to an historical vessel caught in them, as vessels could be becalmed or trapped in them for weeks, usually resulting in fresh water supplies running out (Horlings 2007). Referring to this phenomenon, de Marees (1987:9) writes that when sailing “to a latitude of 7 or 6°, one usually comes into calms, especially if it is not the period of Travados (April, May and June), of which people are much afraid.”[479] He suggests that the latitude of much of the West African coast, “one cannot count on the wind, and must rely on the current, which always runs eastwards towards the bight [of Benin]” (de Maress 1987:9).

But climate is not simply the presence of things that affect navigation; it is the complex, multi-scalar and intricately-related system of weather patterns and their interactions with physical entities such as land and water, and includes the effects that these have on each other (Greenland 2005; see also Griffiths 1989).[480] The combination of unique (mentioned above) and general weather patterns created the environment of historical trade that affects this research. A summary of the key factors and their relation with Elmina and/or the Ghanaian coast is presented here.

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in the trade winds affect the generation of waves (Anthony and Orford 2002:11). The trade winds over the middle Atlantic were one of the prime movers of sailing vessels.

[479] Travodo is the Portuguese term for thunder storm, which were most common in the transitional period between the dry and rainy seasons (van Dantzig and Jones 1987:110), but van Dantzig and Jones (1987:9) suggest that de Marees was commenting on people’s fear of the calms rather than the storms. Tornadoes are most frequent at the commencement and termination of the rainy season (US Navy Hydrographic Office 1951:16).

[480] It is also helpful to note that geographical location is one of the most salient factors in determining the climate of a region (Greenland 2005:256).

Seasons

As is typical of equatorial regions around the world, the Ghanian coast, lying just north of the Equator, experiences what may in general terms be considered two seasons during the year:[481] a hot, humid rainy season between the months of April or May to September or October, and a dry season characterized by little or no rainfall (on land) between November and April[482] (Awosika et al. 1993:31; Gu and Adler 2004:3366; Meredith 1967 [1812]:5; Opoku-Ankomah and Cordery 1994:552). There are periods of change and unpredictability in climate during the year[483] (Acheampong 1982:203; Breuning-Madsen and Awadzi 2005:25; Koranteng and McGlade 2001:188; Lamb et al. 1986:238; Le Barbé et al. 2002:193; Philander 1986:238; Ramel et al. 2006:432), but in general, a drop of wind speed in November indicates the onset of calmer weather, accompanied by the lower wave-fronts of the dry season (John et al. 1977:501). Bosman (1705:111) nicely describes weather conditions on the coast from the perspective of a sailor:

> The Summer is accounted to begin with September, and continue the five subsequent Months, and the Winter takes up the remaining six Months in the Year, and is sub-divided into two Rainy, two Misty and two Windy Months: But the Season alters so much from Year to Year that we have in a manner left off reckoning them; the Summer comes sometimes a while month earlier one Year than another, and the fame is also observed of the Mist and Rain. In short, they come so confused and uncertain, that it is impossible to make any Calculation of them. Formerly, when I first came to the Coast, Summer and Winter succeeded alternately, exactly at a certain time, and the latter was much severer than at present.

[481] Those south of the Equator also experience two seasons, but at opposite times from the north.
[482] Gu and Adler (2004:3366) write that there are major rainfall events over the Gulf of Guinea during December, they simply do not reach the shore.
[483] There are actually two separate rainy seasons within the long rainy season (Acheampong 1982:203; Le Barbé et al. 2002:193; Nixon et al. 1007:S14).

When discussing the seasons of trade along the coast, Hopkins (1973:107) writes that the majority of European slave traders [and other merchants] visited the West African coast between October and March in an effort to avoid the rough weather of the rainy season (see also Adams 1966 [1823]:164; Blake 1967:52; Hair 1994a:64; Rømer 2000:17; Vogt 1979:37). As Bosman explained, weather patterns were not always kind or predictable, but as Adams (1966 [1823]:47)[484] observes, *in general* the weather conditions of the Ghanaian coast are actually considerably more mild than in many other areas of the coast of Africa; by way of commentary he does, however, add that the climate there is still "very obnoxious to the health of Europeans."

Rainfall

It is interesting to note that although Ghana and Togo are coastal, they exhibit generally unusually low rainfall throughout the year (Figure II.2)[485] (Acheampong 1982:199; Anyadike 1992:381; Breuning-Madsen and Awadzi 2005:25; Dickson and Benneh 1970:28; Goudie 1996:34). In two, often distinct rainy seasons (April-July and September-November) coastal Ghana receives an average of only 0.8-0.9 m/year (Nixon et al. 1007:S147; see also Gu and Adler 2004:3373; Le Barbé et al. 2002:193), much lower than would be expected for a similar equatorial coastal environment elsewhere in the world (UNEP 1985:27), including other areas of coastal West Africa (Longhurst 1962:635). However, although the amount of rainfall may not be as high as in other locations, the rains themselves are still significant forces along the coast. As Bold (1823:55) notes, "in the winter [rainy] season along this coast, when the winds are from

[484] See also Mouser (2002:88, 91).
[485] This is a complex phenomenon that is still in the process of being fully explained.

the S.W. the swell and surf on the beach are excessively high, and dangerous in many parts to attempt landing."

Rainfall along the Ghana coast is highly variable and still in the process of becoming well-understood, although it is *generally* accepted that position and relationship of the Inter-Tropical Convergence Zone (ITCZ)[486] with air masses and wind patterns, as well as variations in sea surface temperatures (SST) and currents are significant and interrelated factors (Colin 1988:132; Gu and Adler 2004:3365; Janicot et al. 1998:1875; Jenkins et al. 2002:264; Norris 1998:551; Philander 1986:237; Ramel et al. 2006:434; Weisberg and Colin 1986:240).[487] Relationships between SST and rainfall are

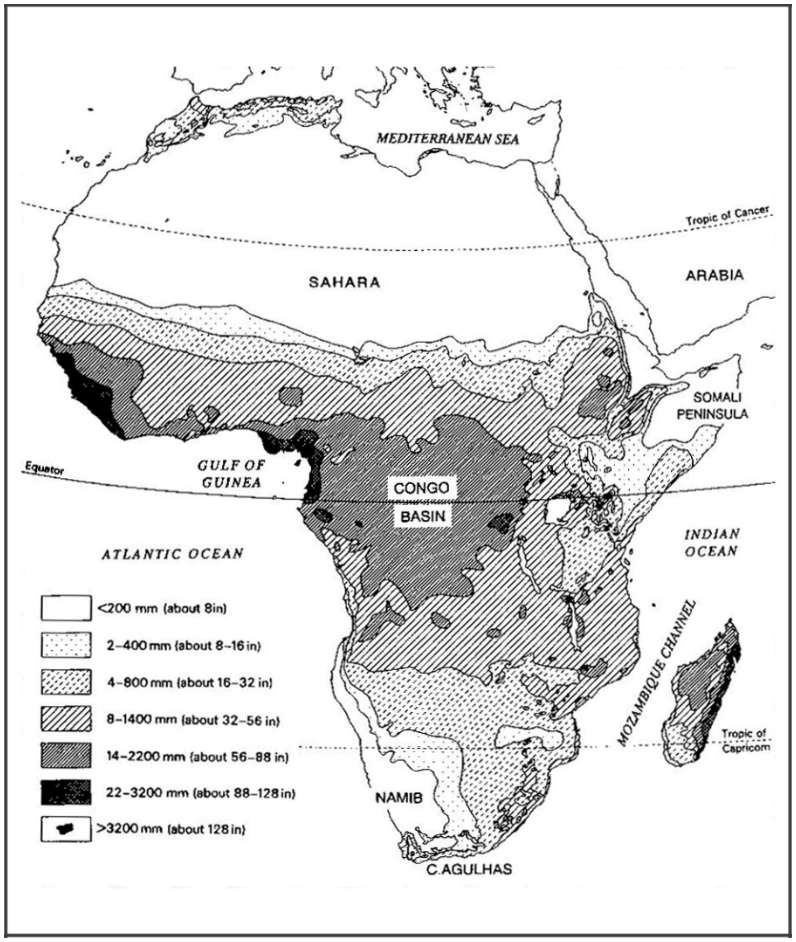

Figure II.2. As is pictured here, central coastal Ghana and Benin clearly receive substantially less rainfall than even closely neighboring regions (from Goudie 1996:40).

[486] Recent research by Sharon Nicholson (2009) has suggested that there is not a *direct* connection between the ITCZ and rainfall on the West African coast; rather, it is the tropical rainbelt that is responsible.
[487] It is also suggested by a number of authors that human influences such as deforestation and land use are becoming more significant factors in the reduction of rainfall in West Africa (Jenkins et al. 2002:264).

complex; they vary in different areas of the Atlantic Ocean (Gulf of Guinea) and produce significantly different results in coastal West Africa and the inland Sahel region (Janicot et al. 1998; Opoku-Ankomah and Cordery 1994). The ITCZ[488] is a complex phenomenon that is suspected to be a causal factor both of rainfall and of the Guinea upwelling (discussed below), but the exact role(s) and degree of influence it holds is debated (Hayward and Oguntoyinbo 1987:124; Nicholson 2009; Norris 1998; Osei and Aryeetey-Attoh 1997:10; Philander 1986; UNEP 1985:14). Simply, the ITCZ is a pulsating "narrow zone of discontinuity between a dry, continental airmass to the north and a tropical, maritime airmass to the south" (Hayward and Oguntoyinbo 1987:114); it is the migrating convergence zone of the Northern and Southern trade winds, as well as other air masses (Goudie 1996:35; Longhurst 1962:634). The ITCZ migrates in relation to a number of factors including earth-sun relations, temperature and equatorial trade winds (Le Barbé et al. 2002:193; Orme 2005:11). The migration of the ITCZ is a key factor in determining wind stress and variation along equatorial zones, but it is in turn affected by changes in climate (Philander 1986:236, 238; Opoku-Ankomah and Cordery 1993:552; Weisberg and Tang 1985:7117). For purposes of this study it is sufficient to attribute surface rainfall and climate variability with large-scale processes that involve both the larger area of the Gulf of Guinea and even weather on a global scale (Goudie 1996; Gu and Adler 2004:3373; Houghton and Colin 1986: 11,738; Koranteng and McGlade 2001:195; Opoku-Ankomah and Cordery 1993:551).[489]

[488] It is also called by other names, such as the Inter-tropical Discontinuity (ITD) (Hayward and Oguntoyinbo 1987:114), but it is most commonly called the ITCZ.

[489] Nicholson (2009:1166) provides a nice summary, stating that "in the boreal summer season three quasi-independent mechanisms control precipitation development over West Africa: ascent linked to the upper-level jet streams, convergence associated with the surface ITCZ, and a coastal circulation cell linked to sea-breeze effects."

Storms

Historical sailors' perceptions of storms are described in Chapter 3, but a number of more technical features are important to highlight here, particularly their affect on currents and the movement of sediment along and across the inner shelf. The driving mechanisms of storms along the Guinea coast are complex and likely are the result of the interactions of numerous different air/meteorological systems. Storms themselves differ significantly depending on numerous other factors, but primarily whether these weather systems occur over sea or over land (Hagos and Gu 2005; Nicholson 2009). Strength, intensity, numbers, and duration of storms along the coast change over the course of the rainy season, with the oceanic storms tending to be weaker and spread over a wider area than their continental counterparts (Figure II.3).[490] Storms of varying strengths affect coastal Ghana, including major hurricane- or cyclone-force storms (Greenland 2005:256), as well as more typical monsoon storms (Healy 2005). Storms tend to encounter the coast from the southeast, and are known to cause rain to sometimes blow "horizontally, or even upwards" (Lawrence 1964:141), indicating the level of powerful storms possible in the region. Storm surge and wave heights are dramatically increased, and currents run dramatically faster (up to 3 knots) during storm events along the coast of Ghana.

The affects of storms on currents and coastal processes are immensely important in terms of the building and erosion of the coast, as well as the destruction and preservation of submerged cultural resources. The zone of breaking waves can extend to 15-20 meters or deeper as a result of storms (Johnson et al. 1982:85; Niedoroda 2005:867), the result of which is significant movement and disruption of sediments on the

[490] That being said, however, while storms along the coast may be considered relatively weak in meteorological terms, their affects on the seas, on the ships on the seas, and on the remains in the seas are anything but weak (see Chapter 3).

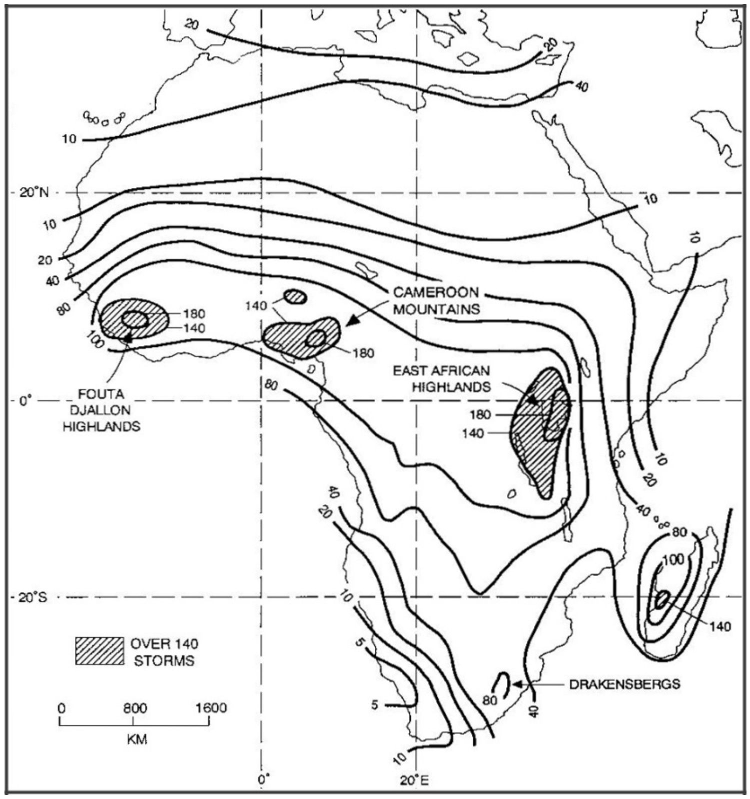

Figure II.3. As can be seen in this image adapted from Goudie (1996:45), Central Ghana lies in the zone receiving between 80 and 100 storms per year.

seafloor. As noted by Niedoroda (2005:867), both waves and currents are agents in the movements of sediments, with the currents determining the magnitude and direction of sediment transport. This is amplified in the event of a storm, with the power of storms to move sediments diminishing only "with increasing water depth across the whole width of most shelves" (Niedoroda 2005:867; see also Blondeaux 2001:353). In storm conditions sediment may be moved or "spilled" onto the inner shelf "from the surf zone, during which time "large-scale surf zone rip currents may reach well seaward of the break point… [This has been observed to contribute] to across-shelf transport on the inner shelf" (Wright 1995:9; see also Nittrouer and Wright 1994:92). The returning or seaward downwelling of storm surge can also be a significant mover of sediment across the shelf, both in seaward and shoreward directions (Gutierrez et al. 2005:81; Niedoroda 2005:868). As is noted in Chapter 6, it is likely that the cross-shelf transport of materials as a result of storms is a contributing factor to the presence of considerable amounts of intrusive material on the Elmina Wreck site.

Wind

As is typical for coastal environments, there is often wind along the Elmina coastline. The predominant year-round source of wind in the Gulf of Guinea is the trade winds (Nittrouer and Wright 1994:88). The winds that affect the coast are predominantly easterly[491] (Meredith 1967 [1812]:7) and blow approximately parallel to shore along the coast of central Ghana, as well as in some other areas of the Gulf of Guinea[492] (Acheampong 1982:204; Philander 1985:23). The alongshore winds in coastal Ghana are generally weakest in May and become the strongest in August (Verstraete 1992:4). Almost year-round, however, the winds tend to be calmer in the morning and pick up near mid-day, becoming the most powerful in the afternoon; the exception to this is, of course, when storms are present, which do not necessarily follow this pattern. Trade winds vary in strength and shift position for short periods of time, by and large in association with the wet season and coastal upwellings (Bakun 1978:148; Gu and Adler 2004:3366, Weisberg and Tang 1985:7117-7118); these shifts affect the types and strengths of winds along the coast. In coastal Ghana, as with much of the northern coast of the Gulf of Guinea, wind in the rainy season is predominantly from the southwest and characterized by high winds and line-squalls[493] (Boateng 1967:32; Hayward and Oguntoyinbo 1987:137-140). Creating similar patterns as storms, sea breezes (onshore winds) are known to increase wave height, decrease wave period, increase cross-shore[494]

[491] Meaning that they originate in the west and travel in an easterly direction.
[492] Rømer (2000:18) writes that the winds along the entire Ghanaian coast blow from the southwest most of the time.
[493] A squall or sudden violent wind often accompanied by precipitation advancing along a front that forms a definite line.
[494] Cross-shore transport refers to "the cumulative movement of beach and nearshore sand perpendicular to the shore by the combined action of tides, wind and waves, and the shore-perpendicular currents produced by them." This is occurring almost continuously with sediments either in suspension or moving in flows along the surface of the seafloor, and it is artificial to separate this process with the other processes

sediment transport seaward, and dramatically increase longshore transport rates (Healy 2005:313),[495] all of which are potential formation factors in the condition of submerged sites. Dry season winds are mostly northeastern[496] trade winds, also known as harmattan

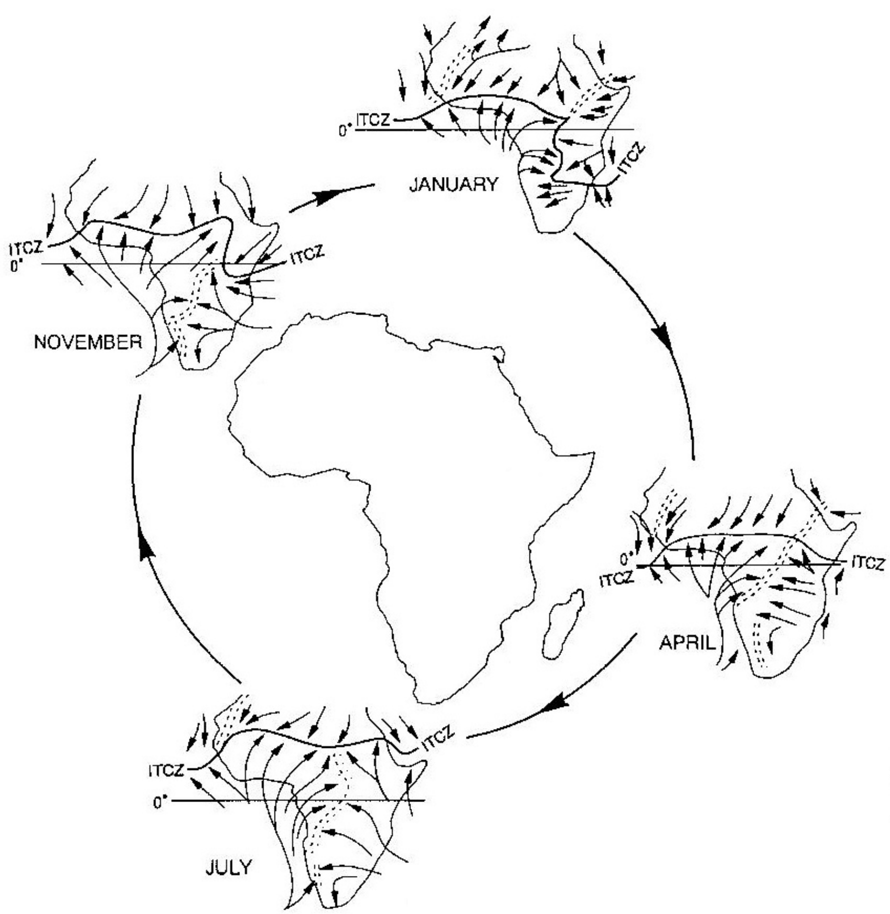

Figure II.4: The annual cycle of surface winds around Africa is shown here in relation to the position of the ITCZ. Other authors (Osei and Aryeetey-Attoh 1997:12-13) depict the winds actually hitting the coast at greater angles (closer to parallel with the coast), but the usefulness here is in seeing the range of influence of the various winds in different seasons (modified from Goudie 1996:35).

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occurring at the coast, including longshore drift and wind currents. The cross-shore sediment transport is responsible for a balancing of sediments between the shore and shelf; hypothetically this process would ensure that the amount of sediment in a system remains constant (balancing from one end to the other), but because of other forces present, it is more accurate to say simply that the cross-shore transport contributes to the movement and balance of sediments between the shore and shelf (Seymour 2005a).

[495] Nicholson (2009:1162) also suggests that the sea-breeze circulation is instrumental in rainfall formation.

[496] Blowing from the northeast to the south southwest.

winds, which are heavily laden with dust from the Sahel and Sahara (Burke 1972; Breuning-Madsen and Awadzi 2005:36; Dickson and Benneh 1970:26; Goudie 1996:36; Ly 1981:232).[497] However, as Awosika et al. write (1993:31), these winds are countered in coastal areas by on-shore[498] winds during the dry season, preventing a complete drying out of the region as is typical in most of sub-Saharan West Africa (Figure II.4).

Air and Water Temperatures

Although it varies with distance from the sea, the average air temperature in Ghana is between 25° and 33°C (Allersma and Tilmans 1993:206; Dickson and Benneh 1970:32-33). Part of the immense and complex system, air temperature contributes to and is affected by other factors and forces such as the ITCZ and SST.[499] Global sea surface temperatures (SST) play an essential role in season changes and rainfall variability in West Africa (Goudie 1996:36; Gu and Adler 2004:3365; Janicot et al. 1998; Nicholson 2009:1168; Opohu-Ankomah and Cordery 1994; Philander 1986;237).[500] The mean annual SST of the Gulf of Guinea is 27°C (Gordon et al. 2000:455; Gu and Adler 2004:3369), but it varies seasonally by between 5 and 7°C, mostly in relation to the Guinea upwelling (Houghton 1983:2070) and with location and time along the coast (Koranteng and McGlade 2001:190). The warmest SST, along with the most relaxed winds, is observed in the months of March and April, while the coldest is during the months of July through September and clearly associated with the upwelling (Bakun 1978:150; Gu and Adler 2004:3369; Philander 1986:237). The combinations and

[497] The dryness of the harmattan winds was actually considered to be “salubrious” by some Europeans on the coast, as it had the effect of drying the excessive dampness of the rainy season and thereby allowing healing of illnesses caused by the moist and humid conditions of the rains (Meredith 1967 [1812]:11-13).
[498] Winds blowing from the sea onto land.
[499] For example, the Guinea upwelling drops overall temperatures by several degrees.
[500] SST is generally equivalent to the temperature at approximately 10 m water depth (Weisberg and Colin 1986:240).

interactions of air and water temperatures are two major driving mechanisms for the larger coastal and meteorological systems that impact coastal West Africa.

Coastal Oceanography

Wind is the primary mover of water in coastal environments (Buckle 1978:194; Viles and Spencer 1995:26), and, as Nihoul (1975:41) writes, "the whole dynamics of the marine system is driven by the sea motion. Dispersion of nutrients or pollutants, migrations, sedimentation and sea bottom erosion are conditioned by the mixing and circulation of the water masses [that are driven predominantly by the wind]". The coastal oceanography of the Gulf of Guinea is a complex system of currents, countercurrents, shifting winds and storms that affect the shelf and near-shore environments in numerous ways. The currents generated by waves[501] (generated primarily by the wind) flowing along the continental shelf and in the nearshore areas are the primary forces that shape the geomorphology of the coast, and affect submerged archaeological site formation processes. Waves and swells in the Gulf of Guinea generally approach the shore from the southwest to south-southwest (Adam 1998:146; Martin 1971:86; Orme 2005:11; UNEP 1985:27),[502] as does the longshore drift.[503] "Surface waves and currents operate together in the coastal zone, interacting with sea bottom sediments in the nearshore zone and on the continental shelf down to depths as great as 200 m" (Trenhaile 1997:74; see also

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[501] This process and the associations of tides, waves and currents are not simple or linear, but for purposes here a simple explanation will suffice. A as explained by Anthony and Orfor (2002:9), "The interaction of waves and tides is embedded at two levels: (1) mean currents that jointly reflect time-averaged wave and tidal forcing, and (2) the effects the large vertical and horizontal tidal excursions have on waves."

[502] "Because of the orientation of Africa's west coast, the southwesterly swells generate mainly east-flowing longshore currents along the west-facing coast… This nearshore wave-driven circulation is reinforced offshore by the Guinea and Benguela Currents" (Orme 2005:11-12).

[503] The longshore drift is the gradual movement of sediments along a coastline that is the result of a number of factors including waves, swells and currents (Seymour 2005a:600). Longshore drift transports the most sediments during the months from June to September in the northern hemisphere (Orme 2005:12).

Suhayda et al. 1982:66). However, “[t]he 10-11 m depth contour has been considered as the outer limit of significant wave action” [504]on the continental shelf of the Bight of Benin coast (Anthony and Blivi 1999:165), and it is accepted that this applies to the Elmina region as well. This is particularly significant because the Elmina Wreck is located just on this boundary and is thus significantly affected by all of the forces that affect sites closer to shore and in shallower water as well.

Waves, Swell and Tide

> The origin of these wonderful phenomena is a secret that the ocean still preserves its own….But whatever may be their causation, we can bear our testimony to at least one of their effects – that of all…experiences of Western Africa none have a more lasting impression on the mind of the coaster than the monotonous rolling of its never-ceasing swell (Allen 1874:70).

The coast off Elmina is a medium- to high-energy coast with high waves and powerful currents (Edmunds and Edmunds 1973:371; Martin 1971:86). Off most of West Africa the break between the continental shelf and deep-ocean is at the 100 to 120 meter contour (Awosika and Ibe 1998:22; Martin 1971:93; UNEP 1985:40; Wright 1995:2), but the distance from shore at which this occurs varies. When the continental shelf is narrow, as is the case off Ghana, the energy of the waves is much higher than on wider shelves (UNEP 1985:40).[505] The strength and effect of swells is directly linked with the width and depth of the continental shelf, and as a result of it being narrow, ocean waves and currents can approach it unmodified and are therefore particularly influential in sediment transport and coastal ecology (Orme 1996:238). Patterns of waves are dictated by wind

[504] In terms of the direct effects of the waves on the seafloor.
[505] This is obviously an important factor to bear in mind when investigating site formation processes.

and the semi-diurnal tides[506] in the equatorial regions of West Africa, averaging a range of 1-2 m up to 4 m, modified occasionally by storms (Allersma and Tilmans 1993:207-208; Buckle 1978:207; Buller et al. 1975:202; John et al. 1977:498; Orme 2005:12; Pethick 1984:52; UNEP 1985:23; Viles and Spencer 1995:43), and are greatest or highest during the months of July and August (Darbyshire 1957:277). Initially wind-driven, waves are generated in deep water and travel shoreward (Buckle 1978:194; Pethick 1984); they are also generated by local winds and storms or the monsoon (Soulsby 1997:65).[507] Swells are generated farther away in the Atlantic Ocean and are a nearly constant feature of the Ghanaian coastline (Allersma and Tilmans 1993:210; Buckle 1978:194; UNEP 1985:25).[508]

The effects of waves are greatest in relatively shallow waters,[509] but during storms or tsunamis caused by earthquakes[510] their depth of influence can exceed 100m (UNEP 1985:55). As swells and waves reach the angled shoreline, the velocity of the wave increases and the wave-pattern essentially bends as it approaches the shore, breaking the waves at an angle oblique to the shoreline (Allersma and Tilmans 1993:210;

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[506] Tides that occur twice a day with two high water levels and two low water levels (Graber 2005:247). Tides also have longer cycles that are called spring and neap tides, each of which occur twice a lunar month (periods of 13.66 and 14.77 days for twice-daily tides), and along the Ghanaian coast these have a range of ~1.6 m during springs to ~0.3 during neaps,(cited in Nixon et al. 2007:S146; see also Graber 2005:247; Howarth 1982:11).

[507] The monsoon is a seasonal, although not linearly consistent, cycle of movement of rain bands in West Africa that provides various amounts of rain at different periods to different parts of West Africa; the variations on location and amounts of rain produced by the monsoon are associated primarily with the ITCZ (Hagos and Gu 2005; Janicot et al. 1998; Le Barbé et al. 2002:195; Ramel et al. 2006:249), although recent research is suggesting that other forces play an even more pivotal role (Nicholson 2009).

[508] The term swell refers to "[l]ong, low waves (wave period typically 12-16 s) generated by distant storms and transmitted across oceans and seas" (Bird 2005:118). Swell is "higher in higher latitudes, slowly decreasing toward the equator. They are characterized by moderate to high (2-3m 50%), long period, uniform swell, with the period of higher swell associated with major cyclones, and lower swell in between" (Short 2005b: 1057-1058). The west coast of Africa is considered a West coast swell environment.

[509] Although the degree of influence is dependent on the wavelength of the swell.

[510] The continental shelf of Ghana is the primary (one of only a handful) location in West Africa that experiences earthquakes (Ambraseys and Adams 1986:679, 681, 698; Amponsah 2004; Arens et al. 1971:72, 75; Attoh et al. 2005:549; Awosika and Ibe 1998:21; Bacon and Banson 1979; Bacon and Quaah 1981; Bates 1941; Crow 1956:52; Wright 1985:151).

Awosika et al. 1993:32). It is this angling towards the shore that produces wave-induced currents and the longshore drift (Gelfenbaum 2005:260; Ly 1981:232). The breaking action[511] of waves, in conjunction with swell and generated current, is the main agent of erosion, transport and deposition of sediments in coastal environments, and this is particularly true in West Africa (Anthony and Orford 2002:13; Buckle 1978:194; Orme 1996:248; Viles and Spencer 1995:24; UNEP 1985:46). The combined efforts and interactions of waves and currents play the most important roles in sediment dynamics of the coastal zone (Howarth 1982; Masselink 2005; Souslby 1997:87; Wiberg 2005:1053; Wright 1995:8).

Currents and Longshore Current/Drift

Two of the primary concerns in understanding currents in this research include their roles in the transportation of sailing vessels on the surface and their obvious role as formation processes in the transport of materials such as sediments and even larger artifacts below the surface, for instance, in the longshore drift. For these reasons, as well as the importance of understanding the complex and interrelated system of currents in the Gulf of Guinea, the discussion on the currents is somewhat extended compared to that of some of the other formation agents. A brief discussion of longshore currents and drift is included because these are both the results of current actions and agents of transformation on the seafloor; their interconnectedness dictates an embedded discussion.

As with all aspects of the ocean, currents are complex in terms of what causes and perpetuates them and their affects on the maritime environment (Gelfenbaum

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[511] "The asymmetry of velocities beneath the crest and the trough of waves is another source of net transport of sediments" (Soulsby 1997:65).

2005:259).[512] Soulsby (1997:45) provides a succinct synthesis of currents in the following quote:

> Currents in the sea may be caused by tidal motions, wind-stress, atmospheric pressure gradients, wave-induced forces, river outflows, large-scale quasi-steady water surface slopes and horizontal density gradients associated with oceanic circulations. In the nearshore region, wave-induced (longshore) currents are dominant, whereas further offshore a combination of tidal and meteorological forcing (including storm surges) dominates. Currents both stir up and transport sediments, and hence the sediment transport largely follows the current direction. However, because the sediment transport rate depends non-linearly on the current speed, and also because the effect of wave-stirring is important, the direction of net long-term sediment transport may be very different from the residual current direction.

As Soulsby notes, it is possible for net sediment transport deposition patterns to not follow the predominant current direction. This is possibly a factor involved in the transport of intrusive materials to the wreck site from the town of Elmina (discussed in Chapter 6), but it is important to note that in this region of the coast sediment movement and deposition patterns follow the predominant path of the currents (Awosika and Ibe 1998:24), so this is not a conclusive explanation. This has been observed by divers on sites across the region, and is also indicated in the consistent sediment deposition patterns detected in the geomorphological analysis of side scan sonar data collected in 2003 and 2009 (discussed in more detail in Chapters 5 and 6, and Appendix VIII).

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[512] An interesting addendum to the discussion on boundaries in Chapter 3 may be found in Gelfenbaum's (2005:260) comment on boundaries and currents. He writes that regardless of their origin, "coastal currents are effected by their proximity to a boundary, either the seafloor or the atmosphere. Boundaries tend to modify ocean currents through the action of friction. The regions, or layers, in which currents are modified are called boundary layers. Boundary layers near the bed and near the surface can be 5-20m thick, so on the inner and middle continental shelf, the dynamics of the boundary layers can make up a significant percentage of the water column." His discussion continues with details of boundary layers, but the association with crossing boundaries in terms of space and in relation to submerged cultural resources is clear.

Under normal or general conditions, the threshold limits[513] of coastal currents reach between 10 and 30 m depth, with the most significant coastal dynamics, including sediment transport, taking place between 10 and 15 m (Allersma and Tilmans 1993:219; Anthony and Blivi 1999:164; Buchanan 1954:31-32; UNEP 1985:40). Most sediments are redistributed by the longshore[514] or littoral[515] currents, and less importantly by the tidal currents (Allersma and Tilmans 1993:209, 213; Awosika and Ibe 1998:24; Awosika et al. 1993:32; Burke 1972; Holmes 1975:1; Pethick 1984:35, 91). The action of the longshore and littoral drift in coastal Ghana are responsible for the predominate and most powerful movement of sediments[516] from west to east, parallel with the coast near Elmina (Komar 1975:18; Webb 1958:308).

Although there is some debate on the matter (Webb 1958), it is generally accepted that there are relatively consistent patterns in the currents in West Africa (Richardson and Philander 1987). That being said, however, these patterns do include variations in surface and sub-surface currents created by seasons and the presence or absence of the ITCZ; variations in coastal morphologies; and variations in the speeds, and at times the directions, at which the currents move (Longhurst 1962; Richardson and Philander 1987:729; UNEP 1985:15). It was vital for the historical sailor to not only be able to read the currents and sea conditions, but also to be able to predict them at different times of

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[513] The depths to which they can affect the seafloor.

[514] A current traveling along the shore that is created by the oblique angle approach of breaking waves, and may also be enhanced or reduced by wind-driven or tidal currents (Seymour 2005b:600).

[515]The littoral may be divided into a number of different zones, but is generally considered to be near shore, generally within the tidal zone and between tides; the sublittoral region includes water out to a depth of 200m or more (Bokuniewicz 2005:593).

[516] It is not possible here to go into all the mechanics of the sediment transport by water, nor are those details necessary for a situated understanding of the environmental processes at work in the region. What are of primary interest here are the macro-mechanisms, such as the speed and direction of currents, that act as formation processes of submerged sites. A selection of the vast literature addressing the detailed mechanics may be found in the following references: Adams and Weatherly (1981); Bagnold 1946; Blondeaux (2001); Johnson et al. (1982); Niedoroda (2005); Nittrouer and Wright 1994; Perry and Taylor 2007; Soulsby (1997:131); Wright (1993, 1995).

year and in different locations. A description of current conditions in the northern Gulf of Guinea by sailor John Adams (1966 [1823]:168-169) nicely illustrates the sea conditions and also demonstrates the intimate knowledge that sailors had of the environments in which they operated:

> The general direction of the currents between Cape Palmas [Liberia] and Bonny [Nigeria], is easterly, varying in velocity from twelve miles in twenty-four hours, to thirty miles in the same time. From April to September, the current runs with the greatest rapidity to the eastward; but from the latter end of September to March, it sets occasionally to the westward. The harmattan wind is always accompanied by a westwardly current; and a tornado gives an impulse to the water in the same direction, which frequently continues during a day or two afterwards.

At least seven currents, the North Equatorial Current (NEC), the South Equatorial Current (SEC), the North Equatorial Countercurrent (NECC), the Guinea Current, the Ivoirian Current, the Equatorial Undercurrent (EUC) and the Guinea Countercurrent are active in northern Gulf of Guinea on a regular basis (Figure II.1, Table II.1).

Abbrev.	Name	Position	Flow	Influence*
NEC	North Equatorial Current	~7°N - ~20°N	westward	minor
NECC	North Equatorial Countercurrent	3°N - 10°N	eastward	major
GC	Guinea Current	3°N - 5°N	eastward	major
	Ivoirian Undercurrent	below GC	westward	unknown
	Guinea Countercurrent	2°N - 3°N	westward	minor
EUC	Equatorial Undercurrent	2° N - 2°S	eastward	minor
SEC	South Equatorial Current	~4°N - ~ 15-25°S	westward	minor

*Influence is determined by proximity of the current to the continental shelf near Elmina, and therefore to its likelihood of impacting submerged cultural resources located there.

Table II.1. This table provides a basic summary, based on the sources and characteristics discussed below, of the particulars of each of the currents active in the northern Gulf of Guinea. The column marked "Influence" refers to the direct or potential impact of each current on submerged cultural sites in coastal central Ghana.

Three of the currents, the NECC, the Ivoirian Current and the Guinea Current, are in direct association with the coastline, and therefore potentially have direct impacts on submerged sites near the coastline. A dense but informative description of several of these currents and their interactions with each other is provided by the US Navy Hydrographic Office (1951:17-18):

> The Guinea Current sets southeastward and eastward along the African coast between Cape Roxo [Senegal] and the Bight of Biafra [Nigeria]. It is a continuation of [the NECC,] a current which sets southward along the western coast of northern Africa…In the Gulf of Guinea the southern limit of the Guinea Current is about the first parallel of north latitude [where it meets the SEC]. The space separating the Guinea and [South] Equatorial Currents is generally limited and there is accordingly presented the remarkable feature of two well-defined streams running in exactly opposite directions side by side. Their courses continue thus parallel to each other and to the land for over 1,000 miles, and a vessel placed in one or the other current will have her progress aided from 40 to 50 miles a day, or retarded the same amount… The [South] Equatorial Current has a westerly course between the continents of Africa and America… In the vicinity of the African coast the line of demarcation between the two currents is indicated as follows: Annobon is considered to be at all seasons in the [South] Equatorial Current, Ilha do Principe in the Guinea Current, and São Tomé, situated nearly midway between the two, as within the influence of one or the other current, according to the season.[517]

[517] An additional and more technical quote demonstrates just how complex these currents are within just a few degrees on either side of the equator: "The mean dynamic surface topography [of the northern Gulf of Guinea] shows a ridge at about 2°-3°N flanked by low dynamic heights… This ridge is a consequence of the strong equatorial front that runs latitudinally at about 2°N in the Gulf of Guinea, separating the warm and low salinity (26°-28°C, 34.5-35.1) tropical surface water north of 2°N from the relatively colder and saltier equatorial waters. The low dynamic heights [of wind-driven waters] along the northern African coast [of the Gulf of Guinea] are the signature of the strong and shallow geostrophic Guinea Current flowing eastward between 3°N and the coast… At about 2°N, a strong westward geostrophic flow is identified as the South Equatorial Current (SEC). At 1°S, the surface geostrophic flow is eastward and opposite to the surface Ekman drift associated with the southerly winds. Note that along the northern coast at 4°-5°N, the sea surface topography slopes upwards from 4°W to 6°E. This westward zonal pressure gradient is responsible for the coastal Guinea undercurrent" (Verstreate 1992:34). See Bakun (1978:147); John et al. (1977:500); Philander (1979:29); Sireyjol (1977:401) for additional descriptions of the complex currents in the Gulf of Guinea.

The exact position of the currents relative to each other depends on the time of year, and, as is seen in the descriptions below, researchers are still struggling to fully decipher the immensely complicated and intertwined systems of currents operating in the northern Gulf of Guinea. All of these currents play tangible roles also in terms of carrying out field research in coastal Ghana, as the strength and direction of currents not only affects submerged sites, but also the conditions in which work is carried out; the faster a current is running, the more difficult it is to accomplish anything in terms of field investigations.

The North and South Equatorial Currents

The North Equatorial Current is a westward-flowing northern boundary to the North Equatorial Undercurrent (NECC) (Bischof, Rowe et al. 2004; UNEP 1985:15) It is found in the North Atlantic from about 7°N to about 20°N, and as such is several degrees north, and, by necessity of the African landmass, west of the research area of interest here. It is fortified by the Atlantic trade wind belt and is a “broad westward flowing current that forms the southern limb of the North Atlantic subtropical gyre” (Bischof, Rowe et al. 2004). It originates on the northwest coast of Africa, fed by the Canary Current, and flows south along the coast until it meets the NECC and turns westward.

The cold South Equatorial Current (SEC) is an intense westward-flowing current between Africa and the Americas and is generally located between its northernmost position at 4°N and somewhere between 15-25°S, depending on longitudinal location and time of year (Bonhoure et al. 2004; US Navy Hydrographic Office 1951:17-18). It has three main branches, the Northern South Equatorial Current (NSEC), the Central South

Equatorial Current (CSEC), and the Southern South Equatorial Current (SSEC), as well as a fourth offshoot known as the South Equatorial Undercurrent (SEUC); all of these are likely the result of the SEC encountering the eastward-flowing Equatorial Undercurrent and splitting (Arnault 1987:5077-5080; Bonhoure et al. 2004; Richardson and Riverdin 1987:3700). The SSEC and CSEC are too far south to be of concern here, but the NSEC, which is a slow, westward-flowing current, does extend above 1°N during the boreal winter, which may have an impact on the northern Gulf of Guinea. The SEUC is an eastward-flowing current located between 3°S and 5°S (Bonhoure et al. 2004), and is of interest here only because its northward turning at the coast appears to be the source of the Ivoirian Undercurrent (discussed below) (Gyory et al. 2005; Norris 1998).

The Equatorial Undercurrent and the Guinea Countercurrent

The Equatorial Under Current (EUC) is located between 2° N and S and travels from west to east across the Atlantic towards the Gulf of Guinea (Verstraete 1992:1). The EUC is centered around the equator and in the thermocline, and is a relatively stable and quasi-permanent feature in both the Pacific and Atlantic Oceans (Izumo 2005:110; Philander 1980:191). It is a strong, “jet-like subsurface current,” the source of which (in the Atlantic) is likely the high-salinity Northern Brazil Coastal Current (Fahrbach et al. 1986:763; see also Bonhoure et al. 2004). In the Gulf of Guinea it exists just under a westward flowing surface current (the SEC), and just above and north of it is the eastward surface flow of the Guinea Current (Bonhoure et al. 2004; Philander 1980:202-203). It eventually splits into two different branches; one splits to the south of the equator where it approaches the island of Sao Tomé, and the other goes north to feed into a westward undercurrent along the northern coast of the Gulf of Guinea (Fahrbach et al.

1986:763-764). It is thought to be tied to a number of oceanographic and meteoric events, including the Los Niños events (Philander 1980:192), and it likely plays a major role in the Guinea upwelling (Izumo 2005:110; Verstreate 1992:55). Apart from it being a major current in the system of the Gulf of Guinea, it is also important to note that the EUC is a key player in the westward-flowing subthermoclinal[518] Guinea Countercurrent between 2°-3°N,[519] a branch of which is the relatively minor westward-flowing Guinea Undercurrent along the shelf[520] (Binet and Marchal 1993:106; Hisard and Merle 1979:327; Verstreate 1992:38). Because it carries cold water, it creates an intense thermocline just below the Guinea Current, a feature that divers can attest is particularly true.

The North Equatorial Countercurrent

The North Equatorial Countercurrent (NECC) is an intense surface eastward current found in both the Pacific and Atlantic Oceans. It appears seasonally in the Atlantic between 3°N and 10°N in the vicinity of the ITCZ. It is bounded by the North and South Equatorial currents and just east of 2°E it essentially becomes part of the Guinea Current (Arnault 1987:5080; Bischof et al. 2004; Hénin and Hisard 1987:3751; Richardson and Riverdin 1987:3691). The flow of the NECC is controlled by changes in seasonal wind forcing and is particularly interesting in that it disappears at the surface for approximately half the year, although it is never completely gone (Hisard and Merle

[518] Below the thermocline.
[519] The Guinea Countercurrent is part of the return flow of the EUC.
[520] Although various researchers call it by different names, this is the same description given to the Ivoirian Undercurrent.

1979:327).[521] The origin of the NECC is the North Brazil Current, but it is also fed by the Canary Current and the NEC. Martin (1971:86) reports that its thickness varies from 10 to 20 m, and its velocity is 0.5 knots (see also Arnault 1987:5077). In addition, Martin notes that "[u]under this superficial current there is an undercurrent flowing east to west. Its mean velocity is 0.1 knots in depths of 30 m and 0.5 knots in depths of 40-50 m." As noted above, this appears to be referring to the same current that other authors have identified as the Ivoirian Undercurrent.

Ivoirian Undercurrent

The seemingly most ambiguous current in the northern Gulf of Guinea is the Ivoirian Undercurrent. Mistaken at times for a reversal in the Guinea Current (Lemasson and Rebert 1973:312), it appears to be its own rather unobtrusive entity that is known by several names, including the Guinea Under Current (GUC), and simply "a superficial undercurrent flowing east to west." The Ivoirian Undercurrent is a slow, narrow, westward-flowing extension of the generally east-flowing South Equatorial Undercurrent (SEUC), which is in turn a branch of the generally west-flowing SEC (Bonhoure et al. 2004). It runs along the inner shelf, directly under the eastward-flowing Guinea Current to an average depth of between 50 m and 80 m (Lemasson and Rebert 1973:304; Verstreate 1992:38) (Figure II.5).

[521] Even with this peculiar behavior, Richardson and Riverin (1987:3700) claim that the NECC has the "largest and most regular season in the Atlantic."

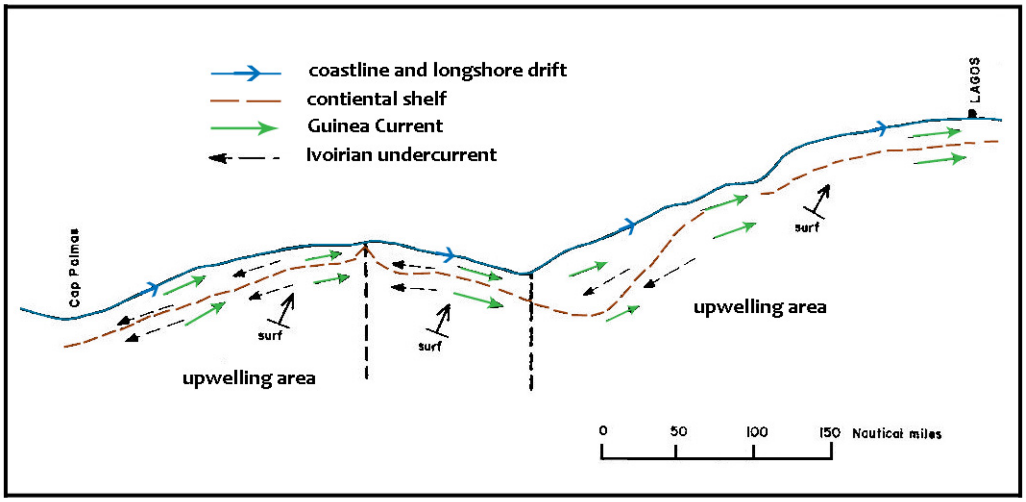

Figure II.5. This simplified sketch illustrates the relationships of the Guinea Current, Ivoirian undercurrent, surf and longshore drift of part of the coast of West Africa, including coastal Ghana (modified from Martin 1971:89).

It is possible that it is both the result of and a contributor to the upwellings along the northern coast of the Gulf of Guinea, although exact origins are not clear (Lemasson and Rebert 1973). As noted earlier, it likely is also related to both the EUC and the SEUC. Its role in the site formation processes of submerged sites along the Ghanaian coast is not clear, but it is a factor that cannot be ignored.

<u>Guinea Current</u>

The Guinea Current is an eastward-flowing coastal current that transports low-salinity, warm waters in the northern extent of the Gulf of Guinea (Hisard and Merle 1979:327). It is an extension of the NECC and the Canary Current, "both of which contribute amounts of water that vary seasonally. Both currents appear stronger in the northern summer months; consequently the Guinea Current is stronger during that period also" (Ingham 1970:3; see also Gyory et al. 2005; Hisard and Merle 1979:327; Longhurst 1962:642), although it runs eastward year-round (Hénin and Hisard 1987:3755;

Richardson and Riverdin 1987:3697). The current is characterized by areas of upwelling, such as the Guinea upwelling, and runs approximately between 3°N and the coast at 5°N. Its greatest velocity is experienced off Cape Palmas, and between it and Cape Coast Castle, just to the east of Elmina. In June it sometimes attains the rate of 85 miles a day [3 knots per hour] (US Navy Hydrographic Office (1951:17-18). It extends in width some 200 miles offshore along most of its length; it is considered the northern boundary of the west-ward flowing SEC (Arnault 1987:5087; Longhurst 1962:644). At the coast the Guinea Current extends from the surface to about 15m deep, extending to 25m deep offshore. It overlays the westward flowing Guinea Under Current (Binet and Marchal 1993:106). As noted above, there has been some speculation that there are actually seasonal reversals in the direction of flow of the Guinea Current (Ingham 1970:4; Richardson and Riverdin 1987:3698), but other researchers attribute the apparent reversal instead to the surfacing of the near-shore Ivoirian Undercurrent (or the Guinea Undercurrent) and subsequent temporary seaward displacement of the Guinea Current (Colin 1988:131; Gyory et al. 2005). The data are still considered somewhat inconclusive on this matter.

All of these currents have variations in location, speed, salinity, temperature, and sometimes even in direction, and each of these factors is dependent on numerous others. To summarize, in general, equatorial currents are “very swift, transport large amounts of water, and have huge spatial and temporal variations” (Richardson and Riverdin 1987:3691). The importance of having at least a rudimentary understanding of the complex suite of currents active in the northern Gulf of Guinea lies in their roles as direct and indirect agents of formation, and, as demonstrated above and elsewhere, their clearly crucial role in historical maritime trade in this region of the world. The different routes that sailing vessels took were directly related to, aided or impeded by, and indeed controlled by the Atlantic currents and winds.

Water Temperature, Salinity and Thermocline (The Guinea Upwelling)

Water salinity[522] varies according to different inputs, namely the meeting of fresh river water and sea water, which has significant impacts on the dynamics, character and distribution of the water masses as they flow over the continental margin (Allersma and Tilmans 1993:209; UNEP 1985:15). General salinity in the Gulf of Guinea is low, usually less than 35 parts per million, and the average temperature of surface water is above 24°C (Houghton 1976:909; John et al. 1977:498), and any temporal variations in salinity "are largely found at the sea surface and coastal regions due to the influence of rainfall and river runoff" (Jones 2003:13). That being said, however, there are variations in salinity and temperature of the various currents circulating in the Gulf of Guinea (Hénin and Hisard 1987:3756-3757; Houghton and Beer 1976).

A phenomenon that is not well understood and which occurs along much of the southern coast of West Africa,[523] and is most intense on the coast of Ghana, is the seasonal Guinea upwelling. The upwelling generally occurs for several weeks during the months of June and October respectively, although there is variation in the times at which the upwelling makes its appearance (Houghton 1976:909-910; Houghton and Colin

[522] Water salinity is intimately connected to SST, a factor that both affects and is affected by atmospheric and oceanographic conditions.
[523] Upwellings are actually typical around much of Africa (Lacombe 1970:62; UNEP 1985:22), but it is the unique Guinea upwelling, which, interestingly, is located along a west-east coast as opposed to the typical north-south position (Clarke 1979:3743) that is of interest here.

1986:11,736; Ingham 1970; Philander 1979:23; UNEP 1985:22).[524] Simply, an upwelling is a mass of cooler subsurface water that is forced to the surface (in the case of coastal Ghana, near the coast) due to one or a combination of forcing mechanisms.[525] This results in the newly-surfaced water near the coast replacing surface water that was moved offshore, creating an upwelling (Bakun 1978:148; Gelfenbaum 2005:260; Houghton 1983:2080, 1989:4822; Weisberg and Tang 1985).[526] At the relaxation of or change in forcing mechanisms, a subsequent downwelling occurs and the water bodies return to their respective vertical locations (Nittrouer and Wright 1994:91). Upwellings may occur over a very short timespan of several hours (Healy 2005:312), or over a period of weeks, as is the case with the Guinea upwelling (Koranteng and McGlade 2001). Associated also is an intensification[527] of the eastward Guinea Current (Philander 1979:23, 29) and a lowering of temperatures on land, although there may be a number of forcing

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[524] Koranteng and McGlade (2001:188) and Houghton and Colin (1986:11,727) report that there are actually two upwelling seasons in Ghana, one major and one minor, but here too, the reason for discussing the upwelling at all is to highlight the variability of offshore conditions and to simply identify potential sources of impact on shipwreck sites. Particular processes and effects will require further investigation.

[525] The most common explanation for this is that wind-generated surface currents are interrupted by the coast, which forces the water to rise in order to satisfy the mass balance of water (Barua 2005:306). It results from "a process combining atmospheric and oceanic factors…Through wind actions, deep oceanic waters are moved upwards to the coast, while surface waters flow offwards [seaward] as a drift current, due to the wind called the Ekman transport" (UNEP 1985:22). Simply, the Ekman transport is the movement of water (current) at right angles to the prevailing wind, a process that eventually dictates that the water moves in a downward spiral called the Ekman spiral (Gelfenmaun 2005:260), creating a vertical displacement of water, which then allows for the upwelling. Although this is the generally understood mechanism for upwellings, it appears that this is not the cause, or at least not the sole cause for the Guinea upwelling. While the driving mechanisms behind the Guinea upwelling are considered to possibly include the wind forcing, they are not considered to be the sole cause of it (Ingham 1970; Lacombe 1970:59-61; Koranteng and McGlade 2001:188; Philander 1979:29; Verstraete 1992). Regardless of its origins, the purpose of this description is to provide a basic picture of the movements of the upwelling and subsequent downwelling so that any potential interaction with submerged cultural resources may be better investigated, understood and interpreted.

[526] It is *possible*, although a great deal of research must be done to confirm this, that the subsequent downwelling of the Guinea upwelling may play a role in the transport of cultural and other material offshore. This is further discussed in Chapter 6.

[527] Increase in speed.

mechanisms at work to create these responses (Clarke 1979:3748; Koranteng and McGlade 2001:188; Verstraete 1992:12).[528]

The upwelling may drop the surface water temperature as low as 18°-19°C (Acheampong 1982:206; John et al. 1977:498), although 20-21°C is also considered a significant drop in temperature (Houghton 1983:2071; Koranteng and McGlade 2001:191).[529] Houghton (1976:909) reports, additionally, that the coldest waters of the upwellings are always found east of Cape Three Points in Ghana.[530] Simply, the "upwelling lowers water temperature, salinity and oxygen content, and…is a seasonal phenomenon [that] may be perennial in some regions" (Bezrukov and Senin 1971:3).[531] In addition to this, the cold upwelled water tends to produce a drop in temperature in the region adjacent to it, which often results in sea fog when moist air is present (Barua 2005:307). The presence of fog created serious issues for visual navigation of sailing vessels on a rough coast in the period of the Atlantic trade, and continues to be problematic for sailors today.

Coastal Geomorphology and Elmina

Discussion to this point has focused on the climatic and oceanographic environment and has only briefly touched on the fabric of the coast and seafloor when

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[528] Verstraete (1992:12) makes the following observation concerning these changes: "[t]he summertime increases in the southerly wind stress in the Gulf of Guinea (the African monsoon) may account for both the cool superficial waters observed from June through early October at and south of the equator, and the strengthening of the eastward Guinea Current observed at 3°-5°N."

[529] Because this colder water is generally more nutrient-rich, it brings with it and attracts a variety of sealife that have significant impacts on fishing industries, weather, and currents (Barua 2005:306—307; Binet and Marchal 1993; Gelfenbaum 2005:260; Houghton 1976:910; Ingham 1970; Lacombe 1970:63; Longhurst 1962:659; Signorini et al. 1999).

[530] Diver experience in coastal Ghana confirms that changes in temperature (also known as the thermocline) can be significant at depths as shallow and 3-5 m.

[531] It is possible that the occurrence of the Guinea upwelling itself actually causes changes in rainfall, but this is not conclusive (Gu and Adler 2004:3368; Opoku-Ankomah and Cordery 1994:552).

mentioning the effects of currents on sediment transport. Of primary concern in the investigation of submerged archaeological sites is the sediment matrixes[532] in which they are located. This includes the composition of the sediments as well as the factors and formation processes that transport, deposit and organize them; in other words, sediment dynamics. Highlighting the importance of the relationship between archaeological sites and sediments, Soulsby (1997:v) writes that,

> The implications of sediment dynamics in the broadest sense are surprisingly far-reaching. Indeed, it is scarcely an exaggeration to say that the birth of civilization in the fertile alluvial valleys of Mesopotamia, Egypt and China was dependent on sediment transport…Younger deposits show evidence of their depositional history…and have preserved the artefacts that form the raw material of archaeology.

One feature prevalent in discussions of submerged sites is the fact that underwater sites often have excellent preservation of organic material. There are various reasons for this, but one of the key factors is that when sediments cover materials they often create an anoxic environment which then serves to insulate and preserve these materials. In fact, in most waters of the world it is rare to find wood remaining from wrecked vessels unless it has been covered over and preserved by sediments. Sediments play other various, often unpredictable, roles in interacting with submerged sites, as is discussed in relation to the

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[532] A brief discussion of the definition of sediment and the differences between sediment and soil may be useful here. Sediments are the "solid inorganic and organic particles accumulated or precipitated by natural or human processes" (Waters 1992:15; see also Stein 1987), and they tend to be unconsolidated. "Soils are the weathering profiles developed by the in-place physical and chemical alteration of preexisting sediments" (Waters 1992:40). The matrix of the seafloor is considered sedimentary. Soils in much of Africa are siliceous (granites, gneiss, sandstones, sands, etc.), and in equatorial Africa, ferralitic (iron-rich laterites) clayey soils are most abundant, with loamy soils predominating in southwestern Ghana (Oduro-Afriyie 1996:165). Most of these soil types are easily eroded through chemical processes of weathering (Oduro-Afriyie 1996:165; UNEP 1985:37) and the mechanical processes of rivers and runoff. Upon its entry into the sea, soil is considered to be sediment.

Elmina Wreck in Chapter 6. The remainder of this appendix is focused primarily on the benthic[533] zone of coastal Ghana.

Sediments in the Coastal Zone

The town of Elmina, located at the coast where this survey is focused, is located at 5°05′N 1°21′W in central coastal Ghana (Figure II.6) and is situated on an outcropping of easily eroded Elmina Sandstone[534] with a narrow eroding beach[535] (Adam 1998:144; Allersma and Tilmans 1993:200; Awosika et al. 1993:31; Dei 1972:419-20, 1985:593; Ly 1981:230; Oduro-Afriyie 1996:161). The metamorphic Elmina sandstone that forms the basement of much of the study area is composed of predominantly fine-grained quartz and feldspar sandstone[536] and is characterized by a lack of biogenic structures[537] (Intergovernmental Oceanographic Commission 1990:143; Martin 1971:83; Ly 1982:205). Elmina's location to the east of Cape Three Points is significant (Martin 1971:86; Orme 1996:254, 2005:16); the rocky headland of Cape Three Points triggers the build-up of sandy spits or bars downstream of the littoral drift (UNEP 1985:77) which in turn interrupts the littoral drift and prevents much sediment from rounding the corner and making it up the coast past Elmina (Awosika and Ibe 1998:25; Bakun 1978:149; Ly 1981:230, 236). The result of this is that very little sand actually accumulates on the coast (Allersma and Tilmans 1993:222). While there may be relatively little sediment making its way along the shelf and accumulating near Elmina (also discussed below), however,

[533] The region of the seafloor or base of the water column; it can include the physical environment as well as any flora and fauna that inhabit that region.
[534] Of shallow marine, Devonian origin (Dei 1985:593; Ly 1982:200).
[535] In fact, the rate of shoreline retreat in central and parts of eastern Ghana is on the order of 2-6 m per year (Ly 1981:238).
[536] Sandstone is primarily composed of quartz fragments (approximately 65%), feldspars (10-15%), clay minerals and fine micas, and other rock fragments (15-20%) (Boggs 2001:134-137).
[537] Features such as reefs that are created by still-living organisms.

there are still significant enough amounts of material to play pivotal roles in the destruction and protection of submerged archaeological sites.

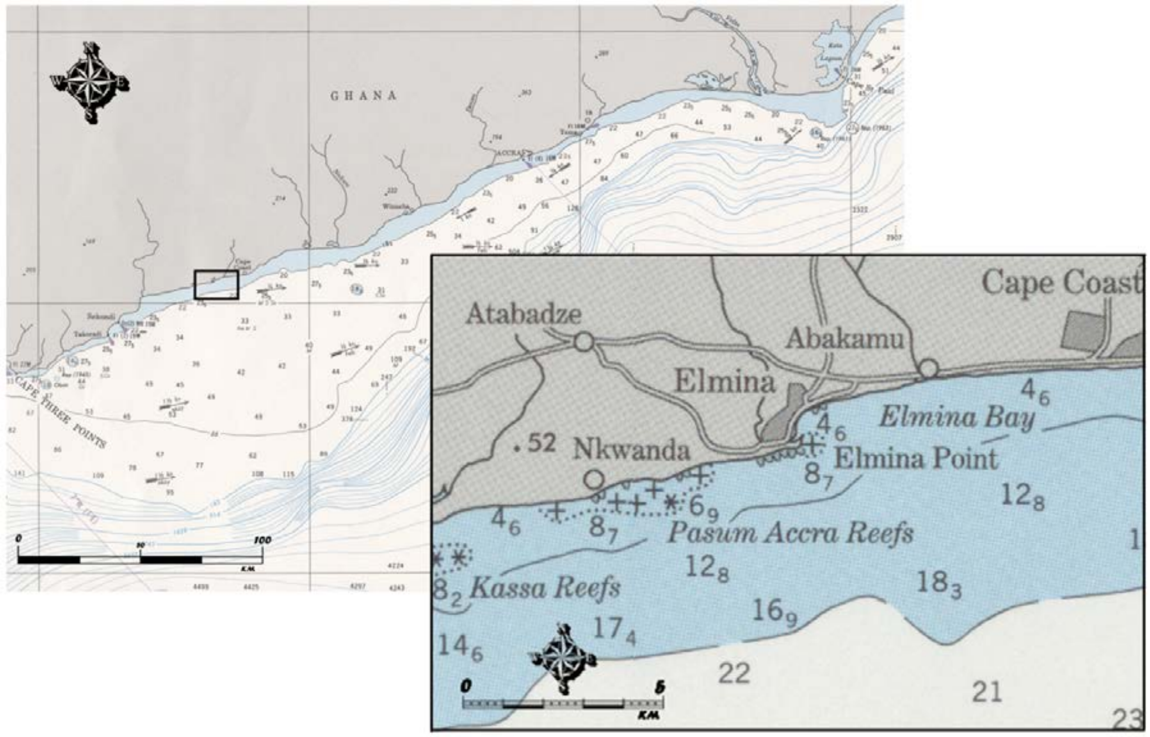

Figure II.6. Nautical soundings show the relatively shallow near-shore zone near Elmina (British Admiralty Charts, 1996). Maritime research in this area has demonstrated the dynamic and varied nature of the seafloor and sediments in this region, dominated in some areas by sand and others by large areas of mud.

In most areas of the world, including much of Africa, the major supply of sediment to the coast is fluvial (Allersma and Tilmans 1991:211; Awosika et al. 1993:32; Milliman and Meade 1983:1; Vanden Bossche and Bernacsek 1990).[538] In west and central coastal Ghana there are no major rivers, however; only one small river, the Pra,

[538] Although there is some debate over the sediment loads of rivers in West Africa (UNEP 1985:43), the information available suggests that the damming of rivers in much of West Africa has had profound reducing effects on sediment transport to the coast (Collins and Evans 1986:8). It is difficult to quantify at this point the affect that this has on the region in central coastal Ghana where I am conducting my research, but it is likely that the effects of damming of major rivers and therefore sediment supplies to the coast will have significant impacts in the future on the whole coast of Ghana and indeed, of West Africa.

which carries predominantly muds during flood period (Ly 1981:239) and is located approximately 32 kilometers west of Elmina, even runs throughout the year (Allersma and Tilmans 1993:203; Boughey 1957:667; Dei 1972:417; Ly 1981:231).[539] This suggests that the sediment supply for this stretch of coast must primarily be from other sources, although the data also vary on this (Allersma and Tilmans 1993:217; Ansa-Asare et al. 2008; Awosika and Ibe 1998:25; Bakun 1978:149; Ly 1981:230, 236; Martin 1971:86; Nixon et al. 2007:S145, S150). There are many other small rivers and streams, some of which are dammed for irrigation purposes, but they have little impact on sediment supply to the coast (UNEP 1985:63). In fact, in his descriptions of rivers and streams on the Ghanain coast, Captain John Adams has but one line of description of fluvial sources near Elmina. He writes: “Elmina, an insignificant stream” (Adams 1966 [1823]:180).

Erosion of cliffs and coastlines does produce some sediments and in the Elmina region this is a more significant sediment source than in some other areas (Adam 1998:144; Ly 1981:230; Orme 2005:13), as the rate or decomposition of Elmina Sandstone is relatively high (Ly 1982:206). To put this in perspective, however, even though coastal erosion is a factor in sediment production and transport (Buckle 1978:198, 205; Fairbridge 2004; UNEP 1985:47), it is likely minor overall, contributing to less than 5 percent of beach sediments (Pethick 1984:68). Some sediment is also brought on shore by currents, tides, storms and other processes[540] (Awosika et al. 1993:32; Buckle

[539] Like most rivers in Africa (Osei and Aryeetey-Attoh 1997:9), the Pra has extremely limited navigational capabilities because of obstructions and the seasonal variation in water levels. Dickson and Benneh (1970:22) have a somewhat differing interpretation of the river systems, suggesting that there are several rivers that flow through the year to the coast, but the impact of these rivers in sediment supply is negligible.
[540] While dry season harmattan winds are responsible for transporting massive amounts of dust over much of sub-Saharan Africa, the impact of the dust on coastal processes is minimal (Breuning-Madsen and Awadzi 2005:36; Burke 1972:1975; UNEP 1985:45).

1978:196; Buller et al. 1975:212; Ly 1981:236; Wright 1995:1), but it is difficult to correlate the amount that remains in the littoral zone with what is deposited onshore. Those sediments (sand, silt and clay) that do find their way to the central Ghanaian coast are then transported and spread over the continental shelf and to the breakers' outer limit, which varies from 10 meters depth to several hundred (UNEP 1985:43, 55). Sand that remains near shore is comprised of medium to fine grains, and further offshore sediments grade to fine muds and silts (Awosika and Ibe 1998:24; Bezrukov and Senin 1971:4; Intergovernmental Oceanographic Commission 1990:138; Ly 1981:236) (Figure II.7). Seasonal current speeds exceeding 100m/s (2 knots)[541] are common in coastal Ghana, and as a result, sediments, including gravels (sediments, including shelly sediments, >2mm in size),[542] are moved extensively along and around the coast.

One final consideration of coastal erosion is factor of sea level change and the warming of global temperatures. Present day sea level rise is estimated at one to two millimeters per year, or 12 to 20 centimeters per century (Allersma and Tilmans 1993:204, 218; Tilmans et al. 1991:4; UNEP 1985:61); while the exact effect of this on sedimentation in the region is unknown, it is likely to have had impacts on submerged archaeological sites and will likely have long-term impacts in the future.[543] In addition, the expected warming of the atmosphere and oceans in the near future is anticipated to change the frequency and intensity of storms affecting coastlines, which in turn will "alter the amounts of wave energy approaching the shore from different directions" (Slott

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[541] Cited in Stride et al. (1982:99).
[542] Based on the Wentworth Grain-Size Classification for Sediments.
[543] Tilmans (1991:1) makes an interesting comment when discussing the history of erosion on the West Coast of Africa when he writes that little is known about coastal erosion before the Atlantic trade, and in fact, it is the forts and castles built by the Europeans along these coasts that may be used as benchmarks for studying coastal erosion.

et al. 2006:1). Regardless of how relatively stable the coastline and coastal processes may have been in the past,[544] the results of these events will play significant roles in the geomorphology of the coast and nearshore environments, and will almost inevitably have even more direct effects on submerged cultural resources.

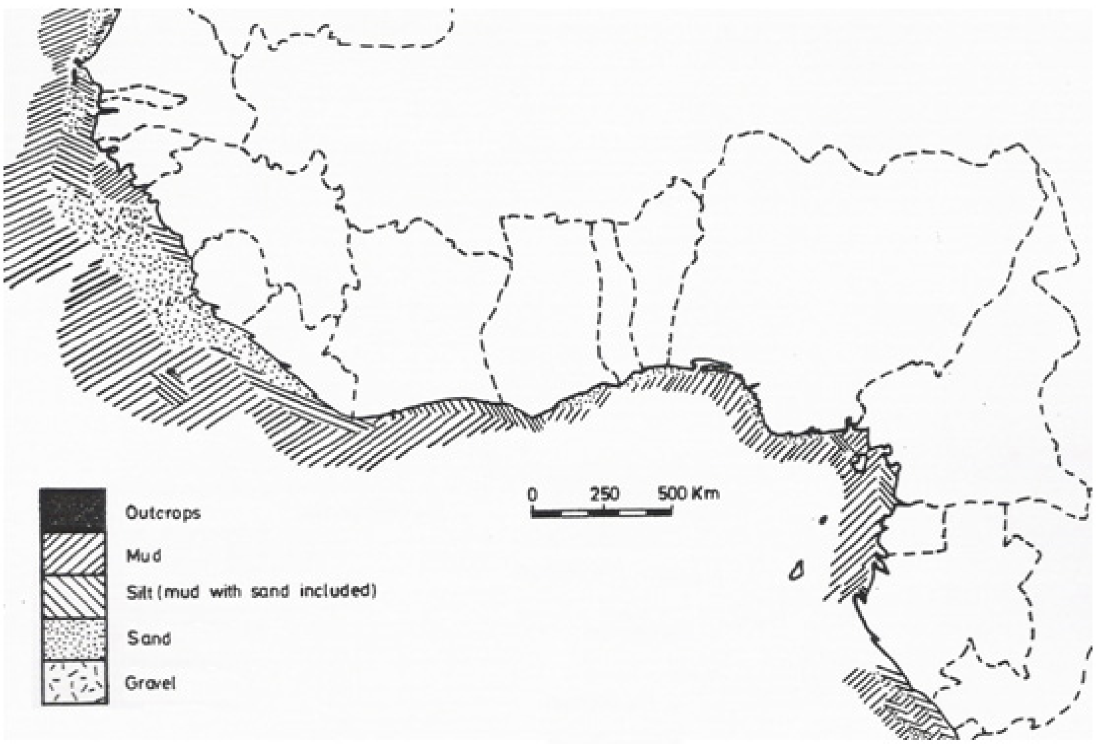

Figure II.7. As is indicated by the generalized shelf sediment distribution, the continental shelf off Ghana is small compared to most of West Africa, but displays significant sediment variety for such a short coastline (modified from UNEP 1985:234).

Marine Flora and Fauna

One final category of environmental agents that should be briefly touched on is that of the flora and fauna of the benthic zone, as these play dramatic roles in the destruction, and even at times in the preservation, of submerged cultural sites (Florian

[544] There has always been variation, but the projection is that variation will become far more extreme.

1987; Stewart 1999:578).[545] Different factors such as temperature, salinity and the amount of light in the water column and that reaches the seafloor, and even the presence of upwellings all play roles in the distribution and abundance of marine organisms (John et al. 1977; Koranteng and McGlad 2001:188). In addition, these factors directly and indirectly influence the types and rates of biodeterioration that affects submerged archaeological sites. Seasonal variations and local conditions such as water depth, currents, tides and pollution also directly influence benthic life. As a general rule, the warmer the water, the greater diversity of biodeteriogens that are present (Pornou et al. 2001:299), which suggests that there should be a great deal of these organisms in the relatively warm waters off coastal Ghana.[546] The most significant factor in this is that the likelihood of organic material surviving over long periods of time in the marine environment is slim unless they are essentially sealed by sediments or other, non-organic, materials, as is the case with the wood recovered from the Elmina Wreck site (Chapter 6). The investigation of formation processes of flora and fauna on submerged sites must be undertaken in relation also to the mechanical aspects of site deterioration, such as currents that carry objects to or away from a site, deposit on or remove sediments or objects from a site, and the chemical factors that affect the decomposition of metals and other objects.

The prevalence of high turbidity, sediment and particulate matter in the waters off the coast of central Ghana is a significant factor in the lack of long-term floral growth on

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[545] They also “play fundamental roles in binding or disturbing sediment particles and thereby altering the ease with which particles can be entrained [put in suspension and transported]” (Wright 1995:9; see also Clifton 2005:271; Nowell et al. 1981), but the primary focus here is their immediate effects on submerged archaeological sites. This is also discussed in Appendix III.

[546] Although there is not a large literature on the topic at present (cf.: John et al. 1977; Koranteng 2001; Koranteng and McGlade 2001).

the seafloor (John et al. 1977).[547] In addition, the predominant longshore drift and presence of seasonal upwellings in this region and in much of Ghana, is largely responsible for the absence of natural coral reefs[548] because the mobile sand smoothes corals and does not provide or allow for a solid foundation for reef growth (Buckle 1978:222; John et al. 1977; McLachlan 2005:7; UNEP 1985:68). It is likely that the yearly upwelling of cold water and lack of accessible bedrock over much of the Ghanaian coastline are also partially responsible for the lack of reefs (John et al. 1977:498; Orme 1996:244). Awosika and Ibe (1998:24) suggest that there is limited coral along the coast of Ghana and Togo, but natural reefs do exist off the coast of Nigeria. The dry season, harmattan, is a time of low cloud cover and minimal water turbulence along the coast, and is the favorable time for growth and development of subtidal algae and other sea life (Blay and Eyeson 1982; John et al. 1977:515).

Because of the lack of natural reefs in the Elmina region, rock outcroppings serve as the bases for plant and animal life (John et al. 1977:498). Shipwreck sites are also prime living areas, as is exemplified by shipwreck sites around the world. Growth of marine plants on calcified or encrusted artifacts and in the sediments trapped between them is also commonplace on shipwreck sites, and the nature of the invertebrate organisms that encrust the artifacts from a shipwreck can be used to provide clues about the history of the ship, both prior to and after sinking (Hageman 2001:65), although a great deal of research remains to be done on this topic. There is ample data however, on

[547] A few exceptions to this have been noted, including some seagrass that grew on the exposed wood of the known shipwreck, likely between the months of December and April, when there is less particulate matter in the water. This may provide a tentative timeline for the wrecking of the vessel, as the wood from the hull likely did not survive more than a couple years at best exposed on the seafloor (Chapter 6).

[548] There are, in fact some coral reefs off the Ghana coast, for example near Tema (Edmunds and Edmunds 1973:371), but they are few and far between.

the effects of other sea life, primarily molluscs, urchins and octopi that the sites attract.[549] Namely, these creatures have the habit of burrowing through the sediments and under artifacts, moving items around or covering themselves with debris (including artifacts) and in the process serve to rearrange easily mobile objects and disturb the sediment matrixes of sites.[550] A limited literature is available on the benthic life in coastal Ghana (see Appendix III), making an in-depth study an analysis of the effects of the floral and faunal species difficult at present. Some observations are discussed in Chapter 6, but the majority of environmental formation process analysis is focused on non-organic agents.

The Environment and Site Formation Research

Familiarity with the climate and geomorphology of a region is an integral and vital part to investigating and interpreting submerged archaeological sites. The complex web of seasons, currents, waves, rainfall, water salinity, temperature, winds, storms, benthic life, and chemical compositions of seawater, each part influencing others, creates an infinitely intricate framework within which to try to understand formation processes. While it may not be possible to quantify or even identify the effects of each of the individual actors discussed here, the cumulative results of each agent are evident. That being said, a number of formation agents clearly play more significant roles than others, and these are generally fairly obvious: namely, the role that currents and storms play in the movement of sediments and the affects of sedimentation in obstructing, preserving, and shaping archaeological deposits. The enormity and complexity of the natural

[549] Appendix III is a compilation and discussion of the fauna observed on the known shipwreck site.

[550] It should be noted that for the known shipwreck site in Ghana, however, the majority of significant site disturbance is from currents, surge and storms. In addition, stratigraphy of underwater sites is a notoriously elusive subject, and one that is only beginning to be successfully investigated (see Chapter 6).

environment cannot be understated, but with careful investigation, it is possible to begin to understand it and its relation to submerged archaeological sites.

Appendix III
Benthic Life

Included in the physical environment of the submerged landscape is a wide range of benthic life. Chapter 6 discusses some of these organisms in relation to their roles as formation agents on submerged sites, but there is in fact very little information available concerning most of the marine life in coastal West Africa, including coastal Ghana. As noted in Chapter 7, one possible interdisciplinary avenue of investigation includes a more in-depth census and monitoring of marine life on submerged archaeological sites as a means not only of understanding the effects of benthic life on such sites, but also as a rudimentary means of monitoring ocean health and ecosystems in coastal Ghana. If this can be done over a period of years, it may be able to provide a basic database of current numbers, types, and conditions of benthic life that may be of use to the wider research community. In addition, a more detailed understanding of the communities of marine life that inhabit submerged sites in this region will provide significantly more complex perspectives on their roles as formation process agents and the subsequent effects different organisms have on different submerged cultural sites. The following is a brief discussion of marine life in coastal Ghana, as well as on the historical and current practices of harvesting those resources. The final portion of the appendix is a summary of species observed at or near the Elmina Wreck site to date.

Coastal Ghana

Some historical data are available in terms of the uses and exploitation of marine resources in coastal Elmina over time. As DeCorse (2001:104-109) notes, while coastal and lagoon resources have long been exploited, and some marine fishing is known to have been practiced prior to European contact, it was not until the end of the 18th and beginning of the 19th centuries that this became more intensive, particularly as seine nets began to be used for larger hauls (see also Dickson 1969:83-84). Dickson (1969:84) writes that historically there were such great quantities and varieties of fish and marine fauna available that there were apparently enough even to support the exorbitant taxes that the Dutch imposed on fish (one-fifth of the catch), as well as the taxes imposed by African chiefs, who often demanded one-third of the catch. Over time as more people took to the sea to earn a living and took advantage of increasing technology, and as more large machinery and trawlers[551] exploited the region, however, the vast quantities of marine life started to diminish quickly and the marine environment started to be seriously degraded (Ansa-Asare et al. 2008; Nixon et al. 2007; Otchere 2003).

Because of growing competition and technological developments, such as the outboard motor of dug-out canoes, fishermen are no longer using traditional methods of fishing that were more discretionary and took in smaller catches; this has resulted in an almost completed indiscriminate harvesting of marine resources, including a greater reliance on juveniles (Figure III.1), which then destroys the means of marine life naturally replenishing itself. As a result of the excessive exploitation of fish and other marine resources, overfishing is threatening to spread to currently unexploited fish populations, including even the small and commercially unwanted fish (Nunoo et al. 2009:171). It is interesting to note that apparently this trend of over-exploitation has direct roots in colonial history in Ghana, where excessive fishing with large nets with

[551] These are owned both by Ghanaian people and by international fishing companies, the latter of which in particular are contributing immensely to the deterioration of the marine ecosystem.

small holes[552] was encouraged over the smaller-yield traditional methods (Walker 2002:395-397). Regardless of its roots, however, the extreme over-exploitation of fish and other benthic life has affected the entire marine ecosystem. In a vicious and frustrating feedback loop, this is affecting the every day and economic lives of local peoples who depend on the sea for their livelihoods, and who, because of the diminishing returns for their hard work, in turn redouble their efforts, causing further damage and destruction.

Figure III.1. Even this juvenile cuttlefish, shown in the palm of Papa Kofi's hand, was slated for consumption. Practices that include the common-place eating of juveniles of any species are simply not sustainable, and the effects are being very clearly seen along the coast of Ghana and elsewhere in Africa (photo R. Horlings, 2007).

The effects of fishing practices are evident on the submerged landscape, particularly on the Elmina Wreck. Shipwreck sites tend to act as artificial reefs, attracting colonizers such as marine flora and small fauna, which then attract a variety of larger organisms including fish and those that prefer to live under objects, as the variations in shapes, sizes, and micro-environments of a wreck site provide ample opportunity for hiding. While some of these organisms have been recorded at the shipwreck site, the paucity of sealife there in general is disturbing; this is particularly the case considering

[552] Called *Ali* nets.

the fact that the generally sandy seafloor offers few such locations for such a variety of marine organisms to inhabit, suggesting that the site should be teeming with life. [553] The scantiness of marine life was evident, for example, in an experiment conducted by Pietruzska and the team in 2007, when a lobster trap was placed at the site and managed to trap only four small (less than six inches) lobsters and a few other small creatures. This is indicative of the fact that even though the rough and concreted objects at the wreck site catch and break nets and lines, fishermen have still been willing to risk these expensive mistakes by fishing there, keeping whatever they manage to retrieve from the site. Evidence of these activities is provided by the copious amounts of fishing line, nets, and weights caught across the wreck site. In addition to severely depleting the marine resources at this unique enclave, the nets also catch and move cultural materials around the site, acting as artificial formation processes.

This history of marine exploitation in the region and the observations made at the shipwreck site provide us with insights into the general current condition of the marine life in coastal Ghana. Unfortunately there is actually a very sparse literature with which to not only compare these observations, but also to provide a basis for future investigations into sealife in the region.[554] A summary of the available literature is as follows:

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[553] In contrast to the ample opportunities offered by the shipwreck site, the anchors at the Double Anchor Site were colonized by barnacles, but there was virtually no other sealife there, as the anchors provided only limited resources that could only be exploited by a limited range of marine life. Similarly, rocks across the region indicated some presence of marine flora, but little in terms of being sustainable environments for a wide range of marine life.

[554] In addition, almost all recent literature concerns heavy metals in marine life and the effects on human consumption.

John et al. (1977:502-503) have identified at least 100 species of algae that live primarily on the rocky areas of coastal Ghana, and provide a list of over 30 species of fauna in the area. Blay and Eyeson (1982:408) have written on the food supply and feeding habits of shad (a fish) in coastal Ghana,[555] noting also a number of flora and fauna in the region, including protozoa, molluscs and anthropods. Buchanan (1954) has identified five different sublittoral (off-shore) zones in which different molluscs live. Bassindale (1961) corroborates Buchanan's findings and provides descriptions of the marine fauna in the Ghana sub-littoral. Edmunds and Edmunds' 1973 offer a discussion of the mollusca off Tema, and Edmunds (1978) book, *Sea Shells and Other Molluscs Found on the West African Shores and Estuaries* identifies many of the mollusc species identified on the wreck site. It is hoped that in the near future there will be a great deal more research done on this fragile coast.

Benthic Life at the Elmina Wreck Site

Although clearly heavily depleted, the variety of marine life at the Elmina Wreck site is fascinating (Figures III.2 and III.3). Future investigations should certainly continue to monitor the benthic life, but also try to investigate more fully evidence of the effects that it is having on the site itself and on the materials contained in the site.

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[555] They identify the peak feeding activity period in July, in the middle of the upwelling. It is presumed that because of low temperatures in the upwelling there is an abundance of zooplankton and other creatures for the fish to eat (Blay and Eyeson 1982:408; see also Koranteng and McGlade 2001:188).

Figure III.2. **This image, captured from video footage, shows several of the extremely curious cuttlefish who followed us for entire dives on the shipwreck site in 2009. It is likely that we also had such on-lookers in 2007, but conditions were so bad that we did not see them. The fishermen friends were disappointed we did not capture these fantastic creatures for dinner (photo R. Horlings, 2009).**

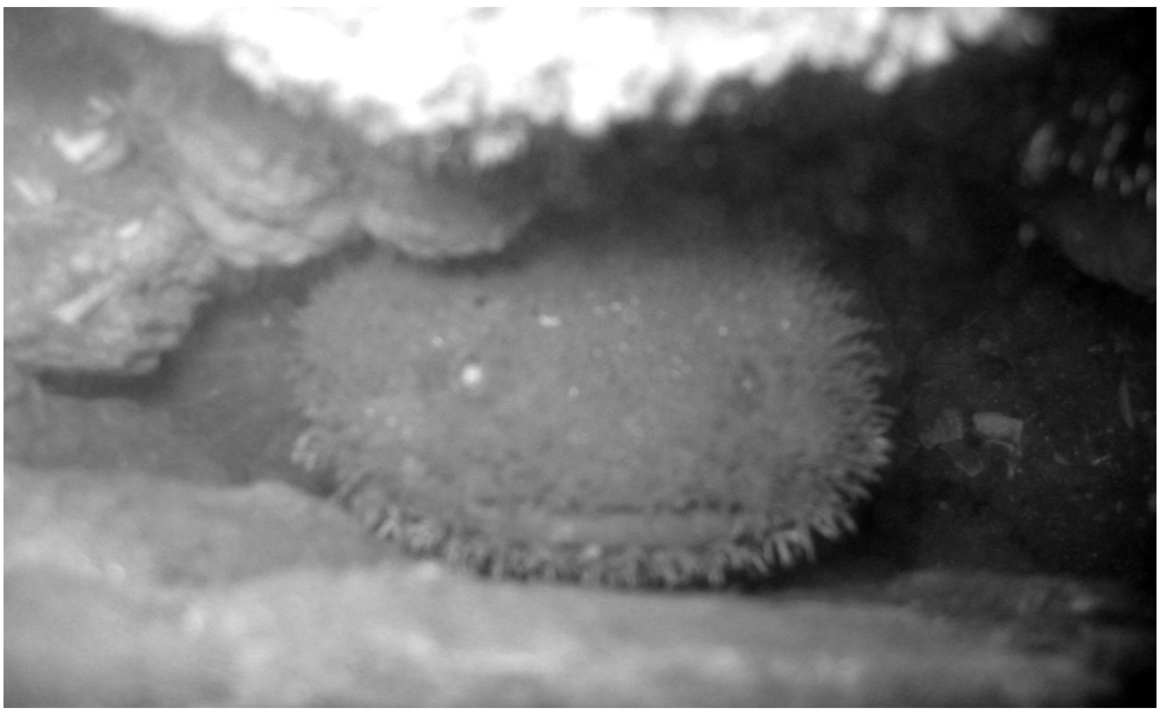

Figure III.3. Several examples of this fish were observed on the shipwreck site in 2009. This particular fish had taken up residence in the empty space beneath the strange object/ machine on the east side of the site. While the species has yet to be fully identified, it is likely of the Scorpionfish family (Scorpaenidae), in which case it has venomous dorsal spines which are extremely poisonous and dangerous. Certainly a wake-up call for dealing with the unknown in literally pitch-black conditions (photo R. Horlings, 2009).

Because at present it is not possible to identify most of the flora and fauna at the shipwreck site by species name, the following list contains the common names for benthic life observed on and near the shipwreck site. Most of these observations are from the 2009 field season when there was visibility on several days of over three meters, but even in the dark conditions of 2007, several different species were identified and are included. In addition, it is important to note that not every species of, for example, bivalve, was noted, as at present we do not have enough information to categorize them.

In no particular order, these organisms were observed:

- moray eels
- lobsters
- (blue) crabs
- possible octopus
- sting rays (several measuring over 1 meter in wingspan)
- electric fauna (discovered because it shocked me in 2007)
- hermit crabs
- fan corals
- remoras
- cuttlefish
- several different species of marine fish – individual and in schools
- likely scorpionfish
- sea snails
- barnacles
- sponges
- bivalves
- molluscs
- African cowry (large, and dead)
- gobi fish
- jellyfish
- starfish
- various algae

Appendix IV
Post-Processing

This appendix briefly discusses some of the analyses that were undertaken in the course of the dissertation research, and which were mentioned in Chapter 4, but have been less emphasized throughout the dissertation. The second part of the appendix presents distributions of various artifacts and features identified in the sediment cores collected at the site.

Botanical Analysis

Analysis of the botanicals collected in cores has only been performed for the cores collected in 2007. Dr. Amy Mitchell-Cook of the University of West Florida analyzed the wood collected in the cores, and Dr. Stephanie Kahlheber of Johann Wolfgang Goethe University in Frankfurt, Germany, analyzed a sample of the botanicals from the shipwreck site, and a number of samples from cores collected at **C2**.[556] Two types of wood were identified from the shipwreck: white oak and red pine, neither of which is native to West Africa, and therefore almost certainly part of the structure of the vessel. Most of the botanical remains from the shipwreck site, including some charred wood and a leaf, were either not identifiable at present or were from West African contexts.[557] Two, however, proved unique. The first is a raspberry seed that is not from West African contexts, and the second is one of the most interesting features discovered in the excavation trenches: an apparently complete tree, including branches, bark and

[556] The botanical analysis was funded by a Roscoe Martin grant from the Maxwell School of Syracuse University.
[557] This is intentionally kept general, as many of the plants from which the remains originated could have either been intentionally on the vessel, carried in by wind or currents, and could be from any number of places along the coast, whether "locally" in West Africa or "locally" in Elmina.

leaves.[558] Dr. Kahlheber identified the tree as birch, indicating that it is not native to West Africa.

Benthic Analysis

Marine organisms and vegetation of many descriptions colonize and live on submerged archaeological sites and play a significant role in the destruction, reshuffling or preservation of them (Ferrari and Adams 1990), as is discussed in Chapter 6. While I did collect samples of shells from organisms on the wreck site and in the cores, the process of identification of each species and determination of their roles in formation processes is not within my erudition. Appendix III lists the fauna observed at the wreck site and discusses hypothetical effects on the site of some of the species, but it is not possible to do a full biological or ecological analysis at this time.[559]

Insect Analysis

A number of insects, including ants, were found in the cores during the microscope analysis. It is likely that some of them are there from having been mixed up in the core material during the initial post-processing in the field, which took place primarily on the outside porch of the field house, but it is difficult to tell. Two other scenarios are also possible: the insects may simply have been mixed in the sediments in the water and were deposited on the wreck site, or they may actually have been

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[558] It may not seem astonishing to find a tree on a shipwreck site, as they are notorious for trapping objects moving along the seafloor. However, a tree that had been travelling on the seafloor, even if it was only the relatively short distance from shore to the wreck site, would have been tumbled and as a result have lost bark and leaves, as well as many branches. The fact that the tree was intact captured my attention and resulted in retaining a few pieces of the wood and leaves for analysis.

[559] In addition, there is a limited literature available on benthic species in Ghana and West Africa (Bassindale 1961; Blay and Eyeson 1982; Buchanan 1954; Edmunds 1978; Edmunds and Edmunds 1973; John et al. 1977), which also makes this task both more difficult and less productive. Until I can work with a fully interdisciplinary team, this aspect will remain less emphasized in my work.

associated with the vessel before it sank. It is not possible to tell at this point, and it is unlikely that even detailed analysis of the insects will be able to answer these questions; that being said, however, in the event more extensive excavation is conducted and sediment samples are collected, we may be able to ascertain this with more certainty. While no detailed analysis of them has been completed now, in the future it should be an avenue of inquiry that is pursued, particularly in terms of what it may reveal about formation processes at sites and across the region.

XRF Analysis

X-ray fluorescence (XRF) analysis[560] using a portable/handheld Bruker XRF analyzer was conducted on samples recovered from cores collected in 2007.[561] The principle aim of this analysis was to identify the elemental signatures and components of materials (Pollard et al. 2007:94, 101-102, 118-120)[562] recovered in the cores, and was used chiefly in investigating the melted material collected in cores from the wreck site. I was able to analyze 189 different samples, including samples from the entire range of artifacts recovered in cores, and was also able to discuss the results of several sample analyses with Dr. Bruce Kaiser, Chief Scientist at Bruker AXS (Figure IV.1). XRF is a powerful tool and while time constraints and my only rudimentary grasp of the potential of the instrument did not allow for the full potential of the analysis, the data I was able to

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[560] XRF analysis is routinely used as a “method for the qualitative study of elements with atomic numbers higher than Z = 10, including both metals and nonmetals” (Garrison 2003:209; see also Rapp 2002:18).
[561] A Bruker hand-held XRF analyzer was very kindly loaned to the Anthropology Department of Syracuse University for a short period in the spring of 2009. Those who participated in a training workshop, including myself, were permitted to analyze their own artifacts. Because time with the instrument was shared among a number of individuals, it was only possible to analyze a representative sample of the artifacts recovered in my cores.
[562] For additional examples of the application of XRF analysis see Ferretti et al. (1997), Sciuti et al. (2001), Veritá et al. (2002).

collect provides compelling arguments towards an understanding of the events that likely lead to the demise of the shipwrecked vessel (discussed in Chapter 6).

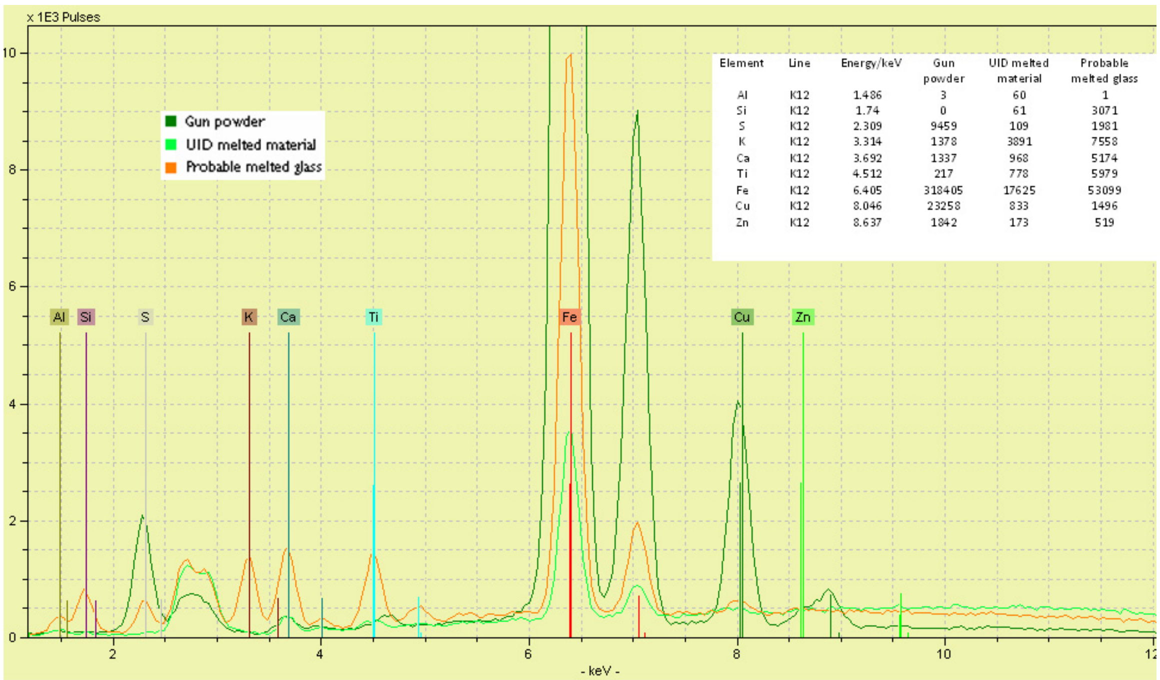


Figure IV.1. This raw spectrum illustrates the primary component of the gun powder material, compared to several other samples. The high Fe content is likely the result of ambient iron oxides in and around the shipwreck site.

Radiocarbon Dating

Radiocarbon tests were run on five samples of wood taken from the Elmina Wreck site. The wood was collected in Cores GW#2, GW#8, GW#13, GW#20 and GW#22 (Figure 4.2). Based on these samples, the date for the hull of the vessel was estimated to be between AD 1642 and 1664 with a 2 Sigma (95%) confidence rating. Results are presented here in Figures IV.2 and IV.3.

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 285980 SAMPLE : Elmina Core #2 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1490 to 1670 (Cal BP 460 to 280) AND Cal AD 1780 to 1790 (Cal BP 160 to 160)	290 +/- 40 BP	-25.5 o/oo	280 +/- 40 BP
Beta - 285981 SAMPLE : Elmina Core #8 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1640 to 1690 (Cal BP 310 to 260) AND Cal AD 1730 to 1810 (Cal BP 220 to 140) Cal AD 1930 to 1950 (Cal BP 20 to 0)	230 +/- 40 BP	-25.7 o/oo	220 +/- 40 BP
Beta - 285982 SAMPLE : Elmina Core #13 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1640 to 1690 (Cal BP 310 to 260) AND Cal AD 1730 to 1810 (Cal BP 220 to 140) Cal AD 1930 to 1950 (Cal BP 20 to 0)	220 +/- 40 BP	-24.9 o/oo	220 +/- 40 BP
Beta - 285983 SAMPLE : Elmina Core #20 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1520 to 1580 (Cal BP 430 to 370) AND Cal AD 1630 to 1680 (Cal BP 320 to 270) Cal AD 1770 to 1800 (Cal BP 180 to 150) AND Cal AD 1940 to 1950 (Cal BP 10 to 0)	280 +/- 40 BP	-26.7 o/oo	250 +/- 40 BP
Beta - 285984 SAMPLE : Elmina Core #22 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1460 to 1660 (Cal BP 490 to 290)	320 +/- 40 BP	-25.5 o/oo	310 +/- 40 BP

Figure IV.2. Details of each sample, including processes of treatment and analysis, are presented in this table.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number: Beta-Avg256

Conventional radiocarbon age[1]: 256±17 BP

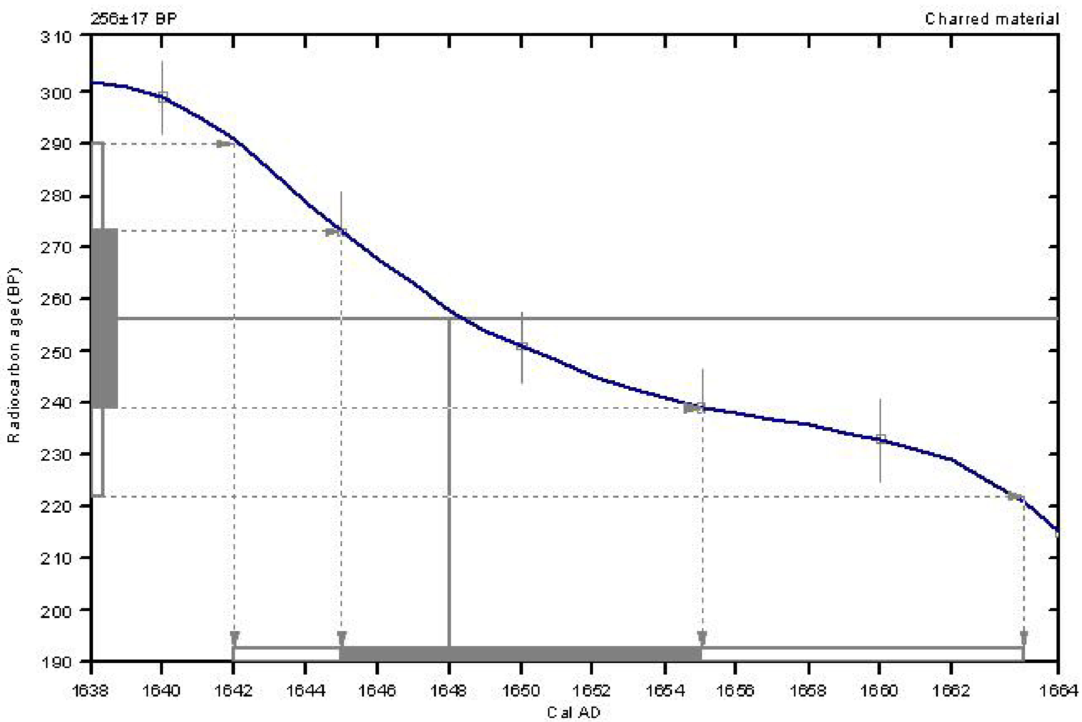
2 Sigma calibrated result: Cal AD 1642 to 1664 (Cal BP 308 to 286)
(95% probability)

[1] *C13/C12 ratio estimated*

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1648 (Cal BP 302)

1 Sigma calibrated result: Cal AD 1645 to 1655 (Cal BP 305 to 295)
(68% probability)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150,

Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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

Figure IV.3. The average for the five radiocarbon dates are illustrated in this Beta Analytic graph.

Analysis of Video and Still Footage

The final form of data post-processing involved analysis of the still images and video footage collected on the few days in which there was some visibility. Both still images and video footage were collected with a simple Canon PowerShot A95 5-megapixel camera in a Canon WP-DC50 waterproof housing.[563] Most of these were from the shipwreck site, although there are also some images from the Double Anchor Site. The video documentation covers general areas and features of the wreck site, but we were also able to document specific objects such as the associated anchor and sixth cannon, as well as newly exposed portions of the site.

Analysis of this footage and of the still images has provided insights into some of the general condition of the site, formation processes that are currently affecting it, and into different cultural features of the site, particularly the unidentified object illustrated in the Elmina Wreck site plan. In addition, it recorded some sealife that we had not yet documented, such as the members of the scorpionfish family buried under objects at the wreck site. It was possible also to draw a number of features of the site based on observations made from the still and video images and measurements and notes taken while diving. A number of images were isolated from the videos using the freeware software package Image J; because several features were apparent in the videos but no still images were taken of them while on site, this proved to be an invaluable tool in post-processing of the video images. These and other observations are included in discussions throughout this dissertation, and several of the captured images are also located in the text.

[563] While the camera produced good quality images, they are not of the high definition quality that is preferred for scientific documentation. All photographic documentation of sites and sediment cores was collected with this camera.

Historical Documentary Research

As noted in a number of places in the text, archival research has been conducted on a potential candidate for the Elmina Wreck called the *Groningen*, or, officially, the *Nieuw Groningen*.[564] Part of the tale, as told by a 17th century governor of Elmina named Hendrick Caarlof,[565] is as follows:

> For that Factor reported to me that the ship Groeningen, having anchored on the last day of February before Del Myna, wished to fire 5 salute shots, as is customary, had caught fire from the last cannon, which had burst. Whereupon proceeding at once to Del Myna it was reporte~~d~~ to me on arrival there that 4 cannon had already been fired, the fifth and last had burst throwing the shot into the Constable's (gunner's) room. The hatch (luyck) of the orlop (overloop) flw overboard; but the worst of all was that the blow (slagh) took its chief force downwards, breaking the orlop in piece which fell into the hold where it made a fearful fire. And as the bursting of one gun could not easily cause such a fire, in my opinion it arose because apparently (as the "~~maats~~" \now often conceal their liquor between the guns and gun carriages)[566] some anchors of it had lain about there, had spouted into the gunner's room ~~where the gun in breaking~~ as also in the hold, the gun (~~stuck~~) broke some large casks of liquor belonging to the Company lying thereabouts. The descending fire progressing so strongly caused the crew, through sheer amazement to get into perplexity. For such combustion dapare rappicheyt van dempen en loschen vereischeende,[567] some, to save their lives, went off by baot and "schuyt", whereby the others, seeing themselves past help through the fire getting the upper hand, each worked for his own life om een goet heen coomen sagen . Nevertheless, 11 seamen and eight soldiers perished in the fire and water, which number could have been greater if the factor Coymans had ~~not~~ not quickly sent out some canoes for salvage. Neither letters nor papers from YHH or anyone were saved. In the blowing up of the ship some goods flew up and got into the hands of the Blacks, part of which has been taken from them, and some fished up by dredging, which

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[564] The name of the candidate vessel was found by Pietruzska in a reference by Porter (1974), with the initial archival work being done by DeCorse on the Furley Collection at the University of Ghana; the Dutch archival work was carried out by Eric Ruijssenaar of the Dutch Archives.

[565] This reference is from the Furley Collection Notebook 1646-1647 pages 162-164, transcribed by Christopher DeCorse, August 2010; the following footnotes (566-568) are his comments.

[566] This text is a bit unclear. "~~maats~~" is crossed out and (I think) "now" inserted. I think the phrase should read: "(as they now often conceal their liquor between the guns and gun carriages)".

[567] Here Furley appears not to have provided a translation, which seems to be a phrase describing the fierceness and intensity of the fire.

> we will continue to do; amounting to what YHH can see from the accompanying lists.[568] I also suspect that as the same cannon had already shortly before been fired a short distance ~~from~~ above Del Myna, as a signal that it came from home, it had then been overloaded through carelessness.

As is discussed in Chapter 6, a number of features of this report nicely correspond with the archaeological record of the site. It is hoped that additional archival and field research will be able to shed light on whether or not the Elmina Wreck does indeed represent the *Gronongen*.

Artifacts

Artifacts recovered from cores provide information concerning the cultural aspects, such as trade goods, of the vessel, and also provide a great deal of information concerning site formation processes and the movement of objects within the wreck site (or other site if there are multiple cores there to allow comparison) and even within the region. Although the focus of this work is not on the cultural attributes of the artifacts themselves, they form a crucial part of the puzzle, and as such are discussed throughout the dissertation. It is also interesting to note that even though the micro-sampling technique only recovers a relatively small proportion of material from a site, when compared to the categories of artifacts recovered during surface collection and excavation on the wreck site, cores recovered more than 50% of those *categories* of artifacts (Table IV.1). Making note of this highlights the applicability and efficiency of data collected in sediment cores, and illustrates the effectiveness of the micro-sampling technique. While it is considered to be an effective tool in and of itself, however, microsampling is not

[568] Again, this is likely Furley's own abbreviation, "YHH" referring to Hon. Hon[d] Sirs in the salutation. I did not find any accompanying lists of the salvaged goods.

ARTIFACT CATEGORY	SURFACE COLLECTION	EXCAVATION	CORES
BALE SEAL (LEAD)		X	
BEAD (LONG)		X	X
BEAD (SEED)		X	X
BONE	X	X	X
BRASS FISH HOOK		X	
BRASS MANILLA		X	
BRASS OBJECT		X	X
BRICK	X	X	X
CASE BOTTLE	X	X	
CERAMIC (UID)		X	X
CHARRED WOOD		X	X
CONCRETE		X	X
CONCRETION		X	X
COWRY (LARGE)	X		
COWRY (SMALL)		X	X
CREAMWARE		X	
EARTHENWARE	X	X	
FIRED CLAY		X	
GLASS		X	X
GLASS BOTTLE	X	X	
IRON OBJECT		X	X
LEAD		X	
LEAD-SHEATHED WOOD		X	
METAL VESSEL (AND RELATED)		X	X
MODERN		X	X
ONION BOTTLE		X	
ORGANICS		X	X
PALM NUT		X	X
PEARLWARE		X	
PEWTER		X	
PIPE (SMOKING)		X	X
POSSIBLE GRAPPLE		X	
SLAG		?	X
STONE		X	X
STONEWARE		X	
UID		X	X
WHITEWARE		X	
WOOD		X	X

Table IV.1. The artifacts listed here represent only the categories of artifacts compared. The melted materials are not included.

considered to be a replacement methodology for excavation or other forms of data acquisition.

Core Comparisons across the Elmina Wreck Site

The sediment cores collected over the course of fieldwork in 2007 and 2009 have formed the basis for much of the analysis and interpretation throughout this dissertation. Data recovered in the cores ranges from artifactual to formation processes to site and environmental data, and has been used in different way throughout the dissertation. Chapter 6 touches on microenvironments across the Elmina Wreck site, and highlights just one data set – melted material – that was used to interpret the site. The schematics presented below provide more details on several other categories of information collected from the cores at the wreck site, including sediment angularity, a plot of beads and cowry shell distribution, wood, burnt material, and charcoal. With the exception of the charcoal schematic (Figure IV.1), the data in all of the schematics is presented in terms of the quadrants created by the crossing baselines defined in 2007 as a means of illustrating spatial positioning across the site. One particularly important feature needs to be highlighted for all of the schematics shown in quadrants: cores that were on the baselines are displayed in both quadrants that they touch, so cores **13**, **23**, **26**, **22**, **12**, **21** and **18** are displayed twice (denoted with a *). While this does not affect general interpretation, it is an intentional effort to avoid biasing any one quadrant. Core schematics are displayed with the cores in each quadrant listed from the north side of the quadrant to the south; the scales refer only to core length. Figure IV.1 is a variant of the information displayed in Figure 6.23 in Chapter 6, but is illustrated here on the core site plan as a way of visualizing the actual locations of the cores.

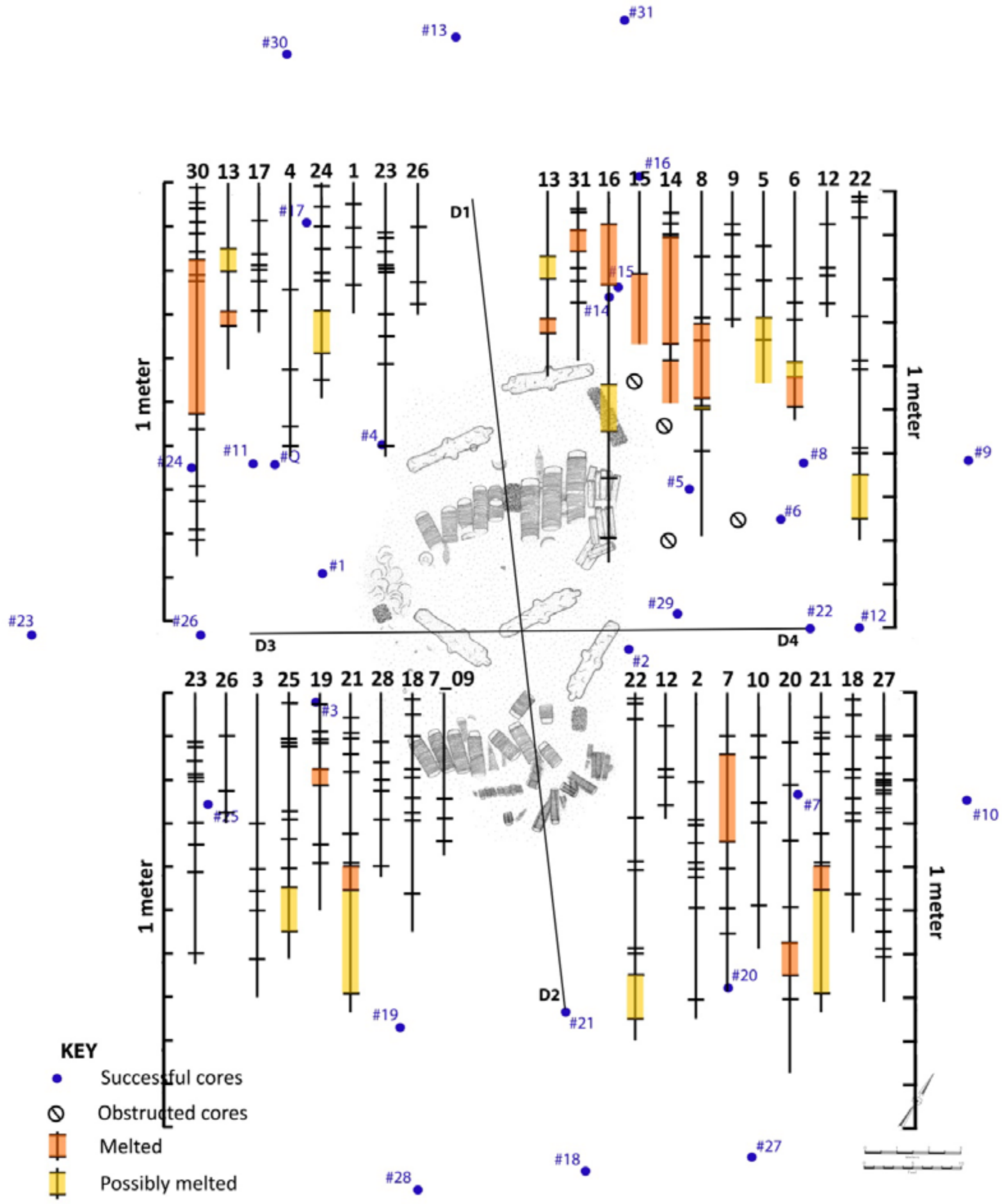

Figure IV.4. **The superimposed schematic of melted material in the cores is designed to illustrate the general distribution only of melted material across the wreck site, displayed by quadrants as were determined by the baselines set up in 2007.**

Sediment Angularity

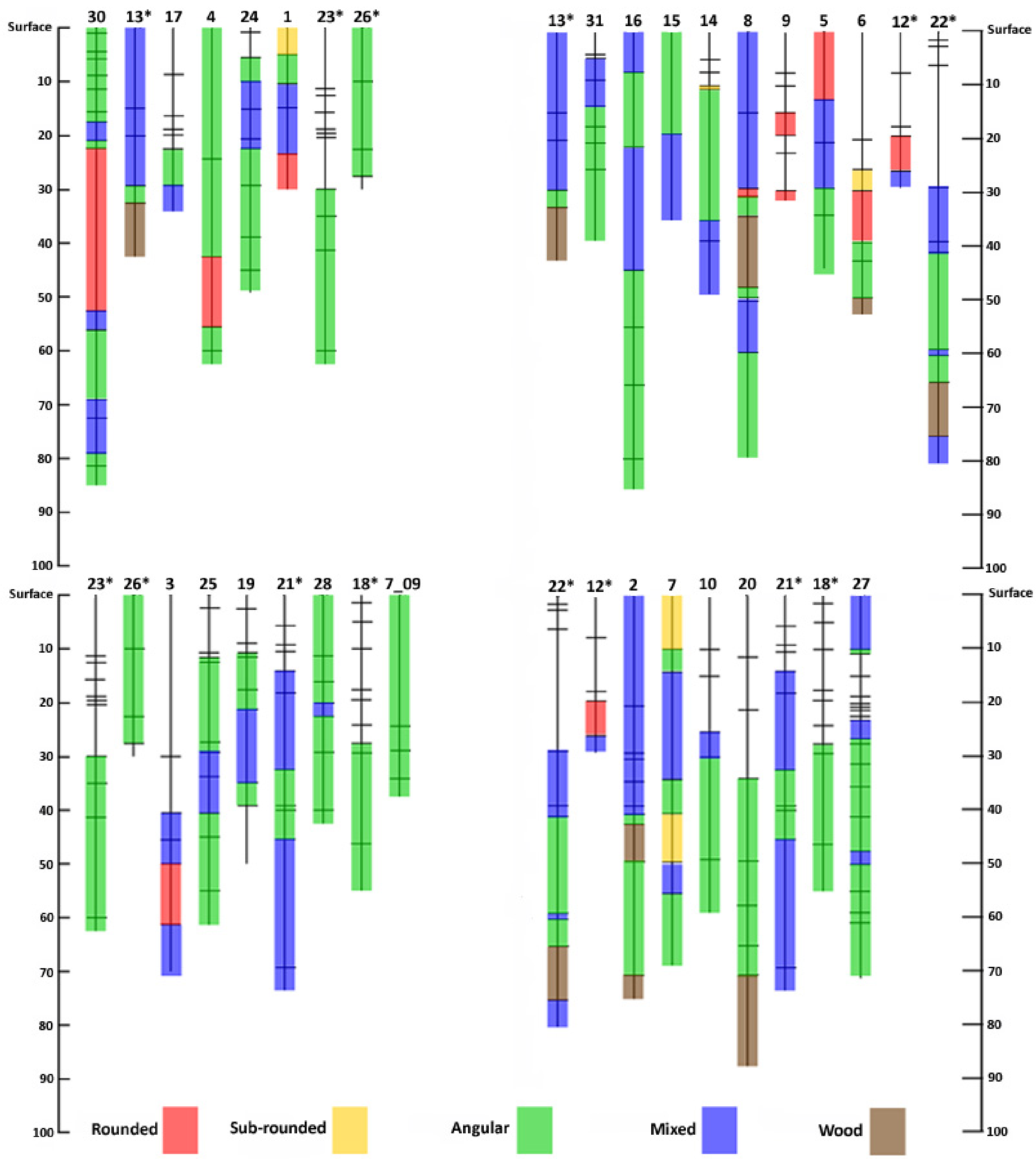

Figure IV.5. One of the purposes for looking at sediment angularity was to try to detect any micro-environments within the wreck site. It is interesting to note that there is a distinctly angular stratum over every wood sample in a core, suggesting that the hull of the vessel was quickly filled with sediment that was later covered with more varied materials. Note also that the most rounded sediments are found in the northeastern quadrant, suggesting that those sediments may be being trapped and rolled in those areas, creating the rounding; differing depositional episodes may also account for this, and more research clearly must be done.

Beads and Cowry Shells

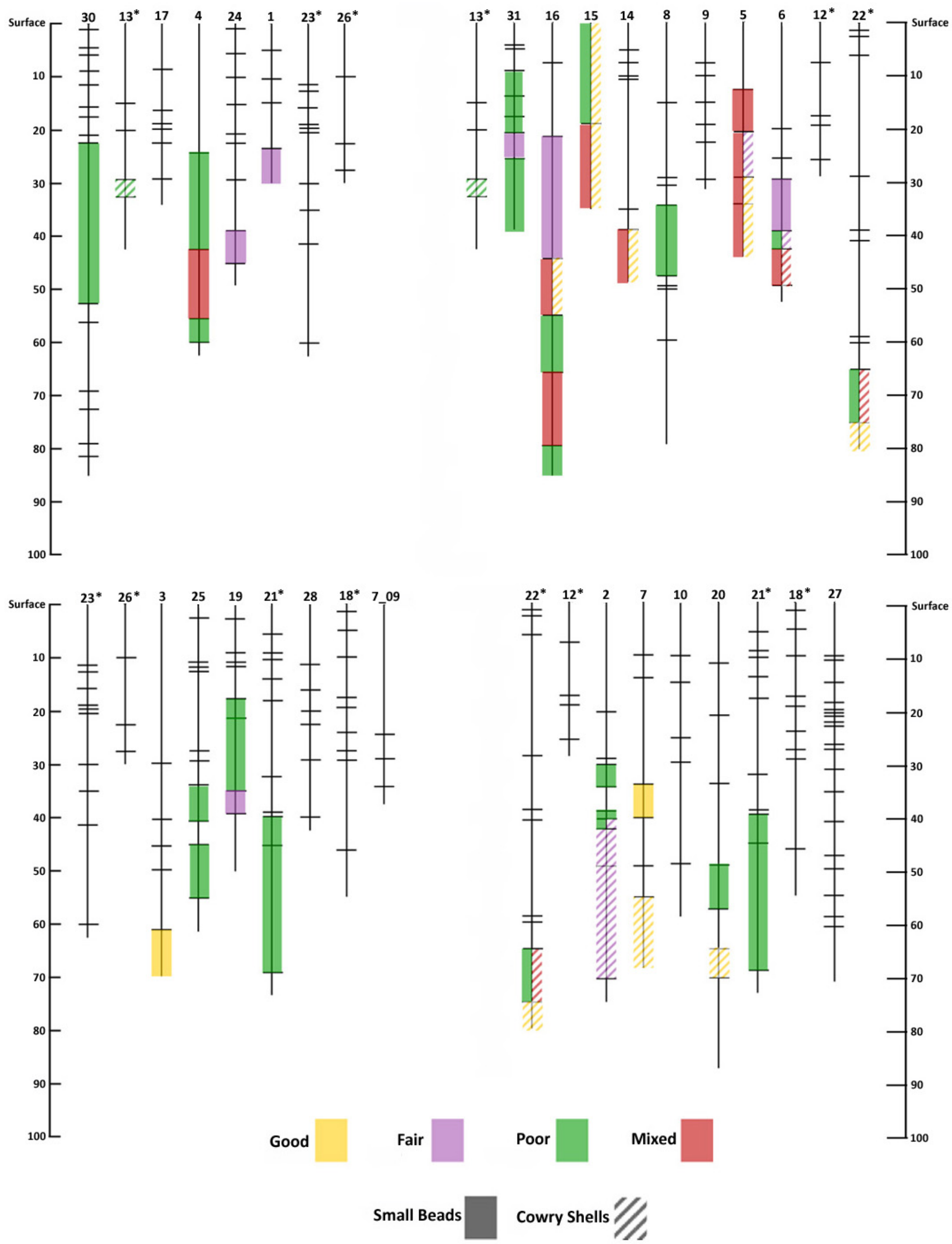

Figure IV.6. While the distribution of these artifacts across the site changes, two things in particular should be noted: none of the cores were collected inside the wreck site due to the concretion, so there may be some biasing there; also, note that there is a great deal more diversity or mixing in the conditions of artifacts collected in the northeast quadrant, suggesting that this is a more active area in which materials are moved around more often.

Wood and Benthic Life

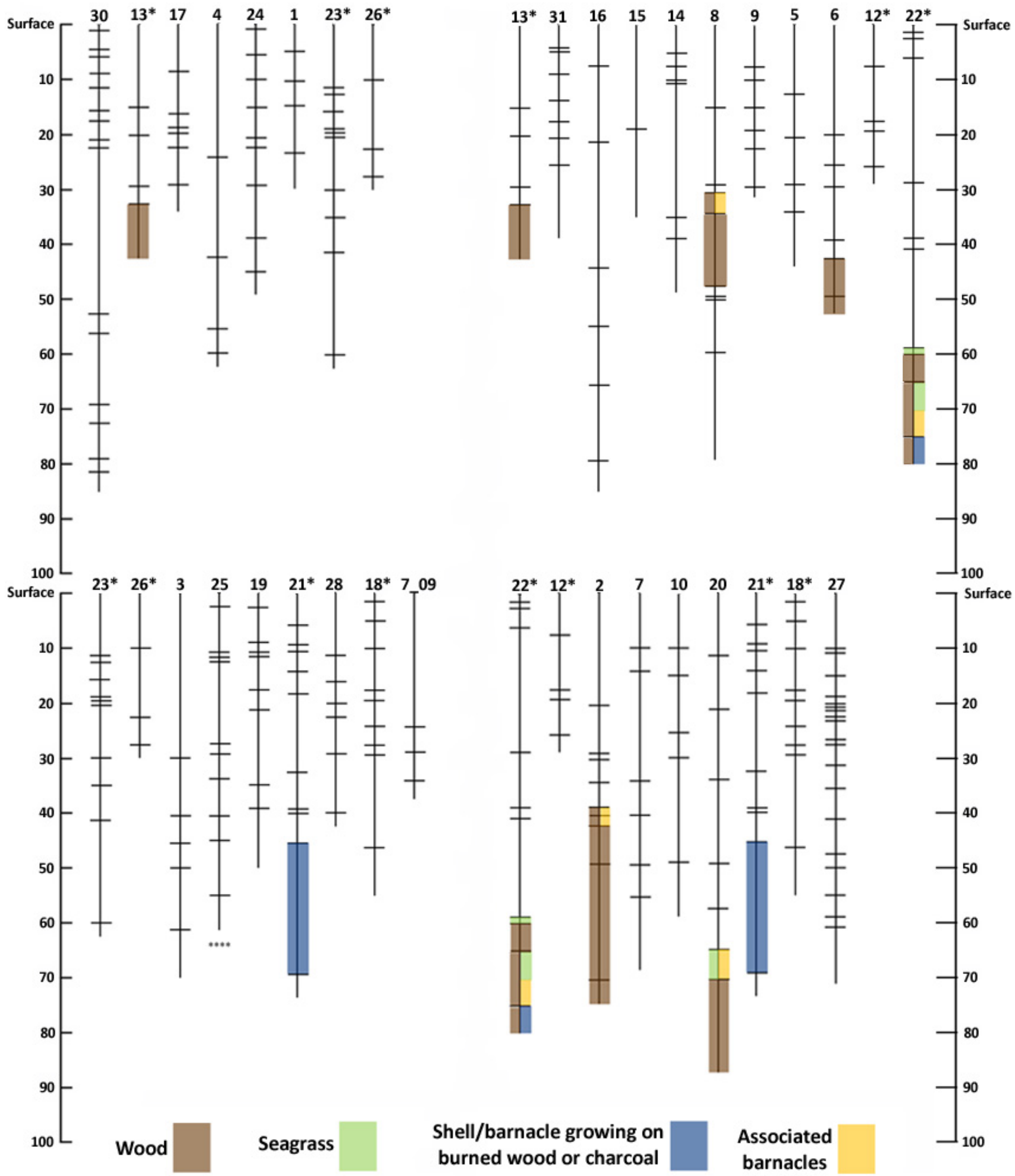

Figure IV.7. While many cores at the wreck site and across the region had wood fragments in them, only six cores are considered to have a significant amount of wood; this wood is either from the hull or from some other structural element of the vessel. Evidence of seagrass and barnacle colonization on the partially burned wood in Core #22 indicates that this part of the hull was exposed for some time. Indirect evidence of barnacles and/or seagrass in association with wood in other cores also supports this conclusion. When the wooden elements collapsed and/or were buried, the barnacles and seagrass died; the size of the barnacles may be an indicator of how long the wood was exposed, but more research needs to be conducted.

Burnt Materials

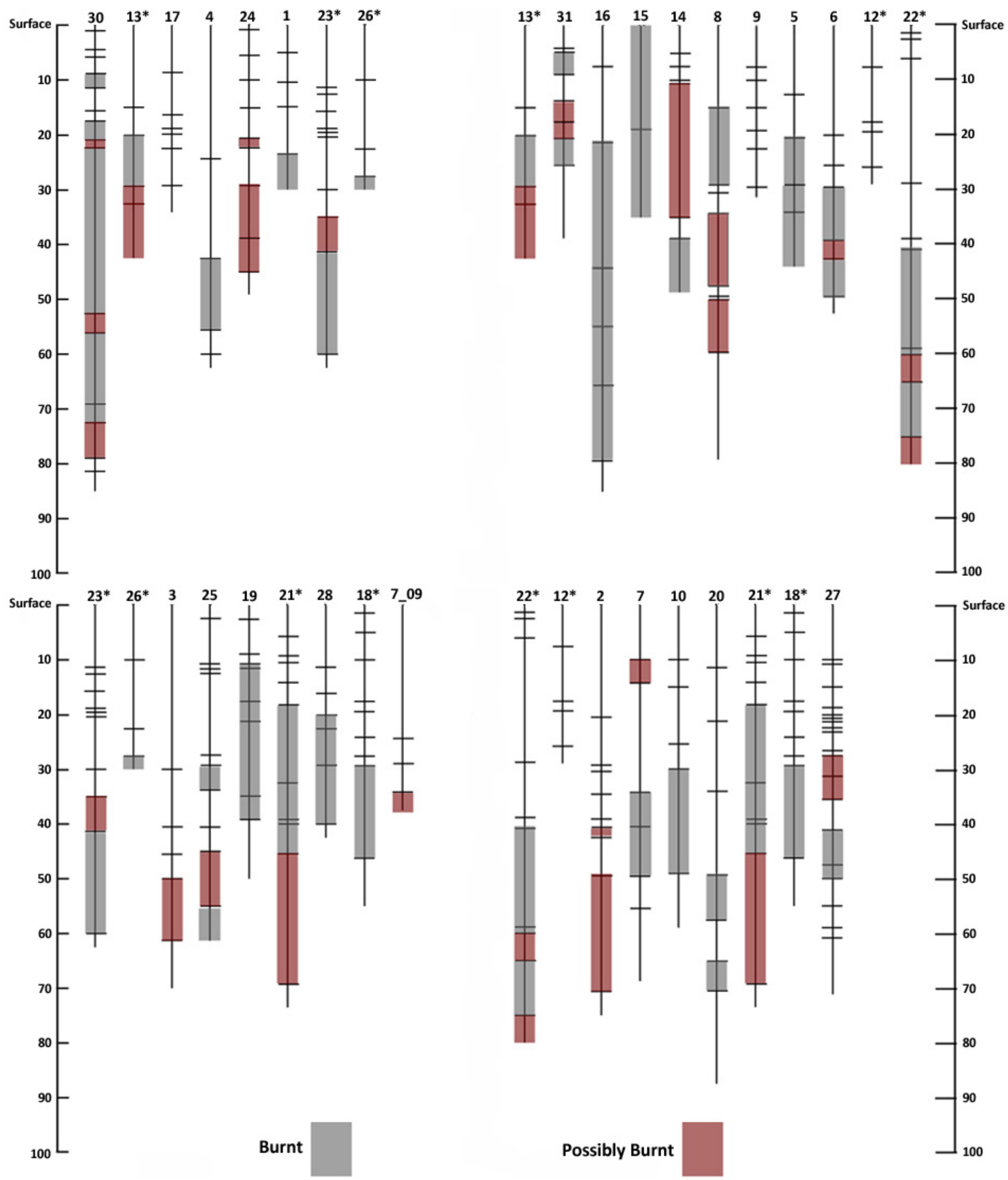

Figure IV.8. The materials categorized in the cores as burnt include cultural objects that appear to have been affected by fire; they do not include charcoal or clearly melted materials. This category is found throughout the wreck site and is likely an indicator of the extent of the fire in the hull.

Charcoal

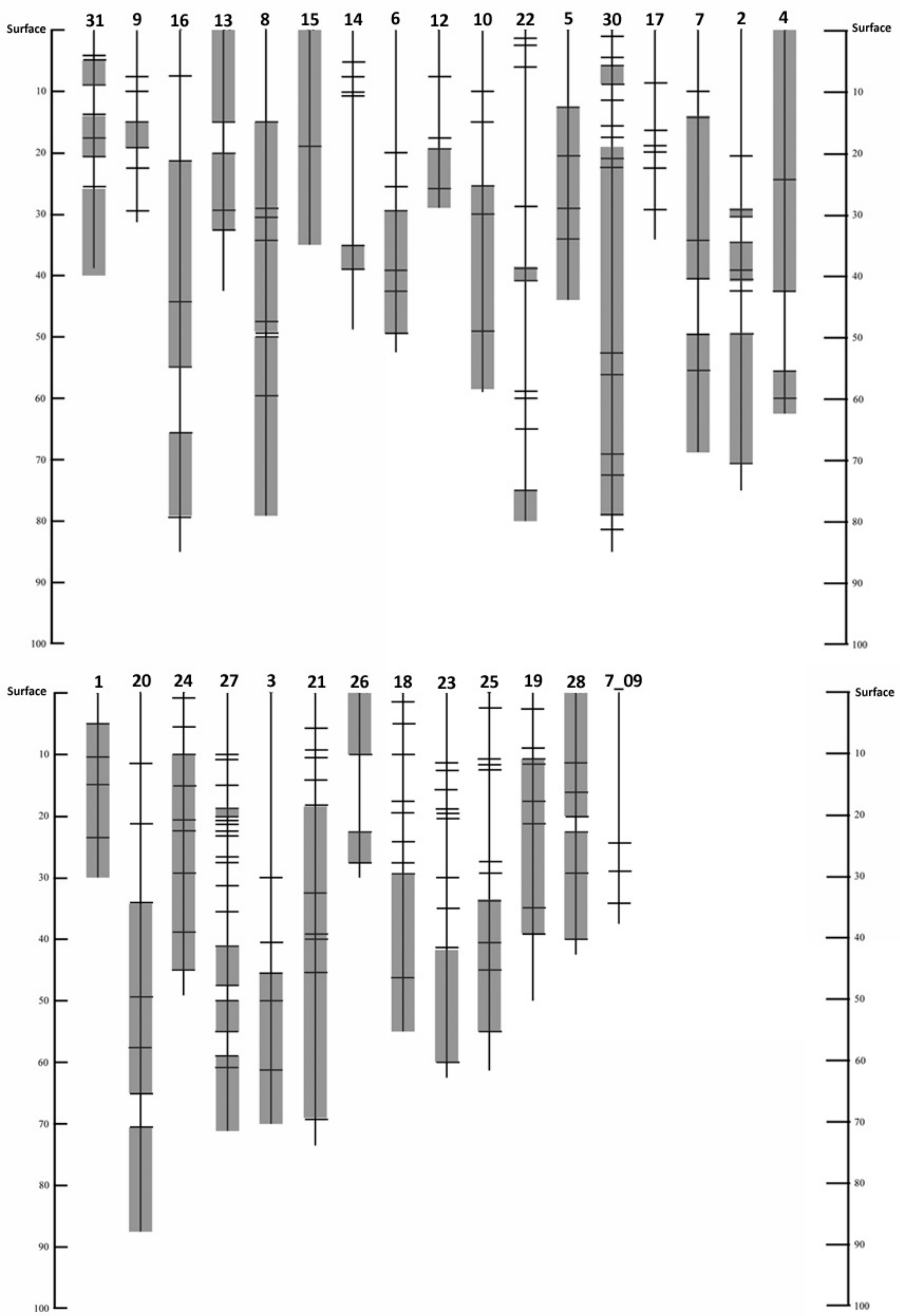

Figure IV.9. Charcoal (indicated in gray) is ubiquitous throughout the wreck site, both vertically in the sediments and horizontally across the site. Because charcoal is also ubiquitous across the Elmina seascape, it is not appropriate to use it as a reliable indicator of fire on the wreck; the large quantities of charcoal on the site relative to other locations, is, however likely a good indicator of fire onboard.

Appendix V
Control Areas

This appendix discusses the intentions behind setting up the control areas, and outlines the methods and materials used to implement the experiment. Before the 2007 field season Greg Cook had already found the Elmina Wreck and with volunteers had created a site plan of it. Some of the obvious effects of the highly dynamic environment on the shipwreck site had already been documented, such as, for instance, the fact that there was no wood extant on the surface of the site. What was completely unknown, however, were the rates at which materials disintegrated and were destroyed in the coastal Ghanaian waters. This project was undertaken as a quantitative means of measuring the rates of deterioration of submerged cultural materials in different dynamic zones of the coast. Essentially, the intent of the control areas was to be able to monitor movements and changes in simulated “shipwrecks” in two different underwater environments – near the surf zone, and in somewhat deeper water where the site was (in theory) less affected/influenced by waves and swells (Figure V.1). It was hoped that by monitoring not only the changes in the objects put in the sites, but also the movements of sediments, changes in current and wave patterns, benthic inhabitation, and wood degradation we may be able to understand the site formation processes that affected historical shipwrecks. This information could then potentially have lent itself to building a predictive model for shipwreck locations, preservation, and composition (i.e. Clark 1989:234).

Figure V.1. **The control areas are shown on this modified GoogleEarth image in relation to each other and to the Elmina peninsula. Both control areas were chosen to be in locations where there were no indicators of possible cultural material in the 2003 side scan sonar data. C2 was, however, intentionally located downcurrrent from a potential target; the target was later confirmed to be a very large rock.**

As noted in Chapter 4, however, unfortunately the materials were transported away from the sites so quickly that nothing remained to monitor after two days in the case of Control Area 1 (**C1**) and likely a similar time frame for Control Area 2 (**C2**).[569] However, even though the experiments themselves did not, in the intended sense "work," several important conclusions may be drawn from them. First, as was indicated by the results of the experiment at **C1**, storm surge and currents were shown to be active much further offshore than anticipated, indicating that any submerged sites in this zone would likely be far more heavily affected by mechanical forces such as current and storm surge

[569] It is unknown exactly how long it took in this instance because we were not able to return to the site for more than two weeks, after which nothing at all remained except for the rebar put in place to mark the site.

than was anticipated. Secondly, as indicated by **C2**, the surf break and storm surge even in the outer surf zone is capable of easily moving stones of more than 30 centimeters in diameter so far away from their deposited location that they could not be found two weeks after they were deposited. Alternatively, the stones also may have been buried so deeply in that time that we could not find, them, although probing around the site did not provide any indications that they were there. This suggests that, although clearly somewhat dependent on the season[570] and on the materials,[571] most historical materials that ended up in the surf zone would have been immediately transported away from their place of deposition. They would likely have been moved inshore and alongshore with the longshore drift, but as we were not able to monitor our materials, this cannot be verified at present. Any future investigations in coastal Elmina must be cognizant of these findings when trying to interpret the actual happening location of events represented by materials on the seafloor.

Although the results of this endeavor were somewhat disappointing, it is recommended that this experiment is conducted again in the future. Next time, however, the lessons learned from this iteration should be applied. Perhaps the most important of such lessons is that while the materials we had were accurate in terms or representing materials on shipwreck sites, the wooden structures were not weighted enough, allowing the entire experiment to be displaced. In the future a great deal more ballast should be applied to anchor the wooden "hull" down, and perhaps the wood should also be

[570] We were working in the rainy season, the most dynamic and dramatic season for oceanic formation processes; in the dry season when seas are calmer, this is likely somewhat different, although the surf zone is highly active year-round.

[571] For instance, the anchor at the Single Anchor Site is in a surf zone but is far too heavy to be moved by oceanic processes. As was also demonstrated by it. however, is that the sedimentation rates in the surf zone are so dynamic that even such a large object can be covered and obscured in a matter of weeks.

saturated with water first to lessen its buoyancy somewhat. The following excerpts are taken from my field notes during the process of creating the experiments and are presented without further comment or interpretation. All photos were taken by Chris Cartellone, a volunteer on the project.

September, 2007

With Papa Kofi's[572] advice and assistance I purchased two different types of wood that (I hope) best approximate the materials that may have been found in historical sailing vessels. We purchased a hard red wood called locally "odom", and a much softer white wood used for dugout canoes called "wawa." The idea is that the red wood would simulate the hull of the vessel, and the softer wawa wood represents interior structure. I had the edges of the red wood planed so that they could be joined. All other surfaces were left as purchased.

I purchased two 14 foot planks of wood of each variety to use in the project. Each odom plank was a little more than five inches wide and about two and a half inches thick. Each was evenly divided into six (about 27 ½ inches or 70 centimeters), with the intention of joining (stacking) three of the lengths on top of each other to simulate vessel planking. One of the wawa planks (12 inches wide, one inch thick) was divided into six 24 inch pieces, and I ended up not using one of the planks.

I had originally intended to build a "corner" of the vessel – using the odom wood as the hull and bulkhead and the wawa as shelves or floor planking, and planned to put all of the experiment items and ballast on shelves within the corner – but realized that perhaps a better way of doing it was to create parts of two rooms. So we built "Ts" of the odom wood and stacked three of these "Ts" on top of each other, joining them with two double-pointed (we had the heads cut off) nails in each part of the T (total height was about 15 inches). On one side of the T we affixed a bottom "shelf" (at the very bottom of the object) and on the other side created a three-sided shelf (top, bottom and the edge opposite the odom "hull"), leaving the long side of the box open.

I tried to find untreated or non-painted/protected nails to use, but was unable to, so we used three-inch and four-inch wood nails and ended up using a couple of two-inch coated nails for additional tacking of shelves.

I coated the "exterior" of the hull with a pitch called "water pitch" used by the local fishermen. The pitch was brown when wet but dried black and rubbery. I applied it on the "outside" of the wreck as well as on the top and sides of the odom wood, making certain that all the joins between the pieces of wood were sealed.

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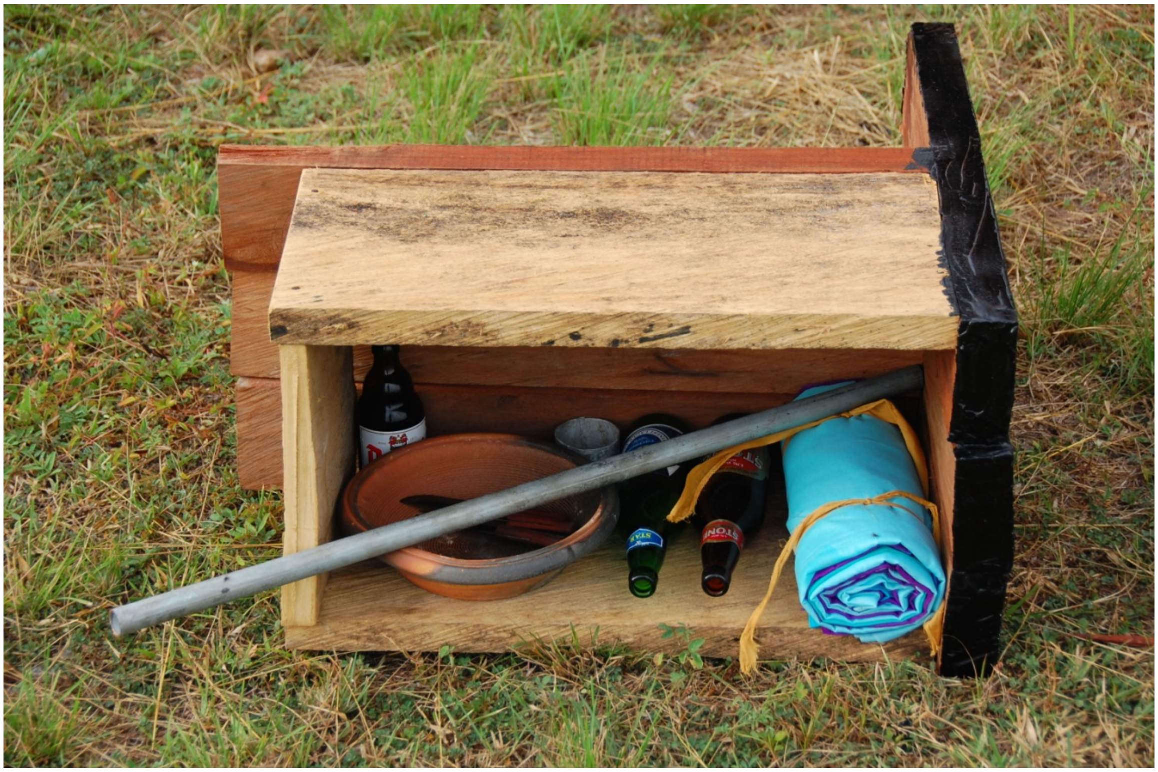
[572] The local fisherman who has been instrumental and invaluable in making every underwater investigation in coastal Ghana possible.

The idea is that the ballast will be on the open side of the T and the items that have been selected to represent objects used or present on historical vessels will be in the slightly more protected double shelf side.

We built two very similar (as identical as possible using a handsaw and uneven wood) wrecks.

I have already explained the making of the “shipwrecks” themselves, but here I should write a little bit more about setting up the sites. As I knew it not going to be possible to take pictures underwater at this time of year, I set them up in the yard as I intended to set them up underwater and photographed them on land.



Each item was intentionally selected to represent some commonly found or known about feature on historical vessels. The first, obviously, is the wood itself, which was explained earlier. The intention of creating a semi-closed environment for these items was to more simulate a room or compartment on the vessel where things may have been slightly more protected, both on the vessel itself and during and after wrecking. There is a massive list of things that I could have selected, but I selected goods based on known frequency of occurrence on historical vessels in this area, from historical vessels in general, and from what was found on the known shipwreck site.

- Bottles – three bottles on each site – two modern Ghanaian beer bottles that approximate historical wine bottles, and one smaller (Belgian beer) bottle to approximate onion bottles or something slightly smaller.

- Iron pipe – I could obviously not get a gun to put on the site, so I approximated at least the barrel on one with the iron pipe. I am aware that rolling processes are different because of the shape, but it may give us some indication about the rapidity of iron corrosion in the area. I also was looking for other things to put in and happened to have this pipe sitting around.

- Three small iron knives with wooden handles – these could have been used historically in any manner, and I was interested to watch a) how quickly such an item might move and b) how they disintegrated, as it would have been a common item on historical vessels.

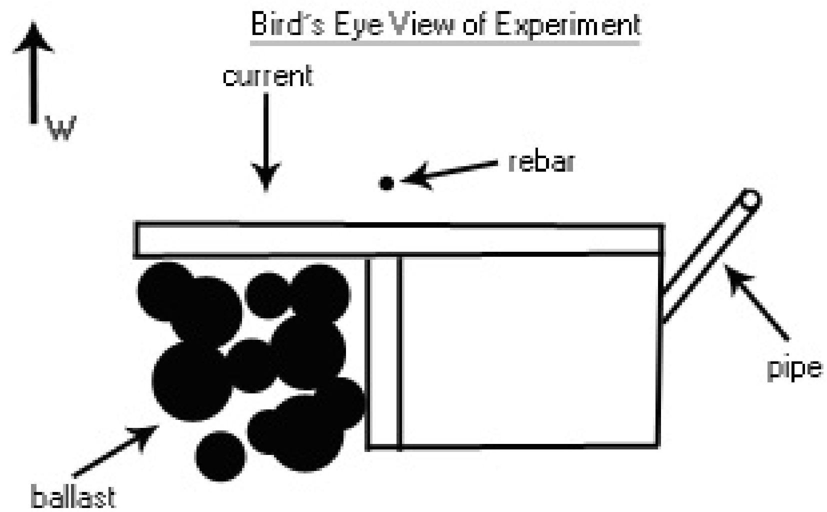
- Tin cup – this seemed a good approximation for a common drinking vessel. It may be too light and flimsy compared to those used in the past, but it was the best we could find.

- Fufu bowl[573] – while I have never heard or read about how this exact form of ceramic vessel might have been used on historical sailing vessels, many types and forms of ceramic were used. Additionally, there were at least two fufu bowls of this general form found on the known shipwreck, which means that someone, at some point, thought these were useful. So I chose to put them down because a) we've seen them on at least one wreck, b) they can represent other forms of ceramic in terms of encrustation, etc., and c) they are cheap and available.

- Cloth bundle – this is perhaps the most materially problematic item in the control, as the fabric is polyester and not pure cotton or silk, as it likely would have been historically. I was also not certain of the size of bundles or of how they might have been wrapped/packaged/shipped. As a result, I chose 12 yards of the cheapest fabric I could find and rolled them together (assuming that the material was at least in bolts). I recognize that the fabric is a different material, but I think for purposes of understanding the role of cloth underwater and how it deals with surge, etc. (as in, whether or not it gets carried away) it will work fine.

[573] A typical ceramic form used to eat certain types of Ghanaian food.

The other side and the top of the box was filled with stones to simulate ballast. I had originally intended to use only what appeared to have been ballast stone used historically, but this did not end up being very practical. So we took stones of varying sizes from the lagoon, but generally between 20 and 30 cm in length to use. The materials were lowered in different phases to the seafloor – it was incredibly difficult to fight the boxes to get them down, even with stones in them. It sounds obvious, but no wonder ships float. At each site we pounded in a rebar piece to mark the site's location should the materials get carried off or buried.



- This is how the sites were set up – the ballast were in a sort of corner shelf, while the other materials were in the more covered side. The boxes were placed with the flat, solid sides towards the current and to the east of the rebar.

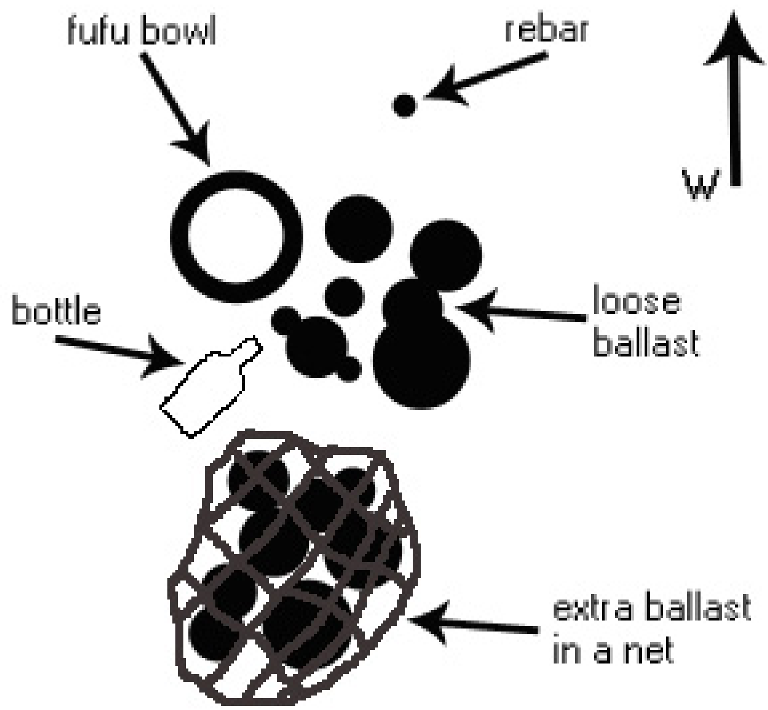
Preliminary methodology and information intended to be collected at each site

- 100 foot circle search
  - Make certain we are not accidentally interfering with a shipwreck site
  - Record surrounding environment
- Probe and/or core site
  - Test depth of sediments
  - Look for changes in sediments
- Note depth/current/swell/visibility info
- Record placement of items

All of the above goals were met when we were setting the sites up, but we only did follow-up on **C2**, where we went at the end of the project and collected six cores around the rebar.

One thing I was particularly interested in looking at is the quality of the wood that was buried beneath the stones. That did not happen this time. Next time.

Drew's sketch below shows **C1** just two days after we set up the site. We did not even bother going back, particularly after we visited **C2** and found literally only the rebar there. Then it really was not worth it.



- The weird-looking thing at the bottom of the sketch is a net we had with extra stones in it that was supposed to have been put on top of the box, but because of miscommunications and not being able to see ANYTHING, it was not.

Appendix VI
Intrusive Material

Shipwrecks and other objects that protrude above[574] the sediments are notorious traps for materials that are being transported along the seafloor or suspended in the water column just above the seafloor. These materials, which can span decades or centuries, depending on their composition and the environments in which they are deposited and transported, are considered to be intrusive to the site: i.e., they were not originally part of the wrecked vessel or other submerged materials. While it is slowly becoming more of a common practice in maritime archaeology to report the intrusive material discovered during archaeological investigations (e.g. Smith et al. 1999; Wilde-Ramsing et al. 2008), it is unfortunate that more reports do not include this information, as it can be an invaluable measure against which to compare not only original material on a submerged site such as a shipwreck, but also a means of understanding contamination and disturbance, and of investigating the formation processes affecting submerged sites. In addition to natural formation processes, such as sedimentation, currents and surge, that affect submerged sites, formation processes also include the cultural circumstances surrounding deposition and the historical environment of the submerged site. Intrusive materials trapped on submerged sites over time are thus reflectors of the changing cultural activities and material culture of the seascape within which the submerged sites are located.[575] Recording them is as much a part of understanding the evolution of

[574] Proud of the sediments.
[575] Interestingly, the quantification and sourcing of litter (essentially intrusive material) on beaches is becoming an area of investigation around the world (Cunningham and Wilson 2003; Earll et al. 2000; Oigman-Pszczol and Creed 2007; Storrier et al. 2007; Tudor and Williams 2004); as with the material on shipwreck sites, these studies are also providing information on changing cultural uses of the sea and beaches (Williams and Tudor 2001).

submerged sites as is interpreting the physical changes that a shipwreck, for instance, has undergone.

The Elmina Wreck site provides an excellent case study of both natural and cultural formation processes within the seascape of coastal Elmina (Chapter 6), as, in addition to indicators of natural processes affecting the site, it hosts a complement of materials that span at least four centuries, from the late 16th through the 20th and into the 21st. Integral to a discussion of formation processes is an understanding of the processes through which intrusive materials found their way to the site and became integrated within it (Chapter 6). For a number of reasons not every intrusive object was collected and recorded at the Elmina Wreck site; however, the materials that were collected and recorded provide adequate information to be able to draw some conclusions concerning the history of the wreck site and the intrusive materials represented there. While an analysis of the range of intrusive materials has been begun (Cook n.d.; Pietruszka 2011), they have not yet been studied as a means of investigating changing cultural material and practices across the region. This will be most effectively done through comparison of cultural materials both at the site and across the region, including the material culture investigated from the Elmina Castle (DeCorse 2001). In addition to investigating changes in culture and materials within the Elmina seascape, comparisons of intrusive materials from this and other sites across the world can provide insights into cultural and natural formation processes of submerged sites across a range of environments and settings, in the process expanding our understanding of formation processes of submerged sites.

As a means of preserving the record of intrusive materials at different sites, Table VI.1 below is a list of the intrusive materials recorded at the Double Anchor Site and the

Single Anchor site. Similarly, the following list is a basic record of both categories of materials and individual objects recovered from the Elmina Wreck site (Table VI.2). The wreck site list is presented in roughly divided temporal categories (by century). Finally, the objects within all the lists are also classified in terms of what processes may have been responsible for transporting them to the sites, whether by floating on the surface, being dropped on site, or being transported along the seafloor.[576] It is hoped that future investigations will continue to build on this database for future reference and comparison both of submerged sites and of cultural and material changes over time within the Elmina seascape.

Table VI.1

Mobile Material on Anchor Sites

Single Anchor Site	Double Anchor Site
fishing line	modern fishing weights
modern lead fishing weights	fishing line
glass fragments	rope
wire frame of lantern	
tin cans (small tomato paste)	
glass bottle	
plastic bag	
battery (size D)	
coconut shell	

suspended
seafloor/ dropped
fishing/ anchoring
indeterminate/ multiple

The color coding of the materials in the table illustrates the *most likely* manner in which they were transported to the sites. As can be seen in the table, most materials can be easily attributed to either fishing activities or seafloor transportation.

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[576] It should be noted here that these materials are only the macro materials recovered at the sites; they do not contain the micro materials collected in sediment cores.

Table VI.2. Mobile Material on the Elmina Wreck Site

17th-ish	18th-ish	19th-ish	Modern
(poss 17th) onion bottle base (5)	onion bottle base (5)	bottle base and finish (2)	metal/tin? pan
(poss 17th) onion body frag (2)	onion body frag (2)	(poss 19th) Iberian olive jar	tin pan lid
Iberian olive jar	case bottle base	bottle base (11)	clear glass cup
yellow brick	Iberian olive jar	bottle neck (2)	Club bottle
pin	earthenware rim sherd	complete bottle (11)	plastic bucket lid
earthenware lid	yellow brick	diagnostic bottle body sherds (12)	plastic water bottle
strainer (red earthenware)	pin	embossed glass	flip-flop?
lead glazed red earthenware	case/bare iron pontil/dip mold	hex bottle (embossed)	modern plate
earthenware rim fragment	case/flared finish/bare iron pontil/dip mold	(poss 19th) case bottle body (2)	modern lead fishing weights*
Martaban (stoneware)	bowl rim frag (pearlware)	case bottle base	fishing line*
Dutch pipe	Anularware bowl rim frag (pearlware	blue transferware	rope*
pewter cap (5)	(poss 18th) Mochaware rim frag (creamware)	whiteware complete crock	fishing net*
lead bale seal (2)	small crock rim frag (creamware)	indigenous bowl rim	PVC pipe
	bowl rim frag (creamware)	salt glaze stoneware pitcher	battery
	earthenware lid	Rhenish stoneware bottle (5)	plastic wrappers*
	strainer (red earthenware)	yellow brick	newspaper
	lead glazed red earthenware	stoneware handle	buttons (2)
	earthenware rim fragment	Nassau stoneware body (3)	rubber gasket
	(poss 18th) Dutch pipe (2)	Nassau stoneware base	foil wrapper
	Dutch pipe	(prob 19th) Anular ware rim frag	plastic spoon
	pewter cap (5)	(prob 19th) pearlware bowl frag	plastic razor cap
	lead bale seal (2)	(prob 19th) Mochaware rim frag	paint chip
		(poss 19th) creamware	rubber hose fragment
		earthenware rim frag	plastic tape?
		pipe bowl	modern fabric*
		(prob 19th) pipe bowl (2)	plastic bags/trash bags*
		lead bale seal (2)	palm kernel shells*
		(poss 19th) pin	

*Note: For items where there are many pieces, no count is given; however, for each of the starred categories, there are is a minimum of ten pieces represented, and usually many more than that.

Several things should be noted in Table VI.2 above: the artifacts recorded were collected in both 2005 and 2007, and basic artifact analyses of historical materials on the shipwreck site were done by Pietruszka (2011) and Cook (n.d.). The dates for the objects have been intentionally recorded as only estimates, because many of them could realistically be assigned a range of dates; consequently, several items are listed in multiple date range columns. What is most important to take from this is the wide variety of materials and dates represented. The color coding is the same as for the objects in Table &, and, similarly, it is instantly apparent that most of the objects likely reached the wreck site by transportation on or near the seafloor. As discussed in Chapter 6, this has implications for the formation processes at work in the region, and indicates a range of processes that are not yet fully understood.

Appendix VII
Canoes

As mentioned in Chapter 3, the importance of canoes in historical maritime trade cannot be overemphasized, as they were a key tool in conducting trade along the West African coast. As of yet we do not have any archaeological signatures that indicate a sunken canoe or the contents of one that overturned, but it is possible that future investigations will reveal such sites.[577] Regardless, a brief discussion of the ways canoes were used is useful in helping to understand historical maritime trade in the Elmina seascape.

Canoes

> There is a continual (?) heavy Surf Beating all along this Shore; so much so; that no English Boat can land; consequently, when it is nessarry to land any materials, in the way of trade; or to fetch the Slaves of to the Ship, it is the pracktice to hire Canoos, and a gang of Negroes for that purpose; whoo is verry Expert in their Business as it is verry seldom they happen any accident …it will be observed, their canoos for this purpose are [large]…being from Fifty to Seventy Feet long, and Padled by Twenty or thirty Men.… (Dent 1826).[578]

Although actually penned over twenty years later, John Dent's observations of native canoes as the mechanism of trade were made when he was a sailor on board a British slaving vessel trading at Cape Coast Castle and Accra on the Ghanaian coast in 1803. Other sailors' accounts echo his description of the canoes and canoe men employed

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[577] See Figure 6.7 in Chapter 6 for an image of the base of a dug-out canoe that has clearly spent some time on the bottom of the sea, as evidenced by the destruction of the outside of the hull, and which was recently washed on shore.
[578] DeCorse (2001:108) suggests that canoes were actually significantly smaller than this, the larger ones measuring under 10 meters.

by merchants of the Atlantic (see Barbot 1746; de Marees 1987:116-119; Hair et al. 1992; Phillips 1746). One observer suggested that it was the canoemen of Mina (Elmina) who were the fittest and most adept at maneuvering their canoes through the harsh water environment of their coast (Smith 1970:517);[579] and Adams (1966 [1823]:6) wrote that they were "almost amphibious" (Figure VII.1).

Figure VII.1. Both paddled and sailed canoes are visible in this image of canoes rounding the rocks in front of Cape Coast Castle. While the seas in this image are calm, the mild appearance only helps to hide the deadly shoals and rock reefs around the Castle and along the coast (photo R. Horlings, 2007).

When Europeans arrived at the coast they found that, because of the rough and shallow coast and the absence of natural harbors, their large trading vessels had to anchor

[579] See also Adams 1966 [1823]:239, 243; Barbot's comments in Hair et al. 1992:382; Brooks 1970:235; Feinberg 1989:68; Gutkind 1989; Smith 1970:516-517; Thomas 1969 [1860]:193);

offshore, thus necessitating the use of smaller boats, including ships boats and local canoes, to reach the shore and transport goods (Feinberg 1989:67; Mitchell 2005:178-180). They quickly discovered that their own ships boats were often not strong enough to withstand the surf (see Adams 1966 [1823]:239; Martin 1972:104; Rømer 2000:192), and it was generally safer to use the canoes and expertise of the locals.[580] Although not frequent, historical records do mention canoes capsizing in rough surf, sometimes with catastrophic consequences in terms of human life (Allen 1874:67-70; de Marees 1987:118; Rømer 2000:192).[581] While the canoemen and their canoes played an invaluable role in the maritime trade along the coast and were generally highly respected, there are records of tensions between the canoemen and the Europeans. For example, as van Dantzig (1978:346) records, the people of Elmina, in a discussion with the Director-General of Elmina in 1739, stated that they did “not want any longer to be held responsible for canoes which may break in heavy seas” or storms. Despite these issues, canoes remained vital to the maritime trade along the coast.

In addition to being the essential link between ship and shore (van Dantzig 1980:82), local canoes and canoemen were used to reconnoiter other vessels in the region and to maintain communication between forts and trading posts along the coast (Feinberg 1989:67-68; van Dantzig 1980:19; Vogt 1979:97). The canoe became so important, in

[580] “The biggest of these [“Canoas”] being capable of carrying a reasonable Merchant-Man’s Boat lading; we generally use them in the transportation of our Goods from place to place” (Bosman 1705:129)

[581] De Marees (1987:117) describes local canoes as being slight and low in the water, but he was extremely impressed with how well they could paddle in calm water. He writes: “They can paddle so fast it appears as if they fly through the water, and one could not keep up with them rowing in a Sloop. If the waves are high, they do not make much progress, as the heaving of the rollers takes away their speed; yet in quiet water there are no Frigates, Sloops or Gondolas which could keep up with them… They know how to adjust their bodies to the pitch of the Canoe to prevent it from capsizing. Since we Netherlanders are not as experienced in this as they are, if we want to sail in them, not being able to adjust ourselves as well and steer them properly, the result is that the Canoes capsize immediately and we fall in the water. Allen (1874:69) later writes that crew were accustomed to canoes capsizing, but visitors were in greater danger in such a circumstance. He also suggests that at times the canoes were intentionally upset so that the canoemen might be rewarded for having “saved” the life of a submerged or startled passenger.

fact, that it was relatively common for Europeans to own canoes for the coastal trade (Feinberg 1989:69; van Datzig 1980:19) and to carry them and local Elminian people to paddle them (Brooks 1970:235; Feinberg 1989:67; Law 1991:42, 149), providing ready transportation upon anchoring at other locations along the African coast (Allen 1874:31; Dickson 1969:96, 101; Feinberg 1989:69; Morgan 2009:224). Large canoes were also used for war on the Ghanaian coast, and were large enough to carry ammunitions and provisions for "50 or 60 men for 15 days" (Smith 1970:528). However, there is no account of any battle taking place on the sea in canoes and they were primarily used as transport for troops, supplies and ammunition, although some attacks were launched from canoes onto shore (Smith 1970:530).

As noted by DeCorse (2001:104-109), while the historical village of Elmina was located on the coast and the people there made some use of the sea, it appears that a heavy dependence on canoes and marine resources developed only after the period of European contact in the late 15th and 16th centuries. Once they became more utilized, however,[582] during a smooth or a calm sea it was not uncommon to see dozens, if not hundreds of fishing canoes on the water at once in the Elmina region, often as far out as two leagues (nearly seven miles), as is noted in accounts from the early 17th century through the 19th century (Adams 1966 [1823]:40; Bosman 1705:58; de Marees 1987:117-122; Hair 1994a:78; Hair et al. 1992:381; Smith 1970:525). This is visible in the Elmina seascape today, where on any given day there may be dozens of canoes in the Bay or in the Benya Lagoon, in which case it is not uncommon to see canoes literally piled on top

[582] Marine fishing was in common use by the 17th century, as indicated by de Marees (1987:117-122); archaeological evidence from Elmina suggests that it was less common before the beginning of the 17th century (DeCorse 2001:108).

of each other as tides change and they are deposited on whatever surface happens to be proximate.

While canoes apparently were not historically as large as their modern-day counterparts (DeCorse 2001:108), there is possible evidence that canoes in Elmina carried sails already before the Europeans arrived (De Marees 1987:116; DeCorse 2001:108, 2008:84-85). Reports of canoe sizes range from 13 to more than 30 feet long and from 1½ to six feet wide, paddled by two to 17 men, depending on the canoe's purpose (de Marees 1987:118; Feinberg 1989:19).

A final note should be made concerning the larger scope or influence of the canoe and African-European maritime connections along the coast. In their discussion of maritime archaeology of the African Diaspora, Ogundiran and Falola (2007:35) make the following interesting observation:

> Canoes, lighters, schooners, and pettiaugers (flatboats) sustained the plantation system in the New World because these vessels were used for the transportation of sugar, rice, and tobacco bound for local and regional markets... As captains and pilots of boats, canoes, and pettiaugers between the Caribbean surf and Carolinian rivers, African boating skills benefited the New World transportation systems. After all, in Western Africa, myriad waterways constituted important highways for commerce, transportation, warfare, and communication with the use of dugout canoes...

Closer to Elmina, one more personal observation merits mention concerning the vestiges of international relations and the sea: the Ghanaian phrase "heava!" which is used in moving the large canoes on land is, I suspect, a direct descendant of the English term "heave!" Other physical vestiges of the past remain to be explored under the sea.

Appendix VIII
Survey Targets

Chapter 5 is a discussion of several key sites and dive targets across the Elmina seascape; for space considerations, only the most diagnostic sites are discussed there. This appendix is a continuation of the discussion of several more representative targets across the seascape; it includes targets in every geomprohological zone, targets at which modern materials were identified, and targets identified from both Cook's 2003 side scan sonar data and from data collected in 2009. As noted in Chapter 5, there are three basic seafloor characteristics, found singly or in various combinations. These include rocky areas consisting of rock reefs and low relief sandstone formations; large expanses of sand, some of it formed into ripple patches of various sizes and shapes; and a few, relatively small and isolated patches of distinct black, sticky mud which are discussed in the literature and have been observed by divers, but do not have a distinct side scan sonar signature other than appearing relatively featureless. Combinations of some of these features, such as sand ripples in conjunction with rocky areas, were considered to be "mixed," but because a wide variety of combinations was observed, the component characteristics were recorded, but this was not considered a separate or distinct category.

The targets are presented here as individual locations and examples of remote sensing targets that were investigated. Connections between target sites or locations are also highlighted in terms of the environment and formation processes, as well as in terms of artifacts. All of the targets dived in 2007 and 2009 are presented in Table VIII.1; as noted above, however, because there is a lot of similarity in terms of the micro or local environments of the target sites, only representative targets from each geomorphological zone are discussed in detail. In addition, because cores were collected at most of the targets dived in 2009, the emphasis here is on those sites, as the core data, in addition to diver observations, serve as an excellent basis for comparison between sites across the region. Table VIII.1 below illustrates the locations of each of the targets discussed in this appendix. Targets presented here are discussed in terms of the criteria used to select them; their physical properties identified in the remote sensing data and by diver observations; changes over time; and potential for future investigation.

Target	Year	Seafloor	Cultural	Core Data
Elmina Wreck Site	2003, 2005, 2007, 2009	varying - sand and shell (2003, 2005, 2007, 2009); mud (2009); scoured areas (2007, 2009)	wreck	yes
05-016 R-B	2007	sand with undulations	no	no
05-016 R-A	2007	sand with undulations	no	no
05-056 R	2007	large rock	no	no
10-13 R	2007, 2009	muddy (2007); sand and shell (2009)	2 iron poles (identified in 2009 as the Double Anchor Site)	yes
07-40 R-B	2007	large flat rock and mud	no	no
06-53 L	2007	sand with low (possibly linear) rocks	modern trash	no
07-28 R	2007	mud	no	no
07-39 R	2007	large rocks and mud	single yellow brick	no
04-45 L	2007	mud	no	no
08-47 L	2007	not recorded	no	no
10-57 R	2007	sand with undulations, some shell	no	no
04-13 L	2007	mud	no	no
04-30 R	2007	patches of sand; patches of mud	no	no
05-04 R	2007	large rock, sand	fishing net, modern debris	no
07-27 R	2007	rocks and sand	no	no
07-26 L	2007	mud, depressions once in a while	no	no
06-32 R	2007	mud near Pasum Accra Reefs	no	no
06-36 R	2007	rocks with soft coral; sand and shell	no	no
06-24 R	2007	large rocks with soft coral; sand with shell and undulations	no	no
06-41 R	2007	mud/silt	no	no
07-40 R-A	2007	rocks with sand; silt/mud	no	no
08-56 R	2007	mud/silt	modern debris	no
08-68 L	2007	mud/silt	no	no

12-23 R	2007	rock with sand; silt/mud	no	no
11-36 R	2007	mud	no	no
08-22 R	2007	silt/mud with shells	no	no
11-29 L	2007	sand with large undulations; some areas mud	no	no
08-12 R	2007	silt/mud	no	no
10-15 L	2007	mud/silt	no	no
11-46 L	2007	sand with undulations; one quarter of the search area was mud	modern concrete with rebar in it	no
10-40 L	2007	silt/mud	no	no
05-52 R	2007	silt/mud	no	no
11-01 R	2007	mud/silt	no	no
11-01 L	2007	mud/silt	no	no
12-04 L-B	2007	not recorded	large cylindrical object standing 1 m above sediments at 45° angle	no
06-35 L	2007	rock and sand	no	no
C1	2007	mud	no	yes
C2	2007	silt/mud	no	yes
Waypoint **46**	2009	hard-packed fine sand	no	yes
Waypoint **303**	2009	sand with scours	no	yes
Waypoint **394**	2009	sand with scours	no	no
Waypoint **397**	2009	sticky mud with scours	no	yes
Waypoint **395**	2009	rock, sand and mud	no	no
Waypoint **398**	2009	rock and sand	no	no
Waypoint **322**	2009	sand	nothing on surface - hit something with core	yes
Waypoint **338**	2009	undulating sand over black silt	no	yes
Waypoint **538: Near Single Anchor**	2009	sand	no	yes
Waypoint **539**	2009	mud	no	yes
Waypoint **253**	2009	sand and silt	no	yes
Waypoint **555**	2009	rock reef and sand	large chain	no
Waypoint **541: Single Anchor Site**	2009	sand	single anchor fluke	yes
Waypoint **411**	2009	sand	no	yes

Table VIII.1. This table provides an overview and quick summary of all the targets investigated in the 2007 and 2009 field seasons. As can be seen in the table and in Figure VIII.1 below, there is a range of geomorphological environments present in the seascape; side scan sonar and magnetometer targets have been identified in each of these different environments. Targets of identified historical significance are highlighted in green and are discussed in Chapter 5 or Chapter 6; targets discussed here are highlighted in yellow and represent different geomorphological characteristics.

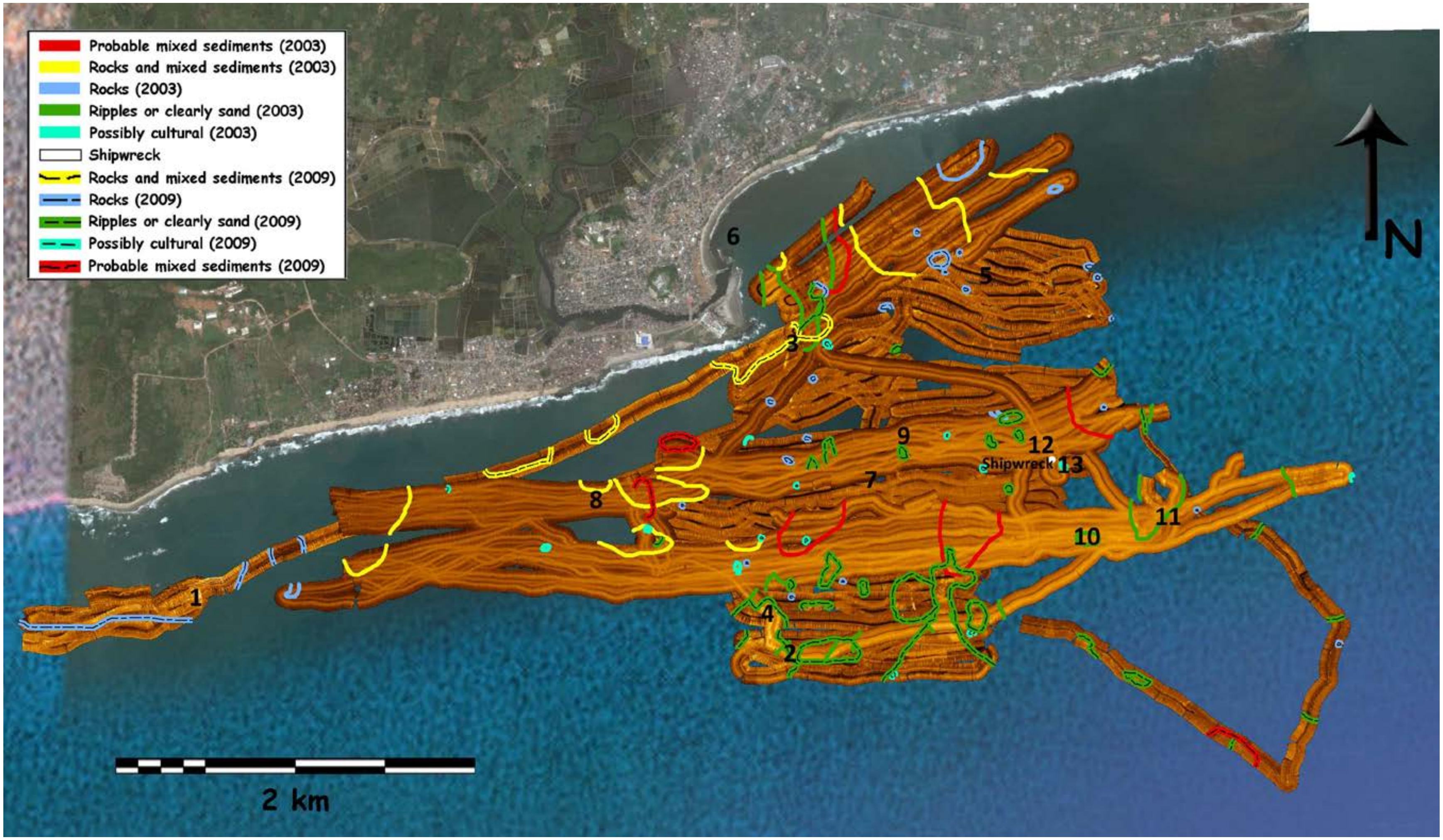

Figure VIII.1. The locations of the targets discussed in this appendix are shown here in relation to their geomorphological settings on the seafloor as interpreted through the side scan sonar data. The Elmina Wreck site is indicated by the small white dot between targets 12 and 13. Note that the target identifiers are only used here to identify their locations in the survey area.

Target 1 - *Reef Site (06_024R)*

This target is one of many located in the Passum Accra rock reefs about one kilometer west of the Elmina Castle. Because reefs are inherently detrimental to sailing vessels, it was necessary to investigate these reefs for cultural material, but this is an incredibly difficult task. Collecting remote sensing data with a towed transducer near shallow reefs is difficult in the best of weather, and the extremely rough conditions in which the data were collected in 2003 meant that the data for this region are difficult to interpret. Two targets that were relatively distinct in the side scan sonar data (such as that indicated in Figure VIII.2) were dived in 2007, with no identification of cultural material. There were soft coral and sea-fans on the rocks, and the area surrounding and between the rocks of the reefs was sand with undulations. Between the rocks was coarse sand and

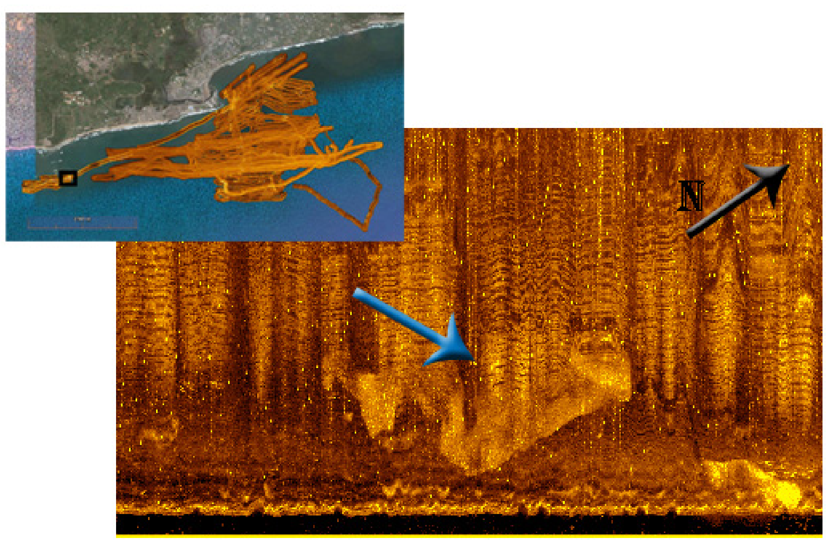

Figure VIII.2. The blue arrow highlights one of the anomalies identified in the 2003 side scan sonar data. While some scouring can be seen along the bottom edges of the object and some elevation can be detected, the target is still somewhat amorphous, and may or may not be as distinct or "real" as it appears. Ripples or undulations may be seen surrounding the target, but the roughness of the data makes them more difficult to distinguish from distortion caused by the waves.

shells. Predictably, the observations made of the target area are in agreement with the geomorphological assessment of the region (Figure VIII.1). The area was not surveyed with the side scan sonar in 2009, although the magnetometer was towed as close to the reefs as was reasonable, but no magnetic anomalies were identified, further supporting the assessment that there is a lack of significant cultural material in the reef. Because only two areas of the reef site were investigated in 2007, if possible the site should be quickly resurveyed in calmer conditions at some point in the future.

Target 2 - *Sand, Ripples and Mud (11_046L)*

This target was dived in 2007 because of its unique appearance in the side scan sonar data as an anomalous feature in the middle of clearly sandy/ripple area. This (Figure VIII.4) is seen occasionally in side scan sonar data and is usually interpreted as some other material, whether it is a different sediment or an object such as a rock, disrupting the migration of a ripple patch. These disruptions in sediment patterns are known to indicate buried material, such as shipwrecks. In addition, it was also the deepest site visited (more than 12 meters deep), located near the expected limits of wave action and therefore of ripple patterns. It is interesting that when diving the site in 2007, the diver observed that he was in silt or

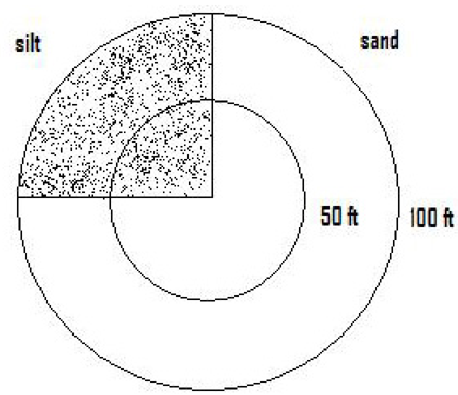

Figure VIII.3. This sketch by A. Pietruzska illustrates what the diver observed in terms of sediments at this location. The circles represent the concentric search circles (at 50’ and 100’) performed to investigate the target.

mud for approximately the same ¼ of the circle each time, while the rest of the area was sand with undulations (Figure VIII.3). One object, a piece of cement with iron rebar bracing in it, was recovered; it is unknown what its purpose was, but it is possible that it was part of the weighting system for a crab trap or similar device. While the target was not revisited in 2009, it is interesting to note the changes that have taken place in the site over the six year time span between remote sensing collection (between 2003 and 2009): the angle of the edge of the ripple patch has changed, and the disrupting patch in the middle of the ripples is no longer visible. No cores were collected at this location. While no data were recovered

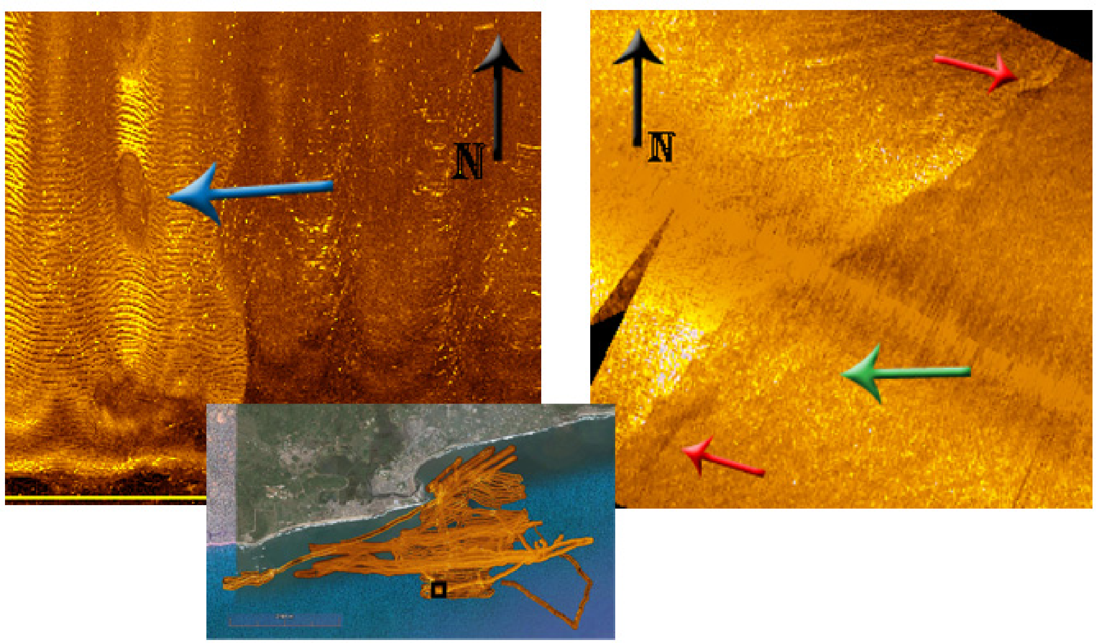

Figure VIII.4. Note in here that the angle of the edge of the sand ripples has changed in the six years between when side scan sonar data were collected in 2003 (left image) and 2009 (right image), and even allowing for some distortion in the data collection, this is still significantly different. Also notice that there is no target visible at all in the 2009 side scan sonar image, although to both the NE and SW of the area dived there is scouring visible along the edge of the sand ripples (indicated by the red arrows).

to suggest that the site has any historical cultural significance, the presence of the disruption in the 2003 data and indications of scouring along the edges of the ripple patches in the 2009 data suggest that this is both a dynamic area, and perhaps one worth revisiting with remote sensing instruments, particularly the magnetometer and echo-sounder, in the future.

Target 3 - *Modern Debris (05_004R)*

This was one of a limited number[583] of targets dived in 2007 that produced significant cultural material. It was selected because of the small but distinct feature in the side scan sonar image and is presented here because it did produce cultural material, even though it was modern. The seafloor was sand with a large, low sandstone rock with some other rocks near it (Figure VIII.5). Fishing net and unspecified modern debris were identified there; it is likely that the fishing net was ensnared on the rock and abandoned. It was not surprising to have debris caught up in these rocks, as the peninsula and

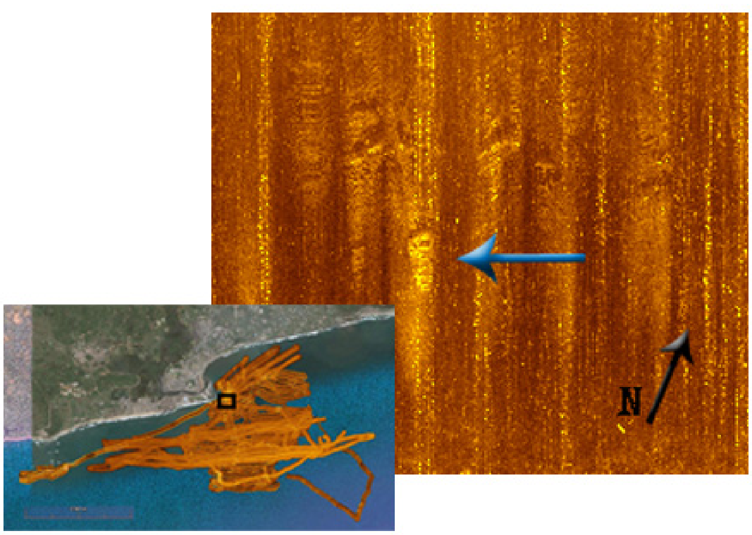

Figure VIII.5. Some scouring is visible around some of the rocks in this image, but very little elevation is indicated. The vertical lines through this side scan image are the result of wave action affecting the altitude and position of the transducer and are considered "noise" in the data.

[583] At least three targets, other than the known shipwreck site, were noted as having some modern trash on them, but generally it was not collected.

associated sandbar naturally trap materials being carried in the current. The site's location so close to the Elmina peninsula made diving conditions difficult. No cores were collected here, and it was not re-dived in 2009. There is no need to return to this site.

Targets 4 (C1) and 5 (C2) - *Control Areas*

As discussed in Chapter 4, both control areas were intentionally located in settings that had no anomalous signatures in the 2003 side scan sonar data. As such, the side scan sonar signature for each area showed different sedimentary properties, but had no indications of anything that may have been considered cultural material.

Control Area 1 (**C1**) was located in relatively deep water[584] one and a half kilometers nearly directly south of Elmina Castle. Side scan sonar data from both 2003 and 2009 indicate that **C1** is in an area of distinct sediment patterning, including sand ripples,[585] similar to the location of **11_46L** (**Target 2** in this appendix) 300 meters south,[586] (Figure VIII.1). The consistency in these patterns, as well as similar patterns located just one kilometer to the east, suggests that they are the result of oceanographic forces such as currents interacting with the peninsula on which Elmina Castle is built.[587] It was intended that this site be located beyond the typical depth range of the actions of waves and storm surge, but diving experience and the resulting immediate[588] loss of most

[584] Based on the side scan data and nautical chart depths it was anticipated to be at least 16 meters deep, but diving measurements place the site at only 12 meters, approximately the same depth as the Double Anchor Site.

[585] It is interesting to note that in both the 2003 and 2009 side scan data sets the sediments do not appear to be in a regular ripple pattern, but appear rather as strips of different-consistency sediments. The reason for this is unclear.

[586] **11_46L** is located approximately 300 meters SSE of **C1**.

[587] Clearly more research is required to verify this, but the geomorphological and oceanographic conditions in the region as seen in the side scan sonar data do seem to support this conclusion (see Appendix II).

[588] We returned to the site two days after planting the control and all but the stones, a bottle, and a local ceramic fufu bowl was completely gone. We did not revisit the site.

control material at the site confirmed that it is still heavily affected. The site consisted of a layer of black silt/mud over sand.

Somewhat surprisingly for a site so close to the shore,[589] Control Area **2** (**C2)** was also a featureless mud/silt sea bottom located directly in the surf-break zone. It was also placed 250 meters to the east of a side scan sonar target (the Large Rock discussed above) in the hopes that if the target proved to be cultural, it would be possible to test the range of movement of materials; in the event that there was no cultural material near it, the site would still provide a study of the near-shore conditions. As was demonstrated also with this site, the experimental materials planted there were very shortly[590] displaced (Appendix V).

Comparison of the cultural material collected in the cores provides some interesting insights to processes around the region. Only one core was collected successfully at **C1** (**C1 Core #1**; 31 centimeters), and while it had virtually no identifiable cultural material in it, it did have a piece of plastic at the top and a fragment of charcoal towards the bottom. While no other sites were investigated as far offshore as **C1** that can be used as comparisons, it is interesting to note that as sites are located closer to the shore, there is generally more cultural material (typically modern) in the cores. For example, six cores were collected at **C2**, each of which contained more cultural material than the one from **C1**.[591] Notably, towards the bases of two cores (**C2 #3**; 51 centimeters

[589] This is unusual because typically as one gets closer to shore the sediments are more coarse, which is the case in some areas nearshore, but for some reason is not the case here.
[590] We know that after a period of about two weeks there was nothing at all remaining at the site except the rebar that had been planted there to mark it. Comparison with **C1** suggests that it is likely that the materials were displaced in a matter of days.
[591] That being noted, however, **C2 Core #6** (34 centimeters) had surprisingly little cultural material in it at all.

and **C2 #3**; 48 centimeters), there were several[592] small (<2 millimeter) fragments of melted material that appear to be very similar to material found on the shipwreck site, located 1.15 kilometers to the south (bearing 165°), and to that found at the Double Anchor Site, located 1.4 kilometers to the south (bearing 195°) (Figure VIII.6).[593] Much more research needs to be conducted on the mechanisms of the movement of artifacts across the shelf in this region (either seaward or shoreward); however, three potential explanations are as follows: 1) the material is not related to either the shipwreck site or the Double Anchor Site, but is rather from some other source closer to shore or from shore itself; 2) the material traveled shoreward, perpendicular to coastal currents, from the known shipwreck site, possibly through storm or upwelling events; or 3) the material traveled shoreward and eastward via the predominant west-east current and waves from the Double Anchor Site (Figure VIII.7). While any of these, or even a combination of them, is possible, at present it is only possible to observe the composition of the materials at different locations and to eventually try to build patterns off of these. Similar melted material was also identified in the core collected at Waypoint **303/394**, but as the site is located

Figure VIII.6. Various types of melted material have been found at the shipwreck site and the DAS, all of which is similar to this in form, although the exact shapes differ significantly. The material found at C2 closely resembles this.

[592] Fewer than five, which, in relation to the amounts found at the DAS and shipwreck site is negligible, but its presence should be noted.
[593] Unfortunately, XRF analysis of the materials from C2 are inconclusive, so it is not possible to demonstrate affiliation with the shipwreck site, and no materials from DAS have been analyzed using XRF.

northwest of the Double Anchor Site and only a few small pieces were noted there, it is an unlikely candidate as the source.

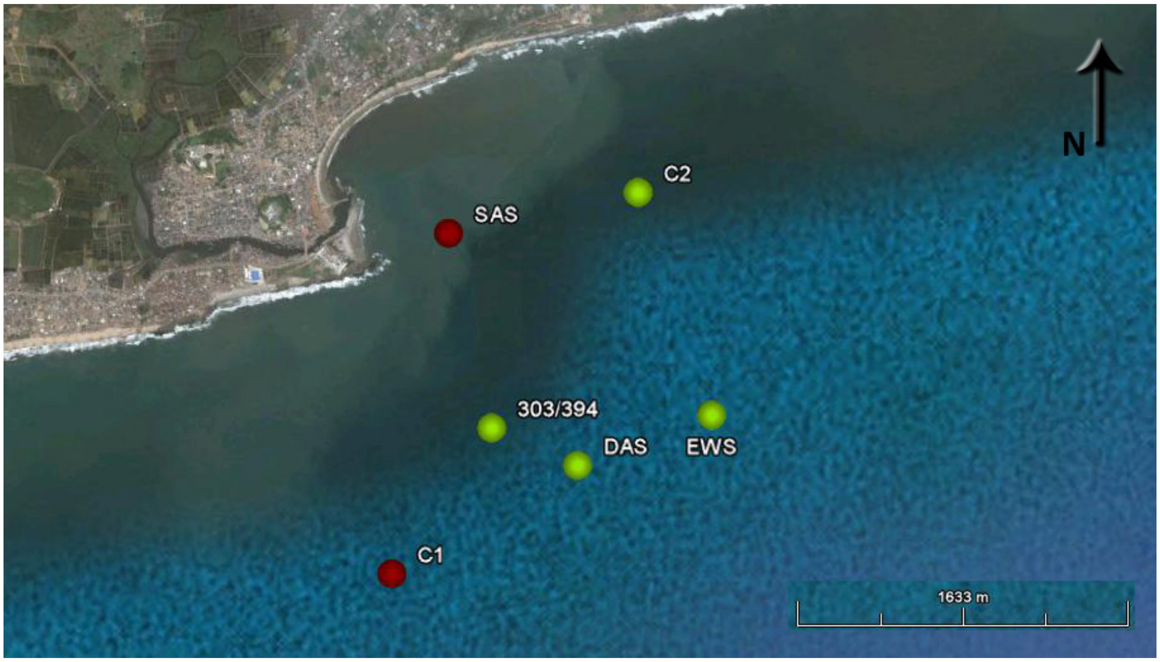

Figure VIII.7. The four sites with identified melted material (C2, 303/394, Double Anchor Site (DAS) and the Elmina Wreck site (EWS)) are illustrated in this GoogleEarth image in green. The Double Anchor Site and the Elmina Wreck site have significant amounts of melted material, while C2 and 303/394 each have fewer than five pieces. Waypoint 322, not identified here because of its close proximity to the wreck site, also has melted material.

Target 6 - *Waypoint 46*

This target (see the geomorphological interpretation in Figure VIII.1) was investigated due to its very pronounced magnetometer signature collected in 2009; there is no corresponding side scan sonar signature from either 2003 or 2009. It is located just outside the mouth of the Benya, in a location commonly used as an anchorage for fishing vessels waiting to enter the lagoon or head to sea,[594] so the target was approached with

[594] It is a religious prohibition in Elmina that vessels do not go to sea on Tuesday (DeCorse 2001:108), and some vessels, while respecting this literally, prepare to go to sea anyway and wait just outside the harbour

the knowledge that there was likely a good deal of debris on the seafloor from the continued use of the area. Modern fishing anchors are typically made out of whatever heavy material can be located, the choice object of which appears to be a truck or large vehicle's cam shaft; it is extremely likely that a number of these anchors, as well as many other objects, are lost in this region and may be responsible for the distinct signature. On the other hand, the area in front of the harbor has been used for several centuries for trade, and it is not inconceivable that historical materials, including potentially wrecks of small ships boats or trading canoes, made their way into the archaeological record in the area as well.

The seafloor at the site is very compact sand. Three dives were conducted in this location in very rough conditions with little to no visibility, and two cores were collected approximately five meters from each other. The cores were incredibly difficult to collect, as the resistance from the seafloor sediments was immense; it felt and sounded like the core was hitting wood, eventually preventing any more than approximately 80% penetration of the core tube into the sediments in both cases. In processing the cores it was discovered that the reason the cores were so difficult to take was the extreme compaction of the sediments, likely due to the repeated pounding and breaking of the surf in this area; in fact, they were so compact and dry that it was not possible to tamp them out of the PVC sleeve, but instead we were forced to tip them at an angle and encourage them to come out with gentle pounding of the tube. There was almost no variation in

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mouth until an appropriate time to leave. In other instances, when seas are incredibly rough, as they tend to be for the months of July through October, the siltation at the harbor mouth makes it impossible for more than one canoe to pass safely in or out of the harbor. This creates a bottleneck (and extremely dangerous situation, as there is no form of organization in this situation, and vessels race to beat each other into or out of the harbor, often missing each other by inches), so vessels wait their turn, however impatiently, in the area surrounding Waypoint **46**.

either the sediments or in the cultural material collected in the cores; in fact, one core (**#2_09**, 83 centimeters) was considered to be uniform the entire way through, although there was some gradation of color through it; the other (**#3_09**, 43 centimeters) was divided into only two strata (see Appendix I). Cultural material recovered in the cores is indicative of the close proximity to shore and modern debris associated with it; however, the unusually high percentage of rusted metal material in both cores[595] confirms that there is at least one source of iron/metal in the sediments, as indicated by the magnetometer.[596] The other notable feature of core materials is that the sediments in them tended to be heavily rounded or abraded, likely an indication of the rough nearshore environment in which they are located. This region should be surveyed with side scan sonar in the future, and perhaps the most effective means of isolating any metallic cultural material would be to use diver-held metal detectors to locate individual objects for further investigation.

Target 7 - *Waypoint 303/394*

Waypoint **303** was a target selected based on its complementary side scan sonar and magnetometer signatures noted in the 2009 survey. The site is located in a region with no sedimentary or other features, and is on what appears to be flat, featureless sand or mud in the side scan sonar interpretation (Figure VIII.1). The target was not large, but there was clearly elevation and potential scouring associated with it in the side scan sonar data. Post-fieldwork[597] side scan sonar comparisons show an almost identical side scan

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[595] It is interesting to note that there was significantly more rust in the second core collected here, taken five meters west of the original core, which likely indicates a closer proximity to at least one source of the rust.
[596] Clearly the presence of rust flakes does not provide any clues as to the form that the source(s) may take.
[597] Due to the lack of a synthesizing software package in the field, it was not possible to make thorough comparisons between the different years of side scan data, so this was completed in the post-field period.

sonar image in the 2003 data, also shown as a hard return approximately ten meters[598] from the 2009 target. There is an additional target located approximately five meters away in the 2009 data, but divers found no indication of either of these, after completing several circle searches extending out to 45 meters.[599] Diver observations noted that the sea bottom was fine sand with some shell. The original waypoint dived was **303**, and nothing was found there, but several deep scours were noted approximately 50 meters to the east, so a new waypoint, **394**, was taken at the approximate location, and a dive conducted there. Two shallow scour marks less than two meters long were noted at the site, but nothing else was visible at the surface.

A core was collected at the original **303** waypoint (Core **# 14_09**), and while it has the typical modern debris and common artifacts in it such as charcoal and palm kernel shells, it is interesting in that it also contains several[600] very small pieces of melted material that looks similar to that found at the Double Anchor Site and the shipwreck site; it also contains some rust. Waypoint **303/394** is located 500 m northwest of the Double Anchor Site (bearing 300°), and 1.1 kilometers west from the known shipwreck site (bearing 265°), making these sites unlikely sources for this material. Only two other sites, **C2** and Waypoint **322**, located just north of the shipwreck site,[601] contained similar melted material, although Waypoint **46** does contain rust flakes.[602] Waypoint **338** is located 1.45 kilometers to the west (bearing 255°) of **303/394**, but it contains none of this

[598] This can easily be accounted for in inconsistencies in GPS data.
[599] It is important to note here, however, that sea conditions were very rough when this site was investigated, making circle searches incredibly difficult and exponentially increasing the potential for a diver to miss visual or tactile indications of any mostly-buried material that may have been present.
[600] Fewer than five.
[601] It is not considered surprising to find similar material to the shipwreck site at Waypoint **322**, as it is in such close proximity.
[602] It is *possible* that that the Ivoirian undercurrent or some other force may be responsible for carrying this material from east to west, but the weakness of the current makes this unlikely. Further research will have to be conducted to investigate this possibility.

material. This means that either the material is being transported from some other location in the region, or that there is possibly some more local source that is not visible at present due to sedimentation. Because there was a clear target in both the 2003 and 2009 side scan sonar data, and there was also a strong magnetometer signature, it is reasonable to assume that there is *something* located there. It is possible that this site is an example of the side scan sonar “seeing” features that are slightly buried, which would explain both why divers did not discover anything there, and may perhaps also illuminate the reason that there were distinct scour marks located at the site. On the other hand, it is possible that the extremely rough conditions and inaccuracies of GPS in West Africa hampered divers in their search for the target, although the likelihood of completely missing any surface indications in the course of three dives is unlikely.

In addition to the melted material and rust, one other similarity was noted between **303/394** and the Double Anchor Site: there were tiny pieces of what appears to be identical plastic wrapper or wrapping paper found in the cores at both locations. It is interesting to note that these are the only two sites in which this identical material was found, and while it may simply be coincidence, it is more likely that the material was transported by currents, wind or storms from one region to another. That being said, however, the direction the material would have had to move, either ESE in the case of moving from **303/394** to the Double Anchor Site, or WNW moving from the Double Anchor Site to **303/394**, does not fit with any of the general patterns followed by any of these mechanisms, and as such, is relatively anomalous and difficult to explain. This site is worth re-investigating in the future.

Target 8 - *Waypoint 338*

Apart from the Chain Site, located ten kilometers west of the Castle, this target is the furthest west of any targets investigated in either 2007 or 2009. The notes for survey and for diving indicate that this site was a strong target in the 2009 side scan sonar data, but upon revisiting the data, this is not the case. There may be several reasons for this, but it is unclear exactly what happened. Two dives were conducted at the site, and the sea bottom was reported to be light brown undulating sand with a fine layer of silt or mud just under the sand that was easily entrained[603] upon disturbance. There is no indication of any surface features such as ripples in the side scan sonar data, and it is also unclear why this would be the case. There was extremely little cultural material of any description, including modern material, in the core (**#9_09**). It is unnecessary to return to this location.

Target 9 - *Waypoint 253*

Although there were other side scan sonar returns relatively near this location (Figure VIII.1), this site was chosen because it had both side scan sonar (2009) and magnetometer signatures. In addition, its location nearly directly south of the Castle and directly in the historical anchoring roadstead made it an appealing target for investigation. Two dives were conducted at the site, and sea bottom conditions were reported as both sand and silt/mud. The sediments in the core (**# 16_09**, 63 centimeters) recovered from the site had surprisingly little variation (only three strata). There was almost no cultural material in it at all, and what was present comprised of charcoal and

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[603] Caught up into the water column.

modern filaments or string, likely associated with the local fishing industry. Until more remote sensing surveys can be conducted in this area it is unnecessary to dive it again.

Target 10 - *Waypoint 411*

This target was a strong magnetometer target identified in 2009, and within 50 meters of it there are several anomalies in the 2009 side scan sonar data, although there is no directly correlating side scan sonar anomaly with the target site itself. The target site is located approximately 450 meters SE of the known shipwreck site (bearing 155°) and west of the Mud Target (bearing 260°) (Figure VIII.1); sea bottom conditions are much more similar to the Mud Target than to the shipwreck site. Two dives were conducted at the target location and one core (**#8_09**, 44 centimeters) was collected there. The sea bottom was extremely sticky, dark/black mud/silt and no anomalies or cultural material were observed in a 45 meter circle search. There was very little cultural material in the sediment core, although interestingly, almost all of it was located in the bottom third of the core, more than 30 centimeters below the surface. This location should be resurveyed with a full suite of remote sensing instruments[604] if possible, and decisions about re-diving the site made on the basis of the additional remote sensing data.

Target 11 - *Mud Target – Waypoint 397*

This was a side scan sonar target (2009) with distinct indicators that there were discrete forms/objects at the site, and the target was considered to have a high probability of containing cultural material. To the north and northwest of the site is a distinct area of sediment changes and activity, as indicated by the 2009 side scan sonar data (Figure

[604] Side scan, magnetometer and echo-sounder.

VIII.8), but the target area itself showed no indication of this (it was primarily a low backscatter region), and in fact we did not encounter textured sediments on the surface at all, even though we had at least one dive at this location with visibility up to five meters. What we did encounter at the seafloor was an exceptionally large area (at least 50 meters across in some areas) of deep,[605] extremely sticky mud, with no other surface features visible. Many other sites have been noted to have a mud/silt covering, but usually the mud makes up a very shallow, non-sticky, blanketing[606] over more coarse sediments, making the composition of sediments at this site unique. Sediment probing indicated that there was no distinct sedimentary change within 1.75 meters of the surface, although there were some differences noted in resistance to the probe, likely indicating more gradual, mixed, or subtle sediment changes (i.e. Nittrouer et al. 1986:25). There was no indication of any sub-surface features in the echo-sounder survey. The presence of the large mud area in this high-energy coastal zone is difficult to explain, although not unheard of in other coastal environments (Niedoroda 2005:868). It is possible that it is related to interactions of currents turning the corner around the Elmina peninsula (Figure VIII.1), and a more remote possibility is that it is also affected by sediments flowing in from the shallow Sweet River to the northeast.

One other thing made this location particularly unique. Divers use compasses in poor-visibility water to ensure that they have covered full circles around the target, however, on three different occasions, compasses indicated that the divers had completed full circles around the target, when in fact they had not. On one dive only about a 30° arc was covered, although on the other two dives at least 180° were covered. In extremely

[605] At least 30 centimeters, although likely significantly deeper.
[606] Usually less than ten centimeters.

rough weather or high-current conditions this is not extraordinary, as fighting the currents and surge can be almost impossible; however, in the case of the two dives covering the least amount of area, the seas were almost completely flat with very minor current, so this could not be the reason. One possible explanation for this is that there is metallic material located somewhere below the sediments that was off-setting the compasses, but as we have no evidence of that now, explanation will have to wait until further research can be conducted in this location.

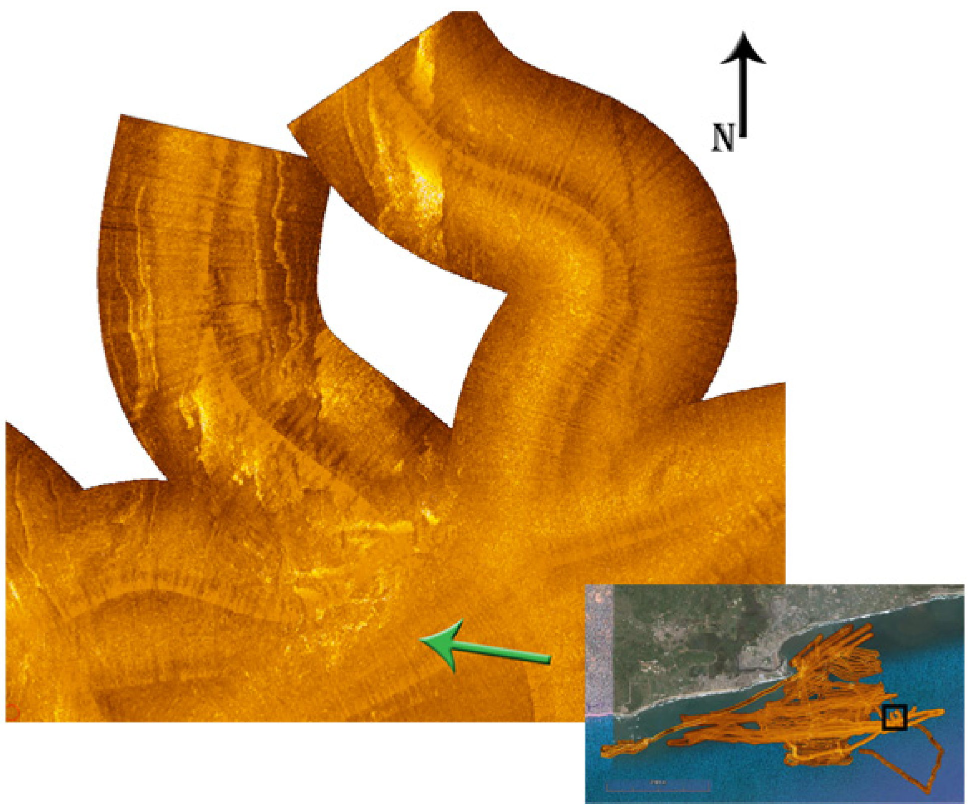

Figure VIII.8. **The target originally identified in the side scan sonar data is located at the base of this unique area of dynamic sediments, although none of them were visible on the surface near the actual dive location. This may be a factor of them simply not being visible in the surface, of discrepancies in GPS in West Africa, or a combination of the two.**

Target 12 - *Waypoint 322*

Waypoint **322** is an enigmatic target identified by a strong magnetometer signature in 2009. Consistent with the geomorphological interpretation of the location (Figure VIII.1), the seafloor was relatively featureless, loose sand and fine sand or mud. Strangely, although the site is situated less than 50 meters north of the known shipwreck site, when the target was investigated on two different occasions, divers swimming in 45 meter search circles with several meters' visibility never encountered any indications of the shipwreck itself. This suggests that there may be a problem with GPS coordinates inaccurately directing the search, or that slight differences in the geo-referencing of the remote sensing data may be off and that the sites are not quite that close together. The latter idea is more probable, as when the site was covered with the echo-sounder, using the same GPS, a distinct anomaly was identified. Despite the apparent spatial inconsistencies, because Waypoint **322** is located so near to the shipwreck location, any data collected at the site should be considered as *potentially* relating to the shipwreck site, although this is also impossible to determine with the available data. While there was no surface indication of any cultural material at the target, the core collected at the target hit something solid a little over one meter below the surface. Unfortunately, without leaving some sort of a semi-permanent marker noting where on the featureless and loose sand the core was collected, it was impossible to identify the exact location of where the core was collected, and subsequent probing at the site did not encounter any buried materials.

Several objects recovered in the core, however, provide some indication that Waypoint **322** is at least influenced by the wreck site, regardless of whether the original (now buried) material is actually associated. While many of the artifacts are similarly non-diagnostic as is the material found in cores all over this region, including the shipwreck site, two types of material in particular merit noting: similar melted material to that found at the shipwreck, and a single small bead that is also similar to those found on the shipwreck site. It is important to note that while the artifactual signature noted in the core is clearly similar to many cores collected at the shipwreck site, it should not necessarily be assumed that the object(s) identified by the magnetometer or that hit with the core are necessarily actually related to the shipwreck. It is entirely possible that the sites are comprised of separate, unrelated entities, and the presence of the object(s) at target **322** may simply be the result of the objects trapping material that is being transported shoreward from the shipwreck site via storms or upwellings. While this is a possible scenario, it is also just as likely that the sites are related, and only considerable investigations in the future will determine how or to what extent. A similarly enigmatic target near the shipwreck site was investigated in 2007 and is discussed below.

Target 13 - *Near Wreck (12_004L-B)*

The final site that should be highlighted is a small target identified in the 2003 side scan sonar data and located approximately 50 meters E/ESE of the Elmina Wreck site. Only one dive was conducted on this site in 2007, and unfortunately the sea bottom sediments were not recorded; however, side scan sonar indications (Figure VIII.9) suggest a relatively featureless and sandy or mud sea bottom. The object discovered at the target was what appears to be a pole sticking one meter out of the sediments at approximately a 45° angle. Because the team intended to return to the site to investigate it more thoroughly but were not able to, no other measurements were collected.

Comparisons between side scan sonar images collected in 2003 and 2009 show distinct changes in the seafloor morphology of this location: images from 2003 clearly indicate the presence of an object at the target location, but while there is an anomaly located more than ten meters south of it in the 2009 data, the target noted in 2003 is not visible. This may indicate that there is more material located at this site, or, less likely, that sedimentation has changed the sea bottom topography to expose bedrock.[607] Unfortunately, so little information was collected on the metal object that it is not possible to identify it, although, basing it on comparisons to the Double Anchor Site, it is

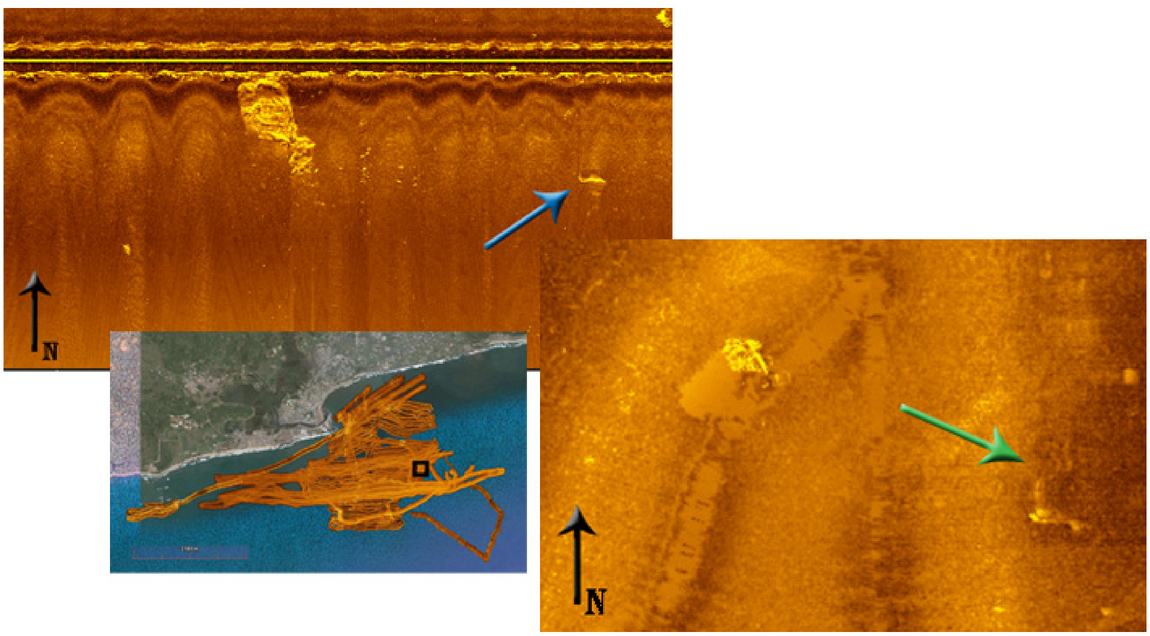

Figure VIII.9. **While the same target was not visible in the 2009 side scan sonar data, a different target, located just a few meters south of it (indicated by the green arrow), was exposed – a testament also to the dynamicism of the region, but also an indicator that there may be other features associated with the target, whether natural or cultural. Another explanation is that the GPS coordinates are off, but this is unlikely, as the relationship of the target to the shipwreck site is clearly visible in both data sets.**

[607] While this is not impossible, investigations indicate that all of the exposed rock is located much close to shore in shallower water; the rocks are likely present in deeper water, but are covered by a thicker layer of sediments, making it unlikely that the anomaly in the 2009 sonar data indicates a rock.

possible that it represents part of an anchor. In the event that it is an anchor, it is almost certainly not related to the shipwreck, as its location relative to the vessel before it wrecked would have been useless in terms of securing a vessel, as it would have been deployed down- and slightly across-current, thereby offering the vessel no security. In a similar vein, the size of the metal object, as well as the size of the anomaly represented in the 2009 data, makes it extremely unlikely that they were moved from an association with the wrecking vessel or the wreck site 50 meters down- and across-current either by natural or even cultural factors. While it is not possible to adequately identify what is represented by the object and other anomalies in the data at this point in time, the evidence strongly suggests that these features, whether or not they are related to each other, are not related to the known shipwreck site. These features certainly merit further investigation.

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