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Introduction

Site Formation Processes of Submerged Shipwrecks

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Shipwrecks have captured people's imaginations for millennia, and with the development of the field of maritime archaeology over roughly the last half century, we have learned a great deal about the past through the systematic study of submerged shipwreck sites. As with any field of study, our collective knowledge base is continually expanding as techniques, tools, and methods become increasingly sophisticated. Although the importance of understanding wreck site formation has been recognized in the field of maritime archaeology since the beginning (Dumas 1962; Frost 1962; Throckmorton 1965; Nesteroff 1972), the expansion of lines of inquiry into the study of wreck site formation have been relatively slow to develop (as noted by Bass 1980; Gibbins 1990; Murphy 1997; Stewart 1999).

Site formation processes consist of a wide range of both punctuated and ongoing events and processes that contribute to the condition of a shipwreck site at a given point in time. Formation on submerged sites begins with the initial deposition event and evolves depending on the subsequent effects of the natural environment and human activity. These processes are affected by deposition (e.g., sinking, scuttling) and depositional environment (e.g., water depth, seafloor composition) followed by the subsequent effects of processes such as wave action, storms, bioturbation, pressure, salinity, temperature, chemical reactions, and human activity. Maximizing the effectiveness of archaeological interpretation is predicated upon attaining a sound appreciation of site formation processes. In depth study of site formation processes can lead archaeologists to a better understanding of a site's matrix, inform heritage managers so that they may better preserve and protect archaeological sites, and inform conservators so they can

properly stabilize artifacts and site components (both in the field and in the laboratory).

The Development of Site Formation Theory in Maritime Archaeology

The relationship between field practice and theoretical research in shipwreck archaeology can be characterized by the delay between its development and acceptance and the integration of theoretical concepts into mainstream shipwreck archaeological practice. For many years, few publications of wreck site investigations paid any attention to site formation. Those that discussed the subject often did not include reference to theoretical concerns, and specific site formation considerations were even scarcer. Undoubtedly one factor is that most maritime archaeological sites are still reported only at interim level, and few sites worldwide are comprehensively published (cf. Red Bay, *Mary Rose*). In recent years calls have been made for a unifying methodology and theory for maritime archaeology based, among other things, on a comprehensive treatment of site formation theory (Gibbins 1990; Stewart 1999; Martin 2011), but this was not always the case.

The Early Years

Shipwreck archaeology has slowly emerged from a past tainted by indiscriminate artifact collection, treasure salvage, and the unrecorded destruction of sites. From the earliest archaeological investigations of shipwreck sites, it was evident that the destructive effects of marine life were more pronounced on rocky substrates as opposed to the more sterile sandy environments (Nesteroff 1972). Frost (1962) and Dumas (1962) pioneered studies of wreck formation, putting forward generalized models for the sinking and wrecking of Classical ships, the so-called tumulus sites (referring to the mounds of ballast stone that overlay the site), while Throckmorton (1965) developed empirical models using a series of dated and documented sites at Methone in southwest Greece.

The 1970s

In the seventies the requirement to identify suitable materials to contain nuclear waste buried under the sea provided an unusual impetus for considering formation processes in the deep ocean environment (Tylecote 1977). In terrestrial archaeology this period saw the introduction of the concept of transforms. Schiffer and Rathje (1973) put forward the proposition that

linking the past to the present depends upon studying the archaeological record in the context of developing and applying the principles from two areas of archaeological theory: *n*-transforms (interactions through time between culturally deposited assemblages and the specific environmental conditions in which they were placed) and *c*-transforms (the spatial, quantitative, and association attributes of archaeological materials as functions of the cultural system that produced them). The late seventies included the further application of such concepts to shipwreck archaeology. Clausen and Arnold (1976) discovered remains of colonies of benthic organisms adhering to the upper two thirds of large concretions, providing evidence that the depth of the sediment in the area had fluctuated over the period of deposition: at least once in the past the conglomerates were largely, or perhaps entirely, exposed long enough to permit these organisms to flourish. Bascom (1976) concentrated on the marine environment of the Mediterranean and Black Sea as preservation media for the purposes of optimizing any search strategy.

Keith Muckelroy attempted to combine these concepts into a comprehensive and systematic approach to underwater site depositional processes. Muckelroy (1977) developed models for addressing what he felt were the basic conceptual concerns in the archaeology of the wrecking event that took place between the ship's existence as a functioning entity and the discovery of shipwreck remains by the archaeologist. In a further refinement (1978) he represented the evolution of a shipwreck as a flow diagram comprising five subsystems: the process of wrecking; salvage operations; the disintegration of perishables; seabed movement; and the characteristics of excavation methodologies. The inputs to the system are the ship itself and any material subsequently deposited on the site, whereas outputs are the material that has floated away, been salvaged, or disintegrated. Within the system the subsystems of sea bed movement, disintegration of perishables, and salvage are linked by positive feedback loops; that is, salvage operations will disturb the sea bed, and material will deteriorate due to the loss of the state of relative equilibrium. Muckelroy divided these mechanisms into two categories: scrambling processes and extracting filters. Scrambling processes are those that disturb the site matrix, making it difficult to interpret archaeological context, while extracting filters are mechanisms that remove artifacts or objects away from the wreck. Scrambling processes begin during the process of wrecking, and include such post-depositional processes as waves and currents, sea bed movement, and bioturbation (Muckelroy 1978; Stewart 1999:567).

Muckelroy put forward a site classification system based on an environmental model that ranked physical attributes (e.g., topography, particle size of deposit, slope, sea horizon, and fetch) and interpreted the results on the basis of the completeness of the archaeological record. He acknowledged the role of natural formation processes (i.e., chemical and biological), stating that explanation must lie in variations in the composition of the objects concerned, in the chemistry of the sea bed deposits, in the quality of the seawater in the area, and other such chemical and biological factors.

The 1980s

The eighties saw a resurgent interest in archaeological "knowability" (i.e., how do we know what we know?) and a parallel urgency in most Western countries for archaeologists to participate in government planning and cultural resource management. There was also an increased emphasis on the study of impacts to archaeological sites (Wildesen 1982), site formation as an aid to predictive modeling and survey, and general concepts of management archaeology.

Parker (1981) advocated a flexible approach, concluding that even "tumulus" sites may be the subject of contamination. Jumbled so-called ships' graveyard sites can also be of value, as can individual wrecking events identified with detailed recording and careful analysis, even when the remains are scattered, mingled, and denuded by illicit excavation. Also there was an increasing awareness of processes and inter-relationships between site formation, materials preservation, and site assessment (MacLeod and Killingley 1982).

Around the same time Murphy (1983) stated that the application of a multidisciplinary approach to shipwreck studies was long overdue and that little was known about the environmental impact on wrecks and, conversely, the impact of wrecks on the environment.

In his seminal book *Formation Processes of the Archaeological Record*, Schiffer (1987) pointed out that because degradation can be caused by specific processes, and not necessarily simply by the passage of time, deposits formed at the same time but subject to different formation processes vary in their degree of preservation. Therefore useful information can be derived from badly degraded deposits, and some information of archaeological interest (e.g., ecofacts) can be added through environmental mechanisms.

Work conducted at the Terence Bay site in Canada during the early part of the decade included observations of the biophysical environment surrounding the wreck site as part of the collection of non-artifactual data.