EXHIBIT A-3

DR. SEAN A. KINGSLEY

PART 3

ANNEXES 4 TO 6

ANNEX 4

TO

EXHIBIT A

4.1. Classification of wreck classes from Muckelroy, K., *Maritime Archaeology* (Cambridge University Press, 1978), 158, 164.

4.2. Stewart, D.J., ‘Formation Processes Affecting Submerged Archaeological Sites: An Overview’, *Geoarchaeology* 14.6 (1999), 569.

4.3. Ward, I.A.K., Larcombe, P. and Veth, P., ‘A New Process-based Model for Wreck Site Formation’, *Journal of Archaeological Science* 26 (1999), 567.

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Annex 4.1

Compared with equivalent depositional and post-depositional processes on land sites, shipwrecks possess many peculiar features. The environmental factors operating under water are different from those found on land, and are outside the range of normal experience. Furthermore human interference, undoubtedly the most important destructive agent in a terrestrial context, is minimal under water, and limited to a few identifiable activities. Finally, the same factors are operative on every site, although in varying degrees, so that the archaeological evidence is more homogeneous in this sub-discipline than in most others, an attribute which further strengthens its internal cohesion. Thus an investigation into the archaeology of shipwrecks constitutes both the final defining characteristic of maritime archaeology, and the starting point for constructing its general theory.

The flow diagram in fig. 5.1 represents the processes through which that organised assemblage of artefacts comprising a ship and its contents will have passed to produce the collection of items excavated on the sea-floor. This assemblage can be regarded as a system, defined by the necessary characteristics of a ship, which has undergone a series of

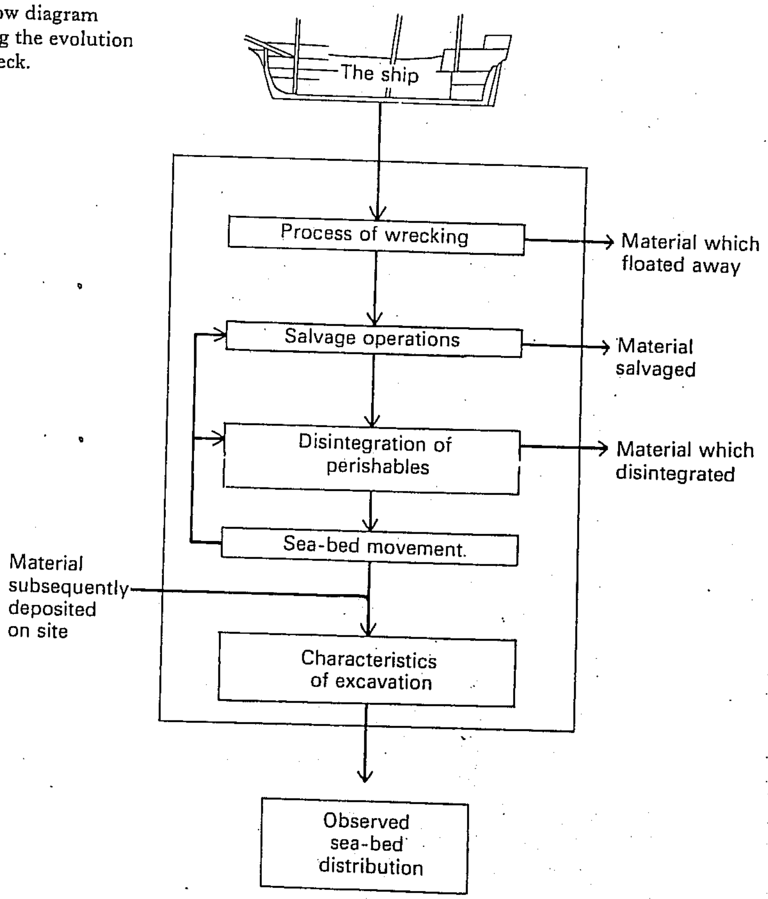

Fig. 5.1 Flow diagram representing the evolution of a shipwreck.

twenty sites according to coherence of their distributions, did not support such an interpretation. In fact, the results of this second test showed no appreciable difference from those achieved in the first exercise; what differences there were appeared to be due to special features in the process of the wrecking of some vessels, rather than any environmental considerations (Muckelroy 1977*b*, 53–4).

In the light of these studies, certain general conclusions were reached concerning wreck-sites in British waters. On the one hand, the sites could be divided into five classes, according to their degree of survival, as described in table 5.2. This classification is more discriminating than the simple good/bad dichotomy which has held such wide currency in the past, and, while it must still be regarded as provisional, it has proved useful in a number of contexts, and will reappear later in this chapter. And, secondly, arising from and making use of this classification, a series of general statements regarding the environmental characteristics

Table 5.2 *The five main classes of wreck site at present apparent in British waters*

	Structural remains	Organic remains	Other objects	Distributions	Examples (see fig. 5.2)
Class 1	Extensive	Many	Many	Coherent	*Mary Rose* (11) *Amsterdam* (15)
Class 2	Elements	Some	Many	Scattered ordered	*Dartmouth* (5) *Trinidad V.* (3)
Class 3	Fragments				*Kennemerland* (1) *Colossus* (20)
Class 4	—	Few	Some	Scattered/ disordered	*De Liefde* (2) *Girona* (8)
Class 5	—	—	Few		*Adelaar* (4) Penlee site (12)

Table 5.3. *The relevant environmental attributes for each of the five classes of wreck-site described in Table 5.2, derived from an analysis of the data from the twenty British sites*

	Topography	Deposit	Slope	Sea horizon	Fetch
	% of bottom sedimentary deposit	Range of sediments	Average over whole site	Sector of open water for 10+km	Maximum offshore distance
Class 1	100 %	Gravel to silt	Minimal	Less than 90°	Less than 250 km
Class 2	More than 70 %	Boulders to silt	Less than 2°	Less than 90°	Less than 250 km
Class 3	More than 30 %	Boulders to silt	Less than 4°	Less than 150°	More than 250 km
Class 4	More than 10 %	Boulders to sand	Less than 8°	More than 30°	More than 250 km
Class 5	Less than 25 %	Boulders to gravel	More than 6°	More than 120°	More than 750 km

Formation Processes Affecting Submerged Archaeological Sites: An Overview

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Although the formation processes operating on submerged archaeological sites are just as varied as those affecting terrestrial ones, nautical archaeologists have not yet devoted much attention to them. Most studies to date are concerned with formation processes at particular sites. This article provides an overview of the major depositional and postdepositional formation processes affecting underwater sites. The most obvious depositional process is shipwreck, which takes several different forms. Submerged sites may also be formed by the drowning of coastal areas due to tectonic or eustatic sea level changes. In these cases, rapid submergence preserves sites better than slow inundation, which allows time for waves and currents to tear the site apart. For both shipwrecks and coastal sites, once submergence occurs, the single most important factor for preservation is rapid burial by sediment. A cover of sediment protects both the artifacts themselves and their spatial patterning from destruction by water and marine organisms. Once deposited, underwater sites are subject to modification by both cultural and natural processes. The best understood postdepositional processes include salvaging, treasure hunting, and destruction by marine borers. Others, such as dredging, construction, and bioturbation, have hardly been investigated at this time. Archaeologists need to devote more attention to the effects of marine animals that live in close association with the seabed, as well as marine plants, whose roots may disturb sites located in shallow water. From this study it is clear that maritime archaeologists must consider formation processes when planning projects, rather than thinking of underwater sites as simply "time capsules." © 1999 John Wiley & Sons, Inc.

> If only one craft had sunk in each year since Paleolithic seafarers reached Melos, 12,000 wrecks would have taken place in the Mediterranean alone.
>
> George F. Bass (1980:139)

INTRODUCTION

The quote above was written by George Bass nearly 20 years ago as part of an attempt to legitimize the field of nautical archaeology, which he believed was still not regarded by many scholars as a completely serious endeavor. Bass (1980:141–150) went on to describe what he saw as the five stages in the development of nautical archaeology. The first stage, which lasted from approximately 1800 to 1948, consisted of fishermen and sponge divers removing works of art from wrecks discovered by chance on the seafloor. From 1948 to 1960, pioneering excavations of

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Annex 4.2

Table I. Depositional processes.[a]

Formation Process	Nature of Submerged Deposit	Example	Reference
Shipwreck			
Intact	Fairly coherent; loss of buoyant material on deck	Yassıada, 7th century	Bass and van Doorninck, 1982
Disintegration	Very scattered; loss of buoyant material on deck and within hull	*Kennermerland*	Muckelroy, 1975, 1978
Capsize	Cargo widely scattered; hull substantially intact, possibly in a different location; loss of most lighter material	Sheytan Deresi?	Bass, 1976
Intentional Deposition	Hull often substantially intact; removal of usable items before deposition; possible addition of refuse	Skuldelev Ships	Olsen and Crumlin-Pedersen, 1967, 1978
Inundation			
Gradual	Destruction of artifacts and loss of spatial context	Agios Petros	Flemming, 1985; Gifford, 1990
Rapid	Substantially intact	Athlit Yam	Galili et al., 1993
Refuse	Patterns of artifacts that were not associated together originally	Dokos?	Wachsmann, 1988:205

[a] Note that the nature of submerged deposit category represents generalities only; the exact effects vary due to the environmental context of each particular site.

while the hull itself may stay afloat for some time before finally sinking some distance away. In the case of vessels carrying cargo on deck, much information might therefore be lost in the event of capsizing. This is an important point, as we know that some ancient vessels did indeed carry cargo on deck or in undecked holds. For example, Egyptian reliefs, such as the one from ca. 1500 B.C. depicting the fleet of Queen Hatshepsut, show vessels carrying deck cargoes. Also, the 4th-century-B.C. Greek merchantman excavated at Kyrenia, off the north coast of Cyprus, may have had an open cargo hold (Steffy, 1994:52). The scattered nature of a wreck deposit may be a clue to the archaeologist that capsizing has occurred. Bass (1976: 295) interpreted the remains of the Sheytan Deresi wreck, which consisted largely of broken pottery vessels scattered over an area of approximately 200 m^2 on the sea floor, as possible evidence for capsizing. This interpretation may help explain why no organic materials or parts of the ship's hull were found.

Finally, it is important to realize that the shipwrecks that survive to the present day do not represent the full range of human seafaring activities. Although wooden and metal shipwrecks dominate the archaeological record, the earliest boats ever constructed were probably made out of materials such as reeds, skin, or leather. Boats of this type have been recorded throughout the world; many traditional forms, from Irish curraghs to Peruvian reed *caballitos*, still exist today (Johnstone, 1980:14; Muckelroy, 1978:128). Due to preservation problems, it is doubtful that many prehistoric boats of these types will ever be discovered.

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A New Process-based Model for Wreck Site Formation

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In order for a model of wreck disintegration to have some predictive ability, it is advantageous that such a model should be process-orientated, scale independent (i.e., be applicable to the wreck as a whole and to individual wreck components) and/or spatially and temporally independent. Existing models and flowcharts for wreck site formation focus on the products rather than the processes of wreck disintegration. The major classes of environmental processes affecting wreck site formation are physical, biological and chemical, which are each closely linked to the depositional environment.

Here a modified flow chart for wreck evolution is presented in which the major variables influencing wreck site formation are the wreck itself, sediment supply and the hydrodynamic environment. The rate of wreck disintegration (dD/dt) may be given by the sum of the rates of disintegration due to physical, biological and chemical processes (ΣdP/dt, dB/dt, dC/dt). A model is developed where wreck disintegration may be plotted against the relative sedimentation rate (dS/dt), which is a first-order control on the forces of degradation. The model possesses the advantageous features noted above, and acts to illustrate the characteristics of a wreck site and provide a framework in which to begin prediction of the nature of the material preserved. Although its application to marine wreck is outlined, the model is applicable to both terrestrial and marine wreck site formation.

Keywords: MARINE ARCHAEOLOGY, SITE FORMATION, MODEL, SHIPWRECK, ENVIRONMENTAL PROCESSES.

Introduction

Existing models for wreck disintegration

Archaeologists are becoming increasingly aware of the role of formation processes in the burial and transformation of archaeological remains (e.g., Nash & Petraglia, 1987). A series of terms has been introduced to describe formation processes in marine and terrestrial environments, including:

- "scramblers"—processes which result in distribution of material;
- "filters"—factors which help discern distribution patterns (Muckelroy, 1978);
- "transformation"—alteration of material, (Clarke, 1968) and
- "translation"—displacement of material (Schiffer, 1987).

In having no temporal or spatial context, nor being specific about the processes involved, the above terms form part of an approach to site formation which fails to distinguish those attributes of the wreck site which relate to the range of wreck-forming processes through time (Ward, Larcombe & Veth, 1998). Previous approaches which describe the general stages of wreck disintegration reside within the context of excavation and collection of wreck material (e.g., Figures 1 & 2). The flow charts fail to distinguish between process-related and product-related attributes, and consequently are more descriptive than predictive.

The relationship between depositional setting and archaeological (wreck) remains in the marine environment is different to that of terrestrial systems, and excavation is also generally more difficult. Consequently, models are useful to help predict the

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Annex 4.3

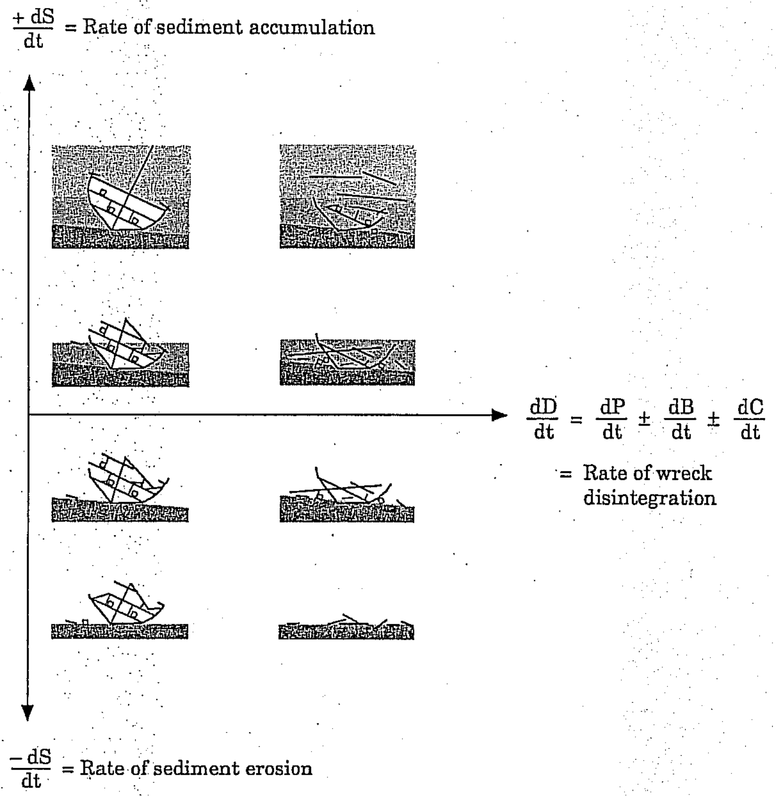

Figure 5. An illustration of wreck formation described by the rate of disintegration (dD/dt) plotted against the rate of relative sediment accumulation or erosion. The combination of wreck deterioration with sedimentation gives rise to several scenarios, which range from the extremes of (1) rapid rates of burial and slow rates of deterioration, resulting in a well-preserved wreck in several metres of sediment (top left), and (2) rapid rates of erosion and deterioration, resulting in very little preservation on a hard exposed seabed (bottom right). The model is independent of time or scale, and is thus applicable to the wreck as a whole or to individual components, and on time scales of hours, days, centuries or greater.

Time a. Time of wrecking. Corrosion will already be occurring on many parts of the wreck.

Time b. Following wrecking. The overall rate of corrosion will increase when some previously protected metal parts of the wreck are fully exposed to seawater. Exposed wreck components will be affected by corrosion at a greater rate than buried parts.

Time c. Onset of a storm. The erosion of sediment from around the wreck will re-expose some parts of the wreck, increasing the net rate of corrosion.

Time d. Storm peak. Chemical corrosion may increase due to the loss of sediment and increased flow of oxygenated water over exposed metal parts (including at shallow depths in the sediment column). The net rate of chemical deterioration will therefore depend on the nature and magnitude of the storm.

Time e. Immediately following the storm. The overall rate of corrosion may decrease as parts of the wreck are buried or reburied by accumulating sediment, or are covered by marine biota. Anoxic conditions may be re-established in some areas. Corrosion tends to cause metals to be coated by metallic salts (such as chlorides, sulphides and carbonates) which may actually help preserve the artefacts within (Renfrew & Bahn, 1996). However, even under reducing conditions, chemical deterioration of metallic wreck components may occur long after biological deterioration of organic components has decreased or ceased altogether.

Whilst we have illustrated a low rate of chemical deterioration before and after the storm, it is unknown whether chemical activity returns to pre-wreck level, because aspects of the sediment and porewater chemistry may have been completely altered by the presence of breakdown products of biochemical and chemical processes.

The process of excavation will itself affect wreck disintegration, through short-term exposure of wreck parts. In addition to the potentially erosive effects of waves and currents, excavation may oxidize to greater depths previously anoxic sediments, creating acidic conditions, and increasing aerobic deterioration of organic material.