Site Formation Processes of Submerged Shipwrecks

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Cultural Site Formation Processes Affecting Shipwrecks and Shipping Mishap Sites

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Most studies of maritime site formation processes have concentrated upon the various natural and to a lesser extent cultural processes physically impacting the remnants of the vessel (the shipwreck) and closely associated artifacts, while ignoring wider influences that have resulted in the current archaeological record. This chapter explores how cultural processes not only affect the transformation of a ship into a shipwreck site but also how continuing human interactions can produce other archaeological sites that are equally important for understanding the archaeology of shipwrecks. In addition, we consider how wider cultural practices, systems, and ideologies also warrant investigation when researching behavioral aspects of shipwreck site formation processes.

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Maritime Cultural Site Formation Processes

In his seminal 1976 paper Muckelroy introduced the notion of applying a specifically maritime-oriented model of site formation processes as a means of understanding the apparent loss and dispersal of structural components and relics from a shipwreck site, resulting in the current archaeological signature (Muckelroy 1976). Muckelroy's original schema considered both natural and cultural processes that worked toward transforming a ship's structure and contents from an organized but dynamic (systemic) state to a disorganized but stable (archaeological) context (Muckelroy 1976:158). To use Muckelroy's (1976, 1980) terms, these processes can be conceived of either as *filters*, which extract material from the assemblage, or as *scrambling devices*, which rearrange patterns. They might also result in additional material being added to the site (such as discarded, abandoned, or lost salvage

gear, structures, or even vessels as well as impacts on the environment and landscape). These effects are eventually seen by archaeologists, who then further contribute to the site transformations by their own invasive activities.

Many authors have sought to improve on Muckelroy's original concept, although most have focused on natural processes (e.g., McCarthy 1998; Ward et al. 1999; Stewart 1999; Martin 2011; and see section 1 of this volume). Despite Gould's (1983) *Shipwreck Anthropology* highlighting a number of potential paths for studying cultural processes surrounding ships and shipwrecks, prior to the 1990s only a few studies appear to have engaged with these concerns (Keith and Simmons 1985; Lenihan 1987; Hardy 1990). However, since the late 1990s there has been renewed interest in cultural transformations affecting wreck sites, such as Souza's (1998) work on post-depositional factors, Simpson's (1999) discussion of historic salvage, Richards's works (2008, 2011) on abandonment, and Stammers's (2004) overview of ship breaking. Recent interest in maritime cultural landscapes has also seen increasing attention given to associated cultural processes and sites extending beyond the immediate wreck environment (Duncan 2006a; Ford 2011).

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Our discussion begins by drawing a distinction between natural and cultural site formation processes evident at *shipping mishap* sites. We use the term *shipping mishap sites* as advocated by Duncan (2000) to include all sites and ancillary places associated with the loss, stranding, grounding, or collision of a vessel. Natural processes can be defined as nonhuman factors affecting the archaeological integrity of the wreck; for instance, chemical and physical processes such as wind, waves, corrosion, heat, and the interaction of organisms with the wreck (Martin 2011). Anthropogenic impacts include activities such as fishing or dredging damage, which, while humanly produced, are unintentional or without direct knowledge that there is an impact upon a wreck site. Some of these aspects are addressed elsewhere in this volume. For the purposes of this chapter a cultural site formation process is therefore considered to be one in which there is intentional human interaction with the wreck site and its associated components. Cultural site formation studies should include not only what people bring in and take out of a wreck site, but where they take it from and to, and why they undertake these actions. As we discuss, sometimes the evidence of these cultural processes may be visible on the surviving structure of the ships, in the distribution of materials and relics around or beyond the wreck, or in artifacts, sites, environmental modifications, and landscapes

associated with other activities linked to the use of the wreck, even in situations where the structure of the vessel is no longer present. It is therefore necessary to consider not only the action that led to the wreck event and its immediate aftermath, but also the long-term behaviors surrounding the site. It is only by achieving an understanding of both natural *and* cultural processes that we can fully comprehend how and why the site exists in its present form, or how and why it may change in the future. From understanding the archaeological signatures of analogous sites, we may be able to derive behavioral influences that were taking place at other shipwrecks in similar circumstances and environments.

While this chapter is not an exhaustive review of all the potential cultural processes acting upon shipwrecks, we consider a range of behaviors, processes, and associated sites and archaeological signatures that might manifest in the archaeological record. Similar types of processes could happen at very different scales, from a small wooden boat through to an aircraft carrier. Processes could also happen at varying intensity and over different time scales. Some of the processes we discuss later were sequential as a consequence of their relationship to the progression of a wreck event, while others could happen in varying order, be concurrent, or not happen at all, depending on environmental, social, economic, or legal circumstances. As noted, many are equally applicable to wrecked, intentionally deposited, or abandoned vessels. Over time, or depending on perspective, one type of site could also transform into another, resulting in different responses and processes taking place. This chapter does not attempt to provide examples or specific detail for the different transformations described; instead, the emphasis is on encouraging archaeologists to look more broadly at wrecks, sites, and signatures. A more detailed study is presented in a forthcoming book by the authors, exploring how communities responded to shipwreck, including salvage operations (Duncan and Gibbs 2015).

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For the sake of simplicity we refer to many of the cultural processes acting upon shipping mishap sites via the portfolio term *salvage*. The archaeological study of salvage is therefore inclusive of not only the processes and signatures associated with the recovery of a ship/derelict/wreck structure and the materials aboard but also the evidence of associated off-site salvage operations, structures, and materials.

In order to understand the cultural site formation processes that have acted upon a wreck site, we must first understand what constituted the ship. Every vessel has a life history. Its construction and form are in a constant state of transformation as repairs and replacements are made to the

structure and fittings, as new technologies (and especially modes of propulsion) supersede and replace old, as its type of utility varies, and as cargoes, passengers/crew, and their belongings aboard change (see Lenihan 1987; Auer 2004). Knowing as much about the architecture, the unique life history, and biographical archaeology of the (as yet) unwrecked vessel is an important first step in understanding what changes have occurred within the site following the wreck or deposition event. For example, Murphy's "one last voyage" hypothesis proposes that "the more economically stressed a ship-producing and/or vessel using group becomes, the more extensive are the repairs performed on a vessel, ultimately extending the ship's use-life beyond sensible retirement" (Murphy 1983:75). These factors may present significant contributions to the wrecking event and subsequent site formation processes and might be incorrectly interpreted as the result of postwreck processes. We therefore need to consider at what point in its life a vessel becomes a wreck and what subsequently happens to turn it into the current archaeological site.

In a series of papers, Gibbs (2002; 2003; 2005; 2006) explored shipwreck cultural site formation processes by adopting a framework used by Leach (1994) in the analysis of disaster response. This framework suggested some of the cultural factors that might influence the occurrence of a shipwreck and the nature of a shipwreck site, including successive salvage processes (fig 9.1).

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Duncan's (2000, 2004a) research has traced how risk avoidance and risk taking behavior played roles in determining shipping routes and wreck locations. He postulated that mariners' recognition of hazards (and potential hazards) and their consequent reactions to the risks posed (i.e., risk mitigation) were a significant factor that determined the occurrence of shipwrecks' patterning and their subsequent cultural landscapes. Picking up on this latter point, he has also explored the role that shipwrecks and wreck material played within the social, economic, and symbolic maritime cultural landscapes of both mariners and landlubbers alike. In particular, the use of wrecks as economic resources well after the wrecking event has been demonstrated to contribute markedly to the final archaeological signatures of wreck sites (Duncan 2006a:213–282). An important underpinning for these works is the understanding that shipwrecks are not "time capsules" (see Muckelroy 1976:56–57; Dean et al. 1992:32; Gould 2000:12–13) but that the wreck sites were, and are, constantly being utilized and accessed well after the wrecking event and hence are transformed on a regular basis.

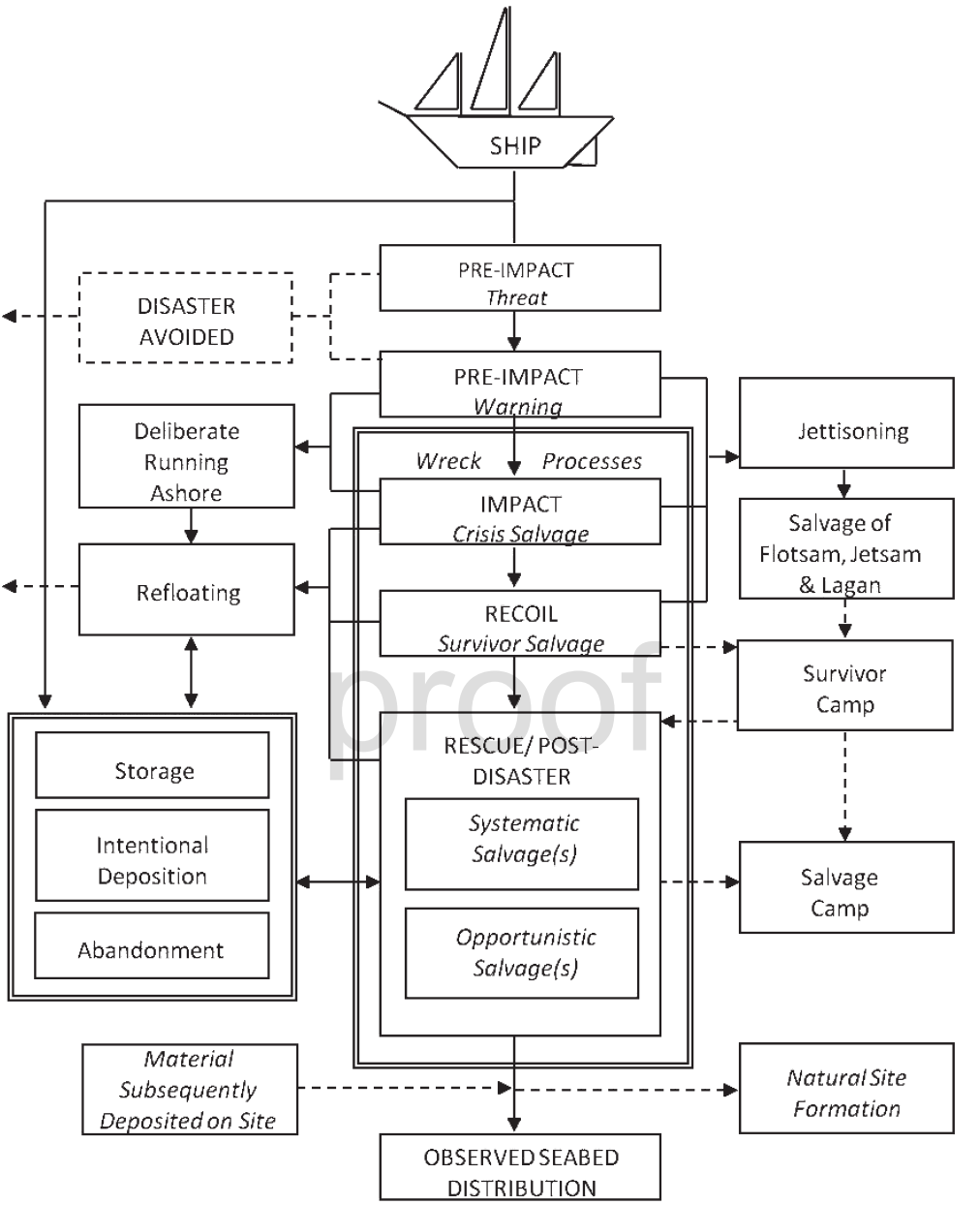

Figure 9.1. Cultural site formation factors in shipping mishaps (adapted from Muckelroy 1978 and Ward et al. 1999).

The Influence of Marine Underwriting on Shipping Mishap Behaviors

If we accept Duncan's (2000, 2004a) premise that risk was a major factor affecting the incidence of vessel mishaps, then the group perhaps most focused on the avoidance of financial risk associated with shipwrecks is marine underwriters. Marine insurance underwriters and marine insurance law therefore provide a useful benchmark for the definition of what actually constitutes a shipwreck. However, the popular definition of a shipwreck is more a loose historical usage than a legal one in terms of marine insurance. Marine underwriters tended to define shipping mishaps not in terms of shipwrecks but in degrees of loss (Broxham and Nash 2000:x). Shipping mishaps were divided into categories dependent on the extent of the loss incurred in the incident (table 9.1). Modern legal definitions stipulate that a wreck is "any part of vessels or their cargoes cast upon land or sea" (De Kerchove 1961:925). Hardy Ivamy (1974:209, 599) specified that a vessel becomes a wreck when it is no longer salvageable.

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Table 9.1. Vessel incidents and loss

Collisions	Where the vessel collides with another vessel or structure.
Groundings	Where the vessel collides with the seabed causing damage to its hull/associated fittings.
Strandings	Where the vessel runs aground but remains partly or wholly above water. There are two types of strandings:
Accidental Stranding	Where the vessel collides with the seabed.
Deliberate Stranding	Where the vessel is deliberately steered ashore into shallow water to avoid becoming an **Actual or Total or Constructive Loss**.
Constructive Total Loss	Vessel is in imminent danger of becoming an actual loss, and is abandoned accordingly.
Actual Total Loss/General Average Loss	Vessel is destroyed and ceases to be recognizable as its original function as a ship or boat. Jettisoned material was also considered a **General Average Loss**.
Abandonment	Could only take place under stipulated conditions where it was recognized that the ship, cargo, and lives of those onboard were under imminent threat.

Note: After de Kerchove 1961.

The processes of wreck avoidance, abandonment, and subsequent salvage have (for at least the last several thousand years) been surrounded by a web of legalities, customs, and rights that have dictated acceptable behavior of mariners in times of shipping mishaps. These legalities and policies have specified who can (or should) undertake vessel abandonment and salvage; how and to what extent it should be done dependent on the circumstances; and as a result, who benefits materially and financially (usually via a maritime *lien*). For instance, the surviving fragments of the *Lex Rhodia de Jactu,* formulated ca. 900–800 BC and considered the ancestor of Western maritime legal codes, outline the contractual obligations pertaining to the jettisoning (*jactu*) of cargo to avoid wrecking (Britannica 1911). This remnant text from a larger document on maritime law describes relevant actions and lien under specific circumstances (such as the implications of cutting down masts, or using divers to salvage) and gives details of the resulting financial relationships. There are numerous successor laws and treatises on relevant precedents (e.g., Molloy 1677; Abbott 1802), as well as modern analyses of these (e.g., Melikan 1990), through which the evolution of these practices can be traced into the modern era.

Marine insurance is obviously another descendant of the *Lex Rhodia* (Roover 1945). Insurance codes provide extensive definition and delineation of risk and liability; detail appropriate priorities, actions, and expectations with regard to salvage of structure and cargo in particular circumstances; and include directives for the disbursement of profits from sale of salvaged structure and goods (e.g., Hopkins 1867; Gow 1917; Hardy Ivamy 1974). These in turn are linked to international and local codes surrounding salvage rights, in particular the Law of Salvage, which balances ownership of the vessel and cargo against the risk and real danger experienced by the salvors (due to environment, weather, or circumstances) and the service provided in the recovery of property (such as technologies and labor used and efficiency of recovery; Brice 2003; Mandaraka-Sheppard 2007; see table 9.2).

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It is notable that the actions of mariners during shipwrecks and strandings were often driven by the stipulations of marine underwriter law and codes. Consequently, it must be considered that behaviors during and after wreck events were not simply to secure the safety of vessel, cargo, and people but may also have been attempts to work within or around various laws or insurance codes. Official reports and even autobiographical accounts of actions during and after wreck events would also have been sensitive to the implications of how these events were represented. Activities such as

Table 9.2. Shipwreck materials

Wreck	Anything without an apparent owner, afloat upon, sunk in, or cast ashore by the sea . . . includes jetsam, flotsam, lagan and derelict.
Derelict	1. Goods or any other commodity (especially vessels) abandoned or relinquished by its owner, either by consent, compulsion or stress of weather—usually with the owner indicating they intend to make no further claim (abandonment).
Jettison	The act of throwing goods overboard to lighten a ship or improve stability in stress of weather or in any other cases of necessity or emergency.
Wreckage	Goods cast ashore after a wreck.
Flotsam	Cargo which floats after jettison.
Jetsam	Cargo which sinks after being jettisoned.
Lagan	Goods cast overboard from a sinking vessel and buoyed as to be subsequently recovered, or large articles which sink with the ship in wreck.
Salvage	The property which has been recovered from a wrecked vessel, or the recovery of the vessel herself.

Note: After de Kerchove 1961.

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abandonment, deliberate strandings, responses to particular environmental circumstances, or accepting or refusing assistance could significantly alter culpability of the captain and resulting claims upon the vessel and contents by salvors. It is therefore postulated that insurance underwriting companies essentially dictated (where possible) a major part of the process of the wrecking event and eventual salvage that took place at many wreck sites. Consequently, understanding the logic behind certain decisions in vessel operation and use, or the behaviors undertaken during the wrecking event and salvage, may require an appreciation of the specific laws and obligations imposed upon mariners under specified circumstances. For instance, the vessel may also demonstrate forms of risk taking, such as deliberate insurance fraud or ship owners and operators choosing to employ worn or unseaworthy vessels, hedging the expense of the loss of cargo against benefits from possible insurance claims (cf. Murphy 1983).

Salvage as Site Formation Process

In order to understand salvage as a cultural site formation process, we must first explore the extent of activities that salvage entails. Some of the

most basic potential questions regarding the study of salvage as both a site formation process and a cultural activity were posed in a short paper by Simpson (1999:4, 6).

> What is missing? What is present? Is the position of this artifact or cluster a product of pre-depositional choices, the wrecking process itself, or the product of salvors grouping salvageable items for recovery at a later time? Are these timbers from the ship or are they left over from a salvage operation. . . . What materials were salvaged and what materials were not? How was the wreck salvaged? Why were certain objects recovered over other objects? Is there a staging area associated with the wreck site?

Simpson (1999:8) also noted that maritime archaeology should not just look at who the salvors were but should also consider any economic and social effects the salvaged material had on surrounding communities (including indigenous groups), the trajectories of artifacts after salvage, and how the meanings of these objects changed over time. All these factors should be borne in mind in the following discussion.

Maritime archaeology has long recognized the need to consider the different forms of salvage across time and different circumstances. Muckelroy (1976, 1980) noted salvage process in his flowchart, while Keith and Simmons (1985) suggested differentiating the impacts of "salvage in antiquity" from those of "modern salvage." McCarthy (2001:93) proposed a distinction between "primary salvage" and "secondary salvage," primary salvage being the recovery of materials by their owners, operators, or agents, presumably close to the time of wrecking, while secondary salvage is the modern recovery of materials by professional salvors or sports divers.

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We have previously suggested (Gibbs 2006) that the concepts of primary and secondary salvage might be supplemented by making the following distinctions:

1. Pre-impact actions
2. Crisis salvage
3. Survivor salvage
4. Systematic salvage
5. Opportunistic salvage

These distinctions are discussed in detail later in this chapter, as are several other major processes, including hulks, abandonment, strandings/groundings, and ship breaking. In addition to the wreck and associated

Table 9.3. Categories of material making up a ship

Category	Materials
Cargo and Contents	Non-fixed items not associated with the mechanical operation of the ship and which were meant to be removable, including the ship's boats and life-rafts.
Fixtures and Fittings	Minor fixed items, fittings, yards, chains, ropes, anchors and cannon, minor mechanical items, and equipment.
Minor Structural	Items not normally removed, but the removal of which would not compromise the integrity of the hull, such as bulkheads, decks, masts, superstructure, major mechanical items, and equipment.
Major Structural	Elements of the ship for which removal would affect the integrity of the vessel, including hull planking, ribs, and other structural items.

Note: Data from Gibbs 2006:3.

materials, the distinctions can also be applied to off-site materials (flotsam, jetsam, and lagan), as considerable quantities of material could float away from a wreck (or be separated from it as a result of the associated salvage operation). Some coastal communities have their own formal and informal codes and rights for accessing wreck materials that wash ashore. This could mean that protection was required, such as by police or customs officials, until the legal owners or agents could organize collection (see later discussion).

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There are many potential sources for studying how people responded to shipping mishaps, undertook salvage, or related to wreck sites and derelict vessels as part of their cultural landscapes, including government, legal and commercial documents, corporate or institutional histories, nontechnical historical accounts, and ethnographic studies. The most detailed and readily available are explanations of twentieth-century principles, techniques, procedures, and equipment for responding to various types of shipping mishaps, including numerous technical manuals (e.g., Bartholomew et al. 2006; Wilkins 2006), descriptive contemporary accounts (Young 1933; Meier 1943; Wheeler 1958; Bartholomew and Milwee 2009), and written oral histories (e.g., Benham 1980). However, there are also ancient and historical descriptions of early salvage attempts and technologies (e.g., White 2005:191), historical studies and analyses (e.g., Bevan 1996; Ahlström 1997; Driver and Martins 2006), and many images and photographs that illustrate these processes and uses.

To simplify discussion regarding salvage or other cultural processes that extracted from, scrambled, or added to material associated with a wreck site, we have previously used a simple hierarchy of a ship's structure and contents (table 9.3). This is based in broad terms on the relative difficulty of removing materials and how they relate to the structural integrity of the vessel (table 9.1). These categories are flexible and not strictly hierarchical, as a large or heavy cargo item, or one situated in the lower hold of the ship, might be substantially more difficult to access and remove than lighter fittings or structural elements situated elsewhere (Gibbs 2006:4).

1. Pre-Impact—Saving the Ship

The captain or person(s) in command of a vessel in peril (including the potential salvor) was faced with decisions that were not only to ensure the preservation of human life but also meant to serve best the long-term interests of the vessel and its cargo. The removal of material from a vessel might occur soon after the realization that it was in peril, prior to the actual wreck event (i.e., "pre-impact"), starting the sequence of decisions and actions that alter the ship and its contents and ultimately manifest in the archaeological site. When a commander was faced with an impending collision or a potentially avoidable catastrophe, deliberate jettisoning of cargo, fittings, and even structural material might have been used to lighten the ship and make maneuverability easier, resulting in jetsam or lagan (Gibbs 2006). A leaking vessel might also have been subject to emergency repairs to maintain buoyancy, such by as plugging holes or pumping.

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In some instances a ship in peril might be able to get external assistance from another vessel, including from professional wreckers who patrolled high risk areas (e.g., the Florida Keys; see Viele 2001). Attempts might be made to undertake *afloat salvage*, either through offloading cargo or through trying to save the vessel by various means such as towing or securing it in place. In some instances a shore-based lifeboat service might be able to make it to the ship or, in heavy seas, send a line from shore via a rocket system. If a line could make it aboard, a hawser arrangement would then be rigged from shipwreck to shore, usually fixed between the mast and an A-frame on the shore (or on a hill, dune, or cliff above it). Passengers could then be hauled ashore in a bosun's chair, and even cargo could be winched over if necessary. In later Western European cultural contexts the rescue of human lives was considered a humanitarian "good shepherd" action with no or low salvage value, although failure to prioritize this over material salvage would often have severe repercussions for the rights the

salvors might have over any property or value (Benham 1986). This was a critical period, as accepting assistance would initiate salvage laws, leaving the captain and ship owners liable to claims. Even when in imminent peril, the captain was expected to negotiate the terms of assistance prior to relinquishing command (i.e., "abandoning" the ship).

2. Crisis Salvage

In the absence of immediate external assistance or salvation before, during, or immediately after a wreck event, a ship's crew and passengers might engage in "crisis" salvage. This form of salvage focused on recovering survival necessities, usually within the more accessible cargo, fittings, or minor structural materials, depending on circumstances and time available (Gibbs 2003). During this period, items might be thrown overboard to facilitate refloating or to aid survival of people in the water (i.e., floatable items were thrown overboard). These processes were often specified by insurance underwriters as precursor actions that must take place before a vessel could be abandoned and therefore declared a constructive total loss (Hardy Ivamy 1974:383). Items thrown overboard might be considered for later salvage and include those materials known as flotsam, jetsam, and lagan (Duncan 2006a:247).

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Rescue services in the form of lifeboat sheds and rocket stations have their own archaeological visibility. Lifeboat rescues would often strategically use kedging anchors to control their drift back to a wreck, which would then be abandoned after rescuing survivors. Rocket lines often left rocket shells on the wreck site, and sometimes lifeboats sank during the rescue. There was also a whole range of infrastructure associated with the lifeboat service itself. This included features located in isolated areas known for repeated shipping mishaps, such as rocket sheds and purpose-made tracks, as well as lifeboat sheds, piers, and wreck bells located within local settlements (see Duncan 2006a:262).

Another form of crisis salvage dictated by risk management during crisis periods was to run the vessel aground deliberately in an area where it would not sink completely or be subjected to further physical damage from the elements. In marine insurance there are various nuances regarding whether a wreck is a stranding or grounding (see table 9.1). While accidental stranding was common, deliberate stranding was also used as a strategy for ships that were leaking or otherwise facing the prospect of actual/constructive total loss. Deliberate stranding was therefore used as a strategy to prevent sinking, preserve the structure of the vessel, and increase opportunities

for repair, refloating, or salvage operations. If propulsion/mobility/steerage and control of the vessel were possible, the desirable type of site would be one where the seafloor was sufficiently soft to reduce damage to the keel and hull when the vessel was driven up and was preferably in an area outside dangerous swell or other hazards. Local knowledge of an area often included insight into which places (such as sand banks) afforded the best opportunities for deliberate stranding should it be necessary (Duncan 2006a:219). This aspect is discussed further in the section on systematic salvage.

3. Survivor Salvage

Following the main wreck event, should the situation of the wreck allow this (such as if stranded on a reef), survivors might engage in more complex forms of salvage ("survivor salvage") before formal rescue took place. Materials might be dispersed in lifeboats or to a survivor camp if land was available. The survivor camp offers a complementary assemblage of the ship's materials and if close enough to the wreck site might also become the base for salvage operations by rescuers or subsequent salvors. This aspect has been dealt with in detail in a previous paper by Gibbs (2003).

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4. Systematic Salvage

Systematic salvage is usually conducted by professional salvors with the time, workforce, and technology to undertake an intensive and sustained effort to remove all or some of the cargo, fittings, and minor and major structural elements. Systematic salvage was most likely carried out by the owners of the vessel or their authorized agents (akin to McCarthy's "primary" salvage).

The extent of a systematic salvage of a wreck (in whole or part) was determined by a number of factors. These factors include the amount of available salvage equipment and manpower close to the site; allocated time; time window (e.g., weather); threat to life; and the real, perceived, or supposed economic, strategic, or social (including symbolic or religious) benefits of successful recovery of material (Gibbs 2006:14). These considerations dictated salvage priorities regarding what to take; the order in which it was taken (and to what extent); and conversely, what to leave behind. Decisions not to salvage, to perform only limited salvage, or to abandon a wreck completely presumably came when the structural remains or the materials within fell below a predetermined threshold.

Salvage priorities, processes, and techniques were dependent upon mul-

tiple inter-related factors, some of which are indicated in table 9.4. Shipwreck salvage literature (e.g., Ward 1956; Bartholomew et al. 2006) embodies some of these considerations in the terminology of several different types of salvage, each implying environmental conditions and/or different types or levels of technical activity (table 9.5). Other forms of salvage and wreck-related activities discussed later, such as refloating, breaking, placement, or abandonment, might arise as a consequence of these.

Systematic salvage might also commence minutes or years after a wreck event, depending upon legal, logistical, and environmental conditions. As already described, a strategy would be formulated based on the condition of the vessel, its circumstances, and the capabilities of the salvors. If the wreck were close to shore, salvage might take place at low tide when access was available across tidal flats. If the vessel was stranded and undamaged rather than derelict, then efforts might focus on the refloating process (discussed later). A salvage camp might be established on shore, to house salvors and possibly officials and to act as a base for salvage gear and storage of recovered materials. Depending upon the activities being carried out, the salvage camp would presumably be in the nearest possible proximity to the wreck.

Various forms of infrastructure might be constructed to formulate transfer of goods from the wreck site. These types of infrastructure might include a corduroy road of logs or tramway, over which vehicles or carts could transport materials; shore-based winches/engines and/or flying foxes (and their associated supporting beds) to haul material ashore; causeways, jetties, or piers from shore to wreck; or breakwaters or coffer dams to shield the site from prevailing weather, seas, and tidal changes. Anchors or structures (e.g., piles/dolphins) were sometimes used to prevent further movement of the derelict. Other environmental modifications could include removal of reef or digging trenches into beaches to facilitate access or removal (e.g., Duncan 2006a:267). Extensive ship breaking in situ and abandonment of all or part of the residual structure were also practiced (discussed later).

For a vessel that had sunk but was still accessible from the surface, one or several salvage vessels such as tugs, lighters, barges, and pontoons were generally used as work platforms. Some of these might be modified or specialized salvage craft, capable of housing the various types of equipment required to access the vessel and its interior and recover goods. Such equipment might include diving gear, cranes, winches, and underwater lifting

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Table 9.4. Factors affecting salvage priorities, processes, and techniques

Size, type and construction of the vessel
Purpose of the vessel (e.g., naval, commercial, passenger)
Type of cargo being carried (size, composition)
Structural integrity of the vessel (or derelict) and potential for recovery
The extent to which the vessel (or derelict) remains above water (grounded/stranded) or submerged
Short- and long-term environmental conditions (weather, swell, currents, bottom composition)
Logistical constraints (e.g., proximity to shore, distance from settlements, and/or transport networks and suitable places for salvage camps/storage)
Technologies and labor force(s) available locally and regionally, including specialist knowledge and experience
Cultural dangers (such as during war, indigenous attack, and contested ownership)
Perceived values of removing different components, which prioritized the order and intensity of removal (e.g., the removal of the vessel's structure in whole or part vs. cargo and contents)
Consideration of hazards, risk, and expense of salvage versus potential profit
Processes and procedures stipulated by legal, insurance, corporate, institutional, or other policies, codes, and guidelines
Other cultural factors (e.g., social, superstitious, or symbolic significance encouraging or discouraging removal of material)
Time since the original wreck event, and the progress of these factors (e.g., primary or secondary salvage)

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Table 9.5. Major salvage types

Salvage Type	Explanation
Afloat	Salvage of a vessel still afloat (and potentially damaged). Assistance provided to ships that are afire, flooding, battle damaged, or victims of other misfortunes at sea.
Offshore	Salvage of a stranded vessel or derelict in exposed conditions.
Harbor	Salvage of a stranded vessel or derelict in sheltered waters.
Stranded	Refloating of grounded ships to restrict damage to the ship or the environment, return a valuable ship to service, remove it for disposal or breaking, or to save cargo.
Cargo and equipment	Salvage of cargo and fixtures prioritized, meaning structure may be destroyed or dismantled to facilitate removal.
Wreck removal	Removal of a derelict without necessarily undertaking salvage (low or no value).
Clearance	Removal or salvage of vessels (sometimes multiple vessels), typically after a catastrophic event such as a war or natural disaster, to ensure a harbor or waterway remains open.
Deep-ocean	Operations, objects are located, investigated, and recovered from the ocean floor, sometimes at great depths.

Note: After Bartholomew et al. 2006:2–1; Bartholomew and Milwee 2009:33.

devices. These vessels might also require their own mooring systems. There are instances where hazardous circumstances resulted in spillage of the salvage materials and the loss of the salvage vessel(s) and/or equipment (e.g., Love 2006:79).

An episode of systematic salvage would continue until the desired value had been extracted and salvage operations were abandoned either temporarily or permanently. A vessel or site might be subjected to successive periods of systematic salvage depending on whether the values of the wreck shifted, the salvage technologies or labor force improved, or environmental circumstances and conditions influenced hazard, effort, or access to the site. Surrounding these cycles of systematic salvage might be numerous episodes from opportunistic salvors, potentially operating with different intentions and values (discussed later).

5. Strandings and Groundings

Stranding sites, where vessels have been completely removed, represent an under-explored archaeological resource (Duncan 2006a: 218). Despite absence of a hull, there may be substantial evidence of significant activity associated with the nature of the wreck event and the processes of removing the vessel (see Duncan 2000:142; 2006a:259). In effect these are "phantom" wreck sites (Duncan 2000:142; Gibbs 2006), but nonetheless the places at which these events occurred are quite possibly as common as catastrophic wreck sites or even more so.

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The difference between deliberate and accidental stranding has already been noted. In either scenario, if a stranded vessel was undamaged, then the simplest response would be to try to refloat it on the rising tide or if necessary wait for a spring tide or seasonal change. This process might entail lightening the ship by careful offloading (and eventual reloading) of ballast, cargo, or heavy fixtures and fittings (such as anchors and cannon). However, for the sake of expediency and safety, these items were sometimes jettisoned without any likelihood of immediate recovery (Benham 1986). Consequently, while the vessel itself would be successfully refloated and removed, the site of the stranding might be marked by considerable quantities of ballast and other material, which in some instances can look much like the signature of a shipwreck (Duncan 2006a:218; 2006b:253, 393, 434, 520).

Depending on bottom conditions, a vessel stranded on a beach might need to be freed from sediment, either manually or through mechanically digging or dredging. Many of the structures used to salvage wrecks had

similar applicability for stranding sites. Structures to access the vessel (such as plankways or corduroy roads), and to undertake the excavation, remove the sediment, and then try to prevent refilling of the hole between tides (shoring and retaining walls), could result in considerable short-term environmental modification. The use of more elaborate structures such as coffer dams and structures placed above and below water could provide placement assurance and/or stabilize the vessel and prevent further slippage into deeper water. Explosives could be used to blast through obstructing reef or rock, while the process of removal might itself damage reef surfaces and seafloors in archaeologically visible ways (such as by gouging from the keel scraping over the bottom). If the tide or the vessel's own power was not sufficient to lift it off the obstruction, then other vessels (such as tugs) could assist in hauling it off. In the absence of other vessels, shore-based structures could be used, such as carefully placed arrangements of underwater anchors, or land-based winching systems known as beach gear, which might include using existing strong points or burying anchors.

A vessel might require repair before an attempt was made to refloat it, such as careening, in which the vessel is rolled onto its side to allow access to the lower hull and keel. In order to careen a vessel, cargo and heavy fixtures and fittings might need to be shifted or offloaded to allow the vessel to list, sometimes aided by rigging block and tackle to hoist the vessel over, with the hawser fixed to another vessel, to anchors, or to points ashore (such as trees or even a buried anchor). In some instances severe damage might require removal of major structural elements (e.g., crushed bow, stern, or masts) to regain hydrodynamic qualities and allow recovery to another location for later repair, salvage, or abandonment.

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Righting a fully capsized or severely heeled over vessel was a complex operation. Depending upon whether the intention was to try to save the structure or simply to remove it, the options might be to bring the vessel back onto its own keel or even refloat it and remove it upside down or on its side. Depending upon environmental circumstances, rotating a capsized vessel could be assisted by tidal changes, careful placement of weight internally, and by the use of buoyancy devices or external winching systems on shore, on salvage vessels, or on the seafloor, although this was also dependent upon the shape of the vessel (cf. Benham 1986:56). To gain sufficient leverage to roll it upright, a headframe or shearlegs might be constructed on the hull.

In attempting to refloat a partially or wholly sunken vessel the main aim was to recover some level of positive buoyancy, which might be achieved in

various ways. Getting wires or hawsers beneath a wreck and winching it up, using external pontoons or flotation devices (such as lift bags), repairing and sealing the hull and expelling the water by pumping or introducing air, placing buoyant objects inside (e.g., empty drums, float bags, or a collection of smaller buoyant objects), or a combination of these were some of the means of achieving this. Modified vessels such as "wreck-raising" hulks, or specialized vessels of various kinds, such as those equipped with cranes, might be used. In order to pass a line beneath a sunken vessel, tunneling beneath the hull might be required. Structural recovery and refloating might also involve sections of a vessel rather than the complete hull.

Recovery of the hull structure was dependent not only on the conditions, technology, labor, and expertise available but also on the structural integrity of the hull and its ability to withstand the strains of being pulled, dragged, or lifted. A failed attempt to save the hull might, at best, leave the derelict where it was and, at worst, result in structural failure and breakage of the hull into parts, negating some or all of its salvage value. The salvage gear itself, including pontoons and flotation devices, wires, ropes, and dive gear, might not be recoverable, or worth the effort of recovery, thus entering the archaeological record. Even after successful refloating, the various structures used to assist the process might remain in place, while the environmental modifications might remain visible or have other long-term consequences.

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6. Opportunistic Salvage

Opportunistic salvage is the nonsystematic removal of structure and contents, likely to be undertaken by people without the legal right to remove material (cf. McCarthy's "secondary" salvage). Opportunistic salvage could and often would commence almost immediately after a wreck event, especially if a ship was breaking up and material was being dispersed close to shore. Many of the priorities for salvage outlined so far also applied in these circumstances, although from a different perspective and with the added necessity in many cases of undertaking such activities while avoiding official attention. Local maritime communities often had their own traditions and codes regarding their priorities, practices, and rights to wreck salvage, especially flotsam and jetsam washed ashore on their beaches, regardless of formal legalities. Intimate knowledge of currents and the likely places for material to wash ashore (flotsam/jetsam traps) meant that they could target the best areas for collection, preferably before legal owners or authorities arrived to deny them access (Duncan and Gibbs 2015).

Opportunistic salvage could be undertaken at various levels, from small-scale plundering of materials washed ashore from a wreck to large-scale looting of the ship's cargo and structure. Assuming that circumstances allowed, opportunistic salvors (also known as looters and sometimes wreckers) might even board the derelict itself and undertake larger-scale removal of cargo or breaking of the structure. Illicit removal of wreck material included a variety of actions with potential archaeological visibility. These include caching of goods (such as in holes, caves, beneath collapsed sand dunes, or in specially constructed lined pits or barrels) and removal and concealment of materials at residences or in more distant and often isolated storage facilities. Salvaged objects might be distributed around the community in various ways for local use, including structural materials and fittings being incorporated into houses, buildings, and fences or reused in local watercraft. Proximity to areas susceptible to wreckings also led to both legal and illicit trading networks, where shipwreck items were further spread throughout the community.

Looters might attempt to distract authorized salvors or guards or employ various means of extending the opportunity to remove wreck materials, including employing drastic actions such as setting a derelict vessel alight to prevent its removal or to conceal previous theft. Most opportunistic and illicit looting was short in duration, and sporadic, but potentially repeated by different parties over an extended period of time. Collection could be a short-term activity or a long term and even cross-generational action as communities waited for seasonal changes in currents and storm events to wash ashore new material, including material from older wrecks (Duncan 2006).

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Although often disorganized in nature, opportunistic salvage potentially removed vast amounts of wreckage, cargo, and other items from the wreck site, as it was often undertaken by whole communities within a short space of time. Secondary sites associated with maintaining civil obedience were often constructed close to wreck sites (e.g., police and customs camps), which in turn were subjected to further criminal behavior (Duncan 2006a: 240–246). The study of opportunistic salvage presents important insights into the removal and deposition of materials in and out of wrecks sites.

7. Hulks

Vessels considered unseaworthy, technologically redundant, or otherwise not worth retaining for transport purposes, yet still structurally sound, might continue to exist as a hulk. Although not a shipping mishap, hulks

are considered here for their potential to generate archaeological signatures that might be confused for a shipwreck site, while aspects of their structural modification might be misleading if the hull is subsequently found by archaeologists (see Delgado 2009). In general, vessels to be used as hulks were derigged and moored, sometimes permanently, in a harbor or roadstead and modified for further use. Given the long-term static sheltered position, structural modifications to interior and exterior could be extensive and dramatic, with some of the characteristic hallmarks of a hulk being the accretion of new structural elements on the upper works and deck. In some instances rigging might be retained for use in sail training or as a crane. Some potential uses for hulks are listed here, each with implications for the types of structural modifications this might require and artifact deposits in and around the site.

- Exclusion or isolation—prison, defense, quarantine, reformatory, valuable or dangerous goods (e.g., powder magazine)
- Storage—including coal hulks
- Accommodation and services—housing, military barracks
- Services—stores, chapel, hospital, school, offices, sail training, blacksmith shop
- Recreational—bathing enclosure, playground
- Barge or lighter—often with a cut-down superstructure
- Landing stage, floating crane, loading, base for other equipment
- Wreck raising or dry dock (floating or fixed ashore) for other vessels
- Fire-ship (offensive weapon)

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Hulks often became long-term and important components of harbor landscapes (see Duncan 2006b). Nearshore hulks were sometimes connected to land by jetties or other structures, although in some cases it was the potential to keep the hulk floating away from shore and isolated that made them desirable (such as for prisons, quarantine, explosives, or storage of valuables; Williams 2005; Menzies 2010). While hulks might rest on tidal flats, many remained floating and in some cases would be moved as required to new locations. At the end of their useful lives most were removed for breaking or disposal elsewhere, incorporated into landfills (sometimes in situ at their mooring), although some were broken in place or allowed to disintegrate (Duncan at al. 2013). Some were even converted back into vessels. Archaeologically, hulks may be visible through surviving

associated structures or mooring anchors (Duncan 2006b:255). Also, given the extended occupation of one area, many of these uses potentially generated significant quantities of refuse, which would invariably be discarded overboard onto the adjacent seafloor (Adams and Davis 1998; Williams 2005). Duncan has observed similar scatters under long-term anchorages for naval, fishing, and pilot vessels (2006a:125, 181, 191).

8. Abandonment and Intentional Deposition

Richards (2008, 2011) has provided an extensive consideration of maritime site formation processes deriving from vessel abandonment: catastrophic (desertion during a wreck event), consequential (ruining a ship to save lives), and deliberate (intentional deposition). This deliberate abandonment category is the most relevant here, with various potential trajectories for vessels outlined.

- Ritualistic discard (e.g., ships use as graves)
- Structural adaptation for use as buildings or foundations or as reclamation structures (e.g., retaining walls, cribbing, breakwaters, training walls, piers)
- Salvage and recycling—stored for recycling of materials (see breaking, below)
- Ship graveyards and breakers' yards—deliberate abandonment in a particular locale (strategic scuttling—sometimes in a single event—as a blockade device or to deny vessels to an enemy vs. discard as refuse in one area over an extended period)
- Strategic modification—(e.g., as fireships)
- Fish aggregation devices, dive destination

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The processes of abandonment might include placement or deposition above or below water as well as above and below ground (Delgado 2009; Richards 2011; Duncan 2006a:111, 124: App. D, 1–26). For placement below water, measures might be needed to ensure that discarded wrecks did not move, such as scuttling by mechanical or explosive means, driving piles adjacent to or through hulls, or other forms of structural modification by demolition or burning, all potentially visible archaeologically. Clusters of scuttled ships were referred to as ship graveyards and were often viewed by the community as shipwrecks, despite their intentional placement (see Duncan 1994; Duncan 2006a:214)

9. Shipbreaking and Destruction

The most drastic form of salvage is ship breaking, the systematic demolition of a vessel for recycling or complete destruction, sometimes also referred to as "shipwrecking" (see Stammers 2004:83). Although a site where a single vessel is dismantled, including in situ salvage of the majority of structure from a wreck, might be considered a breaking site, there were often areas suitable for ships to be broken easily (by virtue of being able to drive them onto tidal flats), or formal yards where multiple vessels could be processed, consecutively or concurrently. In some instances these were related to shipyards. Proximity to where salvaged materials might be processed or transported away, or where contaminants might be removed or disposed of, might also affect the location of a breaking yard (Pastron and Delgado 1991). Infrastructure such as breakwaters or stone jetties was sometime constructed, both to allow access to deep water and to provide shelter from prevailing weather conditions (Duncan 2004b; 2008a; 2008b).

Archaeologically this might be visible in various ways: by moorings, dolphins, or other structures for placement assurance during operations; infrastructure such as wharfs or jetties, winches and winding gear or cables to remove structure, salvage pontoons or barges, and areas for salvaged or ship components or unsalvaged hulks (e.g., Pastron and Delgado 1991; Duncan 2004b; 2008a, 2008b). Many ship breaking yards were located on the periphery of major settlements in marginal coastal areas or in rivers. In some instances breaking yards were closely related to storage areas for defunct vessels, being kept until economic conditions make breaking worthwhile, as well as to abandonment and dumping areas for remnant structure and materials. There are several basic intentions behind breaking:

- To remove structural components for use elsewhere (such as incorporation into another vessel).
- To remove structural materials for recycling (e.g., smelting).
- To reduce the structure to reduce the bulk substantially prior to abandonment or to free up space occupied by the vessel.
- To destroy the vessel completely.

Depending upon circumstances and the intention behind the salvage strategy (i.e., whether to recover structure or other components in an intact state or not), manual cutting, mechanical demolition, or explosives might all be used. Burning was another means of reducing a wreck for discard or to facilitate recovery of noncombustible fixtures and fittings without the

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time and expense of dismantling (Pastron and Delgado 1991). Setting a derelict afire might also happen in accidental or negligent ways (vandalism, for firewood, etc.). Finally, there might be destruction of a vessel, derelict, or hulk for experimental purposes (weapons or structural testing), including through use as a target. Furthermore, as ship breaking methods were often very similar to the methods employed by salvors, investigations of the archaeological remains of former ship breaking yards (Duncan 2004b, 2008a, 2008b) and other current research being undertaken by the authors also offers insights into the potential techniques used by salvage crews in breaking and salvaging wrecks.

Social Aspects of Salvage

Although the focus of this chapter is necessarily on the mechanics of maritime cultural site formation processes, we should briefly pick up on Simpson's (1999:4–6) questions regarding the "who" and "why" of salvage and stress that these activities were embedded in real social, economic, and symbolic worlds. It is important to try to determine the motivations and capabilities of those undertaking activities related to shipping mishaps, including prevention, rescue, and the different forms of salvage and reuse of materials over the short and long term. Many coastal communities integrated these activities into their daily lives, ranging from formal government, institutional, or commercial groups providing services to occasional participation in mishap-related activities, such as opportunistic beachcombing or even the secondary purchase or use of salvaged materials. Accessing wreck sites or beachcombing for seasonally deposited wreck materials could also become cross-generational pursuits, for example with the same wreck or stranding site being revisited over an extended period. Such activities sometimes became effectively "traditional" practice and subject to formal and informal codes of conduct within the community (Knowles 1997; Duncan 2006a). There is also increasing interest in the biography of objects salvaged from mishap sites, their symbolic significance, and how they move through communities (Steinberg 2008; Hosty 2010; Gregson et al. 2011). Some of these aspects will be dealt with in detail in the authors' forthcoming book (Duncan and Gibbs 2015).

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We also need to consider that salvage processes, especially breaking, required considerable skill and experience. There have long been individuals and groups specializing in these sorts of activities, presumably with traditions of technology and practice, as well as associations with wrecks in

particular areas or repeated use of certain locations for activities such as ship breaking. Associations with particular communities, ethnic/caste/social groups, or socioeconomic strata should also be considered. For instance, Pastron and Delgado (1991:65) found that much of the labor force working in the San Francisco breaking yards consisted of low-paid Chinese laborers. In the modern context the Alang (India) ship breaking yards actively exploit low socioeconomic and caste groups (Langewiesche 2000; Kot 2004). However, the fact that salvors were seen as benefiting from the misfortunes of others sometimes led to incorrect perceptions regarding their legality and morality (e.g., Viele 2001; Seal 2003; Bathurst 2005).

Conclusion

The cultural site formation processes surrounding shipping mishaps, and the salvage, modification for reuse, intentional placement, and abandonment of vessels are undoubtedly the causes of some of the most dramatic transformations seen on maritime mishap ("shipwreck") sites. There is greater complexity in the archaeology of vessel mishaps and the technologies and processes of salvage than has traditionally been allowed within maritime archaeological research. In the preceding sections we have attempted to illustrate some of the possible behaviors and actions surrounding vessel mishaps and the continuing uses and transformations in the later stages in the life of a vessel.

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While there has not been the scope to discuss specific historical or archaeological examples, our intention has been to stress that the evidence of these processes is frequently legible within the archaeological record. Evidence of salvage is often very discernible on sites, even if through the absence of the vessel itself. In some instances the mechanisms of salvage (ropes and wires, structures, jettisoned material, and environmental modifications) on land and sea are still obvious. As we have suggested, these processes are worthy subjects for intensive investigation in their own right, especially as salvage processes were the subject of considerable innovation and experimentation, which should be detectable in the archaeological record. Greater understanding is needed of the social, economic, and symbolic significance of many of these actions, as well as their place within a wider landscape of human activity, as is understanding of changes over time. There is a wealth of modern, historical, and ancient documentary, image, ethnographic, and archaeological resources available for the study

of maritime cultural site formation processes, and we hope that these sorts of investigations will become more common as part of the broadening of interest in maritime archaeology.

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Katherine Farnsworth is associate professor of geoscience at Indiana University of Pennsylvania. She received her Ph.D. from the College of William and Mary School of Marine Science with a focus on marine geology. Her research specialization is the interaction between terrestrial and aquatic systems, often focusing on the flux and fate of sediments in coastal oceans. She is a coauthor of *River Discharge to the Coastal Ocean: A Global Synthesis*, as well as of numerous research articles.

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Antony Firth is director of Fjordr Limited, a consultancy based in the United Kingdom that carries out research and provides advice relating to the marine and historic environment for a range of public authorities and private developers. He first became involved in archaeology as a volunteer diver investigating submerged prehistoric landscapes and a sixteenth-century shipwreck. His doctoral research examined the management of archaeology underwater in the United Kingdom and across a range of European countries, encompassing law, policy, and practice. Subsequently he became heavily involved in the emergence of development-led marine archaeology, working on a wide range of projects in the ports, marine aggregates, and marine renewable energy sectors.

Ben Ford is associate professor specializing in maritime and historical archaeology at Indiana University of Pennsylvania, where he is faculty in the Masters of Applied Archaeology program. His Ph.D. from Texas A&M University was preceded by several years of cultural resource management experience and degrees from the College of William and Mary and the

University of Cincinnati. He has edited the *Oxford Handbook of Maritime Archaeology* and *The Archaeology of Maritime Landscapes* and is the editor of the Society for Historical Archaeology Technical Briefs Series. His current research focuses on a Revolutionary War–era town in Pennsylvania and the maritime cultural landscape of Lake Ontario.

Martin Gibbs is professor of Australian archaeology at the University of New England, Australia. He specializes in the archaeology of maritime industries, cultural aspects of shipwreck site formation, shipwreck survivors, and the processes of maritime colonization. His current research projects include the archaeology of the sixteenth-century Spanish explorations of the Solomon Islands and the maritime cultural landscapes of Sydney Harbour. He is coauthoring a book with Brad Duncan on community responses to shipwrecks.

David Gregory trained as an analytical chemist prior to obtaining degrees in archaeology (B.Sc. Hons, University of Leicester, 1991; M. Phil., Andrews University, 1992; Ph.D., University of Leicester, 1996), with a special focus on the application of natural sciences to archaeological and conservation science focusing on the deterioration and conservation of waterlogged archaeological wood and iron. He has worked on numerous maritime archaeological projects as a diver, in both archaeological and conservation capacities. He is currently a research professor at the museum's conservation department, where he is investigating the deterioration of waterlogged archaeological wood, assessment of its state of preservation, and methods of in situ preservation of archaeological materials in underwater environments. He is author and coauthor of more than eighty scientific articles and book chapters on this research.

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M. Scott Harris is associate professor of geology and environmental geosciences at the College of Charleston. He received his Ph.D. from the University of Delaware Department of Geology, M.S. in environmental sciences from the University of Virginia, and B.S. in geology from the College of William and Mary. His research focuses on paleolandscapes and evolution of coastal regions with an emphasis on the coastal plain and continental shelf of the southeastern United States. Recent geoarchaeological studies include geology of the *H. L. Hunley*, the search for Barney's War of 1812 Flotilla in Maryland, sedimentology of the Topper Paleoamerican site, and coastal studies in Greece.

Matthew E. Keith is vice president and geoscience manager for Tesla Offshore, LLC. He received a master's degree from Florida State University. He specializes in interpreting remote sensing data for submerged archaeological resources and site characterization and has conducted research into the site formation processes that impact both historic shipwrecks and submerged prehistoric archaeological landscapes in the Gulf of Mexico.

Ian D. MacLeod is executive director of the Western Australian Museums in Fremantle and has been solving deterioration problems with shipwreck artifacts since 1978, when he joined the museum's Department of Materials Conservation. He has studied shipwrecks in Canada, Scotland, Finland, the United States, and the Federated States of Micronesia. He is a chartered chemist and a fellow of the Royal Society of Chemistry, International Institute for Conservation of Artistic and Historic Works, Royal Australian Chemical Institute, Australian Academy of Technological Sciences and Engineering, and Society of Antiquaries of Scotland. He is an advisor on the conservation of the Confederate submarine *H. L. Hunley* and on the USS *Monitor* projects.

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Ian Oxley began his career in 1980 for the Mary Rose Trust as an archaeological diver, progressing to archaeological scientist. He then joined the U.K. government's Archaeological Diving Unit based at the University of St. Andrews, ending as deputy director. During these periods of employment he embarked on an archaeological sciences degree at the (now) University of East London and an M.Sc. by research at the University of St. Andrews. After moving to Historic Scotland's Inspectorate of Ancient Monuments, he joined English Heritage in 2002 to set up and manage the Maritime Archaeology Team. He is currently the historic environment intelligence analyst marine for Historic England providing leadership in forecasting long-range issues, assessing threats and impacts to the marine historic environment, and delivering workable and cost-effective responses.

Ruth Plets is lecturer in the School of Environmental Sciences at Ulster University. Her research interests include the use of geophysical techniques for underwater archaeology. Such investigations focus on shipwreck and submerged landscape imaging, characterization, and visualization.

Rory Quinn is reader at the School of Environmental Sciences, Ulster University. His research interests are in marine geoarchaeology, specifically shipwreck site formation processes and submerged archaeological landscapes.

Robin Saunders received his Ph.D. from the University of Southampton in 2005. He is a chartered building engineer and a member of the British Hydrological Society. With his background in civil engineering (B.Eng. Hons., University of Southampton, 2000), his doctoral thesis combined his understanding of hydraulic flow with his keen interest in maritime archaeology to investigate seabed scour around submerged three-dimensional objects.

Carrie Sowden is archaeological director of the Great Lakes Historical Society in Toledo, Ohio. Her master's degree is from the Nautical Archaeology Program in the Anthropology Department at Texas A&M University. She has worked on archaeological projects across the world and now focuses primarily on Great Lakes archaeology in the late nineteenth and early twentieth century. She is the assistant editor of *Inland Seas*, a quarterly journal highlighting Great Lakes history.

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Daniel J. Warren is senior marine archaeologist at C & C Technologies, Inc. He received his M.A. from East Carolina University's Program in Maritime History and Nautical Archaeology in 1998. His research focuses on the location, documentation, and analysis of deep-water shipwrecks. He is currently serving as co–principal investigator for the archaeological analysis component of the Bureau of Ocean Energy Management's project Comparative Analysis of an Oil Spill on the Biota Inhabiting Several Gulf of Mexico Shipwrecks.

Kieran Westley is research associate at the Centre for Maritime Archaeology, Ulster University. His current research focuses on the reconstruction of submerged prehistoric landscapes using geophysical, geotechnical, and archaeological methods. He also has wider interests in the use of marine geophysics for mapping shipwrecks and the impact of coastal erosion on archaeological sites.

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