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Analysis of Hull Remains, Ballast, and Artifact Distribution of a 16th-Century Shipwreck, Molasses Reef, British West Indies

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It has often been said that ships wrecked on coral reefs in shallow tropical water seldom preserve their archaeological integrity: that the wood of the hull is not sufficiently well-preserved to warrant study, that smaller iron artifacts invariably are in poor condition, that ballast of such wrecks has no archaeological significance, and that surviving components of these sites are frequently re-sorted and further degraded with each passing storm to the extent that artifact distributions are rendered senseless. This "conventional wisdom" that all shipwrecks are in "marine peril" and must be salvaged as soon as possible has supplied a pretext under which untold numbers of Caribbean shipwreck sites have been obliterated.

Results from three seasons of excavation on a 16th-century shipwreck on Molasses Reef in the Turks and Caicos Islands, British West Indies, indicate that this loss of integrity is not always the case. Field methods for recording distributions of components within the site are described, and the results presented. Although the excavation is not yet completed, and only a small percentage of the total number of artifacts recovered has been cleaned, it is possible to make certain deductions regarding the date, nationality, and size of the vessel, under what conditions she arrived and how she was wrecked on Molasses Reef, and what subsequent activities have affected the site, and our ability to interpret it.

Introduction

The Institute of Nautical Archaeology (INA) is focusing its Caribbean efforts on locating and excavating shipwreck sites dating to the earliest phase of exploration and discovery in the New World. In 1983 INA field teams surveyed, tested, or excavated six late 15th- or early 16th-century shipwreck sites from the Bahamas to Mexico. Only one of these sites has been designated for complete excavation and analysis.¹ The "Molasses Reef Wreck," as this site is called, was discovered on a remote

shoal on the sw edge of the Caicos Bank within the territorial waters of the Turks and Caicos Islands, a British Crown Colony located ca. 120 km north of Hispaniola (FIG. 1).²

Three phases of fieldwork totaling about four months have been accomplished, and it is anticipated another two months will be required to finish the excavation. More than 1,000 artifacts have been recovered from the

1. Events leading up to this project have been discussed elsewhere; see, e.g., M. Toner, "The Mystery Wreck of Molasses Reef," *Tropic Magazine* (May 9, 1982) 6–12.

2. Archaeological investigation of the Molasses Reef Wreck was authorized in a formal Agreement between the government of the Turks and Caicos Islands and the Institute of Nautical Archaeology under the provisions set out in the "Historic Wrecks Ordinance" in *The Laws of the Turks and Caicos Islands*, No. 15 of 1974 (1977) 63–67.

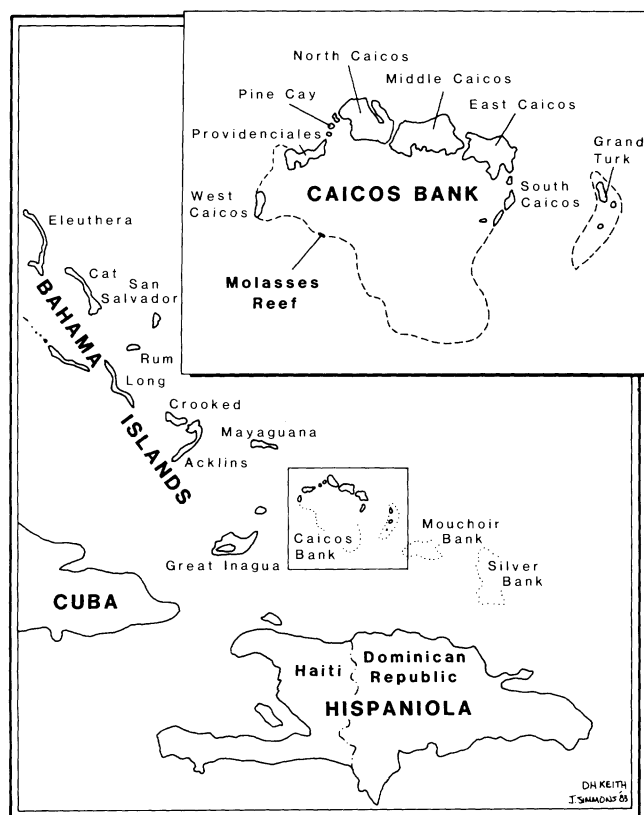


Figure 1. Location of Molasses Reef on Caicos Bank.

site. These are now undergoing cleaning, analysis, and conservation in the Conservation Research Laboratories of the Department of Anthropology, Texas A&M University, before being returned to the Turks and Caicos for display in the planned Museum of Maritime History. Although it will be several years before all the artifacts have been cleaned and analyzed, interpretation of the site based on general artifact distributions and environmental observations recorded in the field is the subject of this article.

Site Location

The geologic structure of the Caicos Bank resembles a giant submerged mesa, 100 km across from east to west, with its flat top rising to form low islands in the north, but remaining 6–8 m below sea level over most of its area. Molasses Reef lies ca. 500 m from the precipitous “drop-off” of the sw rim of the Caicos Bank. A shallow shelf extends from the breakers on the reef to the lip of the Bank where the sea floor plunges vertically to abyssal depths (FIG. 2).

Prevailing winds are from the ESE, and the current has a general set from SE to NW. The location of Molasses

Reef on the very edge of the Bank, and the proximity of the Bank to the Old Bahama Channel (between Cuba and the Bahamas) and the Caicos Pass (between West Caicos and Mayaguana), combine to create a treacherous ship trap. Before beginning work on the reef we conducted a visual survey which provided grim testimony to the effectiveness of the trap. No less than seven other shipwreck sites were discovered, although none was as early as the one we designated the “Molasses Reef Wreck.”³

On a clear day several islands are visible from sea level at Molasses Reef. The nearest of these is French Cay, a small waterless island located ca. 12 km upwind and upcurrent. Directly downwind from the reef and visible from it is the island of West Caicos, today uninhabited. Also visible is the island of Providenciales ca. 23 km to the north.

Site Description

During our initial survey we were surprised at the site’s integrity: it appeared to be unusually intact for a shipwreck in the shallow, high-energy environment of a tropical reef (FIGS 3a, 3b). The most salient features were a mound of ballast stones ca. 12 m in length, 3 m in breadth, and 0.6 m in height, obviously marking the final resting place of the hull, and a scatter of ordnance extending ca. 8 m to the east of the mound (FIG. 4).

Wrought-iron, breech-loading ordnance of a type generally considered obsolete by the middle of the 16th century provided us with our only initial clue to the antiquity of the wreck.⁴ Two large, wrought-iron *bombardetas* and an anchor lay atop the ballast mound, and 15 swivel guns were spread over the seafloor in an

3. H. E. Sadler’s *Turks Islands Landfall*, Vol. 1 (undated) 43, identifies four recorded 19th-century losses: 1856—*Marie Emilie*, 1887—*Anne*, 1882—*Alfred Michel*, and 1882—*Jeanne*.

4. A precise date cannot be derived from the ordnance, but the earliest handbook on metallurgy, Vannoccio Biringuccio’s *Pirotecnia*, C. S. Smith and M. T. Gnudi trans. of the 1540 Venice edition (M.I.T. Press: Cambridge 1966) 222–227, describes only the method of casting guns in bronze, giving the impression that wrought-iron cannon were obsolete by 1540. Charles Ffoulkes, *The Gun-Founders of England* (George Shumway: York 1937) 111, records that the first cast-iron cannon were made in England in 1543. Patterning and type of objects observed initially on the Molasses Reef Wreck corresponded closely with those of the 16th-Century Highborn Cay Wreck reported in M. Peterson, “Exploration of a 16th-century Bahaman Shipwreck,” *National Geographic Society Research Reports, 1967 Projects* (1974) 231–242. The *bombardetas*, *versos*, and their shot were similar to those recovered from the wrecks of Spanish ships lost on Padre Island in 1554 as reported in J. Barto Arnold III, and Robert S. Weddle, *The Nautical Archaeology of Padre Island* (Academic Press: New York 1978) figs. 28, 29, 31, 32 and 35; and Doris Olds, *Texas Legacy from the Gulf* (Texas Antiquities Committee: Austin 1976) figs. 29, 30, 31, 34, 38, 39, 41 and 42.

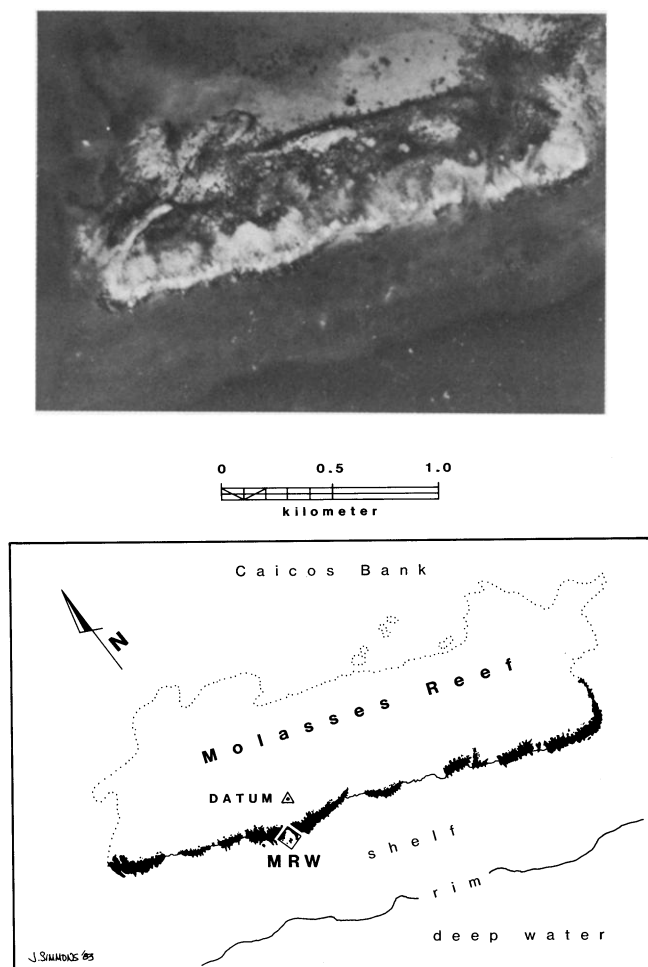


Figure 2. Aerial photo of Molasses Reef (above), and sketch of the site location (below).

intriguing pattern. Mixed in with the swivel guns were shot and breech chambers (interchangeable powder charges) for both types of ordnance. The ballast and ordnance thus formed a continuous, primary deposit marking the final resting place of the ship. Other artifacts were found in a discontinuous distribution to the east, north, and west. Intrusive shipwreck material (e.g., stud-link chain, anchors, and fasteners) from more modern contexts was discovered just outside the excavation boundaries (FIG. 3b).

The ballast mound lay on bare hardpan, or reef bedrock, at its southern end, but its northern extremity was partially overlying a local patch reef. The ballast mound and patch reef lay in a shallow embayment embraced by submerged arms of the forereef on the west and east (FIG. 3b); hence, the site is partially protected from winds and seas on three sides. Most of the site lies in less than 6 m of very clear water (FIG. 3a). The pockets and embayments within the forereef are local depressions in the

reef hardpan. The floors of these pockets are usually covered by a thin layer of coralline sand except in areas adjacent to the arms of the living forereef, where a talus of dead, bleached, and broken coral fragments mixed with sand tends to accumulate (FIG. 5). The sand in these pockets appears to be transient, and the upper sediment and rubble layer in the talus would seem to be analogous to the plowzone of a terrestrial site. The degree of permanence of the talus formation is unknown.

Artifact Distribution

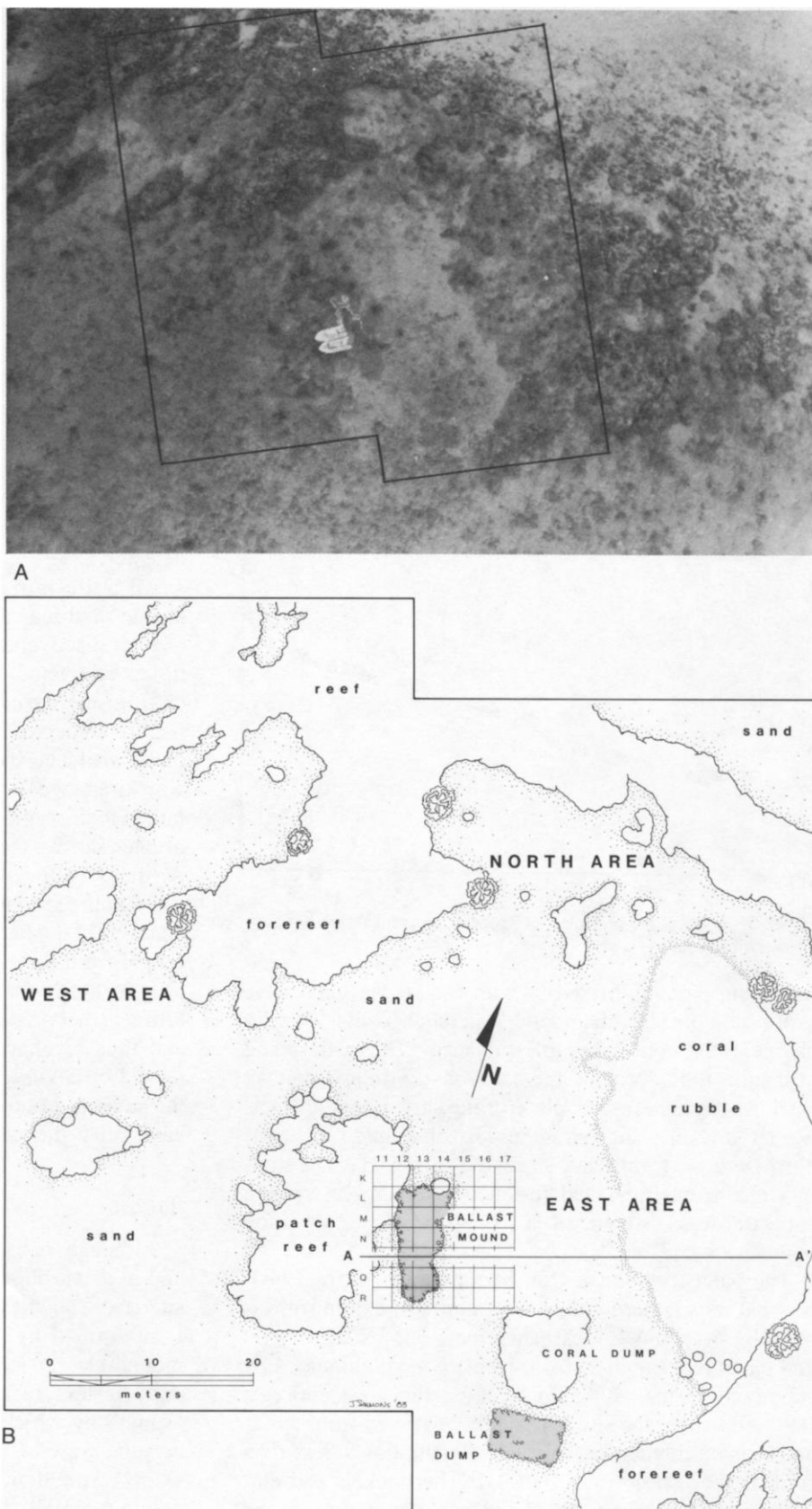
After stripping away the bottom sediments around the mound we determined that the site was not as compact as it had first appeared. Metal detectors helped in this part of the work, but there was no substitute for complete excavation to hardpan, since many of the smaller artifacts no longer contained sufficient metal to trigger a detector.

All artifacts recovered from the site may be classed in one of three categories with respect to the reliability of their discovered provenience. Generally speaking, artifacts recovered from the vicinity of the ballast mound or from the naked or lightly sanded hardpan were thoroughly cemented to the seabed (FIG. 5). Proveniences of these artifacts seem to be reliable indications of the wrecking event and breakup immediately thereafter rather than results of movement on the seabed because of later storms and other natural environmental agencies. Artifacts of the second category, particularly those located in the sand and coral rubble areas, were not usually attached to the hardpan and hence could have been transported from their original proveniences by natural agencies (FIG. 5). The third category is composed of those artifacts that originally had been cemented to the bottom, and thus belonged to the first category, but were suspected of having been pried loose and moved by one of the several groups of treasure hunters who are known to have rifled the site before our arrival.

Ballast

Although ballast stones were excavated individually and in small clusters in the East and North Areas of the site (FIG. 3b), the vast majority were in the primary deposit formed by the ballast mound and ordnance. The mound clearly marks the final resting place of the ship, and clusters of stones elsewhere on the site furnish "spoor" by which the ship's movements within the reef may be traced. The mound had been ransacked amidships by modern salvors in their pointless search for precious metals, but the northern and southern ends were

Figure 3. (A) Aerial photo of the site (photo by Gary and Barni Adkison). (B) General area of investigation outlined in (A).



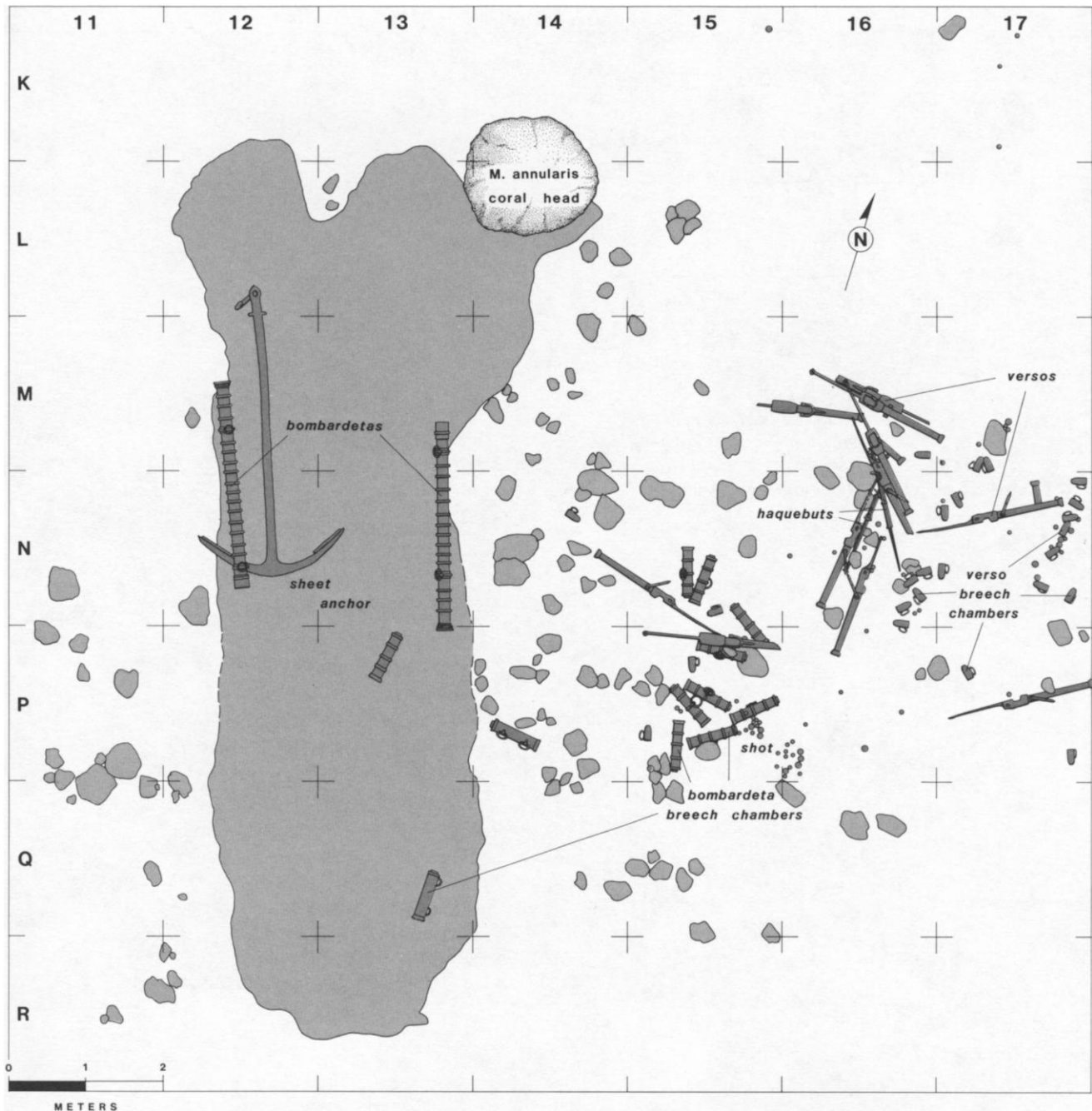


Figure 4. Ordnance distribution plan. Two *bombardetas* lie atop the ballast mound. With three exceptions breech chambers for the *bombardetas* are clustered in squares N-15 and P-15. Most of the *versos*, their breech chambers and many shot, are clustered in squares M-16, N-15,-16,-17, and P-15,-17. Both *haquebuts* lie in square N-16.

intact.⁵ Considerable attention was devoted to the careful disassembly and recording of the ballast.

5. The ballast mound experienced at least two episodes of disturbance at the hands of modern salvors. In the late 1970s a group of treasure hunters dug a trench across the mound immediately south of the

anchor and *bombardetas*. A brief account of this activity and photographs of some of the artifacts recovered appears in C. Crowther, "Have They Found the *Pinta*?" *Turks and Caicos Current* 1.2 (1981) 26-35. In March 1982, only weeks before an INA excavation team arrived to begin work on the site, unidentified vandals detonated several home-made explosive devices on the site and reopened the athwartships trench.

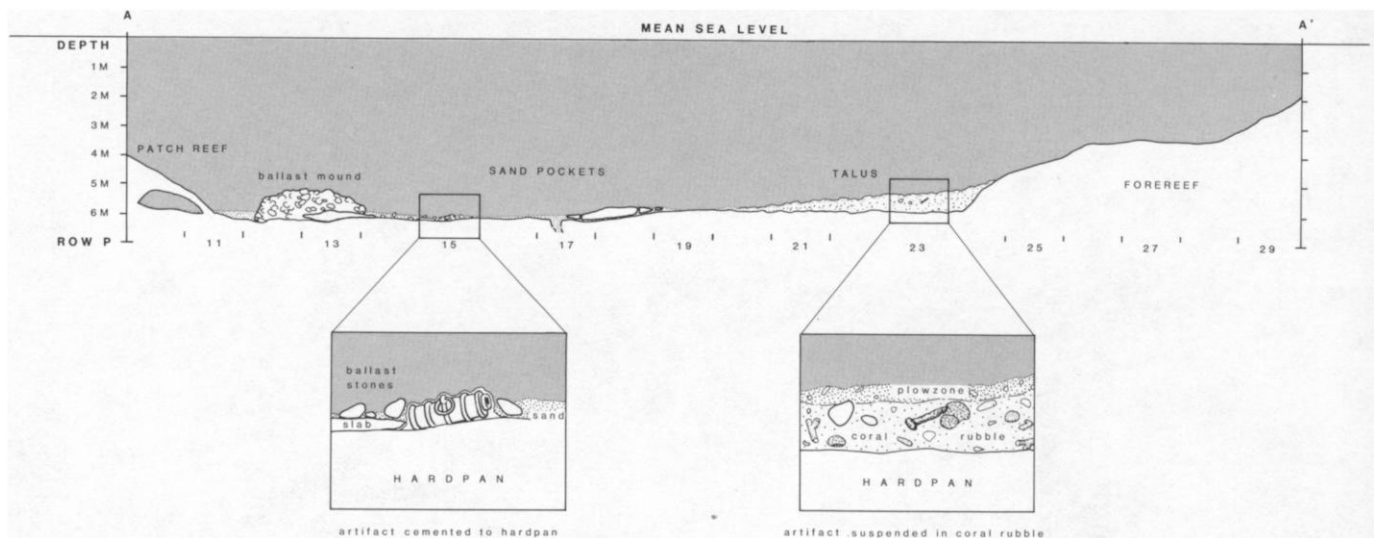


Figure 5. Generalized section A-A' (see FIG. 3b) across site.

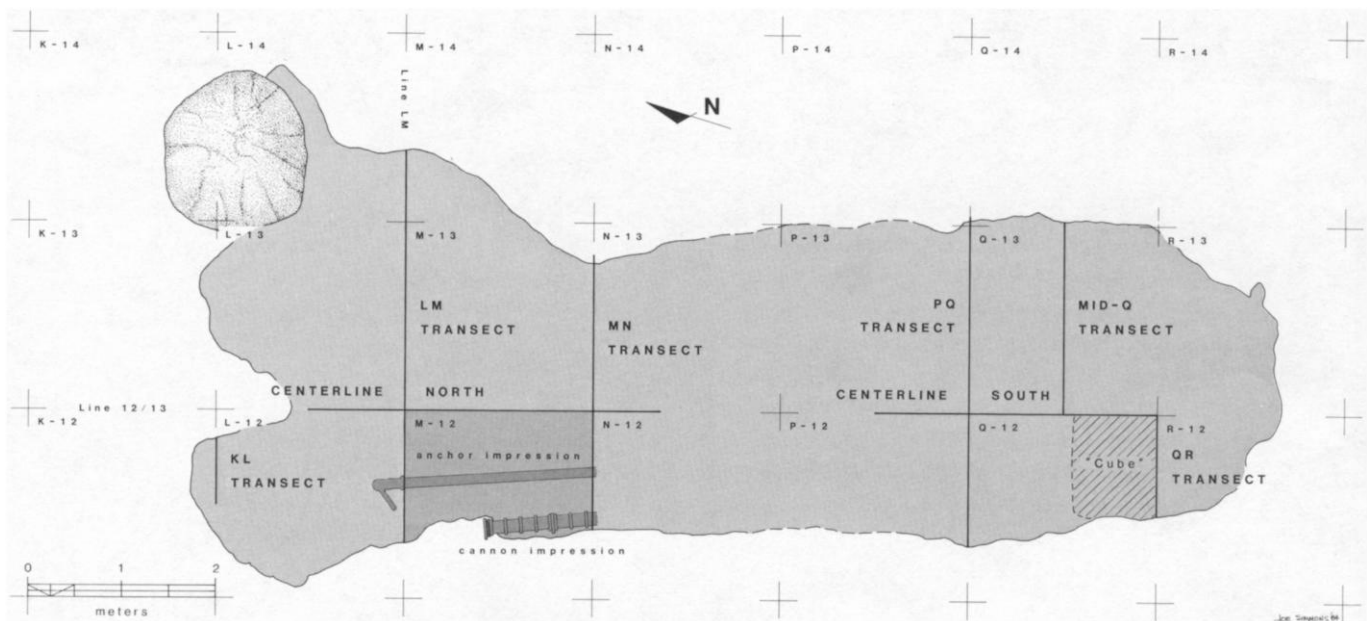


Figure 6. Locations of profiles in ballast mound. Middle of mound was trenched by modern salvors and could not be reconstructed. "Cube" is one cubic meter of undisturbed, consolidated ballast to be recovered at a later date and disassembled under controlled laboratory conditions.

A ship's ballast has the potential for providing information not available through other types of investigations. Obviously, the total weight of ballast is an important clue to the size of the vessel. The configuration of the ballast mound in relation to the preserved portions of the ship's hull should provide important clues for

determining how the vessel was rigged and trimmed at the time of loss. Additionally, the ballast contains evidence of the history of the ship and, to some extent, where that ship has been.⁶

6. Stone ballast is the most thoroughly ignored object category in

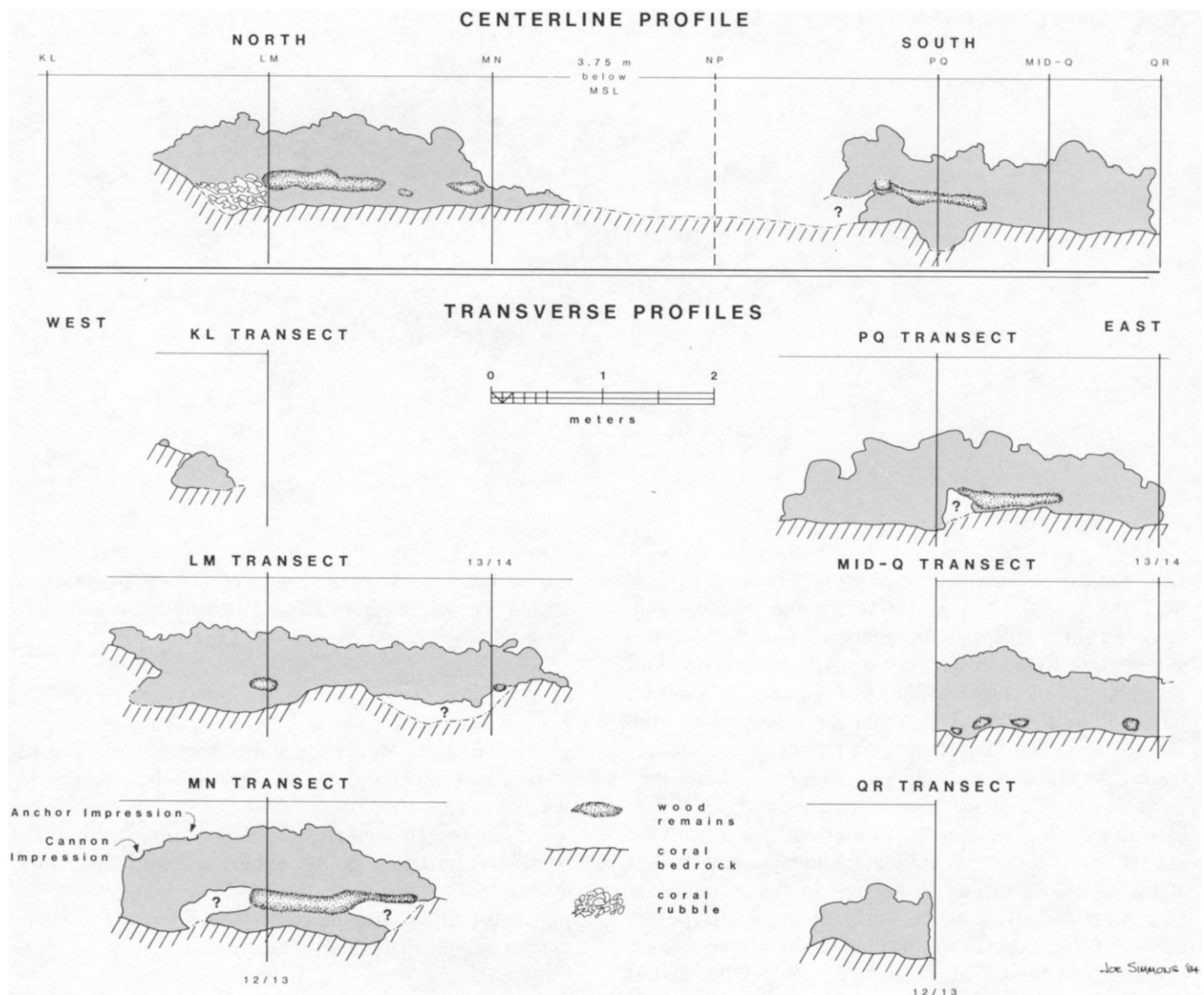


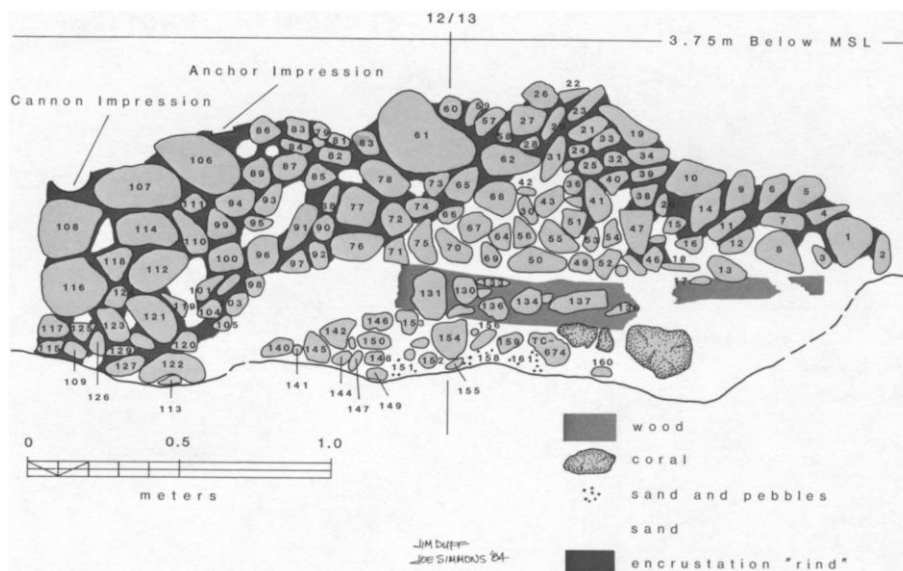
Figure 7. Profiles of ballast mound indicated in Figure 6.

shipwreck archaeology, and for good reason. Beyond the fact that only certain stones are traceable to their original deposits, and that no comparative collections representative of specific regions have been compiled, the potential difficulties involved in deriving geographical origin from a ship's ballast warrant the following *caveats*. (1) Determining origins of the stones depends upon the investigator's ability to discern geographical signatures from the suites of rocks forming the sample. (2) If the stones represent loading episodes in different regions, the investigator must be able to discern different geographical signatures from the combination of suites. (3) If the suite of stones occurring in the ballast represents a heterogeneous mixture resulting from random human collection, mixture, and redistribution, rather than collection from one or more naturally-occurring deposits specific to a particular region, then no clear geographical signature will emerge. For the only published descriptions of rock types en-

In order to record the detectable parameters of ballast stone variation—size, shape, petrological type and provenience—we disassembled the ballast mound one

countered in shipwreck ballast see G. H. Mascle, "Identifications d'échantillons de lest," in Honor Frost and Autori Vari, *Lilybaeum* (Rome 1981) 103–116, and J. A. Gifford, "Description of the Ballast Stones," in George Bass and Frederick van Doorninck, Jr., *Yassi Ada*, Vol. I (Texas A&M University Press: College Station 1982) 321. Some mention of ballast and the problems associated with its analysis appears in Olds, op. cit. (in note 4) 60–62, and M. Audy, et al., "Summary of Field Research Conducted in 1980 at Reş Bay, Labrador, on the Underwater Remains of the *San Juan* and of the Basque Whaling Station," *Research Bulletin* No. 163 (Parks Canada: Ottawa 1981) 6–7.

Figure 8. Profile of MN transect through the ballast mound.



square at a time leaving vertical profiles beneath the grid lines (FIGS. 6, 7). The stones within the profiles were recorded and collected for analysis. Curiously, small stones were found in quantity *beneath* the wooden hull remains (FIG. 8). Stones within each square were removed by hand, with excavators maintaining a continuous vigil for artifacts, unusual stones, and underlying hull remains. As stones were removed from each square they were spread in a single layer over a cleared, level 2 m by 4 m examination area, and arranged by size with the largest stones at one end graduating down to the smallest at the other. Spreading stones out in the examination area permitted us to inspect them individually before they were carried off to the ballast dump and to make a photographic record of all stones found in the ballast mound (FIG. 9).

The final resting place for stones removed from the squares was the ballast dump, an area near the original mound, where the stones were arranged to form a rectangular pile of even height which could be accurately measured to determine the volume of stone ballast carried in the ship (FIG. 3b). When the ballast mound had been excavated the ballast dump measured 3 m by 8 m, and stood slightly less than a meter off the bottom for a total volume of ca. 24 cub m. A "cube" of mound ballast was left undisturbed (FIG. 6) and will be recovered intact at a later date and disassembled under controlled conditions in the laboratory.

If larger stones from lower levels represent permanent ballast, they may help indicate where the ship was built (FIG. 8). If strata or lenses of stones reflecting individual ballast loading events can be detected within the mound, these may provide clues as to which ports the ship visited

during her final voyage. Small coral heads discovered within the ballast may indicate that ballast was loaded at some New World location.

Ordnance

The Molasses Reef vessel was well armed. The list of ordnance identified to date includes: two *bombardetas*, 13 *bombardeta* breech chambers, 15 *versos*, about 40 *verso* breech chambers, 2 *haquebuts*, hundreds of solid shot for these pieces, explosive shot or grenades, at least one shoulder arm, and two crossbows.⁷ A matched pair of wrought-iron, breech-loading *bombardetas* comprised the ship's heavy battery (FIG. 4).⁸ The

7. With one exception, the only examples of 16th-century wrought-iron, breech-loading artillery discovered in the New World have come from shipwrecks. This type of artillery seldom carries inscriptions or other identifying marks that would provide date of manufacture or place of origin. Its method of construction, technique of operation, and performance (range and accuracy) remain largely obscure. The construction of the *bombardetas* recovered from Padre Island is misconstrued in Olds, op. cit. (in note 4) figs. 32 and 35. The reinforcing rings do not overlap the juncture of the bands; rather, both rings and bands butt against each other with their inner diameters touching the staves of the barrel. For an authoritative description of how wrought iron guns were made, see Ffoulkes, op. cit. (in note 4) 8–12.

8. For the purposes of this paper, the term *bombardeta* is defined as a laminated wrought-iron breech-loading cannon with a bore diameter ranging from 0.07 m to 0.11 m, and a caliber (bore length divided by bore diameter) ranging from 15 to 30. This definition is consistent with identifications for pieces recorded in the catalog of the *Museo Ejército* in Madrid; and with descriptions appearing in Jorge Vigón, *Historia de la Artillería Española* (Instituto Jerónimo Zurita: Madrid 1947) 35–36. The best examples illustrating how these guns were mounted in carriages for use aboard ship come from the

breech of the west *bombardeta* lay across one arm of the anchor. The east *bombardeta* was partially covered with ballast stones. Nine of the 12 *bombardeta* breech chambers discovered lay in a cluster 3 m from the east edge of the ballast mound, along with a large deposit of shot.⁹ Two types of swivel guns and their breech chambers lay 2 m further east.¹⁰ The provenience of the two swivels farthest from the ballast mound is suspect, because neither of these was cemented to the hardpan. Beyond these were found two crossbows and a short fragment of an octagonal-barreled shoulder arm, most likely an *arquebuz*.

Wood

Complete excavation of the ballast mound exposed wooden remains of the hull (FIG. 10). The preserved portion of the hull was a 7.5 m by 2.5 m section of the bottom of one side of the ship. No trace of keel, keelson, or endposts was found, and bow and stern could not be differentiated from the surviving hull remains alone.¹¹

Twenty-two frames (ribs) or frame positions could be discerned. Six runs of strakes (outer hull planking) lay beneath the frames, and a few fragments of ceiling (inner hull planking) were preserved on top of frame D. Thin planks called fillers were discovered fitted at an angle between several frames in the vicinity of frame D.¹² The

wreck of the *Mary Rose*. See Margret Rule, *The Mary Rose* (Conway Maritime Press: London 1982) 43, 155, 157, 171. It is not known what these bombard class guns were called in antiquity.

9. *Bombardetas* were usually equipped with several breech chambers as a means of increasing the rate of fire. The breech chamber contained the powder charge and was stopped with a wooden plug. For a description of how this type of ordnance was used, see Vigón, op. cit. (in note 8) 64–65.

10. Swivel gun is a general term for a light, relatively portable gun mounted on a Y-shaped pivot. *Verso* here refers to a variety of wrought-iron breech-loading swivel gun with a bore diameter of ca. 4 cm. Two smaller, lighter wrought-iron muzzle-loading guns with bores of ca. 2 cm are classed separately as *haquebuts*. For drawings and descriptions of these guns see D. H. Keith, et al., "The Molasses Reef Wreck, Turks and Caicos Islands, B.W.I.: A Preliminary Report," *IJNA* 13 (1984) 54–55.

11. Considerable care was taken to record and recover the hull remains because so little is known about the theory and technique of Iberian hull construction during the Age of Exploration and Discovery. The earliest treatises on the subject appear late in the sixteenth century; e.g., Diego García de Palacio, *Instrucción Náutica para Navegar* (Pedro Ocharte: Mexico City 1587) 88–97. The few other shipwreck finds from the 16th century that have been investigated and reported shed little light on the question of how the earliest transoceanic voyaging Iberian ships were built, rigged, and equipped: the *San Juan* (built and lost 1565) was a whaler; the *San Esteban* (41 KN 10) and *Espiritu Santo* (41 WY 3) (both lost 1554) were cargo ships.

12. Analysis of the hull is being conducted by Thomas J. Oertling. Similar fillers were discovered on the Basque whaling vessel *San*



Figure 9. Ballast stones from square M-12 arranged in examination area.

hull remains were interrupted between frames G and P by an area of extremely fragmentary wood, apparently the result of poor natural preservation and the activities of modern salvors. Wood samples taken from frames, planking, and a treenail all were identified as white oak (*Quercus* spp.).¹³

Curious grooves gouged into the hardpan were discovered under the southern end of the mound during excavation of the wood and ballast (FIG. 10). As the direction of the grooves is parallel to and approximates the spacing of the frames, the grooves appear to indicate at least six additional frame positions between the end of the hull remains and the southern terminus of the

Juan, now under excavation in Red Bay, Labrador, by Parks Canada archaeologists. It is believed that these fillers were installed to prevent trash from entering the bilge and clogging the watercourses.

13. Wood identification performed by Forest Products Laboratory, Lufkin, Texas.

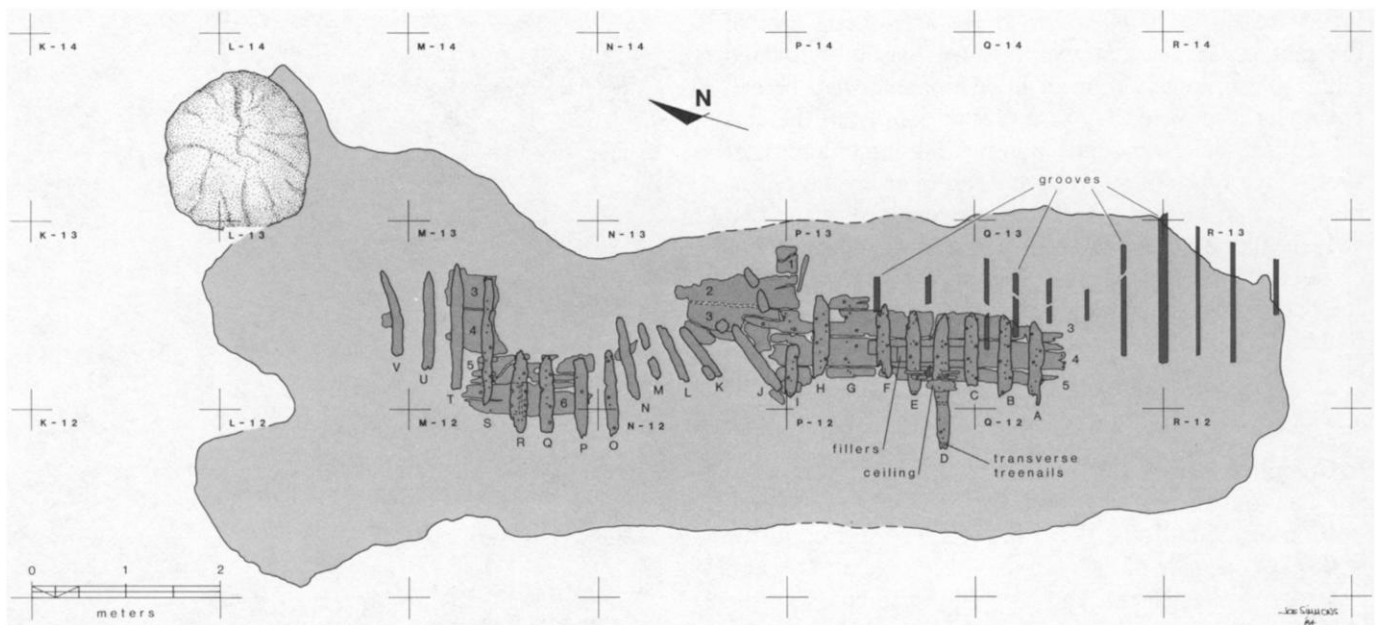


Figure 10. Plan of grooves and hull remains preserved beneath the ballast. Grooves are represented by parallel dark lines in squares P, Q, R-13.

ballast, thus raising the total number of frames or frame spaces to 28.

Interpretation

Muckelroy provides us with a flow chart in which the process of wrecking constitutes a closed system with the ship as input, and with a number of different outputs. As the shipwreck evolves, information is lost through extracting filters and that which remains is to some degree scrambled.¹⁴ Reversing the order of events in this flow chart provides a model for an inductive reconstruction of the Molasses Reef Wreck (FIG. 11).

Observed Seabed Distribution

The grooves worn into the hardpan beneath the ballast testify to the fact that the ship heeled over on her side, grinding her hull back and forth across the bottom in the swell. The grooves appear to have been made by the heads of nails used to secure the strakes to the frames. Her seams opened and smaller ballast stones fell through and lodged beneath the hull. Fillers between the frames clearly indicate that the preserved hull section is the bottom of one side of the ship at the juncture of the floor timbers with the first futtocks. Transverse trunnels in the

western ends of frames A, D, E, and I suggest that these frames were located in the middle of the ship and that the keel lay less than a meter to the west of the surviving remains (FIG. 12).¹⁵

The ship's ordnance appears to have been sorted by weight. The anchor and two *bombardetas* on top of the ballast mound probably reflect their positions in the belly of the ship before the wreck occurred. The *bombardetas* were lying directly atop and on either side of the ballast mound, indicating that they had been carried either as cargo or as functional artillery in storage, but not ready for use. The two *bombardetas* faced in opposite directions, ruling out the possibility that they had been mounted longitudinally on the main deck.¹⁶ The western *bombardeta* was plainly visible and largely free of the ballast mound, but the eastern *bombardeta* was partially incorporated into the mound—another clear indication that the ship heeled over with her keel to the west and her deck to the east.

15. Only the middle 14 frames of the *San Juan* were connected floor-to-futtock by transverse trunnels.

16. Salvagers of the Highborn Cay Wreck, finding two *bombardetas* on top of the ballast mound, theorized that these were bow chasers, despite the fact that they faced opposite directions. See M. Peterson's description, "Traders and Privateers across the Atlantic: 1492–1733," in George F. Bass, ed., *A History of Seafaring* (Walker and Company: New York 1972) 256; and the only published site plan of the Highborn Cay Wreck in Peterson, op. cit. (in note 4) fig. 1, 232.

14. Keith Muckelroy, *Maritime Archaeology* (Cambridge University Press: Cambridge 1978) fig. 5.1, 158.

Two *bombardeta* breech chambers were partly buried in the ballast mound and the others lay in a cluster only a few meters to the east. The swivel guns, 10 of which appear to have been lashed together in pairs, and their breech chambers all lie east of the ballast mound. Numerous wrought-iron rigging components in the East Area and North Area indicate that the ship came to rest with her masts and rigging lying to the NE.

The discovery of a sounding lead at the southern end of the ballast mound in square R-19 and a rudder gudgeon in L-12 at the northern end of the mound offers the only evidence for differentiating between bow and stern. If the gudgeon were still attached to the stern and the sounding lead in service in the bows at the time of wrecking, then the ship sank with her stern to the reef and her bow pointing out to sea.

The presence of shot and other dense, heavy artifacts found more than 50 m from the mound would seem to indicate the movements of the ship within the site area, rather than the rafting of material away from the ship's final resting place on parts of its superstructure. This distribution of shipwreck material within the site plan forms a plainly discernible elliptical pattern with its axis oriented SE to NW. The ballast mound lies on the SW margin of the site.

Scrambling Devices

Characteristics of the Excavation

The hull, ballast, and larger artifacts have been mapped and removed, but another field season will be required to finish the excavation. Special characteristics of the excavation included painstaking attention to accurate mapping of the distributions of artifacts and ballast stones; complete recovery of all artifacts suspected

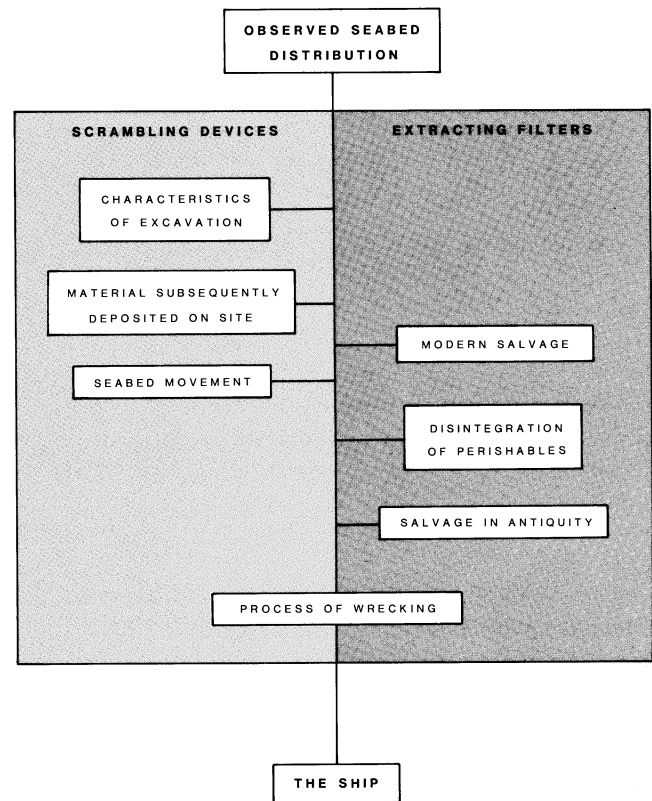


Figure 11. Evolution of a shipwreck investigation (after Muckelroy; see note 14).

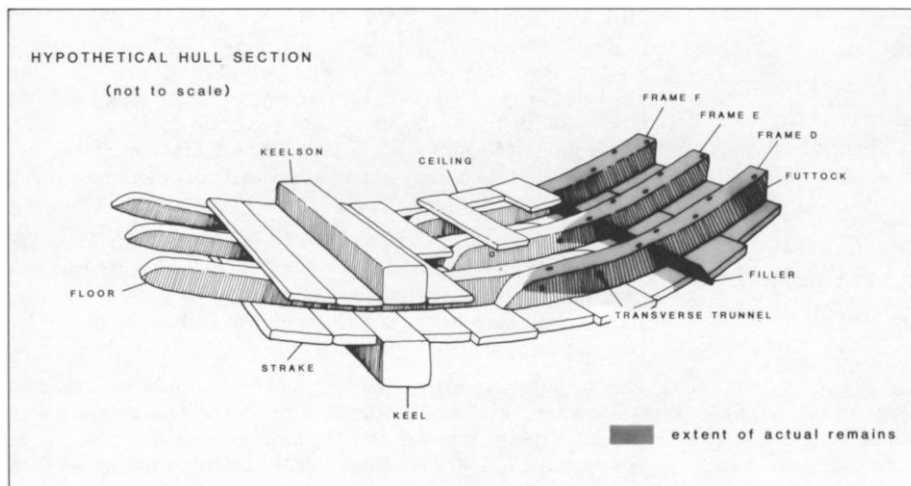


Figure 12. Hypothetical reconstruction of hull section. Actual shape and dimensions of keel, keelson, floors, and garboard are not known. Preserved portions of hull are shaded. Frame spacing slightly exaggerated for clarity.

of belonging to the site; quantification and qualification of the petrological type; size, shape, and provenience of ballast stones within the mound; and mapping and complete recovery of all hull remains.

Material Subsequently Deposited on the Site

The Molasses Reef Wreck may have been the first ship to come to grief on Molasses Reef, but it soon had plenty of company. Scattered ground tackle and fasteners mark the scene of a 19th-century wreck 50 m east of the ballast mound, and virtually the entire length of the forereef is littered with shipwreck material. Several artifacts recovered within the site boundaries are suspected of being intrusive, e.g., a pewter conduit for a type of bidet syringe for which 16th-century parallels are not known.¹⁷

Evidence of modern salvage activity on the site included three modern U.S. coins, a Schwepp's tonic water bottle cap, a large Sears chisel, a pry-bar, and many fragments of two or more home-made bombs.

Seabed Movement

The extent to which seabed movement of artifacts and ballast by natural agencies has scrambled information remains to be determined. Certainly, artifacts and features found cemented to the bottom have not been much affected by seabed movement. There is evidence that at least some of the ballast and artifacts found loose in the sand may have accumulated in shallow depressions in the hardpan as a result of seabed movement. The fact that most of the ceramic sherds found came from interstices within the ballast mound may be an indication that this type of artifact is more susceptible to seabed movement than, for instance, the ordnance.

Extracting Filters

Interpretation of the Molasses Reef Wreck assumes that a great deal of material was lost during the wrecking event and over the intervening centuries through salvage and disintegration of perishables.

A ship of the period sufficiently large to carry 19 pieces of artillery and to cross the Atlantic Ocean would likely have carried eight anchors: one sheet anchor, a kedge or stern anchor, four bower anchors, and at least

one anchor for each of the ship's boats.¹⁸ The absence of any ground tackle other than the sheet anchor and one small boat anchor suggests that other anchors were separated from the vessel during the wrecking event. The ship may have lost her bower anchors before arriving on the reef, but if this had been the case the crew surely would have retrieved the sheet anchor from storage below decks and rigged it for use. Unless the ship's missing anchors have been picked up by modern collectors, they must yet lie on the reef or on the shelf.

Modern Salvage

The site experienced limited modern exploration and salvage beginning at least as early as 1972 when a grapnel anchor, half of a shot mold, and other artifacts were removed.¹⁹ Another episode of limited salvage occurred in 1976. Shot, at least one *bombardeta* breech chamber, two *versos*, and at least one *verso* breech chamber and wedge, ballast stones, and a lead pump valve are known to have been removed.²⁰

Vandals attempted to destroy the wreck site in March 1982 with home-made explosives and a propwash deflector—hallmarks of the commercial treasure hunter. Information recorded during the initial INA survey of the Molasses Reef Wreck two years earlier enabled us to reassemble the site, but it is not known if artifacts were discovered and removed during this raid.

Disintegration of Perishables

After the wrecking event, the ship began to break up. Lighter parts drifted off, organic materials disintegrated, and iron fasteners outlived the wooden structures they held together and were deposited on the sea floor as the shattered ship deteriorated.

The environment on Molasses Reef is not conducive to the preservation of organic materials. A part of the hull survived only because it was buried beneath the ballast. Most of the hull, cordage used in rigging,

18. Palacio, op. cit. (in note 11) 110, gives a short description of the types, numbers, and weights of anchors carried by a *nao* in 1587. Although the Molasses Reef Wreck was probably a smaller vessel, built earlier in the century, the types and numbers of anchors would have been about the same.

19. This incident may have precipitated enactment of the Turks and Caicos Historic Wrecks ordinance (note 2). Half of a two-part shot mold has been located in a private collection in Bermuda. The grapnel anchor could have belonged to a small boat or have been used for grappling and boarding other vessels.

20. The pump valve, one lead shot, and ballast stones are illustrated in Crowther, op. cit. (in note 5) 29, 35. The *bombardeta* breech chamber has been loaned to INA for documentation and conservation. Efforts to locate and study the rest of the artifacts have not yet been rewarded.

17. The object is depicted in Keith, et al., op. cit. (in note 10) fig. 15, 58. Its identification is based on an illustration in P. Salmon, "L'Art du Potier d'Etain," Academie Royale des Sciences (Paris 1788) pl. XI.

wooden tools and instruments, and any cargo of perishables the vessel may have carried such as dyewood, hides, or barrels of provisions disappeared long ago, leaving few tangible traces. The hull held together long enough to permit the ballast mound to solidify, preserving nearly vertical faces where the mound was supported by the hull on its western and southern sides (FIG. 8).

Salvage in Antiquity

Accurate interpretation of the site requires a determination as to what extent the artifactual material, upon commencement of excavation, represented a pristine shipwreck. There is the possibility that significant classes of artifacts were removed by survivors of the wreck or by contemporary salvors. It is possible, given that there is evidence that the ship was not dashed into and shattered by the reef, that some or all of the ship's crew survived the wrecking incident. If the crew had sufficient time to organize the abandonment of their vessel, then they may have removed personal possessions, tools, weapons, and navigational instruments necessary for survival. If the ship were travelling in the company of one or more other vessels, it is possible that the survivors of the Molasses Reef Wreck were picked up soon after the disaster and that the ship was partially relieved of such artifacts and materials as were deemed sufficiently valuable and still accessible. If the ship were not travelling in the company of other vessels or if she had lost her escort, the crew would have been on their own in treacherous, uncharted waters, and their chances of survival would have been considerably reduced.²¹

Process of Wrecking

Although the excavation is not yet completed, the absence of personal effects and navigational instruments suggests that the crew had sufficient time to organize abandonment of their ship. The presence of a *verso* ca. 40 m to the east of the ballast mound and an enormous deposit of shot and other heavy iron artifacts more than 50 m to the west of the mound suggests that the ship spilled cargo, arms, and ballast as she pinballed between the arms of the reef. Perhaps her ballast shifted, creating a severe list which denied her crew any possibility of saving their ship. Holed and taking on water, she worked

free of the reef shallows and drifted into water of sufficient depth to sink. Still partially intact, she came to rest on her side. In the shallow water her deck would have been awash. Over a relatively short period of time the action of the seas nudged her hull westward, leaving a trail of ordnance behind, until it was lodged against the patch reef (FIG. 3b). The hull remained active on the bottom for a length of time sufficient to allow the heads of the nails holding the strakes to the frames to gouge grooves in the hardpan.

The Ship

Some time in the first half of the 16th century, a seagoing Spanish vessel of medium size (ca. 23 m in length on deck) went aground on Molasses Reef. She was heavily armed with a wide variety of weaponry: grenades, crossbows, shoulder arms, at least two types of swivel guns, and *bombardetas*. The ordnance was well made and carefully matched, but secured, rather than at the ready. The ship carried no treasure or trade goods.²² With 34 metric tons of stones in her hull, she was heavily in ballast.²³

The ship approached the Caicos Bank from a southerly direction. Her crew failed to recognize that the bottom was rapidly shoaling beneath them until it was too late to take evasive action. They let go the bower anchors in a desperate attempt to hold their vessel off, but they failed and she drifted stern first into the fangs of Molasses Reef. At the mercy of wind and sea the little ship pinballed off coral heads until she was captured in the enfolding arms of a shallow natural embayment in the forereef. Mortally wounded, she sank and rolled over on her side. Even after sinking, part of her hull and superstructure protruded above the waves. It is likely that some of the crew survived the wreck and escaped to the islands of the Caicos Bank taking their valuables, navigational instruments, and edged weapons with them.²⁴

22. It should be noted, however, that a single green glass seed bead has been recovered from the site.

23. Weight of the ballast was computed by multiplying the volume of stone recorded by an average density factor of 1,306.5 kg/m. The density factor was derived by weighing a known volume of ballast under laboratory conditions. Hence, 26 cub m $\times$ 1,306.5 kg/cub m = 33,969 kg (ca. 34 metric tons). The weight of stone ballast is not to be confused with contemporary volumetric conventions such as toneladas or tones.

24. It may be important to note that a bronze artifact was excavated from within a Lucayan structure on Middle Caicos. The bronze had been refashioned into a crescent-shaped nose decoration reminiscent of a type worn by the Caribs; see S. Sullivan, "Prehistoric Patterns of Exploitation and Colonization in the Turks and Caicos Islands," unpublished Ph.D. dissertation, University of Illinois (Urbana 1981) 144–147.

21. Even when ships were driven ashore by hurricanes there were survivors. Survivors' accounts of other Caribbean shipwrecks may provide some insight into what the crew of the Molasses Reef ship experienced. See Arnold and Weddle, op. cit. (in note 4) 35–48. An account more analogous to the Molasses Reef Wreck may be found in Peter Earle, *The Treasure of the Concepción* (The Viking Press: New York 1980) 61–76.

The objective of the Molasses Reef Wreck Project is to identify the ship through an inductive analysis of the recovered artifacts, ballast samples, and hull remains.²⁵ Although it will be difficult to establish a precise date for the vessel unless a dated artifact is discovered among the hundreds of concretions yet to be cleaned, geographical affinities should be indicated by thorough analyses of the wood used in the construction of the hull, trace elements present in the various metal artifacts, and petrological types of the ballast stones. Once this information is assembled, Old World archives will be searched in an attempt to relate the Molasses Reef Wreck to a recorded ship loss by matching the inventory of artifacts recovered with a manifest or other document.²⁶

Our ability to identify the Molasses Reef Wreck has been severely limited by a decade of disturbances and loss of information caused by modern salvors and curiosity seekers. The effects of extracting filters and scrambling devices resulting from natural agencies are predictable to some extent, but the clandestine activities of salvors are virtually random and often greatly accelerate natural deterioration. Should the absence of valuables and navigational instruments on the Molasses Reef Wreck be attributed to survivors or to modern salvors? What would we have learned from the parts of the ship's hull destroyed by blasting? Until very recently, these activities were limited to the mining of known treasure wrecks; as accessible treasure wrecks are fast disappearing from the Caribbean, however, modern salvors are exploring ways to make treasureless shipwrecks pay off as well.²⁷ As we approach the 500th anniversary of Columbus' discovery of the New World it is certain that other treasureless, but historically priceless sites will be heavily exploited.

These findings contradict Muckelroy's statement, ". . . human interference, undoubtedly the most impor-

tant destructive agent in a terrestrial context, is minimal under water, and limited to a few identifiable activities."²⁸

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28. Muckelroy, op. cit. (in note 14) 158.

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25. An elaboration upon the difficulty of this task and a rationale for its historical particularist approach may be found in G. F. Bass, "Historical Particularism in Nautical Archaeology," in Richard A. Gould, ed., *Shipwreck Anthropology* (University of New Mexico Press: Albuquerque 1983) 97-98.

26. E.g., Fernandez de Navarrete, *Colección de Documentos Inéditos* . . . 2nd series, vol. IX, p. 143, indicates that every India ship of 100 tons was required to carry 4 *pasavolantes* (large guns) with 3 dozen shot, 24 *espingardas* (swivel guns) with 6 dozen shot, molds and lead for swivel gun shot, 200 weight of powder, 10 crossbows, 8 dozen arrows, 4 dozen short lances, 8 long pikes, and 20 shields.

27. E.g., S. White, "More Treasure from the Deep," *Yorkshire Evening Post*, 7 August 1984, p. 4, reports, "So we know that the Turks and Caicos Islands are littered with wrecks but Keith Jessop is not really interested in what we would normally call Spanish treasure, the pieces of eight and gold doubloons (sic), etc. He is more interested in finding Aztec artefacts. These would have been lost by the Spanish, who used Hispaniola as a base to plunder Mexico. . . ."