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The Deep-Sea Tortugas Shipwreck, Florida: A Spanish-Operated *Navio* of the 1622 Tierra Firme Fleet. Part 1, the Site

Greg Stemm, Ellen Gerth
Odyssey Marine Exploration, Tampa, Florida, USA

Jenette Flow
Pasco-Hernando Community College, New Port Richey, Florida, USA

Claudio Lozano Guerra-Librero
Stratigraphy Area, Faculty of Experimental Sciences, University of Huelva, Spain

Sean Kingsley
Wreck Watch Int., London, UK

In 1990 and 1991 Seahawk Deep Ocean Technology of Tampa, Florida, conducted the world's first archaeological excavation of a deep-sea shipwreck off the Tortugas Islands in the Florida Keys, USA, exclusively using robotic technology. Located at a depth of 405m, 16,903 artifacts from a small merchant vessel identifiable as a Spanish *navio* from the 1622 Tierra Firme fleet were recorded and recovered using a Remotely-Operated Vehicle.

Archival and archaeological research suggests that the most plausible identification of the Tortugas ship is the Portuguese-built and Spanish-operated 117-ton *Buen Jesús y Nuestra Señora del Rosario* owned by Juan de la Torre and captained by Manuel Diaz that sailed for Nueva Cordoba (Cumana) on the Pearl Coast in modern Venezuela before attempting to return to Spain in September 1622.

The shipwreck's significance lies in its relative coherent preservation compared to the scattered character of the *Atocha* and *Margarita* from the same 1622 fleet. This condition enabled the distribution of the original cargo and domestic wares to be examined in context. As a small *navio* the Tortugas vessel operated at the opposite commercial spectrum to these large royal 'treasure' ships and thus reflects the more common everyday world of early 17th-century long-distance Spanish commerce and seafaring.

1. Introduction

In 1989 Seahawk Deep Ocean Technology of Tampa, Florida, identified the site of a colonial-era shipwreck in deep waters off the Dry Tortugas islands in the westernmost Florida Keys (Fig. 1). The following year a pioneering archaeological project was initiated. Throughout 1990 and 1991 the site's cargo and domestic assemblage were extensively recorded and recovered exclusively using pioneering remote technology developed around a Remotely-Operated Vehicle (ROV).

The Tortugas shipwreck excavation was unique in many respects. No humans ever physically visited the site. Instead, the operation was completed entirely using a ROV governed by computers and remote technology aboard a recovery vessel at the ocean surface. Remote archaeological excavation was untried at the time and innovation was required for every phase of the operation. Methods for capturing and recording contextual data were complex and environmental conditions at the site, such as extreme pressure, currents and total darkness, complicated all procedures. Mariners, offshore technicians, pilots and ship's officers and crew, as well as experts in robotics, mechanical engineering, computer technology, marine biology and electronics were instrumental in the project's technical success.

Historically this was the world's first comprehensive deep-sea wreck excavation conducted using a ROV. Although a commercial venture with one objective aimed at identifying valuable cargo, the project was also planned scientifically in parallel to examine the site's archaeological

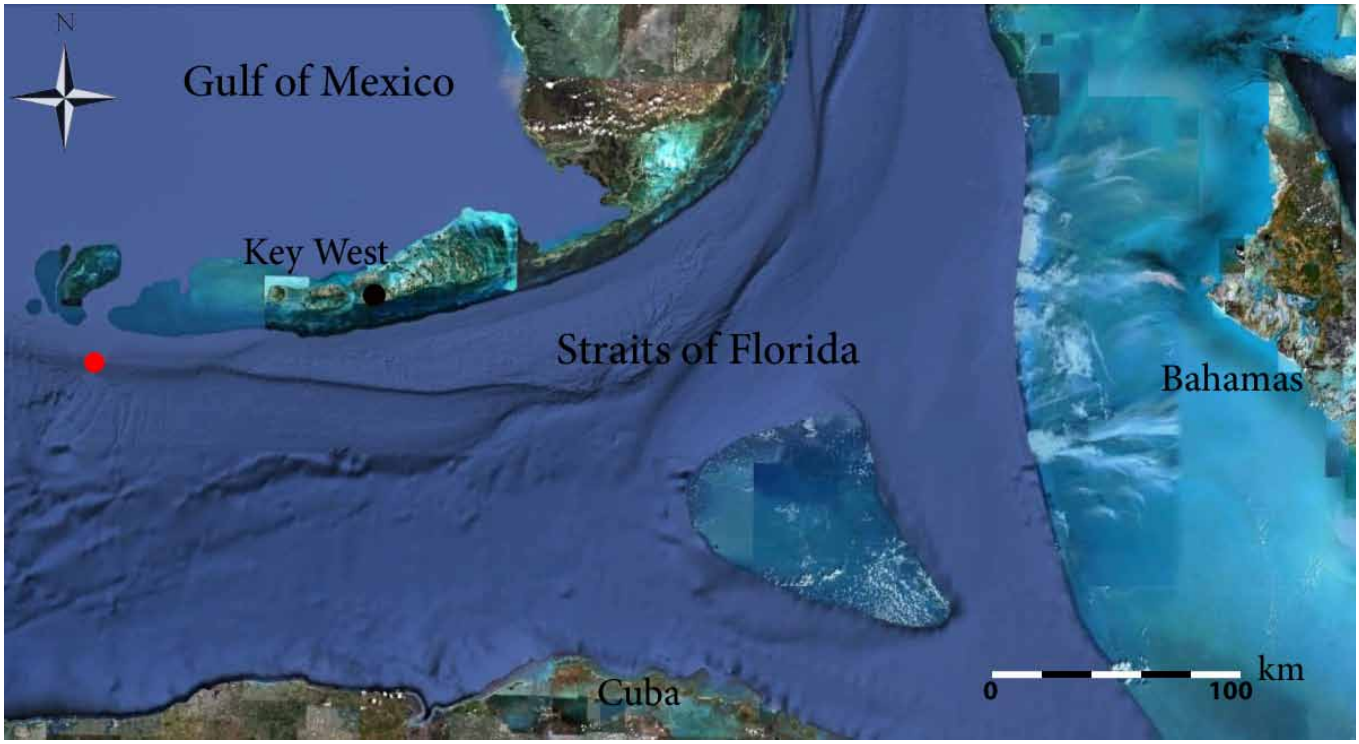


Fig. 1. Location map of the Tortugas shipwreck off the Dry Tortugas islands, Florida Keys.

Fig. 2. The 64m-long Seahawk Retriever *used as the research platform during the Tortugas shipwreck excavation.*

character in detail. The positions of all finds were spatially plotted using a recording system developed by John Astley, Gordon Richardson, Greg Stemm and John Morris. The reliance on a limpet suction device to lift delicate artifacts was successfully evolved and sediments were collected for sieving and the detection of small finds through a pioneering SeRF (Sediment Retrieval and Filtration) system built onto the back of the ROV, from which an important set of artifacts and environmental data were obtained for analysis (cf. Astley and Stemm, 2012).

The Tortugas wreck's material culture – from olive jars to the domestic pottery, silver coins, gold bars and astrolabes (Figs. 3-6) – so closely matches the assemblages associated with the *Nuestra Señora de Atocha* and *Santa Margarita* discovered by Mel Fisher in the Florida Keys that there is no doubt that this wreck comprised part of the ill-fated homeward-bound Tierra Firme fleet of 1622. A combination of historical research examined in conjunction with archaeological data suggests that the most plausible candidate for the Tortugas shipwreck is the 117-ton Portuguese-built and Spanish-operated *Buen Jesús y Nuestra Señora del Rosario* owned by Juan de la Torre and captained by shipmaster Manuel Diaz that sailed for Nueva Cordoba (Cumana) on the Pearl Coast in modern Venezuela (Kingsley, 2012). Unlike the more celebrated *Atocha* and *Margarita*, whose sites are largely disarticulated and scattered across enormous sections of the Florida Keys beneath dense and dynamic sediments, the Tortugas wreck is fundamentally coherent and continuous.

Although elements of the upper stratum of the well-preserved Tortugas hull were documented, notably the stern, bows and a square feature identified as a pump well, it is the extensive artifact assemblages that are of greatest evidential value to historical archaeology. In volume and variety these are unparalleled in published scholarly literature from other 16th and 17th-century Spanish shipwrecks worldwide.

Following its dramatic sinking, pioneering recovery and post-excavation fate, on the twentieth anniversary of the completion of the site's excavation Odyssey Marine Exploration – the owner and curator of the surviving collection today – is publishing a series of specialist papers, in addition to two introductory main reports summarizing the site and artifact assemblages, on the Tortugas wreck's assemblages, focusing on:

- Underwater technology
- Artifacts summary
- Ceramic kitchenwares and tablewares
- Olive jars (*botijas*)
- Inductively-coupled Plasma Spectrometry (ICPS) ceramic analysis

Fig. 3. Seahawk co-director Greg Stemm (right) and Dan Bagley (left) with a variety of artifacts from the Tortugas wreck.

- Tobacco pipes
- Glass wares
- Gold bars, bits and belts
- Silver coins
- Venezuelan pearls
- On-site tortoise shell craftsmanship
- Trade beads
- Animal bones
- Leather shoes
- Sundial
- South American greenstone artifacts
- Archaeology of 16th and 17th-century Spanish fleets

This introductory paper presents the background to the excavation and summarizes the technology used. The marine environment is defined and the anatomy of the site characterized.[1]

2. Background to the Excavation

Consciousness of the presence of a shipwreck in deep waters off the Dry Tortugas, a group of islands located at the westernmost point of the Florida Keys, first arose in 1965, when the shrimp trawler *Trade Winds* snagged its nets and came to a shuddering halt. When the badly

Fig. 4. Bronze astrolabes, gold bars, olive jars and linear-decorated Blue Morisco wares from the Tortugas shipwreck.

Fig. 5. Lead musket shot, tortoise shell lice comb and case, pearls, a sounding lead and wooden spindle weaving battens from the Tortugas shipwreck.

Fig. 6. A sample of ceramic olive jars and tablewares from the Tortugas shipwreck.

ripped nets were pulled in the crew discovered three intact Spanish olive jars, various metal artifacts, pieces of ship's rigging and a considerable amount of wood, including a well preserved section of ornately carved railing. In the absence of technology appropriate for working at such depths, Bob Marx collaborated without success in 1972 with a team of oceanographers from California on the research vessel *Alcoa Seaprobe* to conduct recovery operations. A steel cable was dragged between two shrimp boats several months later and a large anchor snagged and recovered (Marx, 2009: 57).

The character of the fishing hang was finally identified on 20 April 1989 by Seahawk Deep Ocean Technology at a depth of 405m using a Deep Ocean Engineering Phantom ROV operated by Graham Hawkes and Scott Stemm. Later that year on 21 June 1989 a bronze bell was the first artifact recovered from the site. A request for admiralty and maritime jurisdiction was filed in the United States District Court, Southern District of Florida, Miami Division. The motion was granted and title to the wreck was awarded to Seahawk on 29 November 1989.

Due to its depth an archaeological excavation of the Tortugas shipwreck could only be conducted remotely through robotic technology. The 64m-long *Seahawk Retriever* was developed for appropriate use as an archaeological research platform (Fig. 2), and the on-site surveying, excavation and recovery was conducted exclusively using a 3.3-ton Scorpio ROV nicknamed 'Merlin', designed and constructed by AOSC of Aberdeen, Scotland, and tooled for archaeological excavation in deep water (Figs. 7-9).

Merlin was fitted with two manipulators capable of lifting up to 113kg each, a suction dredge and positioning systems. A Sonardyne long baseline acoustic navigation system enabled the location of the ROV underwater to be plotted to an accuracy of 10cm (intra-site was of greater precision). The precise positions of all artifacts recovered during the excavation were mapped *in situ* in custom designed data logging software. Technical and archaeological ROV activities were recorded using live video and both vertical and horizontal color and black and white photography (both 35mm and 70mm). A typical activity would log: the time, event type (eg. artifact removed, dredging stopped, 35mm photo taken, etc.), the artifact number, event action (eg. sherd recovered to basket), east and north co-ordinates, RMS and gyro. Artifacts were initially placed on the seabed in large 4Plex lifting containers prior to recovery (Astley and Stemm, 2012).

Under the direction of offshore Project Manager John Astley and marine archaeologist David Moore, the excavation of the Tortugas shipwreck was conducted over the course of 138 dives in 1990 and 1991, when the contexts of 16,903 shipboard objects were recorded prior to recovery (including 6,639 pearls, around 3,935 ceramic wares and sherds, 1,658 ballast stones 1,590 organic items, 1,184 silver coins and 176 intrusive items). The first of 65 dives commenced on 9 June 1990 and operations finished on 25 November 1990; 659 hours of ROV diving were conducted during the season. The fieldwork recommenced on 19 May 1991, when 73 dives were continued until 3 October 1991; around 830 hours of diving were completed in the second season. The total dive duration for 1990 and 1991 was approximately 1,489 hours.

The entire perimeter around the ballast mound was excavated to a depth of 0.30-0.75m, and 0.75-1.0m around the sternpost and stem, for a total north/south distance covering 24.6m and east/west across an area of 17.0m. A pre-disturbance photomosaic was produced prior to operations (Figs. 12-14), which facilitated the production of the site plan (Fig. 10). Whereas all artifacts were excavated and recovered, the central hull was largely left untouched, with the exception of the removal of extensive ballast stones at the stern, minimally in the bows and along the starboard edge to expose the planking perimeter. Tightly packed, it is unlikely that anything other than the smallest artifacts would have slipped through small cracks between the stones to now underlie the ballast. A comprehensive pulse induction metal detector survey was conducted across the site during different periods between July and October 1991 that identified ferrous materials down to depths of 35cm and non-ferrous objects to 20cm below the sea bottom. A total of 131 targets were investigated as result of this survey (Fig. 11).

Conservation and analysis of the collection continued until July 1998 under the management of Odyssey Marine Exploration, supervised by archaeologist Jenette Flow. An additional phase of conservation, recording and research in preparation for the production of the final reports was undertaken by Odyssey between 2010 and early 2012 under the direction of Sean Kingsley (Wreck Watch Int., London) and Ellen Gerth (Odyssey Curator, Tampa), including conversion of all video to DVD for purposes of long-term archive curation and research, scanning underwater slides to digital form, full re-photography of the artifact collection, select artifact illustrations, animal bone, seed, ceramics, tobacco pipes, tortoise shell and ballast analysis, artifact cataloguing and research, and conversion of the localized artifact positional geospatial data into modern software to generate distribution maps of assemblages.

Fig. 7. The ROV Merlin being winched onto the deck of the Seahawk Retriever. *Photo: John Astley.*

3. The Marine Environment

The 'Tortugas Deep-sea A' shipwreck (henceforth abbreviated to the Tortugas shipwreck in this report) lies at a depth of 394-406m, approximately 20km south of the Dry Tortugas, a group of islands situated near the southwest corner of the Florida Platform.[2] The Tortugas Islands are located around 113km west of Key West and 60km west of the Marquesas Keys. The Gulf of Mexico borders the area to the north and the Straits of Florida lie directly to the east and south. The region displays a low tidal range, which achieves 0.52m in spring. Current measurements taken to the west of the Dry Tortugas indicate a dominant north/northeast flow at a maximum rate of <0.10m/s; cyclic reversals to the south/southwest at times exceed 0.10m/s. Surface measurements indicated maximum current rates of 3 knots during the fieldwork seasons, the result of the meandering Gulf Stream current that sometimes flowed over the site.

Fig. 8. The ROV Merlin docked on the deck of the Seahawk Retriever*. Photo: John Astley.*

Fig. 9. The ROV Merlin being launched from the Seahawk Retriever*. Bottom photo: John Astley.*

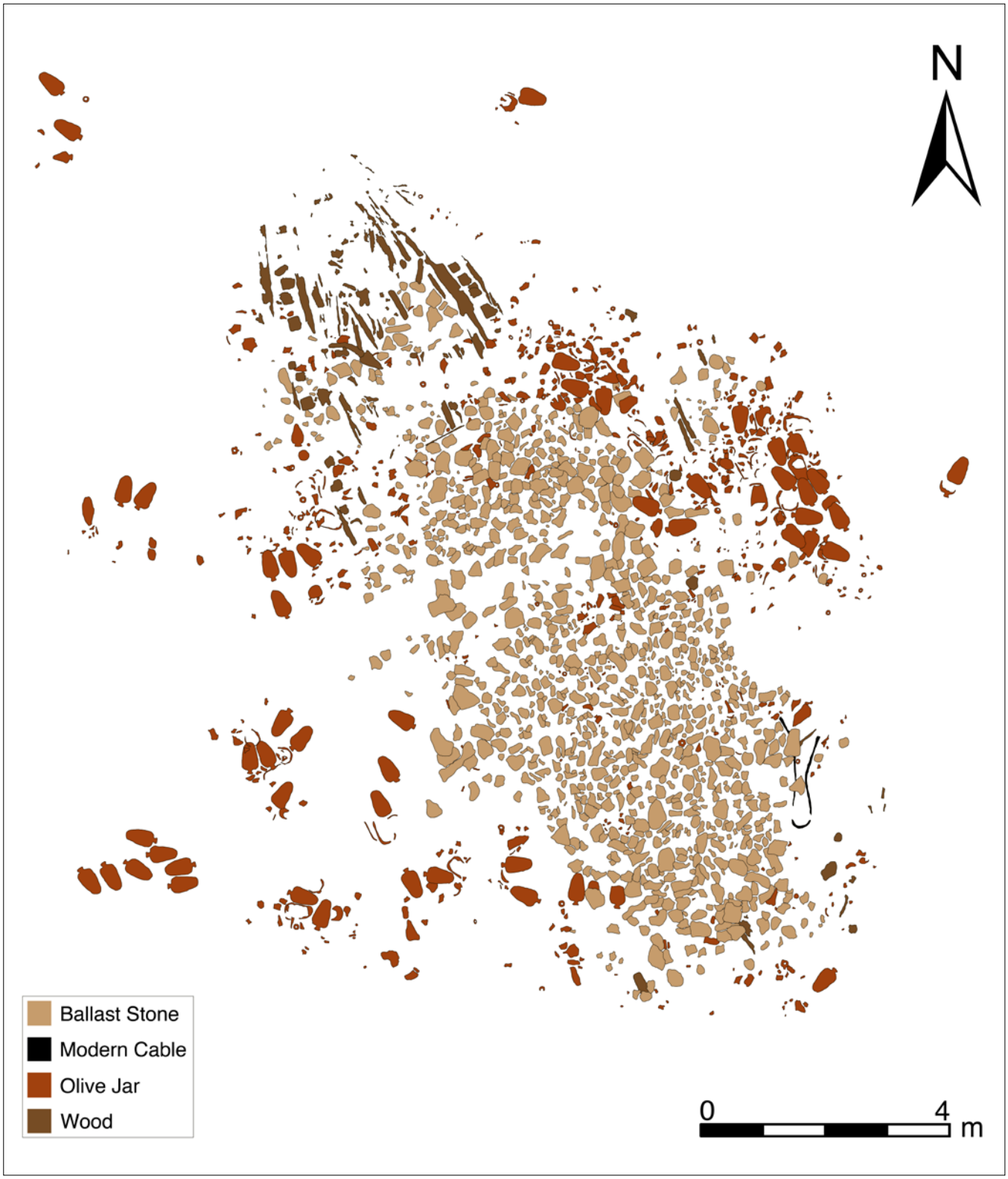


Fig. 10. Pre-disturbance site plan of the Tortugas shipwreck.

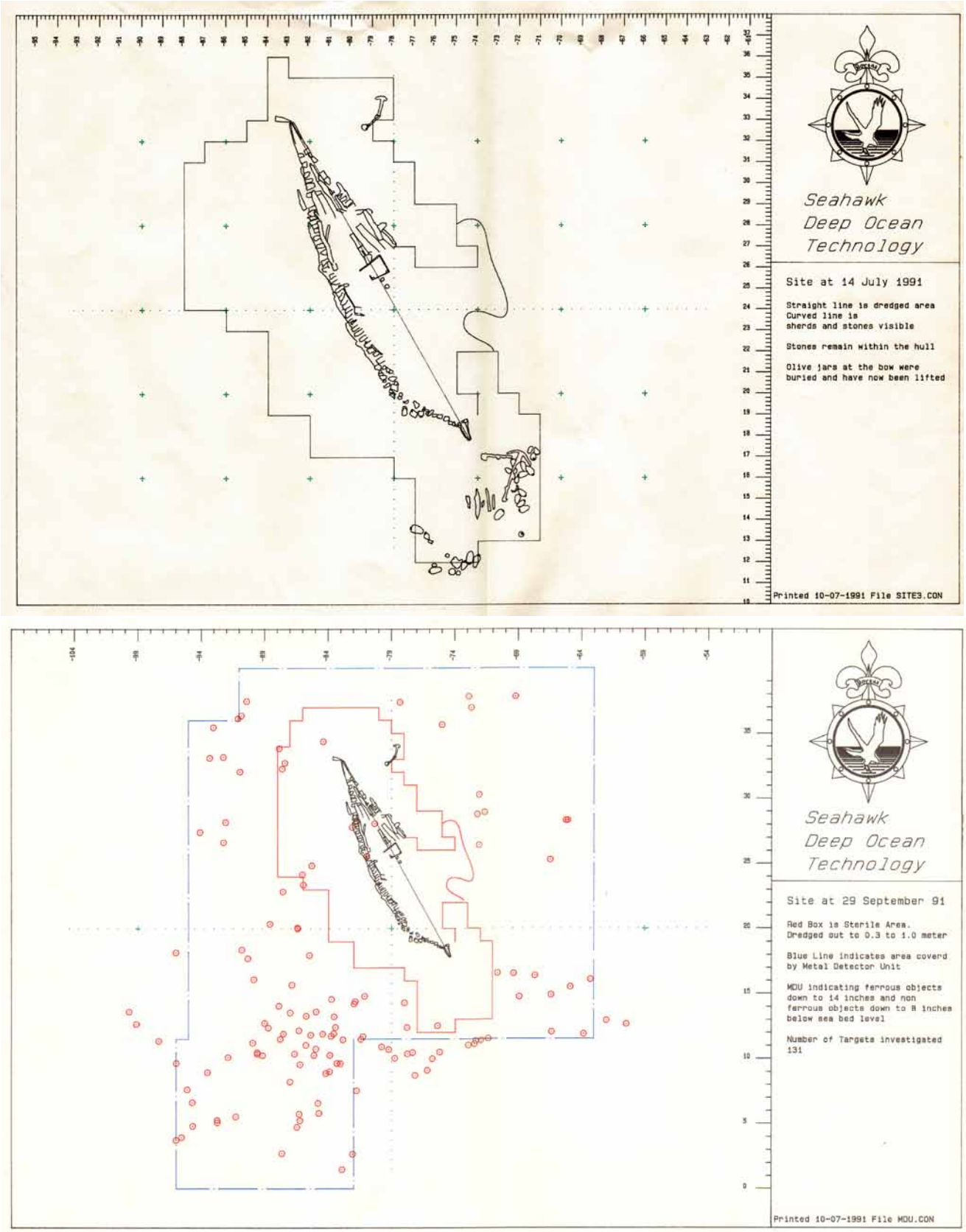


Fig. 11. Post-excavation plan of the Tortugas shipwreck's hull (top) and area examined during the metal detector survey (bottom) (scans of hard copy archival printouts).

Fig. 12. The master site photomosaic being manually assembled.

The study region is blanketed by Holocene sediments varying in thickness from less than 1m in the northeast to greater than 3m in the northwest and averaging about 2m. The sediments consist of soft, carbonate muds and sandy muds (Induced Polarization impedances of 2.01-2.44 ip), soft carbonate muddy sands (impedances of 2.45-2.97 ip) and coarse sands. Core samples reveal compositions comprising 32-34% sand, 43-47% silt, 18-21% clay and 5.3-5.9% Phi. The sediment column is dominated by the calcareous green algae Halimeda in varying states of diagenesis. A minimal amount of small shell is present in the upper fine section (< 5 phi) of the sediment column 0.9-1.4m below the seafloor. Beneath this stratum the sediment structure and content change to a desiccated lag layer up to 0.4m thick dominated by coarse molluscan shells consisting of partial and broken gastropods and pelecypods and coral debris. At depths beyond a maximum of 1.8m below the surface, sediments studied from the deepest cores consist of a bioturbated layer of fine-grained (< 6.5 phi) gray sandy mud (Walter *et al.*, 2002: 162, 168-9, 171), which corresponds to visual observations made on the Tortugas shipwreck site, where shell content was low.

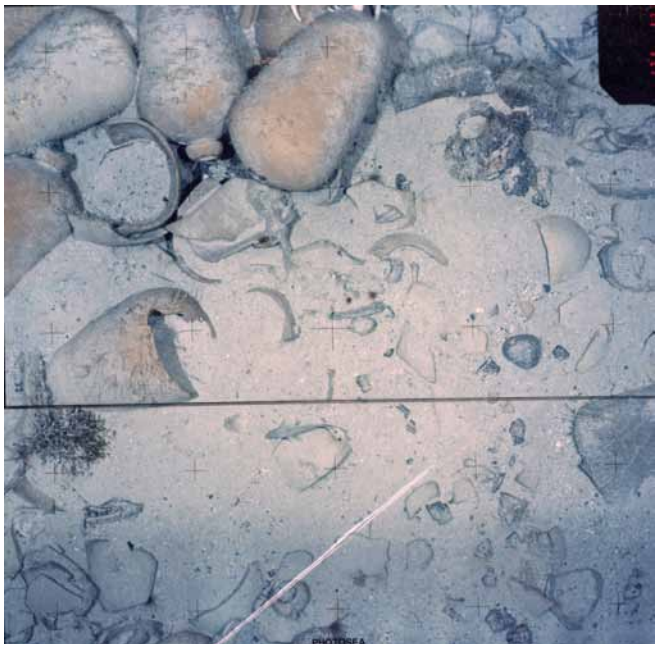


Fig. 13. Detail of the master site photomosaic.

Measurements taken in less than 25m water depth around the Dry Tortugas islands suggest that sediments accumulate steadily at rates of 0.3-0.4cm/yr (Ingalls *et al.*, 2004: 4364). Since this zone is relatively shallow compared to the Tortugas shipwreck site, and is dominated by fine-grained carbonate sediments compared to the stiff muds within the wreck environment, the latter's sediment accumulation rate is likely to be significantly lower (Walter *et al.*, 2002: 162). Visual observations from the Tortugas wreck reveal a dominance of stiff and heavily bonded clay mud, sufficiently dense to enable vertical sections to be cut by the ROV dredge into the sediments without collapsing (Fig. 22). Numerous olive jars were exposed under mud accumulations covering at least three-quarters of their widths (Figs. 34-35), which indicated a maximum undulating sediment drift of 30cm since 1622 on the lower slopes below the elevated ballast pile, which was discovered entirely exposed, as was the upper surface of the hull towards the stern. All artifacts were identified either on the site's surface or within this uppermost 30cm-deep stratum. The impact of hurricane activity on sediment transport remains undetermined for these depths.

The Tortugas wreck lies within one of America's most famous fishing grounds, where 'Pink Gold' was struck in 1949 with its epicenter 112km off Key West. The vast, formerly untouched, shrimp fisheries indigenous to these waters were identified by the Federal Fish and Wildlife Service as perhaps the most productive ever located in America. When news of the discovery broke in 1949, no shrimp boats operated out of Key West. Within three weeks, however, trawlers from North Carolina, northern Florida, Georgia, Mississippi, Louisiana and Texas occupied every space in the town's dock. One month later five new packing-houses were built and local wharfage expanded to the maximum.

The shrimp beds covered around 160 square kilometers and were believed to extend for another 224km northwards to Fort Myers in western Florida. Within a very short period of time 200 diesel-powered shrimp trawlers of 18m length were based in Key West. Crewed by three to four men per boat, full capacity catches weighed 1.6-1.8 tons, which were loaded into refrigerated trucks as soon as they were landed for transport north (Van Dresser, 1950: 124, 126).

The new pink gold grounds were considered so important to the US economy that Government fisheries scientists worked hand in hand with fishermen to develop optimum catch efficiencies. In the 1950s National Marine Fisheries Service engineers experimented with electric tickler chains that shocked the shrimp out of the mud and into nets (Rudloe and Rudloe, 2010: 36).

Gulf fisheries are some of the most productive in the world. According to the National Marine Fisheries Service, in 2008 the commercial fish and shellfish harvest from the five US Gulf states was estimated to be 1.3 billion pounds valued at $661 million. The Gulf also contains four of the top seven fishing ports in the nation by weight and is home to eight of America's top 20 fishing ports by dollar value.

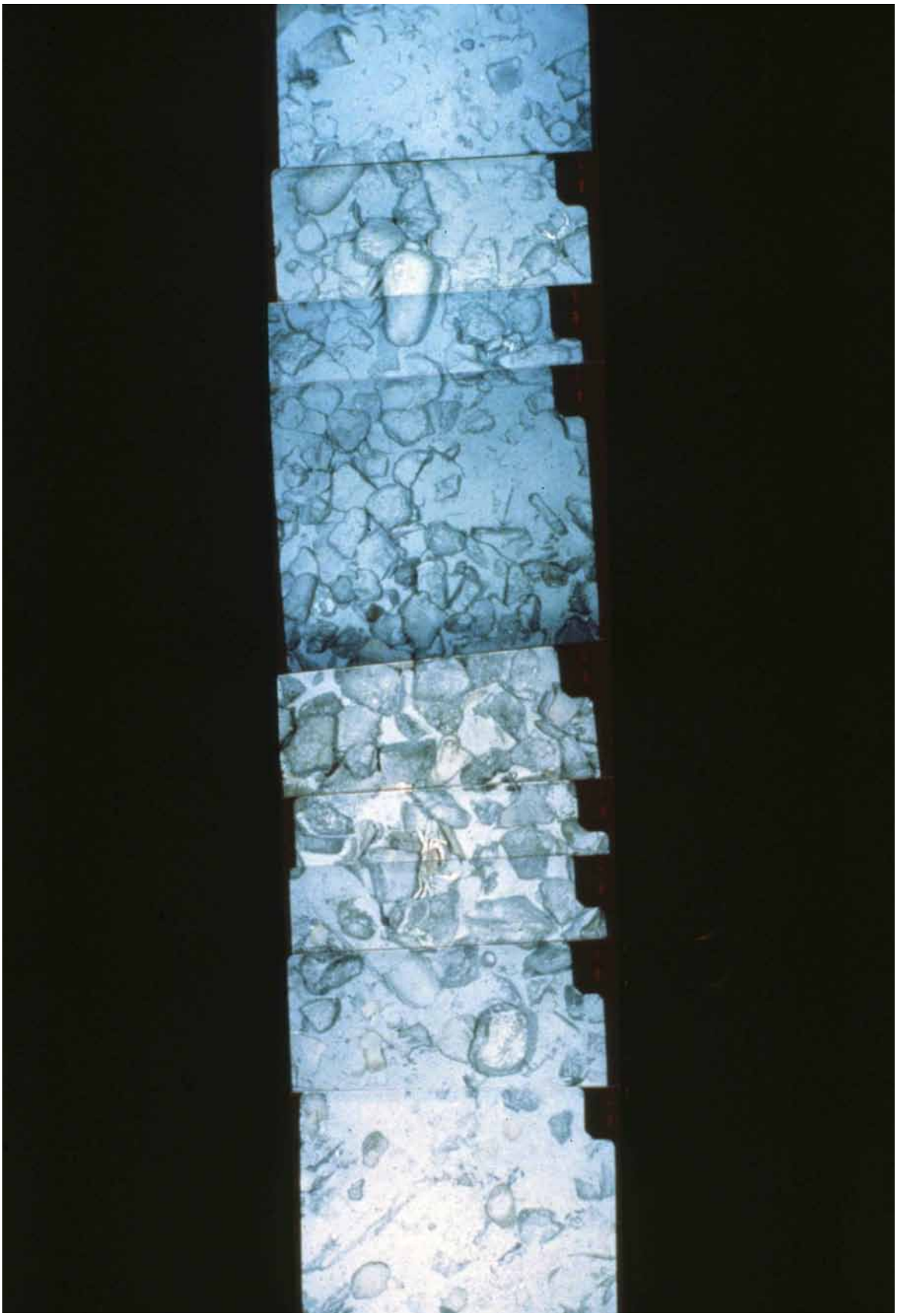
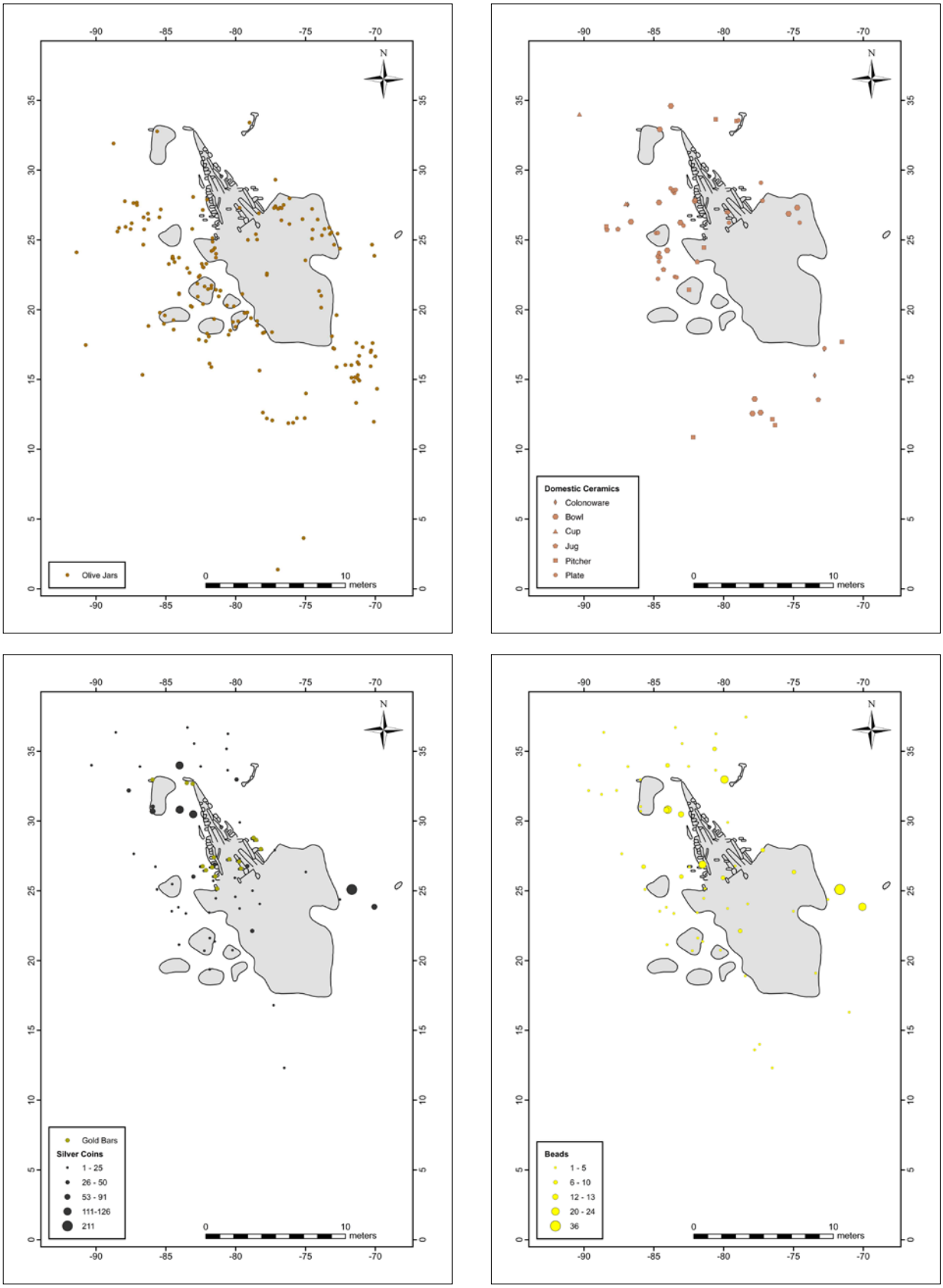
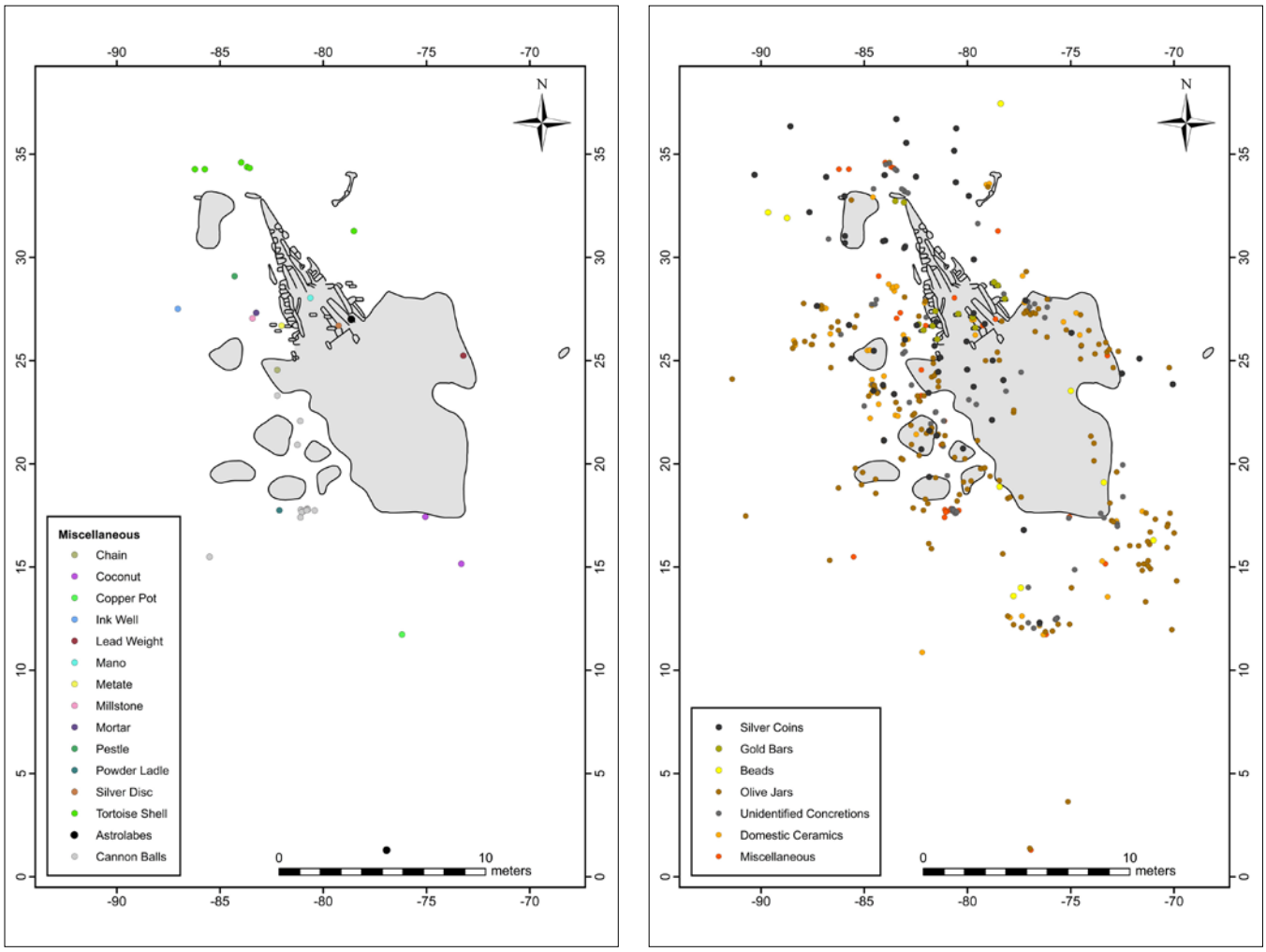


Fig. 14. Detail of the master site photomosaic.



Figs. 15-18. Distribution plans of botijas *(olive jars); kitchen and tablewares; gold bars and silver coins; and beads on the Tortugas shipwreck (top left to bottom right).*



Figs. 19-20. Distribution plans of miscellaneous artifacts and all artifact groups combined on the Tortugas shipwreck (left to right).

Gulf landings of shrimp led the nation in 2008 with 188.8 million pounds at $367 million dockside value, accounting for about 73% of the US total. The Gulf also led the production of oysters in 2008 with 20.6 million pounds of meat valued at $60.2 million and representing 59% of the national total.[3]

In 1997-98 the Tortugas fishery caught 873,620lbs lobster, 665,500lb shrimp, 522,402lb reef fish and 88,695lb king mackerel.[4] The three species of penaeid shrimp (white, pink and brown) comprise more than 99% of landings in the Gulf of Mexico shrimp fishery. Nearly 85% of the pink shrimp harvested in the United States comes from the west coast of Florida, with a commercial value in 2010 of over $17.5 million. Since 2002 catches have declined sharply due to economic conditions in the fishery and hurricane damage, particularly in 2005 when landings dropped from 150 million pounds to approximately 92 million pounds. A total of about 8.4 million pounds of pink shrimp were landed in US fisheries in 2008, mostly off western Florida.[5] Peak concentrations of shrimp are usually found at depths of 250-475m (Stiles *et al.*, 2007: 6), which coincides with the Tortugas wreck's location. As an artificial reef, the wreck site is densely inhabited primarily by crabs and catsharks, but also with lesser amounts of lobster, squirrelfish, shrimp and squid (Figs. 23-28).

The site formation displays conspicuous impacts caused by bottom fishing, primarily in the form of the displacement of artifacts off the main ballast mound onto the lower lying surrounding levels (see Section 4 below). Despite the relative coherent nature of the shipwreck, the original stowage points of the cargo and domestic assemblage are not preserved.

Fig. 21. Ballast stones from the Tortugas shipwreck (top left to bottom right): chert nodule (TOR-90-00342-BL), granite (TOR-90-00341-BL & TOR-90-01098-BL), basalt (TOR-90-00339-BL), the dominant sandstone site ballast (TOR-90-01103A-BL & TOR-90-01103B-BL), quartz sandstone (TOR-90-00340-BL & TOR-90-01104-BL) & oolitic limestone (TOR-90-01100-BL).

Fig. 22. Excavation of the site in horizontal stratigraphic strips.

*Fig. 23. A slipper or shovel-nose lobster (*Scyllarus americanus*).*

*Fig. 24. Rock crabs (*Cancer irroratus*) were particularly common on the wreck.*

*Fig. 25. Catshark (*Scyliorhinus*), common across the site, and present above the ballast mound and broken olive jars.*

*Fig. 26. Squirrelfish (*Holocentrus*) on the wreck site.*

*Fig. 27. A white-striped cleaner shrimp or a peppermint shrimp (*Lysmata*).*

*Fig. 28. Either long-finned squid (*Loligo pealei*), brief squid (*Lolliguncula brevis*) or arrow squid (*Loligo plei*).*

Fig. 29. A typical deposit of intact and broken olive jars on the outer edge of the ballast mound.

Fig. 30. An olive jar being prepared for recovery using the ROV's limpet suction device.

Fig. 31. Olive jars and a Seville White ware dish in situ *on the wreck edge.*

Fig. 32. Intact olive jars in situ *on the east flank of the wreck.*

Fig. 33. A Type 3 olive jar in situ *surrounded by catsharks.*

Fig. 34. Ceramics were located both on the surface and immediately beneath sediments in a stratum usually typically 30cm deep (and 50cm maximum).

Fig. 35. Broken olive jars immediately beneath surface sediments.

Fig. 36 (above left). Extensive ceramics snagged around anchor A1 at the southeast flank.

Fig. 37 (above right). Anchor A3 at the northeast flank, seemingly dragged out of context by shrimp trawlers.

Fig. 38 (left). A bronze cauldron in situ *alongside a cluster of olive jars, a juglet and Columbia Plain dish.*

Figs. 39-42. Two bronze astrolabes in situ *and being recovered.*

Fig. 43. A gold bar in situ *in the stern.*
Note the marine-bored ballast alongside.

Fig. 44. Two gold bars in situ *in the stern.*

Fig. 45. A basalt metate *grinding stone* in situ *in the stern.*

Fig. 46. A cluster of encrusted iron cannonballs in the southeast starboard bow quadrant.

4. The Site

The Tortugas shipwreck lies at a depth of 394.5-406.4m on a northwest to southeast orientation, the keel line extending along a 150º axis (Fig. 11). When discovered the site was dominated by a low-lying mound of amorphous ballast stones, whose main nucleus extended across an area measuring 10.0 x 4.8m (Figs. 10, 25, 33). The total wreckage covers 19.2m long and 15.6m wide. Despite the historical description of four iron cannon required for the *Buen Jesús y Nuestra Señora del Rosario* (Kingsley, 2012), no such ordnance was present on the site.

The exposure of the heavily deteriorated rudder (coordinates 83.5/33.0) signifies the presence of the stern to the northwest (Figs. 67-71).[6] The presence of one concreted iron anchor, A1, to the southwest (mid-shank coordinates 72.7/15.9) reveals the location of the bows (Fig. 36), with the anchor seemingly originally lashed to the ship's port flank at the time of sinking. The shank from a second anchor, A2, underlies it. A third anchor at the north end of the site (A3, mid-shank coordinates 78.7/33.2), seems to be out of context and may have been displaced by bottom trawler activities (Fig. 37). A fourth large anchor was salvaged in 1972 prior to the present project (Marx, 2009: 57) and its present location is unknown.

5. Artifact Distributions

Although the wreck is technically coherent because the hull is articulated and largely concealed by an overlying veneer of ballast, the cargo and domestic wares have been subjected to post-depositional scrambling. Based on a count of the distribution of all finds, just 25.2% overlay the main ballast and hull nucleus, while 74.8% were scattered closely around its perimeter. Subdividing the site into quadrants, as a whole the finds were equally distributed (50.4% in the northern aft half, 49.6% in the southern forward half). However, just 34.9% occupied the portside eastern half of the site and 65.1% the western starboard half (Fig. 20). This would seem to indicate that the ship settled listing to starboard. The furthest displaced artifacts are an olive jar deposited 16.2m due south of the southern edge of the main ballast nucleus (coordinates 76.9/1.4) and an astrolabe dispersed 16.4m south of the southernmost ballast edge (coordinates 76.9/1.3).

The *botijas* (olive jars) were the most conspicuous artifact features on the site and extended across an area 32.8m north/south and 21.5m east/west (Figs. 14, 29-35). Just 26.4% of the total olive jars overlay the main ballast and hull area and 73.6% lay outside their perimeter (Fig. 15). Of the latter, the majority (74.2%) were clustered along the starboard western edge of the wreck. The northwestern site quadrant contained 45.8% of the total olive jars deposited beyond the main ballast and hull area; 28.3% overlay the southwestern site quadrant; 24.2% the southeastern quadrant; and just 1.7% the northeastern quadrant.

The densest clusters of olive jars were recorded within the northeast ballast mound, just outside the southeast edge of the ballast and, more extensively and continuously, on a northwest to southeast axis along the northeastern starboard flank. The above statistics do not reflect balanced cargo stowage. Assuming that the foodstuffs packaged in these ceramic vessels were originally stowed evenly in the hold above the ballast, this class of container has been extensively displaced. The suggested ship's list to starboard may partly explain this pattern, but does not satisfactorily rationalize the low quantity overlying the central ballast mound. The scattering effect is best interpreted as a result

of bottom trawling, which has decentralized and swept the olive jars off the pronounced ballast mound. Once rolled to slightly lower depths, the vessels became inundated with sediments in an environment more conducive to long-term preservation.

The distribution of domestic pottery (kitchen and table-wares) displayed a comparable multivariate distribution pattern that supports the above hypotheses (Fig 16). Just 21.2% of the total ceramic wares used by the crew and passengers overlay the central ballast and hull mound. Outside this zone, once again the greatest presence lay within the northwest quadrant (61.2%), followed by 16.4% in each of the northeastern and southwestern quadrants and 5.5% to the southeast. A significant 77.6% of the total remains were clustered in the northern half of the wreck, which corresponds to the original location of the galley structure.

The gold bars, silver coins and even the beads exhibited highly comparable cluster patterns, which mirror the domestic pottery deposition but with a greater depositional focus on the stern (Fig. 43-44). The gold bars were exclusively concentrated in a 7.3m-long and 4.5m-wide section between the sternpost and aft area corresponding to the galley position, where 61.6% overlay the hull remains (Fig. 17). This pattern is the only anomaly on the Tortugas wreck, where the majority of finds were otherwise outliers beyond the main ballast and hull nucleus. Their general original positions seem to have been retained due to the relatively small size and density of the gold bars.

The silver coins again displayed a significant concentration in the stern area, but otherwise with a perplexing, unbalanced pattern (Fig. 17). Just 9.3% of the silver coins overlay the main ballast mound. The majority, accounting for 61.7%, was recorded in the northwest quadrant. While none overlay the ballast zone to the southeast, beyond its perimeter 28.1% of the total coins were distributed within this quadrant. Just 6.4% was present to the northeast and 3.8% in the southwest quadrant. Two particularly dense clusters were documented: a concentration of 278 coins in the southeast (coordinates 71.7/25.1) and 607 coins in seven clusters in the northwest quadrant across an area of 3.9 x 3.8m (coordinates 84.0-87.7/30.8-33.9). The dense representation in the northwest quadrant again seems to reflect the dual pattern of the ship listing and depositing much of its contents to starboard and the apparent stowage of the silver coins in proximity to the galley.

As would be expected for lighter material more easily dispersed by currents and trawlers, the beads recorded on the Tortugas shipwreck are more evenly distributed across the site (Fig. 18). A minority of 22.5% overlay the ballast mound. The majority, accounting for 45.4% of the total, were once again present in the northwest quadrant, 29.9%

Fig. 47. A section of strakes, frames and ceiling planking exposed towards the starboard stern.

Fig. 48. A section of strakes and frames along the portside stern.

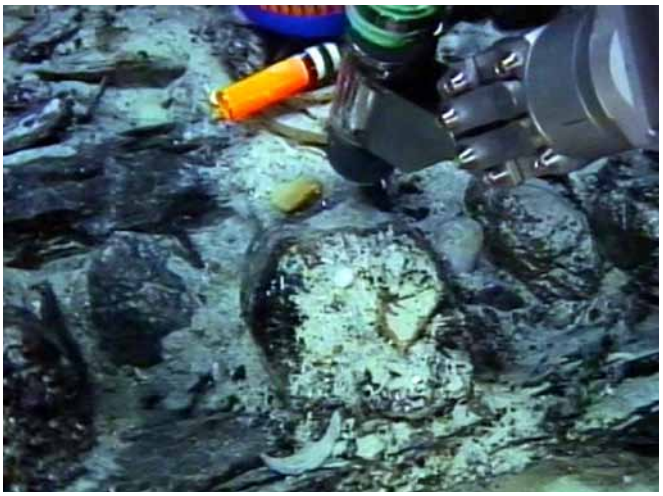
Fig. 49. A section of strakes and frames in the stern.

Fig. 50. Detail of strakes and frames along the portside stern (coordinates 80.12/25.09).

lay to the southeast, 17.6% to the northeast and 7.0% in the southwest quadrant. Thus, the material was almost equally split between starboard and portside (52.4% west of the keel line).

In conclusion, the archaeological data favors the interpretation that the Tortugas *navio* struck the seabed stern first, snapping the rudder, which broke away to starboard. The vessel then settled to starboard. As the upper hull structure deteriorated, the bulk of the ship's cargo and domestic wares stored in the galley correspondingly spilled most extensively westward. The concentrations of the gold bars, silver coins and domestic ceramic wares reflect the general position of the otherwise decomposed galley structure. As the heaviest single artifact on the wreck, the position of a basalt grinding stone *metate* at coordinates 82.0/26.7, plus its *mano* pestle at coordinates 80.6/28.0 (Figs. 19, 45), offers the best general indicators of the galley's original position. A major anomaly on the Tortugas wreck was the identification of a single galley brick; the absence of extensive brick material required to insulate the hearth remains undetermined.

Objects typically identifiable with the galley cabin, including an inkwell (coordinates 87.0/27.5), bronze mortar (coordinates 83.2/27.3) and one of the astrolabes (coordinates 78.6/27.0), also clustered closely around the stern area (Fig. 19). However, several diagnostic elements of the domestic assemblage and valuables have scattered southwards: a gold chain was recorded at the central northern edge of the ballast mound (coordinates 83.79/24.5), while a copper cooking cauldron was identified 6m south of the southern tip of the ballast mound (coordinates 76.19/11.74) and a second astrolabe was even further dispersed 16.4m south of the southern site edge (coordinates 76.9/1.3).

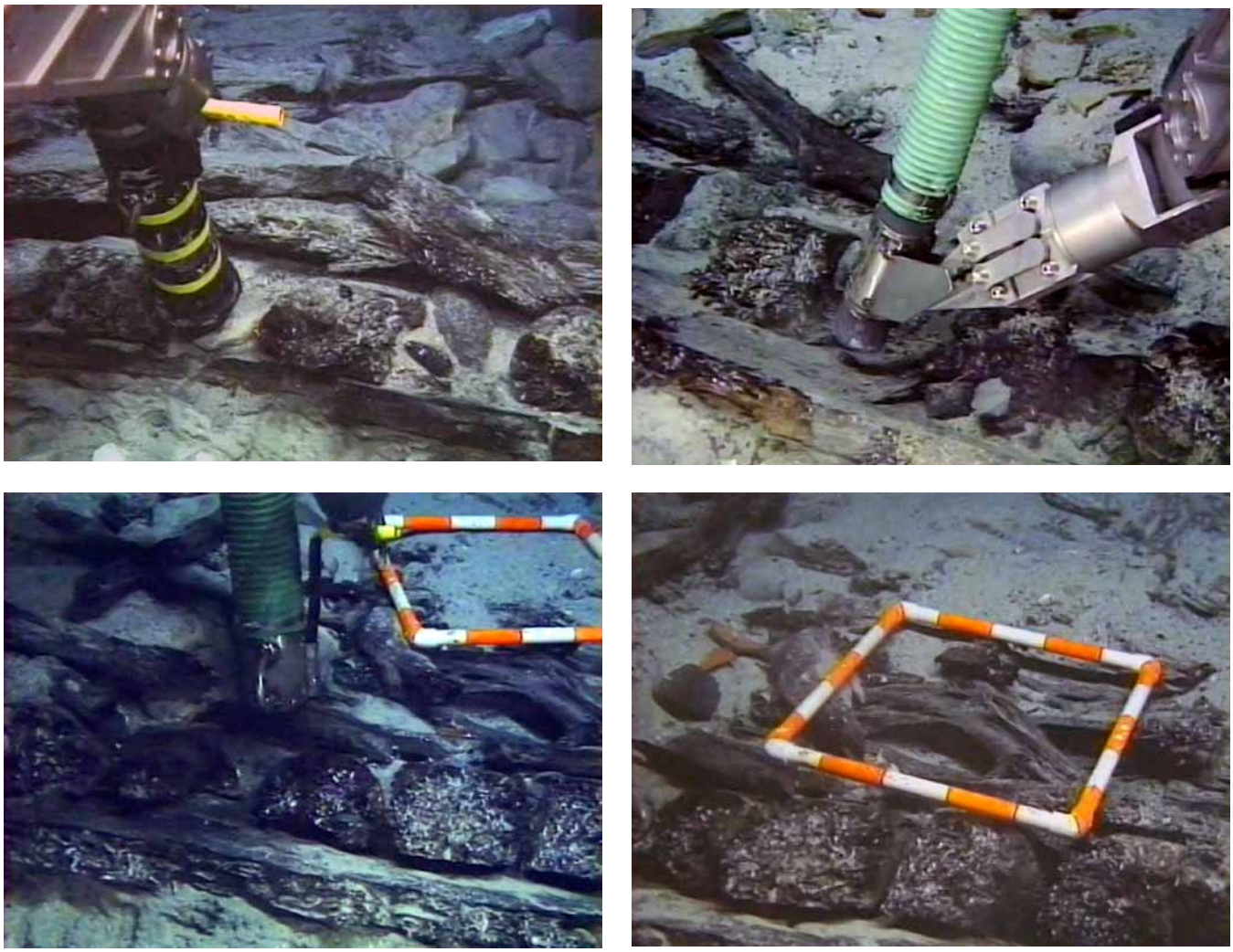


Figs. 51-52. Excavation of strakes, frames and ceiling planks in the stern.

The wreck's 64 pieces of tortoise shell display a divergent configuration, whereby all examples lay offsite northwest of the sternpost with just one example to its southeast (coordinate 83.6-86.2/34.3-34.6 and 78.5/31.3; Fig. 19). The only obvious artifact pattern seemingly reflecting storage in the forward bow half of the hold is a concentration of concreted iron cannonballs recorded along the western edge of the southwest quadrant (coordinates 80.4-85.5/15.5-23.3).

6. The Hull & Ballast

A minor area of the Tortugas ship's hull was examined, focused on the stern third of the vessel at the northern end of the site discovered partly exposed above sediments (Fig. 11). The stem was also uncovered with the objective of determining the ship's length, and the ends of the abraded starboard frames exposed. Whereas the wreck was typically excavated to a depth of 50-75cm, the sediments around the stem and sternpost were trenched to depths



Figs. 53-56. Excavation of strakes, closely aligned frames (some with curved sides), ceiling planks and a floor timber in the stern.

of 0.75-1.0m. The upper level of the pump well retaining shaft was also cleared. In total, less than an estimated one-quarter of the total hull was examined beneath its overlying veneer of ballast. These stones were tightly clustered and it is highly unlikely that any material culture other than the smallest of artifacts and sherds had been vertically displaced through this sealing layer.

The majority of the ballast mound is positioned towards the southeast two-thirds of the visible site, reflecting the requisite structural tapering of the lower hull towards the stern. The weight of the sterncastle/quarterdeck structure would have readily compensated for the lack of ballast in this part of the ship (Moore, 1991). The bows are positioned to the south. The ballast continues all the way up to the stempost.

Samples of the Tortugas ship's ballast stones were examined visually by Dr Stephen Pollock of the Department of Geosciences, University of Southern Maine, USA, followed by x-ray diffractometer analysis of six samples. The following rock forms were identified (Fig. 21), of which sandstone (TOR-90-01103-BL) was the prevalent form within the hull:

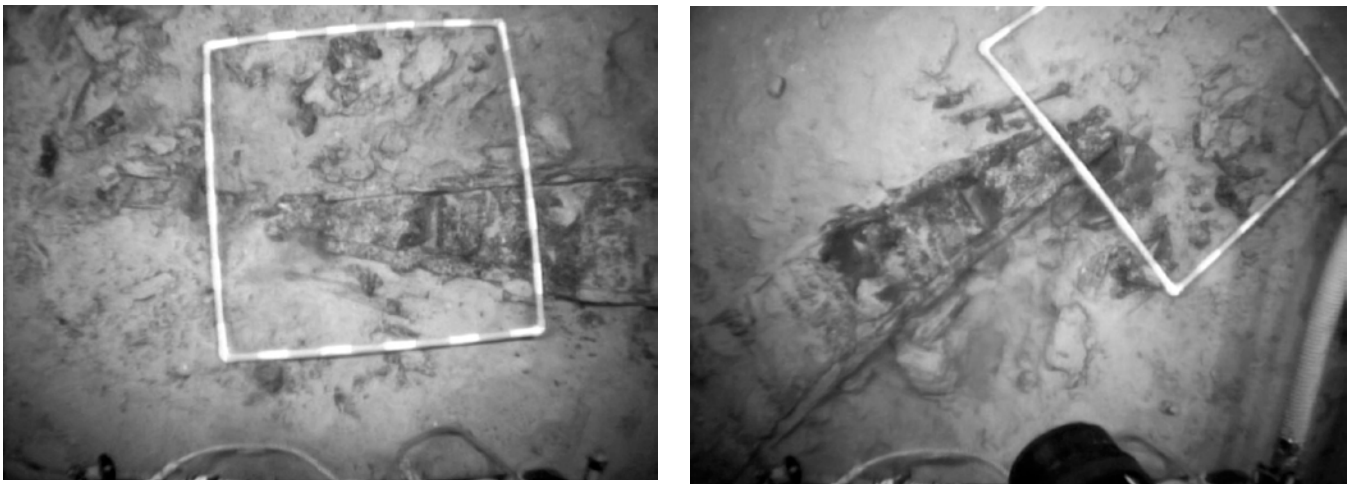
1. Chert Nodule (TOR-90-00342-BL). Laminated and probably derived from a limestone as a chert nodule, but the surface suggests it was a cobble. In addition to the laminate it has a granular quartz core with a small vug at the center with drusy quartz crystals. There are at least two fossil remnants, which are suggestive of corals.
2. Granite (two samples). TOR-90-00341-BL is a relatively unweathered, fine-grained biotite muscovite granite, and TOR-90-01098-BL is a deeply weathered, fine-grained muscovite granite. The feldspars are the most deeply weathered and much of the small sample appears to be just quartz and muscovite, but there is a small area that illustrates an equigranular granitic texture.

Figs. 57-58. Marine borers, calcareous tubes and related hull decomposition.

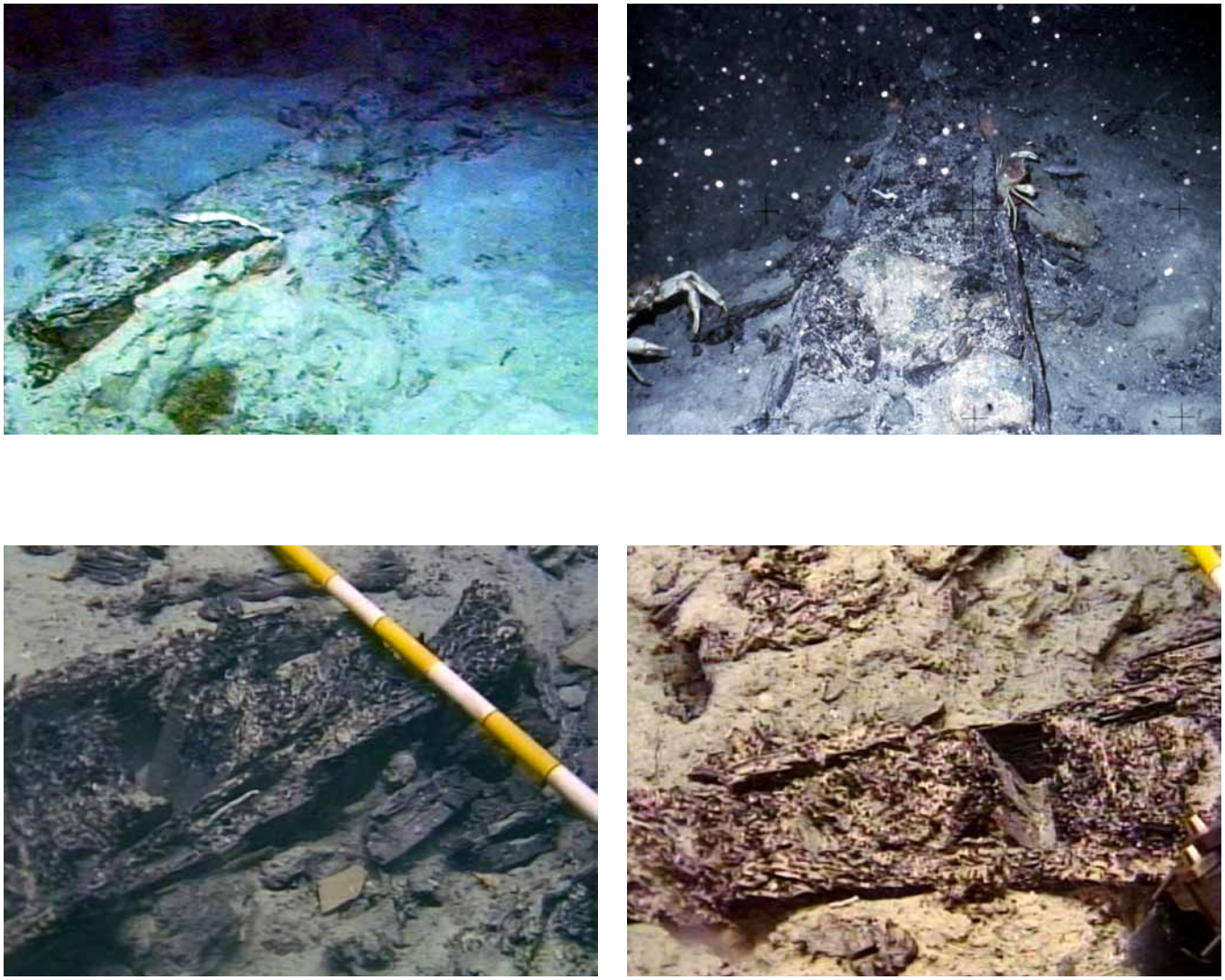
3. Basalt (two samples). Two samples, relatively fresh and unweathered. TOR-90-00338-BL is a typical dark gray to gray black very fine-grained microcrystalline basalt that x-ray diffractometer analysis indicates contains a calcium rich plagioclase feldspar, either labradorite or a sodian anorthite, and the pyroxene augite. TOR-90-00339-BL is a gray-black to black very coarse-grained basalt. The sample appears to be somewhat glassy, mostly due to the luster of the rectangular-shaped, calcium-rich plagioclase feldspar grains. The black 'glassy' grains are probably pyroxene. Minor olivine may be present.
4. Sandstone (TOR-90-01103A-BL and TOR-90-01103B-BL). Well-sorted, fine-grained arenites (a sandstone with less than 15% mud matrix). The small black grains are probably rock fragments. Both are texturally similar and seemingly originally derived from the same geologic formation. Marine boring organisms likely produced the borings in TOR-90-01103A-BL. Remnant shell material appears to be present in at least one cavity. Sample TOR-90-01103B-BL is thinly bedded with either orange shale/mud laminations or shale/mud chips. No fossils were observed. X-ray diffractometer analysis indicates that the sandstone is composed of quartz and magnesium rich calcite. TOR-90-01103B-BL exhibits an isoclinal fold, which appears to be real based on the textural contrast of the laminations and is not a liesegang ring (secondary nested rings caused by rhythmic precipitation in a fluid saturated rock).
5. Quartz Sandstone (two samples). TOR-90-00340-BL appears to be a uniformly textured, fine-grained quartz arenite or quartzite. Rounded grain surfaces are not readily apparent; rather the grains appear as interlocking grains. The former would be typical of an unmetamorphosed quartz sandstone, and the latter a metamorphosed quartz sandstone. The grains are not uniformly elongated, which is more common in quartzites. TOR-90-01104-BL is an elliptical iron stained cobble, its grain size very fine and similar to the weathered surface of TOR-90-00340-BL.
6. Oolitic Limestone (TOR-90-01100-BL). A relatively extensively weathered, fine-grained oolitic limestone. Small spherical to oval oolitic grains are common. Small shell fragments or peloidal grains may also be present. A pellet or peloidal grain is an indurated fecal pellet. X-ray diffractometer analysis reveals magnesium rich calcite. This rock may be local: there are modern oolites on carbonate banks and platforms in the Caribbean.

The scientific analysis has not led to a positive identification of the ballast's provenance. In light of the high-volume transport of heavy iron goods and wine stored in *botijas* to Cumana in Venezuela by the *Buen Jesús y Nuestra Señora del Rosario*, and a postulated return cargo of low density tobacco (cf. Kingsley, 2012), it may be hypothesized that additional ballast would have been required in Venezuela.

In addition to continuous, articulated strakes, frames and ceiling planking (Figs. 47-56), major structural elements preserved *in situ* include a wood-lined pump well retaining shaft (Figs. 76-84), several deck stanchion steppes (one *in situ* at coordinates 80.97/27.73, 4.6m forward of the sternpost where the hull starts to widen away from the sternpost, and another with a tapered end located loose on the surface on the portside bow 3.2m northeast of the stempost at coordinates 75.23/20.38; Figs. 100-102), what appears to be the stump of the main mast still stepped into the keelson just forward of the pump well, and the top of the stempost (with a scarf and associated forward plank hoods butting into the vertical rabbet; Figs. 72-75). The heavily degraded rudder has snapped off to the starboard side of the sternpost, where it lies in association with at



Figs. 59-60. Vertical view of the sternpost.



Figs. 61-64. Detail of the sternpost and tail frames before and during excavation.

Figs. 65-66. Three hooding ends rabetted into the sternpost. Note the dense marine bore tube cover on the upper surface.

Fig. 67. Vertical view of the sternpost with the rudder broken off to starboard and a long timber possibly identifiable as a spar or part of the ship's tiller.

least one iron gudgeon (Figs. 67-71). Immediately to its east lies a long timber with chamfered edges, potentially either a spar or part of the tiller assembly (Figs. 68-69). One floor and a futtock lie loose on the wreck's surface (Fig. 103).

The area of most intensive focus due to the naturally exposed character of its upper surfaces was the stern (Figs. 59-66). As across several areas of the site, prior to excavation this zone was covered with large amounts of marine-bored and degraded fragments of articulated wooden structural components and highly decayed loose pieces of small planking. The marine borers were so effective on the Tortugas wreck that possibly xylophagous rather than lithophagous organisms also extensively attacked and gribbled much of the soft ballast stones.

The sternpost was located interconnected to the hull. The stern terminates at a 10.8cm sided post, which widens forward to 28.1cm. A second tail frame measured 18.7 x 12.5cm. Three hooding ends, the upper line 5.4cm thick, are visible rabeted into the sternpost (Figs. 59-66). At the opposite end of the hull the upper strake flanking the portside stempost, which was exposed for a length of approximately 1.2m, is 6.9cm thick (Figs. 72-75).[7] After the Sonardyne navigation and recording system was calibrated for an accuracy of +/- 10cm, the distance from the *in situ* sternpost to where the keel started to rise to form the lower stempost in the bows was measured at 17.4m (Fig. 12). This dimension provides the maximum total length of the Tortugas ship's keel. Drawing a centerline between each post provides a preserved midship width at the lower turn-of-the-bilge (maximum wreck preservation elevation) of 4.6m.

At a distance of 7.8m forward of the sternpost the uppermost perimeter of the bilge pump well's wooden framed retaining shaft *arca* (103.7 x 76.3cm) was exposed, which proved to be built of 14.5cm wide and 2.5cm thick planks installed on their sides (Figs. 76-80). Two overlying retaining planks were exposed in one trench section (Figs. 83-84). The retaining shaft is centrally placed in the hull overlying the keelson (Fig. 11), which measures close to 28cm wide at this point and displays what resembles a mortise for the mast step just aft of the pump. Beneath a light cover of small ballast stones and olive jar sherds a second layer comprising small lengths of planking, presumably decayed shaft shuttering, was encountered within the well (Figs. 81-82). The underlying sump was not exposed. To portside of the pump and keelson are two ceiling planks: the first (CP1) is 27cm wide and secured 25cm east of the keelson; the second (CP2) lies 25cm east of CP1 and is again 27cm wide (Figs. 87-89).

Wood-framed retaining shafts prevented pump sumps from becoming clogged by ballast stones and bilge debris and were typically constructed over one or two sumps leading into the bilge on either side of the mast step

(Waddell, 1985: 256). In light of Philip II's edict of 1552 that required new ships to have two pumps to improve safety at sea, the Tortugas ship would have been expected to have been built with a similar dual pump arrangement on either side of the mast step akin to the Emanuel Point wreck (Smith *et al.*, 1995: 28-30). This seems not to have been the case.

Structurally the Tortugas pump shaft closely resembles the Basque whaler *San Juan* lost in Red Bay, Canada, in 1565 (Waddell, 1985: 253), although two-thirds of this ship's retaining shaft was constructed to the side of the mast step. Three types of pumps were relied on between the 15th century and the early modern era: the burr pump system, which was based on a foot valve and spear from at least *c.* 1556 to the end of the 16th century; the common suction pump utilized from at least 1433 into the 19th century; and the chain pump. Of these, the Tortugas structure may have operated using the latter type of mechanism. Chain pumps rotated manually using a wheel, usually by foot, were first referred to by Sir Walter Raleigh as an improvement introduced into the English navy in the second half of the 16th century when pumps incorporated blocks of wood as valves to which rags were attached. This technology was commonly described in ship's treatises of the late 16th and 17th centuries as a chain full of burrs (wooden valves or disks) that rotated around a wheel and was considered the best type of pump because they discharged the most water (Oertling, 1984: 29, 32, 43-4, 75-7, 81-2, 73, 75-7, 81-2).

The possibility that the Tortugas mechanism operated using a chain pump is based on the excavation of a wooden disk 1.6m aft of the pump well (coordinates 80.22/27.26) that may be remains of a chain and valve assembly (Fig. 85). An adjacent horseshoe-shaped section of iron also resembles a type of sprocket that could have been embedded in a wooden drive wheel from a chain pump (Fig. 86). If this identification is correct, the Tortugas shipwreck's pump device would represent a particularly early archaeologically attested example, predating the parts from the Portuguese frigate *Santo Antonio de Tanna*, which sank off Mombassa in 1697 and is associated with a chain pump relying on horseshoe-shaped sprocket and s-shaped chain links (Oertling, 1984: 81, 83, 85).

Several sections of interconnected strakes, frames and ceiling planks were excavated on the Tortugas wreck. Some 6.3m forward of the sternpost (Figs. 90-91), the outermost exposed section of the starboard hull (coordinates 81.83/26.79) featured a strake and ceiling planking, both 6.2cm thick, and closely aligned frames with sided thicknesses of 14.1-15.6cm and molded heights of 10.3-13.1cm (from north to south). In many frames the outer surface

Fig. 68. The rudder broken to starboard alongside a possible spar or part of the ship's tiller.

Fig. 69. Detail of the surface rudder structure and possible spar/ship's tiller behind.

was left naturally rounded and thus retained 90º of the external curvature of a tree trunk/branch (Fig. 90).

At a distance of 4.8m forward of the sternpost (coordinates 82.74/27.59), the outermost exposed starboard section of hull featured a strake 5.2cm thick, 6.2cm thick ceiling planking and closely aligned frames of 15.0cm sided thickness and 10.3cm molded height spaced 2.2cm apart (Figs. 92-93). About 3m due north of the sternpost (coordinates 83.77/36.42), two planks lay interconnected, but otherwise disarticulated from the hull, and would seem to represent strakes with butt joints, each about 15cm wide and both covered with an unidentified coating of organic resinous waterproofing (Figs. 94-95). A similar sealant was observed on inner strake edges along the starboard stern (coordinates 83.47/29.08). Midship, and some 6.0m forward of the sternpost, two 25cm-wide ceiling planks were exposed.

Figs. 70-71. Detail of the badly decomposed rudder, collapsed to starboard immediately north of the sternpost (right), with one iron gudgeon in situ *(bottom left).*

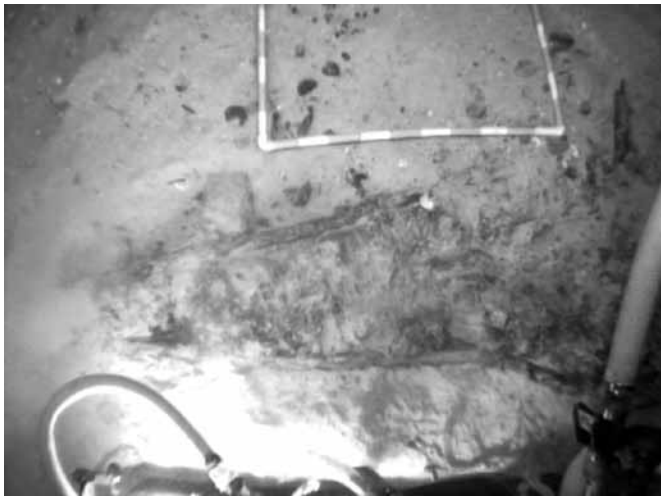


Fig. 72. Vertical view of the stempost area.

A section of the uppermost midship portside hull (coordinates 78.46/28.51) was excavated beneath ballast stones 6.0m forward of the sternpost comprising the uppermost two strakes, seven frames and one ceiling plank (Figs. 96-99). From south to north the central three frames are sided 18.8cm, 21.3cm and 18.8cm and molded 13.7cm and 13.1cm. Two tightly abut one another with less than 1cm space between (and a third frame to the east is similarly spaced). The two western frames are spaced 16.3cm and 15.0cm apart. This unequal framing pattern seems to be a misleading result of uneven preservation: the continuation of this section of hull to the east shows the end of an additional frame broken away at a lower elevation, but otherwise tightly set next to adjacent frames. The uppermost strake in this section of hull is 16.3cm wide and 6.6cm thick, while the ceiling plank is 23.6cm wide and 9.4cm thick.

7. Site Formation

In terms of overall site formation the Tortugas shipwreck is an interesting counterpoint to various wrecks of comparable date, nationality and geographical location. The closest parallels are ballast heaps within the shallow waters of Florida sealing in place substantial hull remains. Even though the Tortugas ship's artifact assemblages have been comprehensively swept to the sides of the central ballast mound, seemingly by shrimp trawler activities, the wreck's material culture is significantly better preserved than regional shallow-water sites.

The Emanuel Point I shipwreck in Pensacola Bay, the earliest shipwreck identified in Florida, represents the coherent remains of part of the fleet of Tristán de Luna, which arrived in Pensacola from Mexico in 1559. The wreck derives from a large vessel with a keel length of 23.6m estimated to have been 29.5m long with a beam of 9.5m, depth of hold of 4.5m and around 400 *toneladas* cargo capacity. The articulated hull extends across an area of 36m and includes the keel, keelson, stem, two gunport covers, as well as the well-preserved lower bow of the ship and a significant section of the collapsed starboard bow. Articulated floors and futtocks, partly covered with ceiling planking, run forward to the stem. A total of 17 athwart ship frames were noted in the lower bow, including seven floors and ten first futtocks. The collapsed starboard side contains the remains of 11 first futtocks and one second futtock. Planking continues uninterrupted on the starboard side for up to 16 strakes, while at least five strakes survive to port side.

Although the Emanuel Point I hull has been examined in far greater detail than the Tortugas site, with the stern protruding beyond the ballast, the white oak rudder collapsed immediately to starboard, and pump sumps preserved

in situ, both formations are strikingly similar. The Pensacola Bay site exemplifies the optimum level of preservation to be anticipated by any future excavation of the largely untouched Tortugas hull. The survival of the pump well and stump of the main mast *in situ* on the Tortugas site presents additional structural features for study that do not survive at Emanuel Point.

The excellent preservation of the hull dated to 1559 in just 3-4m depth has been explained by the site's shelter from storm waves, currents and erosion within a low saline bay, rather than in the open waters of the Gulf of Mexico. The ship seems to have been transformed into an artificial reef that for generations has attracted sea life, resulting in a densely packed layer of oyster shells that shielded and effectively 'capped' the site (Smith *et al.*, 1998: 1), unlike the Tortugas wreck left exposed to the impact of shrimping fleets.

Even though extensive and varied material culture was recovered from the earlier dated site, it is notably less numerous than on the Tortugas wreck, presumably explained by salvage and higher current dynamism. Sediments in and around the Emanuel Point I hull yielded a rich variety of plant remains and animal bones, stone, lead and iron ammunition, metallic galley wares and ceramics. The pottery assemblage, for instance, consists of 2,012 *botija* sherds, red to green-glazed El Morro ware (128 sherds), maiolica (59 sherds) and glazed redwares (Smith *et al.*, 1998: 119; Mullins, 1998: 136; Williams, 1998: 140). These are numerically far more restricted than the collection of at least 209 intact olive jars and rims (plus over one thousand sherds) and 2,304 kitchen and tableware rims, handles, bases and sherds, including 1,474 tin-glazed maiolica tablewares from Tortugas.

Lying at a depth of 6m on the edge of Hawk Channel, 3.2km off Marathon in the Florida Keys, the 'Mystery Wreck' comprises a comparable compact and consolidated mound of square-shaped cut igneous ballast stones, probably granite, overlying a coral reef. Exposed sections of the hull include stern timbers, the bow assembly and midship timbers. Stern timbers comprised the eroded sternpost, three closely spaced tail-frames and remains of both port and starboard garboard strakes. Remains of the bow include the forward end of the keel and two small, curved disarticulated bow frames.

Midship timbers represent the vessel's keelson, two floors, a rider, a fragment of ceiling plank and seemingly a small section of the pump-box. The ship's keel is approximately 19m long, while the ballast extends beyond the exposed ship remains across an area of 22 x 15m. This ship was possibly an *aviso* or dispatch vessel lost during the first half of the 17th century. The hull associated with this ballast

Figs. 73-75. The stempost area under excavation.

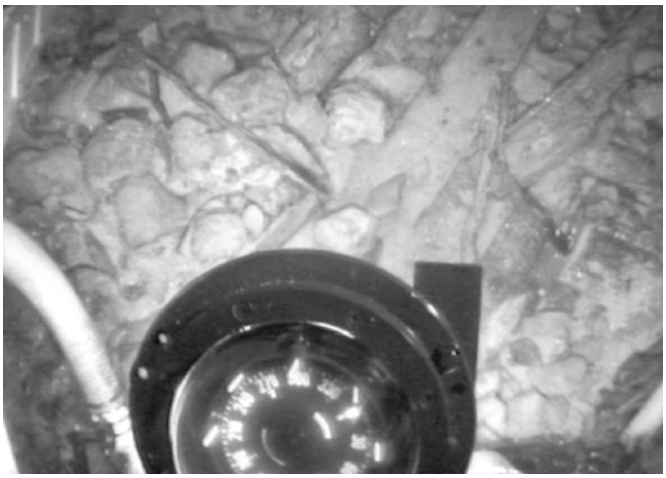


Fig. 76. Vertical view of the uppermost perimeter of the bilge pump well's wood-framed retaining shaft before excavation, overlying the keelson. Ceiling plank CP1 is visible immediately east of the pump box.

Fig. 77. Vertical view of the bilge pump well's wood-framed retaining shaft during excavation.

Fig. 78. Vertical view of broken olive jars embedded in the upper stratum of the bilge pump well's wood-framed retaining shaft.

Fig. 79. Side view of the bilge pump well's wood-framed retaining shaft before excavation.

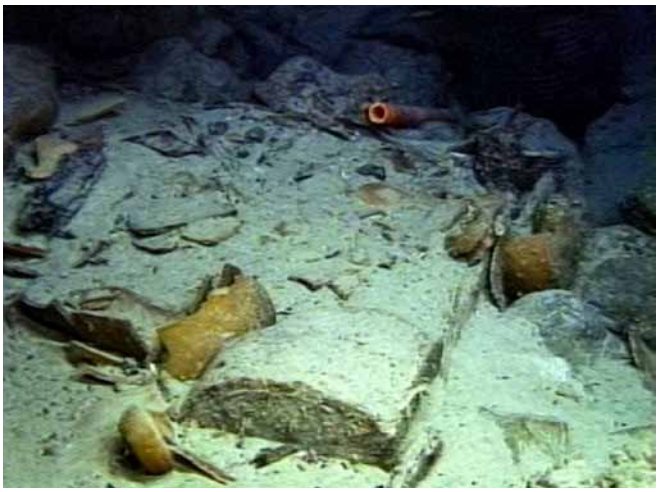


Fig. 80. The bilge pump well's wood-framed retaining shaft before excavation.

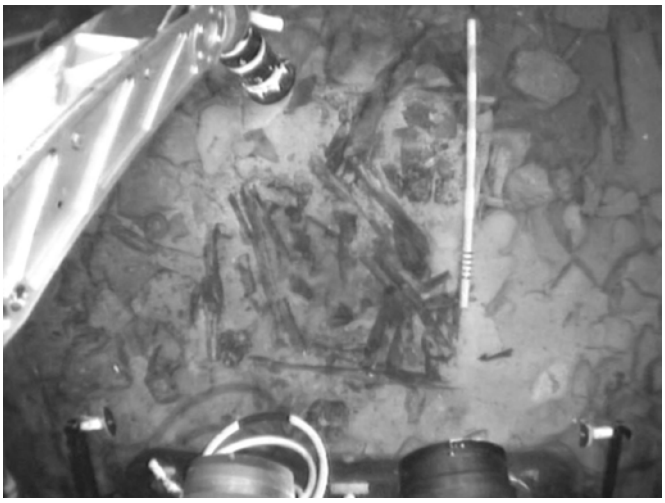


Fig. 81. Vertical view of thin plank sections, remains of shaft shuttering, in a second layer underlying the olive jar fragments within the bilge pump well's wood-framed retaining shaft.

Fig. 82. Detail of wooden shuttering beneath the olive jar fragments within the bilge pump well's retaining shaft.

Figs. 83-84 (top right and middle left). The double layer of side-edged planks used to build the bilge pump well's retaining shaft

Fig. 85. A wooden disk aft of the pump well, possibly remains of a chain and valve pump assembly.

Fig. 86. A horseshoe-shaped section of iron resembling a sprocket from a wooden chain pump drive wheel.

Fig. 87. The keelson and possible mast step assembly (left) with ceiling plank CP1 to the east.

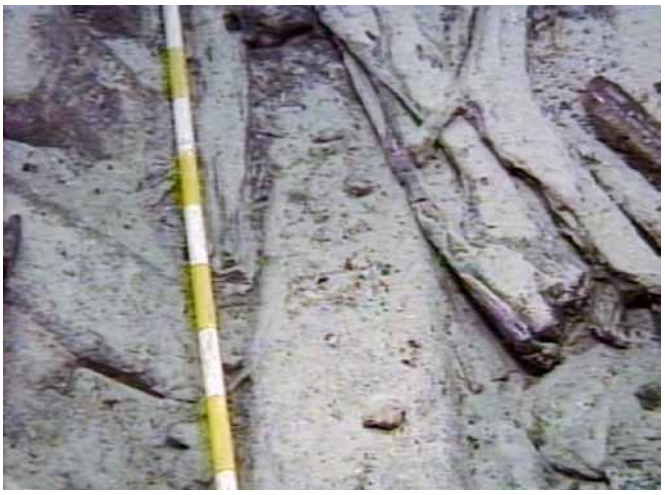


Fig. 88. The keelson towards the stern.

Fig. 89. Ceiling plank CP1 and CP2 east of the pump well.

Figs. 90-91. Section of a starboard strake, ceiling plank and frames 6.3m forward of the sternpost (coordinates 81.83/26.79).

mound is far less intact than at the Emanuel Point and Tortugas sites, and its ceramic assemblage contains just three olive jar necks and 90 potsherds, including four *botija* rims (McKinnon and Scott-Ireton, 2006; Smith *et al.*, 2006).

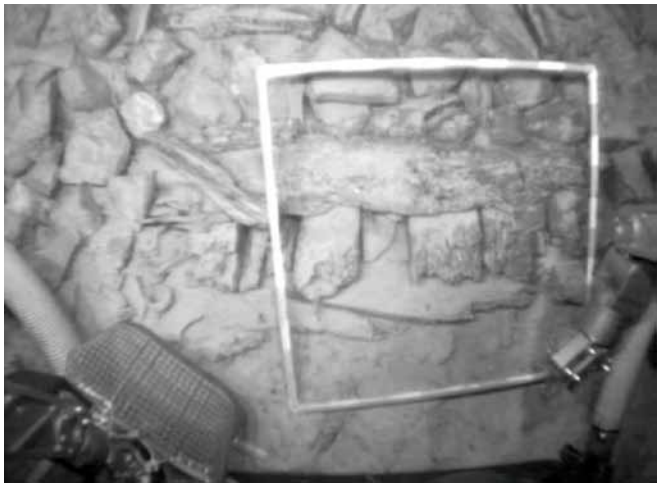
All three shipwrecks cited above reveal the importance of sealing layers for preserving underlying sand and mud inundated wooden hulls in anaerobic environments. With its notoriously thick and ever-shifting sands, the Florida Keys may be considered especially conducive to hull preservation, irrespective of date, exemplified by 324 76-85cm-long cement barrels with a minimum estimated weight of 644 tons that pinned down a 20m-long hull at Loggerhead Reef off the westernmost Dry Tortugas island. The 'Barrel Wreck' dates broadly to *c.* 1840-55 and is most probably the schooner *John Howell* burnt off the Dry Tortugas islands in 1847 (Gould and Conlin, 1999).

The 9m-long section of lower hull strakes and frames from the *Atocha*'s stern is a final example of hull remains well preserved by being sealed by a durable overload, in this case more than 30 wooden chests containing over 100,000 silver coins and 115 gold bars, 1,041 silver ingots, over 750 piece of silverware and 200 copper ingots (Mathewson, 1986: 106, 115). The combination of deep sediment cover and overlying material culture was also sufficient to preserve the ceramics to an equal level as the Tortugas collection (cf. Marken, 1994). Too little is known of the seemingly Spanish colonial site FOJE-UW-9 in shallow waters off the Fort Jefferson National Monument on the Tortugas Islands to compare preservation levels (Johnson, 1982).

While the hull of the 300-ton Spanish *San Martín* lost *c.* 1618 between Florida's Sebastian Inlet and Jupiter Inlet was well preserved in sand-inundated sediments (Moore and Muir, 1987), cargo did not survive. By contrast, the rocky seabed where the Spanish galleon *Nuestra Señora*

Figs. 92-93. Starboard strakes, ceiling planks and frames 4.8m forward of the sternpost (coordinates 82.74/27.59).

Figs. 94-95. Two planks 3m east of the sternpost (coordinates 83.77/36.42) coated with a resinous layer of waterproofing.



Figs. 96-97. A section of two strakes, seven frames and one ceiling plank along the portside hull, 6.0m forward of the sternpost (coordinates 78.46/28.51).

Figs. 98-99. A section of strake, frames and ceiling planking along the portside hull (coordinates 78.46/28.51).

de la Concepción sunk off Hispaniola in 1641 may not have facilitated the preservation of the hull, but significant non-contextual artifacts have been recovered (Borrell, 1983).

The study of the 367m-deep mid-19th century Jacksonville 'Blue China' shipwreck off Florida, where over three-quarters of the cargo had been destroyed, demonstrates the susceptibility of cargos such as on the Tortugas site to off-shore shrimp trawler impacts (Gerth *et al.*, 2011: 198-202).

8. Conclusion

The 'Tortugas Deep-sea A' shipwreck was the world's first archaeological excavation conducted solely using robotic technology. A Remotely-Operated Vehicle was custom-tooled with equipment suitable for sensitive archaeological excavation, recording and recovery methodologies. The combined package enabled 16,903 artifacts of widely varying medium to be examined comprehensively at a depth of 405m. The safe recovery of human teeth, 565 seeds and tiny pearls and beads testifies to the system's success.

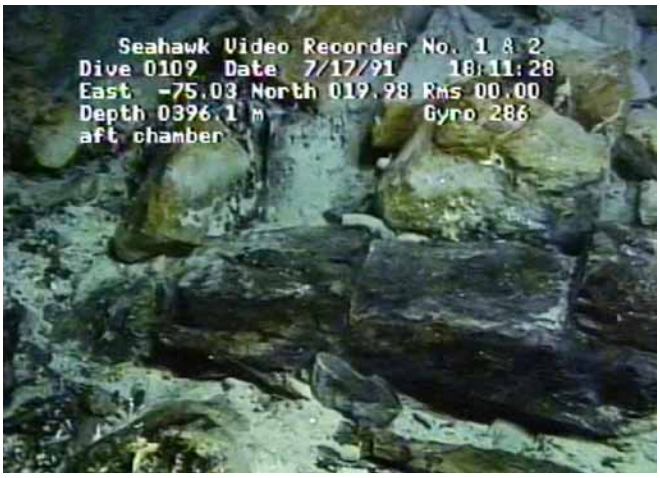
The site's formation was characterized by a central ballast mound contextualized with extensive material culture, although the majority of artifacts were not technically *in situ*. Some 75% of the finds were deposited outside the ballast mound's perimeter, with a strong emphasis to the west suggestive of the hull's collapse to starboard. The relocation of anchor A3 off the portside sternpost and an astrolabe plotted 16.4m south of the ballast edge further reflects significant post-depositional site interference. Since the Tortugas shipwreck first came to consciousness after artifacts were snagged in a trawler's nets, and because the region has been renowned as a focus of southern North America's shrimp fisheries since 1949, the site's integrity has undoubtedly witnessed multiple impacts.

Despite this anthropogenic disturbance the Tortugas wreck remained a continuous and coherent cultural entity with intact ceramic wares and considerable elements of its domestic assemblage preserved from olive jars to leather shoe fragments. The heavily gribbled planking condition is best explained not by marine boring activity, which even tunneled into the sandstone ballast, but by the stiff mud's less ideal wreck preservation capacity than sand-inundated environments.

The limited human remains suggest that the ship's company largely took its chances in the open sea at the time of sinking. The absence of the four iron cannon on the wreck's surface – historically documented for the *Buen Jesús y Nuestra Señora del Rosario* (Contratación 1172, N.2, R.1) – reflects the possibility that some shipboard objects may have been jettisoned. The ship's anchors on the seabed, however, are anomalous in this regard. The presence of a single hearth brick from the galley structure, and the lack of rigging, are additional notable anomalies.

The wreck's 17.4m keel length corresponds to the dimensions of a Spanish ship with a 30 *codos*-long keel and thus an overall breadth of 10 *codos* and a total length of around 36 *codos* (20.7m) and 106 tons (conversions based on Spanish *Ordenanzas* regulations for shipbuilding of 1618: Rodríguez Mendoza, 2008: 179, table 11; Fernández-González, 2009: 12). These dimensions, considered alongside the wreck's Venezuelan pearl cargo, ship magnitudes and outward-bound destinations of the historically attested 1622 Tierra Firma fleet, indicate that the most plausible identification for the wreck is the 117-ton *Buen Jesús y Nuestra Señora del Rosario. Contratación* 1172, N.2, R.1 specifies that this merchant vessel was built in Portugal, but it is believed to have been Spanish operated by its owner, Juan de la Torre (cf. Kingsley, 2012).

The presence seemingly of just one pump centrally overlying the keelson reinforces the non-Spanish characterization of the Tortugas ship. Following the 1608 *Ordenanzas*



Figs. 100-101. A stepped stanchion along the portside bow (coordinates 75.23/20.38).

Fig. 102. A deck stanchion in situ 4.6m forward of the sternpost (coordinates 80.97/27.73).

Fig. 103. A futtock under excavation.

regulations, Spanish ships involved in the Indies trade were legally bound to be constructed with two pumps, one functional and one spare. Accordingly, "The judge of la Casa will force every owner or master of Nao of the Armada or Fleet to take two pumps, one as a spare; if this rule is not followed, the ship cannot be dispatched" (*Ordenanzas* 1608, Libro IX, Título XXVIII, Ley 11). The presence of a single rather than dual pump system overlying the keel would not have been permissible for Spanish merchant vessels, but seemingly would have been acceptable for a Portuguese vessel built and included in the *flota* system when Portugal was annexed into the Spanish empire between 1581 and 1640.

The identification of both endposts, the rudder, bilge pump well and stanchions indicate that important structural features await future fieldwork. The survival of extensive artifact assemblages, unparalleled in volume on other early 17th-century Spanish sites, however, remains the most significant characteristic of the Tortugas shipwreck.

Notes

1. The significant volume of gold bars, silver coins and pearls discovered on the Tortugas shipwreck, coupled with Seahawk's status as a publicly-traded company, inevitably led to an abrupt rise in stock value and trading activity. In turn, in 1991 this attracted the attention of the US Securities and Exchange Commission (SEC). The Tortugas wreck was investigated based on false rumors that the site was a fabrication (the underwater photographs were considered too well lit to have been taken at a depth of 400m) and that the gold bars were modern forgeries. The federal trial began in October 1997 and in November the jury voted in favor of a complete vindication of Seahawk's directors.

In the meantime the company's directors had chosen to resign to safeguard its interests. The new directors went on to sell the entire collection and archive. In January 2004 both returned to the market place at an auction held in Beverly Hills, where Greg Stemm bought back all the surviving materials – including the artifacts and precious underwater video archive, the basis of the current scientific Tortugas publications – for Odyssey Marine Exploration. Some 8,501 Tortugas artifacts today remain in Odyssey's permanent collection in Tampa, Florida (cf. Vesilind, P.J., *Lost Gold of the Republic*, Shipwreck Heritage Press, Tampa, 2005: 87, 90, 93, 96, 221-22). The dispersal of archival material explains why some data required for the Tortugas reports is problematic (eg. hull description and plan, underwater still photographs).

2. This site has been classified as the 'Tortugas Deep-sea A' on the possibility that additional shipwrecks will be discovered in adjoining deep waters in the future.
3. See: http://www.epa.gov/gmpo/about/facts.html.
4. Shivlani, M., *Development of the Dry Tortugas Ecological Reserve: Characterization of the Commercial Fishery* (no date).
5. See: http://www.fishwatch.gov/seafood_profiles/species/shrimp/species_ pages/pink_shrimp.htm.
6. The coordinates cited in this report are localized on-site measurements based on the creation of an electronic recording grid, illustrated graphically on all distribution maps in this report.
7. The hull dimensions provided in this report are not derived from direct ROV measurements, which were not undertaken in 1990-91. Instead, they are based on imprecise measurements taken by comparing features to surveying scale rods set immediately next to planking. Analysis of the Tortugas hull, based on black and white vertical photomosaic imagery, is ongoing.

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