VALUE OF SHIPWRECK DATA IN DATABASES

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ABSTRACT

Shipwrecks are archaeological sites. This paper divulges details of the components of shipwreck sites in order to illuminate the value and extent of information possible. For the most part the Belitung Wreck is referenced throughout the text when available, otherwise other examples are incorporated to highlight the topic. Here is an introduction aimed at an audience unfamiliar with nautical archaeology terminology and methodology. Rather than suggest how to build a database for the purposes of data mining, this information will benefit projects, like McGill University's Indian Ocean World Center, intending to include shipwrecks as part of their dataset. Further, exemplars from other parts of the world where the analysis of shipwrecks has proven useful are included.

Abbreviations: IOW (Indian Ocean world), IOWC (Indian Ocean World Center), MCRI (Major Collaborative Research Initiative), OREP (Oxford Roman Economy Project).

INTRODUCTION

Shipwrecks are valuable sources towards understanding our human past. Details of Southeast Asia shipwrecks are summarized in order to point out what information shipwreck sites can provide, with a specific focus on the Belitung Wreck as an example of how any one shipwreck can contribute to multiple narratives towards multiple disciplines. This paper ultimately points out the importance of integrating maritime archaeology information into the developing Indian Ocean World Center (IOWC) database project. Information cross-correlation could help to address major questions in various fields of research such as past shipping activities, worldly affairs and global climate. This paper does not provide a how-to guide on the integration of shipwreck data into databases nor does it discuss the potential of doing so through data mining. Instead, it provides insight into what kind of information can be obtained from a shipwreck. It shows exemplars from other parts of the world where the interrogation of shipwreck data has proven useful.

Shipwreck data is a valuable source for research on the history of a region and its connectivity with global networks. Southeast Asia is a geographical nexus within the Indo-Pacific Region between both the Indian Ocean and Pacific Ocean networks; it constitutes the social, cultural and environmental edges of the far eastern end of the Indian Ocean and the far western end of the Pacific Ocean, thus to discuss maritime archaeology of Southeast Asia is to investigate the inter and intra-connectivity of the Indo-Pacific Region.

The Indian Ocean World (IOW) is an ocean-centered concept that connects people and environment across the massive seascape of its namesake with networks expanding out across the globe. The connectivity of this space could be largely contributed to shipping activity thus it is important to explore the many facets of shipwreck archaeology and explain the value of shipwreck data in the IOWC database. The extent to which shipwrecks can add value to an ocean-oriented project is provided through examples on the Mediterranean World. This is not necessarily to say that the theoretical framework for the Mediterranean World should be adopted in the IOW but it is an example of the extent shipwrecks provide value to multi-disciplinary databases.

INDIAN OCEAN WORLD CENTRE

The scope of the Indian Ocean World Center is the study of the Indian Ocean World between the early centuries BCE to modern times. The IOWC consists of nodes of focused research that contribute to wider questions of human-environment interaction. The geography of the research area is west to east from East Africa to eastern Southeast Asia, and north and south from China to Australia and/or the Red Sea to Madagascar. Its philosophy is established by the center's director Gwyn Campbell and aims to study the IOW from the region's autonomous things, people and environment; it is careful to not necessarily adopt the same explanations for shifts in the technology, infrastructure and socio-politics as they are understood in the Mediterranean and Atlantic, for example European slave ships in the Atlantic were purpose-built but this is not necessarily the case in the Indian Ocean and the labour, dockyards and ship dimensions should not be extrapolated from a different region's history to the IOW (Campbell 2015; 2014; 2013a; 2013b; 2013c; 2012).

The IOWC can be described as the epicenter for a Major Collaborative Research Initiative (MCRI) which entails over forty scholars and tens of students gathering information in their specialties on the natural and cultural interactions in IOW. The aim of the project is to investigate the rise and development of the world's first `global economy' from the early centuries B.C.E. to the present day. Its scope includes exchange of commodities and ideas and environment which may have helped to shape the exchange, such as cyclones, volcanic eruptions, monsoons, etc. The information is provided by a network of ten teams working in institutions across the globe on a range of topics, from the economy to the palaeo- and historic climate of the Indian Ocean or from Zheng He to the natural disasters in the Philippines and to the technical development of document analysis. The teams operate in an open door policy in which the work of one specialist can contribute to the gaps of someone else's work.

The significance of IOW research teams are the people and work generated within the MCRI network web. The project regularly organizes meetings, workshops and conferences in which scholars from very different specialties meet and share information within the teams and the broader network. Each team generates primary data on their specific node, the culmination is Big Data. In order for the whole network to have access to this Big Data, a database is being developed as a key deliverable to the MCRI. This sharing and centralization of data moves away from the island-researcher notion of subjective building of tables for data organization; and instead promotes objective record keeping, which supports the agency analysis of things, people and places. The latter point allows data to speak for itself instead of through the lens of one scholar's research question. The database aims to organize the data so that patterns can emerge across multiple specialties.

The issue of how to integrate shipwrecks in databases is being tackled as a key deliverable within the MCRI based at the IOWC, McGill University. The MCRI/IOWC Database information will be useful for statistical and comparison information. The outcomes could be displayed in multiple formats depending on the researchers' interpretation: diagrams, tables, maps, etc. At present, the MCRI/IOWC Database is hospitable for entering single archaeology site location and time; this could expand to include individual entries on artefacts, ship construction and maintenance, and the natural environment of the shipwreck sites.

MCRI/IOWC DATABASE

The concept and purpose of the MCRI/IOWC Database focuses on classification and cross-correlation of information; due to the amount of information being generated it is referred to in computer programming as Big Data. The Big Data is being organized through Bayesian Networks in a relational model database in order to enable queries that may shed some light on links and drivers of human-environment interaction. One of the main objectives of the project is to build the relational database in a manner that it is accessible to researchers for them to query, interpret, and integrate diagrams, tables, maps, and so on in their own work. The expectation of how it will work is as a cross-correlator between multidisciplinary data for interdisciplinary research questions. The current stage of the relational database is progressing due to a partnership with the McGill Geographic Center. Experts in Geographic Information Systems (GIS) software and webpage design are members of the MCRI and are developing the database output and a webpage for global data input.

At the current stage of development, the Big Data is composed of historical documents and modern-day anthropological interviews. The data generated by the various teams from these two disciplines in one database is advantageous because it invites queries entailing a *longue durée* framework over a large geographic area. The current development of the database is strong in supporting hypotheses from documentary sources and modern-day observations.

Up to now there is no perfect database system. The reason for this could be largely due to the lack of diversity in the subjects of the Big Data. Potentially, the IOWC database could be a good solution. The IOWC's MCRI is focused on an Indian *Ocean* landscape, with a body of water at the center; thus it is evident to include archaeological data from within the water that could contribute to hypotheses on the cause and effect of human-environment interaction. Other databases exist that include archaeology data and some of that data is from the water. Some databases also include archaeology from the IOW, but these are limited to terrestrial sites or only the geographic location and date of an underwater site. Although this paper does not aim to provide guidance on how to build a database, it is relevant here to mention other databases currently available as open sources and explain what other maritime databases have done thus far to include shipwreck data. For example, the *Maritime Buddhism* database within the Electronic Cultural Atlas Initiative network includes data of ports and other coastal sites with Buddhist artefacts (Blundell and Zerneke 2014); although the database seems to have had shipwreck data in the past (Brown 2004) this does not seem to be the current case (Yahja 2014). Another database, the *Shipwreck Asia* database includes details of shipwreck site locations and dates (Kimura 2015), but it does not include the details of what artefacts and features are in the sites (Kimura 2010). So if the MCRI/IOWC Database did include shipwreck sites, what kind of information would that bring to the project?

Perhaps it is worth reviewing how valuable shipwreck data has been to Mediterranean regional history, another sea-oriented network study. The Mediterranean region's history has evolved beyond unilinear approaches such as mono-directional trade patterns displayed on static maps and instead towards network models of connectivity (Leidwanger et al. 2013; 2015). The team in the Oxford Roman Economy Project (OREP) are testing hypotheses set out fifteen years ago (Horden and Purcell 2000) with data drawn from the Mediterranean Sea. The rich data of the Mediterranean from both land and sea archaeology excavations and within maritime and hinterland historical archives is adapted to socio-spatial networks. The results indicate certain periods of time correlate with changes in infrastructure, technology and resource extractions. For example, the graph of the mid-point date of 1,189 shipwrecks in A.J. Parker's catalogue (1992) displayed his proposal that a boom in the Roman economy occurred during fifth century BC to fifth century AD and especially within the second century BC. Two decades after Parker's publication the OREP published on their work which included Parker's data and five-hundred more shipwrecks graphed with the 'noise' of long date ranges removed (Wilson 2011). The results in Wilson's (2011) graphs show a different bell curve with the rise in economy in the first century AD with a swift drop in the second century AD. In fact the drop in the number of shipwrecks is regarded as significant after the first century CE just when the major port of Portus was built and evidence of export increase in African Red Slip ware are confirmed in terrestrial excavations (Wilson 2011: 35). The accumulation of data on shipwrecks and its interpretation in graphs broadly point out the "diminishing returns are not yet set in and the accumulation of more data continues to be worthwhile" (Wilson 2011: 34). The OREP is also capable of pointing out gaps in the data and hypothesize reasons why these exist, for example shipwrecks may be available for study along the North African coast where few underwater excavations have taken place (Wilson 2011: 35-36). Another example expounds on the directional changes of trade to the east and north of Crete after the volcanic eruption of Thera in 1500BCE (Leidwanger et al. 2015). These examples from the OREP on Mediterranean Big Data test longue durée spatio-temporal hypotheses with maritime archaeology data. As mentioned, the hypotheses being tested by the OREP were proposed fifteen years ago by Peregrine Horden and Nicholas Purcell (2000), their work re-evaluated Braudel's (1972) concepts, which he tested only on the sixteenth century, to a much longer time period from Classical antiquity to the modern era.

From the Mediterranean example above we know a shipwreck database works (Wilson 2011: 33-59). When querying a database that includes shipwrecks the results can provide graphs of higher or lower shipping activity based on the number and type of ships, it can indicate the supply and demand of cargo, cause and effect of coastal infrastructure on urbanisation and/or politics, global climate changes and impacts on marine animal ecosystems; the list goes on.

The IOW has similar studies of the past social and cultural paradigms with interpretations influenced strongly by Braudel (1972), such as Michael Pearson's *The Indian Ocean* (2003) and in Southeast Asia Anthony Reid's *Age of Commerce* (Reid 1988; 1994). Major *longue durée* hypotheses were developed in these studies and continue to orient research questions within the Indo-Pacific Region but neither of these volumes consider the archaeological evidence in equal measures to the historical evidence. Like in the Mediterranean World the Indian Ocean World has developed longue durée hypotheses (Pearson 2003; Reid 1988; 1994) based on activities largely centered on the seascape; further, like the Mediterranean the IOW has a dataset of shipwrecks which provide plenty of information to test economy-oriented hypotheses over a longue durée. So what kind of data do the shipwrecks in the IOW offer that can contribute to the MCRI/IOWC database?

The MCRI/IOWC database is a centralized multidisciplinary database which has the capacity to integrate evidence of social, culture and environment data from both land and water; thus, developing a thoroughly holistic approach. The current working structure of the MCRI/IOWC database requires each entry to include three important details so it can cross-correlate time and space, each entry must have a date and a geographic location narrowed to latitude and longitude. The historic sources are scoured for references to dates and locations of specific events in the past. Shipwreck sites have the same capacity to provide to the database data on the location and dates of artefacts, features and context. In order to appreciate the significance of what this data could have on IOW outputs it is relevant to explain what data can be generated from shipwreck archaeological sites.

SHIPWRECK VALUE FOR DATABASES

Similar to a house or settlement, shipwrecks are remains of a place where humans conducted social, cultural and political acts with culturally-imbued objects. Entire seascapes can be created from the remains of shipwreck (Adams 2001). Christer Westerdahl (1992; 2002) proposes a very strong framework where both land and sea constitute the "-scape", the maritime cultural landscape. How this differs from conventional landscape archaeology is all in the perspective, maritime cultural landscapes start from the perspective of the water and interprets materials from that angle. In the Braudelian interpretations mentioned above Michael Pearson's (2003) *The Indian Ocean* is a historian's exercise in interpreting the maritime cultural landscape of the Indian Ocean. Below I espouse a similar exercise to Pearson (2013) and share how a shipwreck could be used in the same way as a historical document to draw connection between activities at sea and on land. I do so with the primary example of the Belitung wreck, a 9th century shipwreck hypothesized to have origins in the Arabian Sea Region and archaeologically excavated off the island of Belitung to the east of Sumatra, Indonesia. So, using this example, what is the maritime cultural landscape of the Belitung wreck? How could this example of underwater archaeology in Southeast Asia contribute to a Social/Natural Science and Humanities database on the Indian Ocean?

Hull Design

The design of ship's hull with the intention for transport of economic goods is constructed for two purposes: 1) integrity of the ship, and 2) maximum cargo (Steffy 1994:8-10). The integrity of the design had to transport objects and people while withstanding violent marine environments, depending what area the ship moved over was a major contributing factor to how a ship was built.

For example, if a ship was to move over sheltered waters and short distances then the hull could be shaped to a maximum capacity design – that of a rectangular parallelepiped or cuboid, as is the case with barges; therefore the rectangular center of a ship is its profit area and the rest of the area to the ends and sides is overhead (Steffy 1994: 10). Whereas in order to operate in (stormy) open waters the ship had to entail some elements of design such as curved sides and pointed bow that may not have suited the cost-benefit ratio but did get the transport mechanism, the ship, safely from one location to another (Steffy 1994: 10). An example of seafaring capacities is the *Jewel of Muscat*, a reconstruction of the Belitung Wreck. In order to calculate the correct dimensions for the reconstruction the archaeological site plan and archaeologist were consulted along with information derived from contemporary archaeological ship's timbers, the bow of the ship was not intact and exact dimensions were calculated based on available information of the interior structure (Belfioretti and Vosmer 2010: 116; Burningham 2011; Vosmer et al. 2011).

Hull shape is important in seafaring/sailing capacities and cargo transportation. In a database the data on the hull of the ship can note the technology of shipbuilding and highlight information on wood species, tools required for shipbuilding, and ship maintenance in shipyards (Adams 2001). Anthropology specialists in ship construction, often ethnographers but some iconographers, are working in a positivist manner on gathering more specific data so that we move away from boat-type categorization and instead towards agency of ship components (Maarleveld 1995; McGrail 2001; 2004). This is especially important in terms of fastenings (McCarthy 2005; McGrail 2004).

Fastenings

Fastenings are the small thing that connects or fastens two different parts of a ship (i.e. one plank to another). They are cultural constructs and highly indicative of where and by whom a ship was built. Consequently, fastenings can narrow survey areas for past locations of shipbuilding and maintenance. In a database if the detail of a fastening is included then there is strong potential for correlation of ship construction technique to cultural group and therefore location of shipbuilding.

The Belitung Wreck is of a fastening tradition in which the planks of the ships were sewn together with plant fiber twine (Nicholas Burningham, pers. comm., February 2015; Flecker 2000; Jackson 2012; Eric Staples, pers. Comm., February 2015). Although the initial publication state the vessel was stitched (Flecker 2000), the drawings of the wreck's fastenings were indeed sewn (Flecker 2000: 207, Figure 14). Sewn plank construction fastens a plank to another plank with continuous, connected stitches in a crossover X style (see Figure 1). Sewn ships are identified as a tradition based on ethnographic and iconographic evidence in the Middle East and western India (Agius 2002; 2008; Blue and Staples 2015; Vosmer 1992). Sewn planks are of the Arabian Sea Region, a regionally identifiable ship construction technique, and are separate from that of stitched planks which are of the Southeast Asia Region (Mangiun 2013; see Figures 1 and 2). Stitched planks are a tradition ascribed to Southeast Asian manufacture based on archaeological evidence of twine in shipwrecks. Stitching fastens a plank to another plank by individual stitches with one discrete vertical line rather than continuous sewing (see Figure 2).

Figure 1: Picture of shipwreck planks sewn together.

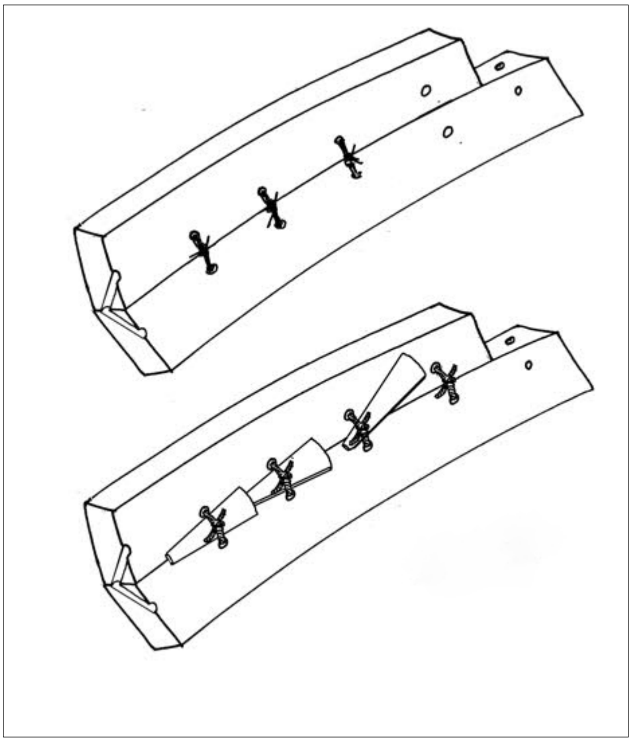

Figure 2: Drawing of ship planks stitched together. (courtesy of N. Burningham).

The Belitung Wreck was fastened by sewing and does not include any nails; however, nails are another defining fastening for ship construction technique. Chinese boatbuilding tradition includes bulkheads and metal nail fasteners, whereas Southeast Asian boat-building tradition includes fasteners of wooden treenails or dowels. *South-China-Sea Tradition* hybrids are a combination ascribed to ships' fastenings and building sequences that combine both Chinese and Southeast Asian traditions (Flecker 2007; Manguin 1984). Here is it useful to bring in multiple other shipwreck examples from the Southeast Asia Region to highlight the discussion on *South-China-Sea Tradition* hybrids. *South-China-Sea Tradition* shipwrecks can include evidence on a sliding scale between the two traditions of Chinese and Southeast Asian (Manguin 1984), for example, the hull of the Ko Khram and Phu Quoc II shipwrecks have dowels, metal nails and bulkheads so these are hybrid but more towards the Chinese end of the sliding scale; whereas the Longquan and Nanyang wrecks both have treenails so these are examples of hybrid vessels resembling the Southeast Asian tradition of the sliding scale (Brown 2009; Flecker 2007; Kimura 2010; Kimura 2015; McGrail 2001; Orillaneda 2008; Orillaneda and Ronquillo 2011).

Wood Species and Dating

A shipwreck is not just a pile of timbers but indeed they are timbers. Wood species contribute to seascape/landscape studies with identifying logging areas, shipbuilding centers and possible trade patterns in timber. Aside from the knowledge to be gained of the past, wood species identification can narrow survey locations for archaeologists of shipbuilding activities and contribute to conservationists' research in landscape management practices.

In the Belitung Wreck the major elements of construction such as the keelson, planks and futtocks are identified as multiple species of woods largely sourced from Africa. Recalling that Arabian Sea peoples tradition is to sew a ship's timbers together, the twine which held the ship together was originally identified as hemp from the Caucasus and expected to have been an import to the Middle East long before the 9th century date of this shipwreck (Flecker 2008: 386). Later, specialist-analysis identified the twine as hibiscus (a plant found in Southeast Asia but not in East Africa or the Middle East); the wadding between the fastening-twine and the wooden planks is *Melaleuca* a plant sourced from Indonesia (Nicolas Burningham pers. comm. in Flecker 2008: 386). So, although the main component of the vessel, the planks, are associated with African trees and were cut and shaped according to Arabian Sea Region ship construction traditions the vessel may have undergone major maintenance in Indonesia when the chalking was partially replaced and tightened with Indonesian plant fibers (Flecker 2008:386; Vosmer et al. 2011).

Tools Required for Shipbuilding and Ship Maintenance

Dockyards in specific geographic areas can be associated with shipwrecks based on the tools required for shipbuilding and ship maintenance that are found on-board the shipwreck, these are present due to adjustments or general repairs of the ship made while sailing.

Where ship building/maintenance occurred can be inferred from fastening types and timber species. For example, the Belitung Wreck, originally an Arabian Sea peoples' construction and found off the coast of Indonesia, showed signs of maintenance work in Indonesia (Flecker 2008). From these observations maritime archaeologists deduced the possible explanation that the ship had originally arrived from the Arabian Sea area, sailed to China (based on one type of cargo) and wrecked off Indonesia. Prior to the wrecking, while it sailed in Southeast Asia the ship went through normal maintenance over the course of a long voyage and required some local maintenance on the hull in order to continue.

If we could gather all the data about all the ships' hulls that had repairs it may give us hints about who could conduct repairs and where in the Southeast Asia Region. It also shows the importance of certain locations strategically located on maritime routes, where ships from all nations would stop to refit or careen. In a database this information from shipwrecks would contribute to locate these important international centres for ship maintenance and trade goods exchange.

Cargo

Cargos, like ships' hulls, have a story that starts with production, travel and ends with use and deposition. Studies of cargo in Southeast Asia is largely centered on ceramics (Van Tilburg et al. 2014: Session 8; Brown 2004; 2009), whereas other artefact studies are rare but growing (i.e. Craig in-prep, Fahy in-prep, Orillaneda in-prep). Ceramics from shipwrecks have contributed to ceramics dating and market shift hypotheses. Ceramic cargo on the Belitung shipwreck are used to support the hypothesis that the sailors conducted a unilinear west to east and return direction sail which started from the Arabian Sea Region to China, where they picked up ceramic cargo, and left to return to their home-port but stopped into conveniently-located Indonesia (in-terms of geography and hospitable ports for gathering supplies), where they later wrecked (Flecker 2008). This hypothesis is based largely on the ceramic cargo, ship's hull and the location of the shipwreck. If the rest of the Belitung cargo were considered as closely as the ceramic cargo would the hypothesis remain the same or would a different, and perhaps larger, network of connectivity come to light? Metal coins, for example, are now being considered along with contemporary historic documents on the monetary system of China, Japan and Korea. Angela Schottenhammer (2015) points out the evidence of bronze coins from the Belitung, Intan and Cirebon shipwrecks align with comments on money in documents from the Imperial courts of China, Japan and Korea. Why would a 9th century ship bring back to the Arabian Sea money from China, Japan or Korea? A further example is the Santa Cruz, a 15th century shipwreck off the coast of the Philippines being reconsidered by Bobby Orillaneda. Orillaneda initially developed hypotheses of the ship's trade route with the ceramics cargo in his masters (Orillaneda, pers. comm., November 2010), for his doctorate he is returning to the wreck and investigating the site as a whole with multiple different types of cargo which is testing the original hypothesis of the trade route, not only in its direction but the entire validity of mono-directional trade route hypotheses. This type of work requires in-depth analyses of multiple artifacts to be conducted and the results of the entire assemblage analyzed as a whole; however, few studies are available on cargo aside from ceramics. In the case of the Santa Cruz there are two other studies which can contribute to Orillaneda's study, that of Brian Fahy's work on metals and organics and the author's own work on stone and glass beads. The separate cargo studies are already showing different patterns of exchange then when the trade route hypothesis was based solely on ceramics.

If in a database we could have the detailed inventory of cargo composition as separate entries of different types of cargo we could trace the journey of particular objects through time and space and develop new hypotheses on patterns of the distribution of artefacts.

Environment of Shipwreck Site

Archaeology can contribute to environment studies; it can reconstruct climate and past environments therefore connecting causation between human-environment interactions. Shipwreck site formation processes can extrapolate data on marine life, water currents, air currents, seasonality of weather and animal migrations, sedimentology of the seabed, bathymetry, salinization, temperature, coastal erosion-stabilization, etc. (see the example of the *Liberty* shipwreck in Ridwan this volume). On the one hand, this information can contribute to the macro scale of climatology studies. For example, the water temperature and sedimentology are datasets useful to geological oceanography and ultimately research in global warming. On the other hand, shipwreck deposits can contribute to micro-scale analysis. In archaeological studies of shipwreck sites the shipworm is the main macro-organism investigated to explain micro-organism migrations and changes. Wood borers inside shipwreck timbers, such as the teredo navalis, can indicate the salinity, temperature, and pollution of surrounding waters (Garrison 2004; Palma and Santhakumaran 2015). This information can contribute to local knowledge on marine resource health, oceanography, and marine biology which in turn informs climatologists of shifts in micro-organism migrations either vertically in the water column or horizontally across oceans, an example of which is eutrophication (Chislock et al. 2013) the nutrient saturation of water in which phytoplankton cannot live causing multiple knock-on effects such as warming of the oceans and ecosystem alterations (National Research Council 2005a; 2005b; Marker 2007). The possibilities and reliability of qualitative and quantitative studies on natural factors in shipwreck sites is often focused on studies of water currents and scouring (digging-out), such is the case off East Africa (Breen et al. 2001; Breen and Lane 2004; Quinn et al. 2007).

In a database, it would be interesting to have detailed entries on shipwreck site environments. That information could be extracted from site excavation reports to regroup data about the different types of environment and contribute to information directly on micro-organisms and ultimately climate variations.

CONCLUSION

This paper illustrated the breadth and depth of information that can be gathered from shipwreck sites. Databases that include details of shipwreck sites will include information not available in other databases. If shipwrecks are included in the IOWC database, the information can feed into what the larger database is aiming at: global economy and climatology studies. Shipwrecks provide information of shipbuilding traditions, the types of artefacts available on site and how cargo and environment studies can contribute to trade route hypotheses. Specialists in maritime archaeology can investigate shipwreck sites to provide data that can contribute to the sciences and humanities. This paper builds towards future work on how to integrate shipwreck data into the IOWC Database. Shipwrecks in Southeast Asia have illustrated the amount and diversity of information. This is contextualized within a wider ongoing database project at McGill University's Indian Ocean World Centre.

From the example of Parker's shipwreck database in the Oxford Roman Economy Project we have concrete evidence that the inclusion of shipwrecks in a multidisciplinary project can indicate major impacts and shifts in the Mediterranean Sea (Wilson 2011). In the Indian Ocean World most known shipwrecks are in the Southeast Asia Region, starting with shipwreck input from this region and expanding it across the Indian Ocean World to East Africa could contribute to studies on major migrations and ecosystem fluctuations, the output of which can help us to better understand human environment interaction.

The culmination of all this information on the Belitung Wreck points out shipwrecks are not just piles of timber and the value of shipwreck data in a database. The ship's hull was discussed in terms of its sewn fastenings that indicate the ship construction technique originated from the Arabian Sea Region. A unilinear methodology was originally applied to the cargo's ceramics which were used to explain the directionality of the ship as from the western Indian Ocean and its main destination having been China before it was on its return journey. When later organic species analysis was conducted on the twine of the sewing and the wadding between the twine and planks a secondary hypothesis was proposed that the Belitung Wreck had stopped for hull repairs in Indonesia, where it later wrecked. Maritime archaeologists can and are returning to shipwreck sites to re-evaluate the site as a whole, including multiple artefacts in their analyses instead of a focus on one type of artefact to explain trade routes; this developing multilinear analysis of cargo has opened shipwreck sites to new developments in Big Data database outputs on network connectivity. Although not developed in this paper, there are many other aspects of a shipwreck that would be interesting if set into a database, such as decorations which hint at symbols and rituals and folklore, or weapons which may indicate allies, etc.

ACKNOWLEDGEMENTS

I sincerely appreciate and send thanks to Brendan Gillon and Gwyn Campbell, my mentors in the MCRI/IOWC Social Science and Humanities Research Council of Canada, IPPA 2014 conference organizing committee, Charlotte Pham and Veronica Walker-Vadillo for continued enthusiasm and help with the many drafts of this article, Maritime Oman team and for continued invitations since 2012 to stimulating formal and informal events on Arabian ship construction techniques, Nicholas Burningham for many discussions on ships, and the JIPA editor and reviewers for your kind contributions to this work.

REFERENCES

Adams, Jonathan. 2001. "Ships and boats as archaeological source material." *World Archaeology* 32 (3):292-310. doi: 10.1080/00438240120048644.

Agius, Dionisius A. 2002. *In the Wake of the Dhow: The Arabian Gulf and Oman*: Garnet-Ithaca Press.

Agius, Dionisius A. 2008. *Classic Ships of Islam: From Mesopotamia to the Indian Ocean*. Leiden: Brill.

Blue, Lucy K. and Eric Staples. 2015. "Sewn-plank Boat Workshop." GU Tech, Muscat, Oman, February 14th to 16th.

Blundell, David and Jeanette Zerneke. 2014. "Electronic Cultural Atlas Initiave: Early Austronesian Historian Voyaging in Monsoon Asia: Heritage and Knowledge for Museum Displays Utilizing Text, Archaeology, Digital Interactive Components, and GIS Approaches." *International Journal of Humanities and Arts Computing* (8):237-252.

Braudel, Fernand. 1972. *The Mediterranean and the Mediterranean world in the age of Philip II*. London: Collins.

Breen, Colin, Wes Forsythe, Paul Lane, Tom McErlean, Rosemary McConkey, Athman Lali Omar, Rory Quinn, and Brian Williams. 2001. "Ulster and the Indian Ocean? Recent maritime archaeological research on the East African coast." *Antiquity* 75 (290):797-798. doi: doi:10.1017/S0003598X00089304.

Breen, Colin, and Paul Lane. 2004. "Archaeological approaches to East Africa's changing seascapes." *World Archaeology* 35 (3):469-489. doi: 10.1080/0043824042000185838.

Brown, Roxanna. 2004. "History of Shipwreck Excavation in Southeast Asia." In *The Belitung Wreck: Sunken Treasures from Tang China*, edited by Seabed Explorations New Zealand Ltd.

Brown, Roxanne. 2009. *Ming Gap and Shipwreck Ceramics in Southeast Asia: Towards a Chronology of Thai Trade Ware*. Bangkok: River Books Press Dist A C.

Campbell, Gwyn. 2012. "Keynote Opening Speech." The Dimensions of the Indian Ocean World Past: Sources and Opportunitues for interdisciplinary work in Indian Ocean World History, 9th -19th Centuries, Western Australia Museum, Fremantle, November 12th-14th.

Campbell, Gwyn. 2013a. "Africa in the Indian Ocean world in the first millennium CE." Proto-globalisation in the Indian Ocean world, University of Oxford, Oxford, UK, November 7th-9th.

Campbell, Gwyn. 2013b. "The Historical Debate over the Origins of the Malagasy." East Africa and Early Trans-Indian Ocean World Interchange, McGill University, Montreal, Canada, November 21st-22nd.

Campbell, Gwyn. 2013c. "Keynote Speech." The European Impact on the Indian Ocean World, McGill University, Montreal, Canada, September 9th-10th.

Campbell, Gwyn. 2014. "Keynote Opening Speech." Trade in Animals and Animal Products in the Indian Ocean World from early times to c.1900, McGill University, Montreal, Canada, October 23rd-24th.

Campbell, Gwyn. 2015. "Welcome Address." Currencies of Commerce in the Greater Indian Ocean World, McGill University, Montreal, Canada, April 23rd-24th.

Chislock, M. F., Doster, E., Zitomer, R. A. & Wilson, A. E. 2013. "Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems." *Nature Education Knowledge* 4 (4):10.

Conway-Jones, Hugh. 2006. "Purton Barge Graveyard." Accessed June 30th. http://www.gloucesterdocks.me.uk/canal/graveyard.htm.

Craig, Jennifer. In-prep. Doctoral Thesis on maritime archaeology perspectives of Southeast Asia human-environment interactions. Anthropology Department, McGill University.

Fahy, Brian. In-prep. Doctoral Thesis "Holistic Shipwreck Narratives in 14th and 15th Century Southeast Asia", Oxford Centre for Maritime Archaeology, University of Oxford.

Flecker, Michael. 2000. "A 9th-century Arab or Indian shipwreck in Indonesian waters." *International Journal of Nautical Archaeology* 29 (2):199-217. doi: 10.1111/j.1095-9270.2000.tb01452.x.

Flecker, Michael. 2008. "A 9th-century Arab or Indian shipwreck in Indonesian Waters: Addendum." *International Journal of Nautical Archaeology* 37 (2):384-386. doi: 10.1111/j.1095-9270.2008.00193.x.

Goddio, Franck. 2007. *Topography and Excavation of Heracleion-Thonis and East Canopus (1996-2006): Underwater Archaeology in the Canopic region in Egypt*, *OCMA Monograph*. Oxford: Oxford Centre for Maritime Archaeology.

Jackson, Robert. 2012. "Photo Logs: Construction." Accessed July 17th. http://www.jewelofmuscat.tv/image/tid/9.

Maarleveld, Thijs J. 1995. "Type or technique. Some thoughts on boat and ship finds as indicative of cultural traditions." *International Journal of Nautical Archaeology* 24 (1):3-7. doi: 10.1111/j.1095-9270.1995.tb00706.x.

Manguin, Pierre Yves. 2013. "Early Shipbuilding and trans-Indian Ocean Voyages." East Africa and Early Trans-Indian Ocean World Interchange, McGill University, Montreal, Canada, November 21st.

McCarthy, Mike. 2005. "Ships' fastenings from sewn boat to steamship."

McGrail, Sean. 2001. *Boats of the world: from the Stone Age to medieval times*. Oxford: Oxford University Press.

McGrail, Sean. 2004. *Boats of the world: from the Stone Age to medieval times*. Oxford: Oxford University Press.

Muckelroy, Keith. 1978. *Maritime archaeology*. Cambridge; New York: Cambridge University Press.

Orillaneda, Bobby. In-prep. Doctoral Thesis “The Santa Cruz shipwreck: a 15th century Southeast Asian trade vessel”, Oxford Centre for Maritime Archaeology, University of Oxford.

Orillaneda, Bobby and Wilfredo Ronquillo. 2011. Protecting and Preserving the Underwater Cultural Heritage in the Philippines: A Background Paper”, in *Proccedings of Asia Pacific Regional Conference on Underwater Cultural Heritage* (eds) Staniforth, Mark, Jennifer Craig, Bobby Orillaneda, Gay Lacsina, Rey. National Museum of the Philippines, Manila.

Palma, P. and L.N. Santhakumaran. 2014. *Shipwrecks and Global 'Worming'*. Oxford: Archaeopress.

Parker, A. J. 1992. *Ancient shipwrecks of the Mediterranean & the Roman provinces*. Oxford: Tempus Reparatum.

Patience, Kevin. 2006. *Shipwrecks and Salvage on the East African Coast*. Bahrain: Dar Akhbar Al Khaleej.

Pearson, M. N. 2003. *The Indian Ocean*. London; New York: Routledge.

Robinson, Damian. 2013. "Heracleion in context: The maritime economy of the Egyptian Late Period." Queen's College, University of Oxford, March 15th-17th.

Schottenhammer, Angela. 2015. "Bronze Coins and Silver Ingots: The Major Currencies across the East Asian Mediterranean." Currencies of Commerce in the Greater Indian Ocean World, McGill University, Montreal, Canada, April 23rd.

Van Tilburg, Hans, Sila Tripati, Veronica Walker-Vadillo, Brian Fahy, Jun Kimura. 2014. "Proceedings of the 2014 Asia-Pacific Regional Conference on Underwater Cultural Heritage." Vol 1: Sessions 1-7; Vol 2: Sessions 8-15. Electrical Pencil: Honolulu, Hawaii.

Wilson, Andrew. 2011. "Developments in Mediterranean shipping nd maritime trade from the Hellenistic period to AD 1000." In *Maritime Archaeology and Ancient Trade in the Mediterranean*, edited by Damian and Andrew Wilson Robinson, 33-59. Oxford: Oxford Centre for Maritime Archaeolgy.

Yahja, Alex. 2014. "Maritime Buddism Shipwreck Exploration: A Prospect with Robotics and GIS." Buddhist Culture and Technology: New Strategies for Study, Papers from the Maritime Buddhism Workshop held in conjunction with the United Nations Day of Vesak Celebrations.