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REVIEW ARTICLE

Traditional Shipbuilding Communities: An Urgent and Neglected Research Topic in Maritime Anthropology

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Abstract
Equating maritime anthropology to the ethnography of fishing communities has driven researchers to neglect certain subjects (and objects) such as traditional shipbuilding communities. It has also limited the array of sources of information. Few anthropological studies have focused on traditional boat building, while these practices are heading toward extinction, given the wide distribution, increasing reliability, and decreasing prices of synthetic materials for ship and boat construction. While fiberglass boats are replacing wooden vessels, many artisan shipbuilding traditions around the world have managed to survive, but most of them have remained in the shadows. This paper provides a seminal state of the art and points out sources of information to solve questions on traditional shipbuilding. It attempts to propose a methodology based in a set of questions that anthropologists should ask when recording traditional shipbuilding practices. We argue that the information gathered by following the set of questions is valuable for its own sake in order to maintain vanishing maritime traditions, but the surviving ethnographical record is also priceless as it is the only way to fill gaps in the archaeological and historical record. Finally, it contains a short reflection on the difficulties of building a typology of traditionally built vessels.

Keywords Boat · Ship · Raft · Dugout · Canoe · Float · Shipwright · Shipyard · Ethnography

Doce sombras, ahora viejas ya no reman,

ya no cruje el maderamen en el agua,
solo quedan los recuerdos en la arena
donde yace dormitando la piragua
José Barros (1969)

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Introduction

Maritime anthropology has "fundamentally been centered in the study of men and women dedicated to fishing, their reality and problematic, a tendency that only changed recently, when anthropologists turned their view toward other maritime life modes" (Rubio-Ardanaz 2007, 9).

In *Models of Social Organization*, Frederick Barth (1966) touched tangentially on the fishing labor, techniques, and performance. However, the first comprehensive attempt to build an anthropological account of how communities organize for fishing was made by Firth (1975). In archaeology, a major contribution was made by Cleyet-Merle (1990) with his book *La prehistoirepréhistoire de la pêche*. Shortly after, the concept of maritime anthropology was coined, but there is still no agreement on what it encompasses (Rispoli 2006, 1). Casteel and Quimby (1975) asserted that maritime anthropology goes beyond social/cultural anthropology and includes research in the fields of physical anthropology and archaeology, while Acheson (1981) and Pascual Fernandez (1991) consider maritime anthropology equivalent to the anthropology of fishing communities. More recently, maritime anthropology has been promoted by some states seeking fishing sustainability, and thus, its applied component, beyond reports and papers, has resulted in management strategies (Breton 1981, 1991).

Equating maritime anthropology to the ethnography of fishing communities, however, neglects potential research subjects (and objects) of maritime anthropology, such as traditional shipbuilding communities. It also limits the array of sources of information by disregarding archaeological materials and old written documents. Despite the growing interest in the anthropology of fishing, very few anthropological studies have focused on traditional boat building, which should become a major concern within maritime anthropology, as fiberglass boats are rapidly replacing traditional wooden vessels. Moreover, as asserted by Carabias (2000, 32) traditional boats and ships might seem to be a randomly chosen topic; however, the subject is paramount as it is close related to the structure and functioning of maritime, coastal, lacustrine and riverine societies, their subsistence strategies, sociopolitical organization, technology, trade and exchange systems, movement patterns, territoriality (*maritoriality*), and symbolic dimension, among others.

In his foreword to Horridge's (1982, v) monograph, Sean McGrail explains there are few indigenous records documenting the use and construction of boats in Southeast Asia before their contact with the European explorers. He adds that archaeological and critical studies have just recently started to reveal new information. This situation is definitively not unique to the boat building tradition of Southeast Asia. Most artisan shipbuilding traditions around the world have remained in the shadows and demand further anthropological research, but very few attempts have been made in regard to this.

Barandiarán (1994) built a guide for ethnographic interviews among maritime communities, which has been followed since then by many Spanish-speaking scholars. The guide includes eleven questions addressing the normative system, the structures, and functions characterizing the way of life in fishing communities. With a similar aim (1982, 1996, 2015), this paper attempts to propose methodology, encompassing a set of questions that should be the lowest common denominator when researchers are recording traditional shipbuilding practices and reporting on the communities that built them. Although it is seminal, it provides a review of the state of the art and points out some potential sources of information where some answers to the questions on traditional

shipbuilding can be found. It finally makes a short reflection on the difficulties of building a typology of traditionally built vessels.

It must be clarified that this paper is not an attempt to create a methodology to record ships, ship timbers, or ship construction, as this was already published in 1993 when Paul Lipke, Peter Spectre, and Benjamin Fuller edited an excellent book titled *Boats, A Manual for their Documentation*, that proposes a complete methodology to record vessels' shape, construction features, and cultural environment. This methodology is divided into six main tasks:

1. Basic description and dimensions;
2. Photographs, sketches, delineations, and basic drawings;
3. Accurate drawings of shape and construction features
4. Analytic study of shape and replication;
5. Detailed contextual study; and
6. Comparative physical and cultural study.

Lipke et al. (1993) explain in detail the process of measuring and recording all the components of a vessel and give examples for sketching and drafting ship shapes and construction details.

A methodology to record ships, ship timbers, or ship construction could also be easily adapted from nautical archaeology and has already been published by Castro et al. (2018:4), based on Steffy's publications (1994, 1995). A description of the procedure to record small watercraft was recently published by Minh-Hà L. Pham and Fuquen (2021) as Appendix B of *The UNESCO Training Manual for the Protection of the Underwater Cultural Heritage in Latin America and the Caribbean.* Finally, the work of Castro and Gomes-Dias (2015) also contains a framework to follow when recording any contemporary shipbuilding community that uses molds, gauges, and ribbands for the construction of vessels.

State of the Art

As early, Thomas Hariot (1588) documented the construction of dugouts in Virginia, USA and in 1667 Du Tertre described the canoe manufacturing method of the Caribbean, and explained that the Caribbean designs were more complex that those of eastern North America (Meide 1995, 17). During the eighteenth century, some authors produced inventories of local watercraft, such as the *Caderno de todos os barcos do Tejo* in Portugal (Souza 1785), or *Verzameling van vier en tachtig stuks Hallandsche Schepen in Holland* (Groenewegen 1789), to cite only two examples. In the first half of the nineteenth century, the French admiral François Edmond Pâris recorded almost 250 types of different traditional boats during his voyages, and published his *"Essai sur la construction navale des peuples extra-européens"* (1841). In the late 1890s, Baldaque da Silva (1891) produced an important inventory of watercraft types and fishing gear in use along the Portuguese coast, and admiral Maufroy de Seixas paid a team of photographers and model makers to record all the traditional boats in that country.

The first modern attempts to record traditional boat building were made by Hornell (1920a; 1920b) in the 1920s and 1930s, as he recorded "The Origins and Ethnographical Significance of Indian Boat Designs" and "The Outriggers Canoes of Indonesia."

During the preparation of the Kon-Tiki expedition in 1947, Thor Heyerdahl (1950) consulted with the local population of the Ecuadorian Coast in choosing the wood and the construction of his balsa-raft, and his expedition diary contains valuable ethnographic notes on the construction of traditional rafts in the region. Due to the success of the Kon-Tiki expedition, several researchers showed interest in the traditional construction of balsa-rafts in the South American Pacific. Heyerdahl (1955, 1957) himself published two papers on this subject, and another paper was published by the Ecuadorian scholar Emilio Estrada (1955). However, it was the work of Clinton Edwards (1960, 1965) that most contributed to our understanding of the construction and use of indigenous watercraft through the South American Pacific coast.

In 1964, Chappelle published a work on the bark canoes and skin boats of North America, based on previous work by Edwin Tappan Adney, conducted during the end of the nineteenth century and the first half of the twentieth century, and his research on Inuit skin boats (Adney and Chapelle 1964). In the following decades, Horridge (1978, 1979, 1981, 1982, 1986) published extensively on the lashed-lug boats of Southeast Asia, whereas John Patrick Sarsfield (1985) wrote on the lofting techniques used in the construction of the *saveiros* in Brazil. Octávio Lixa Filgueiras produced an important series of monographies on Portuguese traditional watercraft (1970, 1977, 1978, 1980, 1981a, 1981b, 1984, 1987, 1989, 1992, 1994a, 1994b). Following the steps of Edwards (1965) on the Pacific Coast of South America, Walter Andritzky (1987) carried out a historical and ethnographic work with the balsa-raft builders at Sechura, Perú. In 1986, Lautaro Nuñez Atencio published a description of the archaeological data pertaining to the early balsas, from Chile, used for oceanic navigation. In 1990, Jenny Estrada (1990) documented several steps of balsa-rafts construction off the coast of Ecuador. At the end of the 1980's and the beginning of the 1990s, the Viking ship museum of Roskilde started a program for recording traditional boatbuilding from different parts of the world. Together with this the recording of the construction of a dugout from the Punan Bah people from Borneo was published by Nicolaisen and Damgard-Sorensen (1991), along with the building of a bundle reed raft from Bolivia by Madsen and Hansen (1992).

In the same decade, Lotika Varadarajan (1993) included some information on contemporary shipbuilding practices in India in her paper "Indian boat building traditions. The ethnological evidence." In 1995, Chuck Meide published *The Dugout Canoe in the Americas: An Archaeological, Ethnohistorical, and Structural Overview*. One year later, Lev Smarcevski (1996) further recorded the *saveiros* in Brazil, and in the same year, Barnes (1996) dedicated two chapters of his book *The Sea Hunters of Indonesia* to boat construction. Also, in 1996 Leshikar published her comprehensive and colorfully illustrated study on the *Earliest Watercrafts: From rafts to Viking ships.* One year later, a broad scope study carried on by Rubio-Ardanaz (1997) took into account the means, modes, and relations of production among fishermen in Santurtzi, Biscay. It was a comprehensive study on the material culture/technologies used by fishermen that dealt *in extenso* with fishing boats as the center of social processes and networks linking members of coastal communities.

In the 2000s, McGrail (2001) published his volume *Boats of the World,* which is an account of traditional boats around the world in a broad chronological perspective, using different works by himself and other scholars. One year later, Barnes (2002) published the chapter "Yami Boats and Boat Building in a Wider Perspective" as part of the book *Ships and the Development of Maritime Technology in the Indian Ocean*, which also included

Susan Beckerleg's (2002) chapter "Continuity and Adaptation by Contemporary Swahili Boatbuilders in Kenya." In this decade, Carlos del Cairo and Catalina García reported the existence of traditional shipbuilding practices in Pasacaballos and Tierra Bomba in the vicinity of Cartagena de Indias, as well as the construction of Cat Boats on the island of San Andrés, Colombian Caribbean. In 2000, Diego Carabias published his illustrated contribution on pre-Hispanic navigation in central-southern and meridional Andes.

Haslett (2006) consulted the population of the Ecuadorian Coast in order to build a balsa-raft to travel from Ecuador to Mexico, and Dewan and Hosler (2008) conducted engineering studies to test the resistance and life expectancy of this type of boat.

In the second decade of the twenty-first century, Ortiz-Sotelo (2012, 2014) recorded different traditional vessel types in the Peruvian Coasts. Castro and Gomes-Dias (2015) published a paper about the molds, *graminhos* and ribbands used in the construction of the *saveiros* in the Baía de Todos os Santos in Brazil. In a comprehensive paper, Prieto (2016) documented the entire process of fabrication of the *Totora caballitos*—reed boats—at Huanchaco, Perú. This work was complemented with an extensive historical and archaeological study framing these boats in a broader historical and cultural perspective. In the same line, combining archaeological evidence, historical sources, and ethnographical field work, Lira (2018, 2017, 2015) recorded the use of dugouts by Mapuche communities in the lakes, rivers, and coast of northern Patagonia. A similar methodology was used by Alexandra Biar (2016, 2017) to study the dugouts of west Mexico, recording their use in Lake Pátzcuaro, Michoacán. Favila Vázquez (2016) also recorded the traditional navigation in Los Tuxtlas, in the Gulf of Mexico, and the Balsas River in western Mexico, using archaeological, historical, and ethnographical information. Castilleja González (2018) described the relations between the elevated body of water of Pátzcuaro, in Mexico, and how changes in the lives of the fishermen and other peoples of its margins are reflected in changes of the watercrafts, from dugouts to fiber glass boats. Closing the decade, the *International Journal of Nautical Archaeology* dedicated a considerable portion of the issue 48(2) to traditional sewn vessels, encompassing the papers: "Sewn Boats of Southeast Asia: the stitched-plank and lashed-lug tradition" (Manguin 2019), "Re-sewing the sewn: an ethnographic record of repair and reuse of sewn-plank river boats in Goa, India" (Shaikh 2019) and "Archaeological, Historical, and Ethnographic Approaches to the Study of Sewn Boats: past, present, and future" (Staples and Blue 2019). In his master thesis, Rubio recorded the use of traditional log rafts on the coast of the Atacama Desert, northern Chile (Rubio 2020, Rubio et al. submitted). Elizabeth Parra is also currently writing a dissertation on the shipbuilding community of the Colombian Pacific known as *Culimochos* and Carlos Del Cairo and Juan David Sarmiento (2021) have been recording traditional shipbuilding among the Wayuú in La Guajira. Pamela Lara Tufiño and Roberto Junco Sánchez documented the construction of a *cayuco* by de Mayan communities of Lacandona Jungle, México.

Trejo Rivera (2022) recently documented the construction process of a *cayuco* (dugout canoe) since the selection of the tree until it was navigated in the swamps of Centla in Tabasco, México. Jaramillo Arango (2022) conducted a deep historical research about the development of navigation of balsa rafts in northern South America since 200 AC until the eighteenth century. Other relevant studies that deserve mention here are those of Diana Ortiz, who is leading a study of the construction, use, and abandonment of rafts at Cantón Playas, Ecuador, and of Alex Chávez Paredes, who is writing a thesis on traditional watercraft from northern Perú. Publications of these studies are pending.

Although there are many works on the subject with different scopes, around the world, the most influential research published so far on traditional shipbuilding has focused on Indian, Southeast Asian, North American Arctic, and South American watercrafts (Fig. 1).

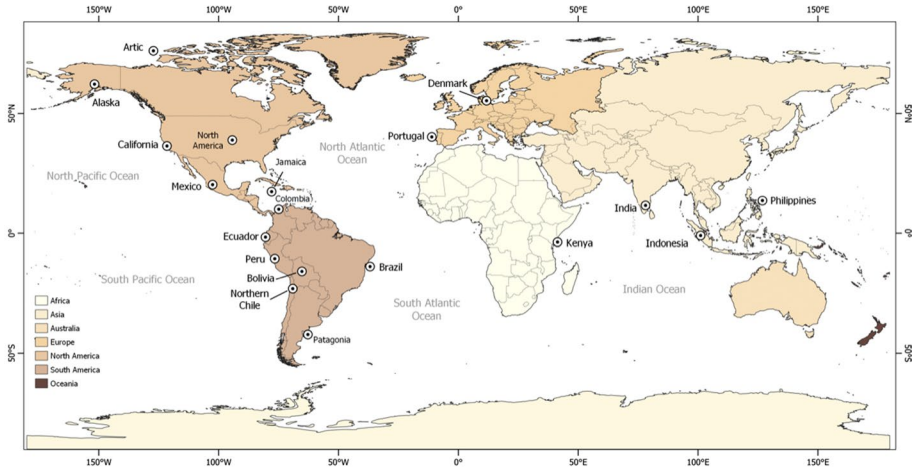

Fig. 1 World distribution of reported surviving traditional boat and shipbuilding practices

However, traditional boat building has been reported in other regions of the world, such as the African West and East coasts, which have tremendously rich traditions. Considering that these practices are all heading toward extinction, given the wide distribution, increasing reliability and decreasing prices of synthetic materials for boat construction, further efforts should be carried on to record what is left of these practices. The information that might be gathered is valuable for its own sake to maintain vanishing maritime traditions. However, the surviving ethnographical record is also priceless as it is the only way to inform the missing pieces of the puzzle of the archaeological and historical record relating to traditional boat building and the communities among which these practices still survive.

Sources for a Holistic Anthropological Approach to Traditional Boat Building

Horridge (1982) reconstructed the story of the "lashed-lug" boatbuilding technique, using descriptions compiled by the Jesuit Priest Fr. Alcisco Alcina in the Philippines in 1668. Based on this information, he concluded there was little if any influence of European colonization on Philippine shipbuilding in the seventeenth century. The eighteenth century shows a completely different picture in which traditional Philippine boatbuilding acquires divergent characteristics from those described by Alcina. Horridge (1982), however, found many correspondences between Alcina's descriptions and the boats being built in Indonesia in the 1980s. Two nineteenth-century models help to inform his description of the "lashed-lug" boatbuilding technique in the seventeenth century.

Horridge (1982) presents an outstanding example of how to record traditional shipbuilding techniques, as he makes a rigorous contrast of the existing sources, including the first documentary evidence of traditional boat building in Southeast Asia and contrasting it with traditional boats recently built in Indonesia as well as the nineteenth-century models kept in a museum in Berlin and a private collection in Breda. The author even researched the archaeology of some prehistoric plank boats from Northern and Western Europe that share

features with the lashed-lug technique; this yields the hypothesis that the recorded techniques might have originated from a common source before the European Bronze Age. The mosaic of sources he consulted, in an effort to explain the development of the lashed-lug technique in a large time span and a broad geographical area, is an encouraging example for anthropological research on traditional shipbuilding.

The use of ethnohistorical sources has been a constant in the research on raft navigation in South America. The pioneering texts of Lothrop (1932) and Murphy (1941) relied on Spanish historical sources to characterize the boats, their materials, and their building techniques. This method was followed by most researchers interested in traditional navigation in this region, including the already mentioned studies by Heyerdahl (1955, 1957), Edwards (1965), Andritsky (1987), and Dewan and Hosler (2008). Among the sources used by these authors, we should highlight the document known as the "Relación Samano-Xerez," probably written by Bartolome Ruiz, the pilot of Francisco Pizarro's second expedition to South America in 1526 (Navarrete et al. 1844), as well as the detailed description of a balsa raft written in the eighteenth century by the naturalists Juan and de Ulloa (1748) (Fig. 2).

Although it may apply to any other culture, Leshikar (1996, 13) wisely asserts that for the case of early American watercraft, information can be gathered in letters, books, journals, sketches, and paintings of early European explorers. She suggests modern ethnographic data, should be used cautiously, but still they provide insights into pre-Columbian traditions that survived the contact. She concludes that to gain more concrete knowledge about the very earliest American watercraft, we must depend on the archaeological record.

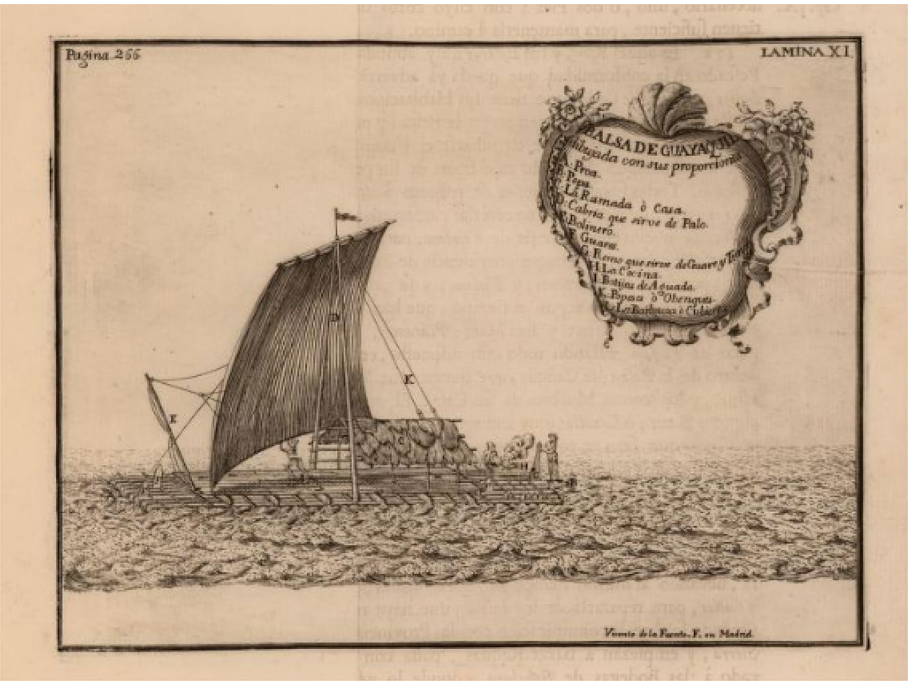

Fig. 2 "Balsa de Guayaquil." Engraving contained in the description of Jorge Juan y Antonio de Ulloa (1748). Courtesy of the John Carter Brown Library

Consistently, Carabias (2000, 32) proposed a methodology, which integrates and confronts archaeological, ethnohistorical, and ethnographical data. Despite Leshikar's (1996) suggestion to cautiously use ethnographical data to inform on precontact practices, Carabias accurately invites us to focus on groups of boat and shipbuilding communities that have remained isolated until very recent times, when attempting explanations of temporal continuity.

Barnes (1996) makes extensive use of a long tradition of ethnographical work among the people of Lamalera, Indonesia. He quotes written sources of the eighteenth century, such as Valentyn, who wrote in 1724, but his sources also encompass writings from the beginning of the twentieth century, such as Hornell (1920a, 1920b), Bode (1925), and Erns Vatter (1932). As his research goes beyond shipbuilding, his sources are not only related to shipbuilding practices but include a broader perspective on the life and culture of the people of Lamalera, making him more successful in gathering data and showing how an investigation of shipbuilding cannot be constrained to sources only dedicated to that subject. It must be kept in mind that ultimately anthropology is about the people and their culture, not about a specific practice or material culture. Barnes's coverage of the state-of-the-art bibliography gave him the understanding of more recent changes in the shipbuilding industry, such as the abandonment of some violent rituals related to boat construction and the substitution of animal blood for holy water as related to the religious and governmental demands of the second half of the twentieth century.

The replacement of traditional tools with more modern artifacts is a transversal subject in Horridge (1982), Barnes (1996) and Castro and Gomes-Dias (2015). Beyond interviews, Castro and Gomes-Dias (2015, 212) propose archival investigation to reconstruct the genealogies of the shipwright families, aiming to answer questions regarding the transference of knowledge. They also refer to the Iberian shipbuilding treatises to trace the origins of the technique used in Brazil to predetermine the boats' shapes and proportions.

Cross-cultural comparison is another useful source of information, as it traces the path toward generalization, which is the main goal of anthropological theory for the North American Processualism school and its derivatives, thus contrasts and similarities with other cultures should be analyzed. This is the case in Horridge's (1982) work, partly because it is based on Alcina's documentation of the lashed-lug boats, where he constantly compares the ships built in the Philippines with those built in Europe and the Americas. The existence of daggerboards in South American rafts is of particular note to several specialists and has been described as and compared with similar technologies in other parts of the world (Estrada 1955; Edwards 1965).

Although it does not constitute a section separate from the text, Horridge's research includes an extensive illustrated glossary encompassing terms for ship timbers from outside the nautical world. Barnes (1996, 204) also offers a translation of a vast lexicon and explains that boat parts are named after parts of the human body, as the launching is considered a birth. Even the presence of two pregnant women is required during the placement of the keel. Barnes (1996, 209) clarifies a "misleading impression" about plank names given by Horridge. The author explains that the port side and starboard side plank names are the same, and that the only named planks are the central ones, as the rest of them are considered mere extensions. Castro and Gomes-Dias (2015) also offer translations for several words used by *Baiano* shipwrights, some of which are traced back to Portuguese historical sources. Thus, etymology and lexicology have to be taken into account.

In addition to these sources of information, we should consider experimental boat building examples. This adds an understanding of the traditional construction techniques, once the knowledge held by the original builders is no longer available. This is the case of

the experiment conducted by Arnold (2006) in the building of a Neolithic dugout using stone tools. Better known is the case of several Viking style ships rebuilt in an effort to understand their technological process and performance such as the *Roar Ege*, a reconstruction of the Skuldelev 3 ship, or the *Sea Stallion from Glendalough*, reconstruction of the Skuldelev 2 ship, both conducted by the Viking ship museum of Roskilde, based on archaeological remains. Also there is the well-known *Kyrenia II*, the reconstruction of a Greek wreck from the fourth century BC found in Kyrenia (Pomey and Rieth 2005).

Based on the experiences gathered by the examination of these previous works, a researcher looking for the development of broader geographic and chronological frameworks, capable of moving beyond particular ethnographies, should research:

(a) Historical written sources,
(b) Ancient archaeological remains with features common to the shipbuilding tradition of interest,
(c) Photographs, sketches, drawings, and paintings (iconography) that show the use of the boats in the past,
(d) Recent general ethnographic accounts about the population of interest,
(e) Genealogies,
(f) Ship models kept in museums and private collections,
(g) Ethnographic and linguistic research on the boats that are currently being built and used,

Relevant Questions for an Anthropology of Traditional Shipbuilding Communities

In this section, we will formulate a set of questions to encourage future research, based on brief considerations of various aspects that have been recorded in previous research of traditional shipbuilding. Each question reflects a group of aspects and challenges. Few researchers have addressed these subject in the reviewed literature on traditional shipbuilding, however, the first question researchers should ask themselves and the community is how can the population under study benefit from its research.

(1) What are the characteristics of the vessels, their main dimensions, cargo capacity, displacement, uses, and propulsion method?

Although the main purpose of this paper is to formulate a set of questions about the cultural context of traditional shipbuilding, hard evidence is a stepping stone of any scientific study, and basic information regarding the vessels themselves must be recorded as the first step of inquiry in the broader research.

(2) What was the influence of the contact with migrant or colonizing populations on the traditional shipbuilding communities, and how did it impact the emergence or development of the local shipbuilding industry?

In the Southeast Asian tradition, it is clear that the practice of boatbuilding predates contact with the Europeans. This situation is not fully clear in other communities such as the Brazilian shipbuilders of the *saveiros,* who might have learned to build boats from

the European colonizers and thus they are hypothesized to have retained the use of a late medieval Mediterranean technique to determine the shape and proportions of the ships they build (Castro and Gomes-Dias 2015: 410).

In the case of the Chilean sea lion skin floats or pontoons, the traditional supplies (blood, hair or cactus resin, and red mud) used for the caulking mixture known as "almagre" were replaced by ground bricks, iron oxide (*colo*), oil, and/or grease (Carabias 2000, 43).

In the specific case of the Inuit, referred as Eskimos by Leshikar (1996, 13–14), she asserts that given the differences between traditional North American Arctic watercraft (*kayak* and *umiak*) and European ships, there are few chances that the latter exerted an influence on the traditional Arctic watercraft construction. She adds that there is little European influence on American dugouts. Still, in the case of *kayaks* and *umiaks*, she considers the possibility that the Inuit might have adopted the technology of the sail from early sixteenth-century European ships, or even earlier, as a result of contact with the Vikings.

We consider that the contact between native shipbuilders and the naval industry of migrant or colonizing populations exerts an influence and entails major, or at least, minor changes to the traditional boat and shipbuilding practices and watercraft being built.

Horridge (1982, 4) provides some detail on the pre-contact maritime tradition of Southeast Asia, and he explains that by the eighteenth century, it was fully replaced by the European system that took advantage of the readily available boat building and repair industry. Horridge displays a cultural-historic perspective, which is common among many nautical archaeologists. That is why the questions about migration and diffusion of the particular boat building techniques that he studied are central to his argument (Trigger 1989). Many researchers would agree the cultural-historic paradigm has largely been overcome; however, this fundamental question of transmitted practices must be at the center of any anthropological study on shipbuilding.

The influence of traditional boatbuilding on colonizing or migrant populations of boat and shipbuilders must be considered as well, such as in the case of the adoption of the Indian bark canoes of North America by Europeans. Europeans not only preferred the Indian bark canoes to their ships, but also retained their basic design, although they built larger vessels (Leshikar 1996, 14).

(3) How has the circulation of fiberglass boats and the introduction of synthetic materials and modern tools affected the traditional shipbuilding industry?

Barnes (1996) and Castro and Gomes-Dias (2015) touch on an important subject: how the introduction of synthetic materials has affected the traditional shipbuilding industry in more recent times. It is highly plausible that the introduction and the increasingly affordable price of metal and fiberglass boats has driven some traditional boat building techniques to extinction. In other cases, it has at least led to the substitution of wood and organic materials in the construction of certain parts of the hulls, upperworks, and rigging or the use of synthetic materials for the sails (Estrada 1990). For example, most vegetable fiber riggings have been completely replaced by synthetic materials (Fig. 3), as well as natural and traditional caulking materials.

(4) What is the geographical area and period of influence of a particular boat building technique, and what is the degree of adaptation for the uses, materials, and tools used in the construction of the vessels?

Fig. 3 Balsa raft with synthetic Latin-rig in Cantón Playas, Villamil, Guayas, Ecuador in 2019. Photograph by: Antonio Jaramillo Arango

An outstanding example of environmental adaptation and fitness is the case of the Indian bark canoes explained by Leshikar (1996, 14). These vessels were lightweight, strong, and stable, and so well suited for the local river rapids, waterfalls, and shallow waters of North America, that they were almost immediately adopted by the European explorers and traders. Their range was as wide as the locations of the

paper birch trees from which the bark was taken and encompassed almost the whole of North America, possibly from pre-Columbian times until the nineteenth century.

Meide (1995, 28) explains in detail another craft that was successfully adapted to the environment: the case of the five individual dugout canoes lashed together on the Dunajec River in Poland. This river is variable in depth, has a rocky bottom with protruding stones, and is fast and narrow. Meide explains that the flexibility of the lashed dugouts allows single components to override obstacles, allowing for the possibility of retaining buoyancy in case one of the dugouts is holed.

Dugouts were even more widely distributed over time than bark canoes. Meide (1995, 1) asserts dugout canoes were possibly the most popular of aboriginal watercrafts. Leshikar (1996, 16) explains that beyond their North American distribution, there is plenty of evidence that demonstrates they are present in South America and the Caribbean as well. The construction and use of dugouts in the Americas might have dated to a moment previous to the full transition to sedentarism. One of the oldest surviving vessels of the world is the dugout from Pesse, Netherlands, dated to 6315 BC and there is archaeological evidence of dugouts in America as early as 5000 years ago, as the finding of De Leon Springs, Florida. Iconographical evidence, specifically a sketch found at a rock shelter in Val Verde County, Texas, might push back the date until 6000 years ago. Contemporary Mexican studies, referred in other sections of this paper, display good evidence to ensure that despite the fact they date so far back in time, they are still being built today. Double and multiple lashed dugouts are widely distributed as well. In Venezuelan, they date back at least to 1513, when reported by Ponce de León; Mayan examples have been reported as early as 1641, and evidences of them have been found in places as far from the Americas as Finland. Dugout stabilizers are widely distributed as well. Examples have been reported in Europe, Ecuador, Mexico, and Java, just to mention a few (Meide 1995).

When referring to the lashed-lug boats of Southeast Asia, Horridge (1982) concludes that the "construction system was very widespread; it can be traced back to the beginnings of the records and it is particularly well adapted to the uses required and to the materials and tools available" (Horridge 1982, 1). Estrada (1990) documented how the Peruvian sailors used to go to the Ecuadorian coasts to acquire vessels and raw materials to build additional boats in their territories. Carabias (2000, 32) rigorously reported on the geographical distribution and temporal range of *caballitos de totora,* South American reed rafts, balsa rafts, and sea lion skin floats or pontoons.

(5) How is the information on boat construction stored and transmitted? In which ways has innovation occurred?

Horridge (1982, 2) explains that there are no plans or written records in the lashed-lug tradition; however, the knowledge is orally transmitted with a high degree of fidelity, demonstrated by the fact that the planking pattern and the position of the lugs on a group of boats built in a single village are the same. The plank lengths and the position of the lugs are determined as fixed proportions of the keel and its extensions. Castro and Gomes-Dias (2015, 411) have also studied how the information is transmitted and how innovation has occurred among the shipwrights of Valença and the Baía de Todos os Santos area in Brazil. Following Piero Dell'Amico (2002, 58), the authors explain that boat-building transference of knowledge occurs by three means: practice by apprenticeship with an experienced master; by apprenticeship with a master but using poorly understood geometrical methods that are fixed through time, or using technical drawings

and theories that apply to a wide range of watercraft. The authors propose a cultural evolutionary approach to the question of the transference of knowledge and the processes of innovation (Richerson and Boyd 2005). They support the idea that cultural mutation is neither random nor directional (Castro and Gomes-Dias 2015, 412). In Centla, México, the elders are the once who store the knowledge about traditional boatbuilding and it is transmitted thought the dugout construction practice itself (Trejo Rivera 2022).

(6) How many person-hours does it take to build a vessel? Is there a convergence of specialized and unspecialized workforce, and what is the division of labor? (Organizational chart with functions).

This question is directly related to the division of labor in the shipyard or the place where the vessel is built, the time spent, and the number of men required to construct a boat (Horridge 1982, 7). This could be accurately described with an organizational chart describing the specific functions of specialized and unspecialized labor. Meide (1995, 5) references evidence that points out that the Caribs spent entire years building their canoes, before the acquisition of European tools. Contrastingly, he reports as well a contemporary case in which an informant asserted he can build a dugout canoe in 2 days. Barnes (1996, 221) measured the time it took a sailmaker to weave a section of a sail measuring approximately 28–30 cm (cm) and it took him about half an hour. Castro and Gomes-Dias (2015, 420) assert that it takes 120 days to build a *saveiro*. Lira (2016, 2015) recorded between 1 and 25 days for building a dugout in north Patagonia, depending on the number of persons involved and the stage that is taken into account. Arnold (2006), during his experiment of building a Neolithic dugout, recorded 58 days of work by a team of two men for the whole process, using only stone tools and fire. Building a 5.30 m (m) long *cayuco* in the Lacandona Jungle took 14 days distributed in a period of 2 months (Lara Tufiño y Junco Sánchez 2022). We suggest labor investment can be more accurately measured in person-hours, accounting, and specifying specialized and unspecialized labor.

(7) How is the production a factor (business model when it applies) based on the shipyard or the place of construction of the vessel, in those cases when the watercraft is built in non-specialized facilities?

As Castro and Gomes-Dias (2015, 411) inquire about the production and distribution relationships, they explain that "In some places the ships are built at the shipwright's expense and sold afterward, in others the buyer pays for the work and the timber, while in others a contract is established based on a specific project." Diana Ortiz (pers. com.) recorded that the balsa-raft building is carried on by demand, and single families take care of the construction process. For building the dugouts of northern Patagonia, Lira (2015, 2016) recorded community work called *minga*.

(8) Who takes part in the production and distribution chains, and how does the supply of raw materials work? (Table 1) When are the trees cut and which species are preferred for the different pieces? How are the materials transported to the shipyard or the place of construction? Which treatments do the materials undergo before they reach the shipyard? Are the trees naturally curved, or do they undergo a reshaping process as documented by Brad Loewen (1998) for early modern Iberian ships?

Table 1 Materials used in the construction of different vessel types distributed by region

Ship type	Origin/distribution of the vessel types	Common name of the material	Scientific name* of the material
Bark canoes	North America	Paper birch**	*Betula papyrifera*
		Caulking (Gum from black or white spruce)	*Picea glauca/Picea mariana*
Balsa rafts	Africa and South America	Balsa or balso	*Ochroma sp.* (*O.pyramidale, O. Piscatoria*)
Reed raft	South America and California	Totora or junco	*Typha angustifolia*
Reed boats	California, USA	Bulrush or tule	*Schoenoplectus californicus, Schoenoplectus acutus*
Lashed-lug boats	Southeast Asia	Rigging: Areng palm	*Arenga sp.*
		Dowels: Magroove/Sapan	*Biancaea sappan*
Wayuú boats	Caribbean (Colombia and Venezuela)	White ceiba	*Hura crepitans L*
Dugouts	Lacandona Jungle, Mexico in current times	Mahogany	*Swietenia macrophylla*
Dugouts	Pre-Hispanic México and current Jamaica	Ceiba	*Ceiba pentandra*
Dugouts	Northern Patagonia	Laurel	*Laurelia sempervirens*
Dugout	Southeast USA	Cypress	*Taxodium distichum*
		Pine	*Pinus elliottii*
Dugout	North Pacific USA and Canada	Western red cedar	*Thuja plicata*
Aztec canoes	Pre-Hispanic Central Mexican Basin	Ahuehuete, American cypress, and pine	*Taxodium huegelii*, *Taxodium distichum*
Gommier canoe	Caribbean in current times	Gommier or gum tree	*Dacryodes excelsa*
Skin floats or pontoons	Chile	Sea lion	*Asclepias jubata*
		Quisco spines	*Leucostele chiloensis*

*Species and genera names in literature sources were updated to reflect accepted nomenclature in The Plant List (2013) and WFO (2022)

**The use of hickory, chestnut, cottonwood and spruce has been reported as well, but it was less frequent

In the particular case of the lashed-lug boats, there are fascinating remarks on the timber supply and transformation in the fact that the measurements of the boats are given to the men who go to the mountains to cut the trees. Barnes (1996, 213) explains that in the case of shipbuilders from Lamalera, the trees are traded with people living in other hamlets. The Areng palm (*Arenga* sp.), used to make fibers, only grows in the mountains, so it has to be traded with people from the inland villages, which poses a question about the distribution chain. In Ecuador, the disappearance of *Ochroma* sp. trees on the coast has resulted in communities obtaining timbers from further north (Estrada 1990). In the case of Mexico, given its durability, workability, resistance, and buoyancy, Lara Tufiño and Junco Sánchez (2022) recorded the use of mahogany (*Swietenia macrophylla*) by contemporary Maya dugout builders in the Lacandona Jungle. Favila Vázquez (2020, 2022, 30) reported the use of ceiba (*Ceiba pentandra*) by the classic Mayas in the Petén for the same purpose in pre-Hispanic times. The use of Ceiba for dugout construction has been reported as well in the case of contemporary Jamaica (Leshikar 1985) and it can be traced to the sixteenth century as recorded by Spanish historians for the case of the indigenous Arawak (Leshikar 1996, 20). Leshikar (1985) reported that the dugout builders of Jamaica prefer to use the base of the tree for the bow, as it is stronger than the end, and thus more resistant to wave collision.

Castilleja González (2018) and Trejo Rivera (2022) analyzed the selection of trees as the first step in the construction of *cayucos* in Tabasco, México. Trejo describes how the dugout builders take into account the constitution, shape, size, and availability of trees. According to Leshikar (1996, 14), paper birch provided the superior and preferred bark for canoes, however elm, hickory, chestnut, cottonwood, and spruce were used as well. The seams were sealed with gum from black or white spruce, tempered animal fat, and powdered charcoal. In the case of Aztec canoes, *ahuehuete*, American cypress and pine were the most common materials.

The log rafts of the Chilean Atacama Desert are made from balsa wood (*Ochroma* sp.), obtained from the Peruvian Amazonian Forest. The use of this same wood has been reported in the case of Africa. In the case of Brazil, documented by Castro and Gomes-Dias (2015, 418), the partial deforestation of the Brazilian Atlantic Forest has generated a highly regulated market of timbers; however, the shipwrights still go to the forest with the timber supplier to choose and mark the trees they want, using no more than a futtock mold, a chock, and a metric tape. Timbers are not pre-shaped in the forests anymore.

Given the restrictions imposed by the available tools, Southeast Asian traditional shipbuilders cannot make more than two planks from each single tree. The timbers are selected within naturally grown wood (Barnes 1996, 217). They discard trees with rotten cores and, apparently, eliminate the sapwood before the logs are transported to the shipyard. This material tends to rot and break, especially if it is cut in the moon's last quarter ("after the 22nd day or before the 3rd day"). The planks are cut by moonlight, and they are roughly shaped by someone who knows the particular twists to fit in the boat curves (Horridge 1982, 7). According to Barnes (1996, 214), seasoned wood is preferred, but most commonly, the wood is freshly shaped. The trees are felled; branches are lopped off and split apart by parties of men and women who may be away from the village for 2 or 3 days. This task is extremely labor intensive (Barnes 1996, 213). The Bugis avoid joints coinciding with knots, while other communities deliberately try to avoid knots in general, but this has not been reported among the boatbuilders of Lamalera (Barnes 1996, 217).

In the case of the sea lion (*Otaria jubata*) skin floats or pontoons of Chile, Carabias (2002, 43) reported that the shipwrights use uniquely male skins, as they do not have protruding udders and teats. He explains as well that the skin must be healthy, as wounds

cause the floats to break. The skins are softened by immersion in fresh water before they are cut and the edges are sawn with Quisco (*Echinopsis chiloensis*) spines and braids of nerves, tendons, and intestines of the same animal, ram or sheep. After this stage, the floats are made watertight by caulking the seams with a mixture composed of blood, hair or cactus resin, and red mud. This caulking substance is known as "almagre." There is evidence, that the skins are sometimes reshaped by filling them with sand, which is later discarded.

In the case of the dugouts of northern Patagonia, the trees are carefully chosen, with very few branches and knots, and felled exclusively for the building of the boat, during April or May, when the sap is down. The wood is selected from trees that are easy to work with medium mechanical resistance, as in the case of Laurel (*Laurelia sempervirens*). The Punan Bah from Borneo cut the branches and take off the cortex in the place where the trees felt down. They divide the tree into two halves and start to empty the trunk by removing the sapwood until they give a preliminary form to their dugout. Then, a group of men transport this preform through the forest using little branches displayed on the floor and pulling it with rattan cords, just into the nearest river, which will deliver it into the village where the building process will be finished (Nicolaisen and Damgard-Sorensen 1991). Castilleja (2018, 170) explains that *Tepari*, *Tepari sapichu* and *Icharhuata* (types of dugouts, based in size) builders of Pátzcuaro, México, leave the shavings of wood inside the trunk while it is being hollowed and they remain there until the canoe is transported to the shores of the lagune to retain the moisture of the wood while it matures and the vessels is finished and launched. They employ trucks and yokes for its transportation to shore. Heyerdahl (1950) documented that Ecuadorian raft builders submerge the *Ochroma* sp. wood in the water right after it is cut to decrease porosity and improve its naval performance and life expectancy. In ancient times, in Ecuador, the logs were transported by river to shipyards on the coast. Nowadays, the same process is carried out with industrial trucks (Estrada 1990).

(9) Where are the ships built? Describe the shipyard or building location and how it is prepared.

Castro and Gomes-Dias (2015, 420) explain that in the case of Valença and the Baía de Todos os Santos area in Brazil, the municipality expropriated certain shipyards, and since then, the shipwrights have built their vessels on the river margins where they keep their tools in improvised sheds (Fig. 4).

Meide (1995, 5) asserts that the Maoris of New Zealand would choose suitable trees for dugout canoes and later planted crops in the vicinity for their consumption during the period spent working the trunk. For the construction of dugouts, Guerrero Ayuso (2009) proposes that a great part of the process should be done under a shadow to protect the wood, avoiding fast drying, which can result in violent contractions and cracks. In the case of the Punan Bah from Borneo, the building of their dugouts was carried out under a shed made with big leaves, protecting the trunk and the builders from the sun (Nicolaisen and Damgard-Sorensen 1991). There is very little information about historical shipyards and probably even less about the infrastructure in which boat building communities build their vessels. Therefore, it is important to record any surviving evidence about these settings and their preparation. Diana Ortiz (pers. comm.) documented that, in Ecuador, the rafts are built in the backyard of the household in charge of the construction.

(10) Which tools are used for shipbuilding, and how have they evolved?

Fig. 4 *Saveiro* under construction in 2013 at the riverbank of Valença, Bahia, Brazil. Photograph: Rodrigo Torres

Horridge (1982, 10) gives some insight into the evolution of the tools used by boat builders. An example is the wooden *kilik* or *kirik*, which was replaced by the steel *singkolo*. These tools are used to trace the contour of contiguous planks. After the trace is made, the excess wood is removed with a chisel to make the edges of the planks match precisely. Similar instruments called *naga* (dragon) and *ruki* are used by the people of Lamalera for the same purpose (Barnes 1996, 214). Barnes even asserts that certain traditional tools are better suited for twisting and adjusting the planks to generate the awkward shapes of traditional boats than some comparable tools used for similar purposes. Barnes (1996, 241) recorded two types of toolboxes: wooden toolboxes reserved for the high-status master builders called *kelpa*, and woven baskets called *kelpe*.

Meide (1995) asserts that bivalve shell scrapers, Clear Fork gouges, and Dalton Adzes, some of the technologies used for dugout building, existed as early as 10.500 BC to 9.900 BC. He adds that ethnohistorical sources report evidence of European techniques and tools used in northeast Florida, by USA dugout builders as early as 1500 AC, making the traditional burn and scrape methods obsolete. In the case of the dugouts of current northern Patagonia, Lira recorded the use of axes and adzes up until recent times (Lira 2016, 2015). In his experiment for constructing a Neolithic dugout, Arnold (2006) used only stone axes and adzes with the help of controlled fire over the surface of the trunk. Castro and Gomes-Dias (2015, 419) explain that most of the work that used to be done with axes and adzes is nowadays made with chainsaws. Trejo Rivera (2022) included an explanatory scheme in her article in which she shows the stages of construction and the tools involved in each of the stages. She explains how, currently in México, dugout builders cut the trees using a chainsaw, which is also used to reshape the trunk that will become a *cayuco*. Strips of the trunk are removed with iron axes. The trunk is later hollowed using gouges and iron adzes and finished using a sander. Lara Tufiño and Junco Sánchez (2022) documented a similar

process (Fig. 5). However, in the latter case, they use machetes as well. Leshikar (1996, 14) explains that axes, wedges, hammers, knives and scrapers of stone, bone awls, and wooden mauls were some of the pre-Columbian tools used in the construction of bark canoes. She adds that, according to early European sources, in addition to stone utensils, the Aztecs used copper tools to build their canoes and piraguas (large canoes). In her earlier contribution Leshickar (1985) explained that contemporary Jamaican dugout builders use only iron axes, a plum-bob made out of a rock and a string, and a "hovel," which is a hand adze that has a pronouncedly curved blade. Castilleja (2018, 170) recorded the extraordinary ethnographical account of Tatá Fidel, a dugout builder of Pátzcuaro, México, who manufactured his adze using a piece of iron from the railroad.

Interestingly, Meide (1995, 53) provides evidence of iron tool use by the dugout builders of the Northern Pacific USA and Canada several hundred years before the contact with the Europeans. The material of this tool resembles Japanese medieval iron and might have been traded through the Bering Strait. However, based on a personal communication, Meide asserts Aboriginal northern people have been known to collect iron from fallen meteorites.

(11) What are the measuring units used for the construction of the ships and their equivalence to the metric or imperial system?

Concerning the instruments, Barnes (1996, 214) asserts that the position of the lugs is determined using a lontar-leaf measurement (*tenutu*), which introduces an indispensable subject for the recording of shipbuilding practices: the measuring units, and their metric

Fig. 5 Contemporary Maya dugout builders of Lacandona Jungle, México, sitting on a recently built *cayuco*. The picture displays some of the tools involved in the construction process. Photograph by: Alberto Soto/ SAS- INAH

or imperial equivalents. The use of body parts such as the arms, elbows, fingers, and feet and their later standardization in measuring instruments has been pretty common. Casado-Soto (1988) and Castro (2008) have provided the metric equivalences for the measuring units used by early-modern Iberian shipbuilders. Castro and Gomes-Dias (2015, 417) also recorded and gave equivalents for some of the measurements used by the *saveiro* shipwrights. In the case of the Punan Bah from Borneo, they used estimated measurements by eye, using different reference angles to obtain fixed points of measure. The symmetry of both sides is measured from their extremities, and from the center they measure the general form of each gunwale. Castilleja (2018, 116) reported the use of the metric system, by contemporary Pátzcuaro dugout builders.

(12) Does the ship have a name? When is the ship named, and how is the name given? Who names it? What is the gender of the vessel? Does the name fall within a more general local tendency to name ships? Are all the ships considered to belong to the same gender?

Giving names to vessels is a worldwide practice, and they tend to be consistent within cultures. For example, early modern Iberian vessels were named after saints; the ships of the Colombian navy are named after particular places in the country. It is also a common practice to name private boats after the beloved or offspring of the owner (Fig. 6), most commonly a woman. This introduces the question of the gender of the vessels. The British, for example, have traditionally referred to ships as "she," but some other cultures consider

Fig. 6 Balsa raft with synthetic Latin-rig and painted with name of the owner in Cantón Playas, Villamil, Guayas, Ecuador in 2019. Photograph by: Antonio Jaramillo Arango

them masculine, or it might depend on the type of boat. Even though academic journals are insistently moving toward gender-neutral denomination, this is an important and interesting aspect to record. Barnes (1996, 230–238) dedicates various pages to the given names and slogans written on the boats of Lamalera.

(13) Which apparently nonfunctional, aesthetic, or symbolic characteristics are built into or added to the boats? What is their meaning or use? How much labor investment does it take to create these features, and who builds, paints, or makes them? Do they require different materials from the ones used for the rest of the construction?

Any ship recording should include a description and explanation of the aesthetic and the (apparently) nonfunctional features common in vessels. Figureheads and the eyes on the bow or *oculi* are probably the most ubiquitous and the examples that have persisted longer through time among maritime cultures (Hornell 1923, 1938). Barnes (1996, 208) also carefully recorded the presence of ears (*tilu)* and mouths (*fefa*) and a short section is dedicated to the bow decorations that are mounted on the stern post and are known as *tamóto.* He asserts, "Some deny the decorations on these devices have a meaning, other than providing individuation, but others claim that each design, called *keriki kelada*, is an identifying sign which has its own meaning" (Barnes 1996, 239).

The apparently nonfunctional or aesthetic features play an important symbolic role during boat construction and use, and they imply additional labor investment. Barnes (1996, 212) also reports some very interesting features of the whale hunters' boats of Lamalera in this regard. Particularly the tool marks known as gua gate that are carved in the inboard face and outboard face of the planks at the places where the scarves between strakes should have been made, in the cases when the wood available is too short or too long, to match the desired location. Other tool marks are described by Barnes, who explains that dowels should not coincide with any of these lines. "Tradition says that if a whale spots an imperfection in the construction of the boat, she will strike it at precisely that spot. The substitute marks are intended to prevent the whale from seeing where the nature of the wood available has forced the builders to deviate from the proper design" (Barnes, 1996, 213).

The conch shell engravings from the Late Prehistoric Period at Spiro, Oklahoma, reveal canoes were decorated and carried standards. There is evidence of canoe decoration in Mesoamerica as well. An engraving on bone found in Tikal depicts a canoe with very high bow and stern and the bow is ornately decorated and carved with a Mayan god. A mural in the Temple of the Warriors at Chichén Itzá displays an animal head carving in the bow of a canoe. In the pre-Columbian Basin of Mexico, there is evidence that Aztecs decorated their canoes for warfare and ritual, even including seats, although it is uncertain if these features were part of the structure. Further historical and ethnographical evidence demonstrates that they have been tinted at least since contact with the Spanish explorers (Leshikar 1996). Meide (1995, 39–40) reported several cases of canoe decoration and asserted "…the most dramatic and intricate decorated canoes are those of the North Pacific Indians."

(14) Do the shipwrights use any storage information devices such as molds or gauges? What are the rules of thumb for the construction of a vessel?

While there is no written information on how to build the lashed-lug boats, information has still been passed from masters to apprentices through fake scarfs, the tradition of deceiving the whales, as previously discussed, and adding other tool marks pointing to the

ideal location of plank joints. When Richerson and Boyd (2005, 53) referred to cumulative cultural evolution, they explained that artifacts are powerful cultural information containers. Beyond its ritual significance, are not these fake scarfs a magnificent form of the written record, storing the information on an ideal construction?

Castro and Gomes-Dias (2015, 410) assert that since the fourteenth century, shipwrights have used procedures to determine the basic dimensions and shape of vessels. The use of molds, gauges, and ribbands has been documented in the archaeological record of Spain, Portugal, Bulgaria, Canada, and the USA. These molds, gauges, and ribbands help the shipwrights obtain the shape of the frames by determining their rising and narrowing (Castro 2007) (Fig. 7). Some other molds, as documented by Smarcevski (1996), serve the purpose of determining the scantlings of the vessel, which are the proper dimensions and proportions of the structural components that make the vessel durable and reliable, yet sufficiently light. These molds and gauges are tremendously capacious information-storage devices, and synthetize complex mathematical operations. The convergence of molds and a set of rules of thumb contain all the information required to predetermine the shape, scantlings, and proportions of a vessel.

(15) What are the rituals carried on from the provision, selection, and transformation of the raw materials until the launching ceremony of a vessel? What are their functions, and how much resources are invested into them? Are there rituals or tokens believed to confer magic protection to the boats?

If we strictly stick to the ritualistic purpose of tool marks among the Lamalera boats, the aesthetic features of a boat tend to be closely related to a symbolic behavior surrounding the vessel. Barnes (1996, 217) explains that among the Lamalera people, all the decorations are usually finished before the big final feast, which in turn attracts laborers, as palm wine and a small meal are offered in exchange for smoothing the leftover materials of the hull. He also explains that certain decorations on the sails are made strictly by women (Barnes 1996, 226).

Maritime communities tend to be very ritualistic when it comes to boats and sailing. If possible, any rituals carried on from the provision, selection, and transformation of raw materials until the launching ceremony should be considered. Based on Alcina's description, Horridge (1982, 24–25) includes some interesting comments on the antique launching ceremonies of war vessels in Southeast Asia. Barnes (1996, 204) asserts that the boats are considered to possess a life and a soul, thus improper behaviors toward the boat are considered to yield fatal consequences for the vessel. During ship construction, the family must be fully committed to the building process, and there should be no quarrels, grumblings, or conflicts within the clan or with other clans. There must be submission to the clan leader and unanimity in discussions. The people of Lamalera celebrate a feast for all the traditional boat builders and their descendants after the keel, sternpost, and stem are made ready. But ritualistic practices start even before the construction process. Barnes (Oleona 1989: 12 in Barnes) has reported on the songs that are sung while raw materials are being gathered in the mountains, specifically when heavy trunks are being pulled or while rattan bindings are being used to pull trunks down the shore.

Ceremonies do not stop once the boat is built. Among the people of Lamalera, when a boat needs to be rebuilt, they summon the boatbuilders of the clan to place their tools on a large stone where a chicken is sacrificed to put its blood on the tools, the stone, and a specific house post. The ceremony goes on by dividing the chicken, giving the legs to the great

Fig. 7 Maestre Chico from Valença using his molds and *graminho* to demonstrate the drawing of a full size master frame. Photograph by: Rodrigo Torres

master builders (*ata mol a bela*) and wings to the small master builders (*ata mola kena*). Finally, the master builder in charge hits the rest of the boat-builders with a flat wooden mallet and tells them to eat and drink and work the next day as hard as he does (Barnes 1996, 241). This ritual tells a lot about the social status differences within the workforce. A ritual of this type, attended by Barnes in 1982, included all the boat builders of two villages

for a total of 15. A single master builder is in charge of the construction, but from time to time, a collaboration of the other shipbuilders is expected. When Barnes wrote his book, the use of chicken blood was substituted by holy water in most rituals. Many more rituals follow the one described above until the boat is finally launched.

(16) What is the life expectancy of the vessels and their particular components? Are repairs made in the shipyards by the shipwrights, or do the operators make them? Is there a preference for the boats to be repaired by the shipwright who built them? How does the boat finish its life span?

Barnes's (1996, 22) research also includes some information on the life span of the vessels and how they are repaired. Based on ethnohistorical sources, Carabias (2000, 33) reported that after intensive use, the *caballitos de totora* start to decompose and their operators carry them home or to the beach on their backs, untie and wash them, and finally tie them together again. He adds that, to prevent rapid decomposition, northern Peruvian fisherman usually have more than one *caballito* and they alternate their use. Lira (2016, 2015) recorded a life span of 10–12 years for the dugouts of northern Patagonia. He also recorded repairs in some archaeological remains of dugouts, made with vegetal fibers in some cases and tin in others. Finally, these dugouts were commonly abandoned on the banks of rivers, lakes, and coast or were recycled as containers for food and water for animals. In the case of the South American rafts, Estrada (1990) has documented how the *Ochroma sp*. has to be prepared to have a greater life expectancy. Dewan and Hosler (2008) have also calculated the logs' resistance against shipworms, and Haslett (2006) has experimented on boat resistance in tropical waters.

(17) How are the boats part of a broader carpentry scene? Are there comparable or different wood and vegetable fiber used for purposes beyond shipbuilding, such as houses, temples, and furniture?

Horridge (1982) includes the boats in a more general schema of carpentry that encompasses the construction of temples, houses, and furniture.

In Guayaquil and Babahoyo, Ecuador, there were entire neighborhoods of houses manufactured with balsa (*Ochoroma* sp.), which is the wood used for traditional rafts. These houses had the advantage of being able to stand on the river shores of the region and be transported wherever needed. Currently, it is possible to see some of these houses in the city of Babahoyo. Ceiba (*Ceiba pentandra*), the wood species used by classic Maya dugout builders in the Petén during pre-Hispanic times (Favila Vázquez 2022, 30), has deep cosmologic connotations in the communication between the underworld and the supraworld. Additionally, it was used to build lintels and decorated boards with writings and iconography. The wood types used to build dugouts in Pátzcuaro, México, are used to build furniture as well (Castilleja 2018, 3).

A description of boat types, with their particular uses and ways of sailing, makes an ethnographical record of traditional boat building communities complete. However, the operational stage encompassing the sailing way and the distribution of labor and profit among the crew members and the related coastal community might constitute completely different research.

Any record of a ship's construction process should be carefully illustrated. Horridge (1982) and Castro and Gomes-Dias (2015) have interesting illustrations that constitute

help in understanding the point they are trying to explain. Further questions that can be asked when recording traditional shipbuilding practices can be found in Minh-Hà L. Pham and Fuquen (2021). Finally, beyond his own interest and the previous set of questions, the researcher should consider and document as well any information that the boat or shipbuilders consider important or worth a mention.

The Tension Between Typologies

Any anthropological research aiming at recording ship construction should attempt to have an illustrated typology; however, this tends to be a difficult stage of the process. While Horridge (1982) includes the *kora kora* as part of the lashed-lug tradition that also encompasses the boats built by the people of Lamalera, Barnes (1996, 201) explains the people of Lamalera trace a clear distinction between their *téna lama faij* (boats with places for rowers) and the *kora kora* built by the Muslim villages of the Solor Strait. This example illustrates the tension between native typologies and the typologies built by social scientists trying to understand boatbuilding traditions in a broader geographical area and within a larger time span. Despite the success of some typologies, Barnes (1996, 201) has expressed his frustration in this regard in the following words "…these terms show how readily boat names can be used to designate completely different boat types in different regions."

There are many approaches to a broad typology of shipbuilding. Hasslöf (1963) proposed distinctions based on the construction concepts of "shell first" and "skeleton first," which was originally applied to the Nemi ships and was later complemented by Basch (1972) and Greenhill (1976), referring first to the construction sequence and later on to the existence or inexistence of fastening elements between the planks. Following a text by Patrice Pomey (1988), Hocker and Ward (2005) introduced the concept of philosophy of shipbuilding and made a distinction between "Shell based," "Skeleton based," and "Bottom-based" vessels. In turn, McGrail (1985, 2001) classified the different types of water transport that can be found around the world since prehistoric times based on three attributes: buoyancy, fundamental concept, and techniques.

(a) How buoyancy is applied, which segregates floats (buoyancy is directly applied) from rafts and boats (buoyancy is indirect). How buoyancy is derived divides rafts (from the characteristics of the individual elements that build the vessel) from boats (from the form of the whole vessel).
(b) Boats can be classified by reference to the sequence in which the boat is built. It can be described following the builder's concept of his boat. Even by building a hull to which the framing is fastened to the planking, or by building a frame first fashioned to the shape required and then fastening the planking to the framework.
(c) The principal techniques the builders use to convert their materials into a boat. These can be reduction, construction, transformation, or a combination of all three.

Few studies have approached the typology of fishing boats. Ojeada (2003) proposed a typology for the port of Castro Urdiales (1550–1890), while others have proposed typologies for more recent periods. Mateo (2004) proposed that fishing boats can be classified by size, autonomy, and action range as "high-seas ships" and "coastal boats" and that the same terms are used to classify the type of fishing they perform. Madaria (1999) has classified the vessels according to the treatment they give to fish as "fresh-fishers," "freezers,"

and "factories" (*"fresqueros," "congeladores" "factorías"*) or by the type of fishing they conduct "tow," "fence," "fishing line with hooks," and "shellfish fishing" (*"arrastreros," "cerqueros," "palangreros," "poteros"*). The difficulties of building an accurate typology have been extensively discussed by Casado Soto as he explains:

> The name to designate different typologies of vessels can rise waves of confusion that might make researchers wreck or might take them to remote beaches where they can get lost. This is so because a single word can refer to a specific type of vessel, or to two or more types, or even used as a generic term which encompasses a whole group of different classes of ships. This problem can be found in contemporary documents, as well as in successive or very distant times. To make it even worse, the phenomenon does not only appear in separate and distant places. It might also appear in the record of ships of a single place or zone (Casado Soto 1998, 171).

The difference between the local typology recorded by Barnes (1996) and the typology suggested by Horridge (1982) can be clarified by the fact that the first one is based on the boats' propelling force source, while the second one is based on the construction method. This means both typologies are acceptable. However, each of them fulfills a different purpose. Notwithstanding, the tension illustrates that any typological attempt carried on by a researcher must be carefully explained, starting with the principle on which it is based. Sometimes more than one typology might be necessary to provide a comprehensive picture. This is especially so if the typology proposed by the social scientist diverges from the typology used by the locals. It is worth of mention that Carabias (2000) recorded the indigenous names of the different vessel types he described in his complement to Nuñez (1986) typology. Images are indispensable, and their explanatory capability should be enhanced by expanding on them to highlight differences.

There are several good examples of traditional shipbuilding typologies built by social scientists, among them the ones proposed by: Nuñez (1986) for septentrional Chile. Based on the construction methods and materials, Nuñez asserted vessels could be divided in small *caballitos de mar* made of vegetable fibers, larger wooden balsas, boats made of inflated sea lion skins, and the dugouts. Leshikar (1996, 13), in turn, proposed a typology for pre-Columbian American vessels, based on the materials and construction methods as well, and it encompasses floats, rafts, dugout canoes, bark canoes, plank canoes, reed boats, and skin boats. Then, there are the more specific proposals of Jaramillo Arango (2022), which divides or groups the balsa rafts used in the Pacific of northern South America based on size, propulsion system, and use, and is applicable to a large time span. In addition, Meide's (1995, 40) typology of American dugout canoes encompasses types from southeastern USA, Mesoamerica, the Caribbean, and the North Pacific.

If the typology aims to define boatbuilding tradition and work from a taxonomic perspective toward a "phylogenetic" study of ships, the most appropriate approach relies on the construction method and features and not on the purpose, the size, the propelling system, or any other aspect. The aim should be to describe a "shipbuilding tradition," defined by Reith (1998, 178–180) as a considerable number of shared traits comprising "architectural signatures" in a group of ships. In the same way, McGrail defines a boat building tradition as "the perceived style of building generally used in a certain region during a given time range" (McGrail 2001, 10). This does not deny in any sense the existence of regional particularities and the need to better understand the development of shipbuilding traditions and rhythms, encompassing external influences, local practices, and shape changes in the typologies responding to specific purposes and hydrographic conditions. It just complements the existing classificatory schemes that seek to simplify the complexity

of a multidimensional reality (Loureiro 2012, 27). Any classification is, however, a construct, an approximation of reality (McGrail 2001, 7). Each ship is, as a matter of fact, unique, but the architectural signatures allow us to source the ships to a common cultural horizon, and despite the fact that any individual trait or traits can be shared by vessels produced by other cultures, what makes a tradition unique is the cluster of many, if not all, of the traits within a single ship (Castro 2008, 77).

The need for a typology also shows that the researcher cannot be satisfied by recording the construction process of a single vessel. Instead, he must also research previous vessels built by the shipwright or shipbuilding community. Recording a single vessel informs us about the construction and design process, but research on earlier vessels sheds light on the evolution of the techniques and on whether different types and sizes of boats are built by the subjects of ethnography.

Conclusion

Boats are special artifacts, reliable companions of a life's work, and in some cultures have names and are protected from magical perils. They are built with special care and follow traditions that were often passed from a boat builder to the next with care and precision. Their study is fascinating and ties a wide range of human beliefs, emotions, expectations, and certainties. The tendency to equate maritime anthropology with the anthropology of fishing has neglected the study of practices such as traditional shipbuilding. Given the proliferation and the increasingly affordable prices of fiberglass boats, synthetic materials, and modern tools, traditional wooden shipbuilding seems to be condemned to extinction, or at least many of its traditional components will be inevitably changed forever. Thus, the topic should become a main area of inquiry within maritime anthropology. The ethnography of traditional shipbuilding provides valuable information for its own sake but at the same time helps to inform the incomplete puzzle of the archaeological record and historical accounts. When a researcher engages in the study of traditional shipbuilding communities, a wide array of sources should be consulted. Across this paper, a preliminary set of questions have been drawn from major works, and some of the potential sources of information have been identified. Further efforts should complement these questions, and the list of potential sources must be increased. It must be kept in mind that the ultimate goal is to define shipbuilding traditions within a large time frame and the geographical area it encompasses. This should always entail cross-cultural comparison and attempts at generalization.

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Declarations

Ethics approval This article does not contain any studies with human participants or animals performed by any of the authors.

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