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APPENDIX B

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Basic Terminology of Shipbuilding

(Appendix to Unit 14: *Asian Shipbuilding Technology*)

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Core Knowledge of the Appendix

This appendix provides additional information to support Unit 14: *Asian Shipbuilding Technology* and to some extent overlaps and complements, Appendix C: *Introduction to Metal Shipbuilding Technology*.

On completion of the Basic Terminology of Shipbuilding appendix student will:

- *Understand that nautical terms are a technical language*
- *Have knowledge of the terminology and function of the main structural components of wooden vessels*
- *Have knowledge of the terminology and function of the basic rigging elements of a sailing vessel*
- *Have knowledge of the terminology and function of boat accessories*
- *Understand some of the characteristics of Asian boat design that differ from western boat building traditions*
- *Understand that there are different sequences in how a boat is constructed*

Introduction to the Appendix

As in any specialized profession, it is mandatory to use the appropriate vocabulary when describing the various elements of a ship. It is true that there are many good marine dictionaries (see Steffy (1994) on which this exhaustive list is based), but there are always limitations, and often the available terms do not always apply to ancient shipbuilding, much less than to South-East Asian constructions, concepts and local terminology.

Therefore, it is important to take note of any specific terminology used when visiting a boat yard or meeting a boat builder, in order to attain the most appropriate vocabulary. By describing vessels using authentic terms we not only help preserve national maritime heritage, but also provide keys for interpreting ancient written sources or for enabling linguistic connections.

Although it is impossible to standardize nautical vocabulary, there is basic terminology that can be addressed. It is important to use this terminology and to understand the purpose of each element, so that boat remains can be described and/or interpreted as accurately as possible.

1 Direction and Positions

Fore and aft: relative to the ends of the ship; fore is located at the front and aft is located at the back.

Athwartships: across the ship, relative to the sides, perpendicular to the keel.

Amidships: the middle of a vessel, either longitudinally or transversely.

2 Around the Hull

'In naval ethnography, it is the hull, stable element, which characterises the boat' (Admiral Pâris cited in Amos, 1998, pp. 33), indeed, the shape of a boat is the direct expression of the hull design. It is the main structural component; a watertight body that provides buoyancy to the boat. Its construction is affected by the extent of technical knowledge, available materials, intended routes, cargoes, economics, environment, social structure, political influences and a host of other prevalent factors. There is, therefore, a direct relationship between hull forms and historical periods, even if ships cannot be dated exclusively on the basis of hull design.

It is important to be able to understand and describe hull forms; to notice how the various curvatures served a unique purpose, depending on the type of vessel and the period and geographical area it originated from. Hull form is also directly associated with site distribution of cargo, artefacts, and timbers (Steffy, 1994, pp. 12).

Bow: refers to the forward section of a hull. The point that is most forward when the vessel is underway, specifically from the point where the sides curve inwards.

Stern: is the rear or aft part of a hull.

The bows and sterns once formed the 'hearts and minds' of ships. This is where the crews lived and the gear and valuables were stored. Personal artefacts, anchors, cable, tools, money, scales and other items reflecting ownership and operation are normally found in these areas. Their construction is even more impressive; it changes constantly, timber after timber set in different sizes and directions to satisfy the demands of seaworthiness. The best shipwrightry was required here. This is where we can learn about the disciplines, the economics, the technology and the philosophies of societies, and how each society approached these problems in different ways (Steffy, 1994, pp. 11).

Sternpost: a vertical or upward curving timber, or assembly of timbers, that are stepped into or scarfed to the after end of the keel, or heel, at the stern (Steffy, 1994, pp. 280).

Stem or stem post: a vertical or upward curving timber or assembly of timbers, scarfed to the keel or central plank at its lower end, into which the two sides of the bow are joined (Steffy, 1994, pp. 280).

The prow is also the name given by seamen to the beak or pointed cutwater of large ships. The upper part of the prow is usually furnished with a grating platform.

Starboard: refers to the right side of a vessel, as perceived by a person on board, facing towards the bow.

Port: refers to the left side of a vessel, as perceived by a person on board the ship, facing towards the bow.

Bilge: the area of the hull's bottom on which it would rest if grounded (Steffy, 1994, pp. 267).

Flat bottom/chine: the bottom of a ship may be round, flat or flat floored, with a single or double chine, and with a slight or sharp deadrise. The chine is the 'angular junction of the bottom and side of a vessel' (Steffy, 1994, pp. 269) and can also refer to the longitudinal timber located just inside the junction.

The deadrise is the angle at which the bottom planking lies to the horizontal. Most flat bottomed boats, such as most traditional Chinese vessels, have no keel.

Transom: one of the athwartship (transversal) members, fixed to the sternpost that shaped and strengthened the stern (Steffy, 1994, pp. 281). It is the surface that forms the stern of a vessel. Transoms may be flat or curved and they may be vertical, raked forward or raked aft. Chinese ships usually have a flat transom at the stern.

Bowsprit: a spar projecting forward from the bow (Steffy, 1994, pp. 268). Its purpose is to provide an anchor point for the forestay (a piece of standing rigging which keeps a mast from falling backwards), allowing the foremast to be stepped farther forward on the hull.

3 Longitudinal Structure

Strakes: single plank or a combination of planks that stretch from one end of the boat to the other.

Plank: components of strakes that are not all constructed in one piece.

Keel/keelson/keel piece: the keel is the main longitudinal timber of most hulls, upon which the frames, dead woods and ends of the hull are mounted; it is the backbone of the hull. The keel runs through the middle of the ship, from the bow to the stern and serves as the foundation or spine of the structure, providing the majority of structural strength for the hull.

A keelson is an internal longitudinal timber, mounted atop of the frames along the centreline of the keel. It provides additional longitudinal strength to the bottom of the keel, acting as an internal keel. It is fastened to the keel partly to give additional longitudinal stiffness to it, but principally to bind the longitudinal members (keel and hog) to the transverse members (frames and floors).

Hog timber (rising wood): a fore-and-aft structural member of the hull fitted over the keel to provide a fixing for the garboard planks (first strakes, near the keel).

Gunwale: is the upper edge of a vessel's side. In sixteenth century vessels, the wale is against which the guns rest (Steffy, 1994, pp. 272). It is a strengthening wale or a structural band added to the design of the ship, to accommodate the stresses imposed by the use of artillery.

Stringer/side stringers: general term describing the longitudinal timbers along the inside of the planking. They are usually fixed to the inside surfaces of the frames (Steffy, 1994, pp. 281) to reinforce the structure.

Bulwark: the extension of the ship's side above the level of the weather deck.

Freeboard: height of the ship's sides above the waterline.

Sheer: the upward curve of a vessel's longitudinal lines as viewed from the side.

Double-ended: a vessel whose bow and stern have approximately the same horizontal shape, such as rounded, pointed or square ends (Steffy, 1994, pp. 270).

4 Transversal Structure

Frames: transverse members that are made up of more than one piece of timber, usually floor timbers and pairs of futtocks, set against the planking.

Floor timbers: transverse structural members lying across the keel and tying the frames on either side of the keel together. They are also the central futtock or futtocks of a sawn frame, lying across the keel. Floor timbers join both sides of a vessel together and make up the sub-structure for external keel fastenings, engine beds and mast steps.

Timber: general term to describe any piece of wood used in shipbuilding.
One piece of ribs or frames, especially those steamed or bent into place, are frequently called timbers.

Rib: a small transverse member, often flexible and composed of one or more pieces, that stiffens the outer skin of a hull (Steffy, 1994, pp. 278). Although often used for frame, rib is more properly applied to small craft, such as canoes or small boats.

Futtocks: a frame timber (that is not a floor timber, half frame or top timber) that constitutes one of the middle pieces of a frame. They are pairs of timbers which, with a floor timber, constitute a frame and essentially support the side planking.

Beam: a timber mounted athwartships to supper decks that provide lateral strength. Large beams are sometimes called baulks (Steffy, 1994, 267).

The breadth of a ship is the width of a hull, sometimes called beam because it is technically the length of the main beam.

Thwarts/benches: transverse structural members that support masts, provide lateral stiffness and that are often used as a seat in small boats.

Bulkheads: a vertical partition that is either fore and aft or athwartships (Steffy, 1994, pp. 268). It usually applies to every vertical panel aboard, apart from the hull itself. In South-East Asian technology, they usually refer to the Chinese design of forming watertight compartments.

At some point during the fifteenth century, sailors and builders in Europe realized that walls built within a vessel would prevent cargo from shifting during passage. The word bulki meant 'cargo' in old Norse and any vertical panel was called a 'head'. As a result, walls installed abeam (side to side) in a vessel's hull came to be known as 'bulkheads'.

There is evidence of bulkheads in Chinese shipbuilding technology since the Tang Dynasty.

5 Decks & Deck Features

Deck: is a permanent covering over a compartment or a hull of a ship. The primary deck is the horizontal structure which forms the 'roof' of the hull and both strengthens the hull and serves as the primary working surface. Vessels often have more than one level within the hull itself.

Poop: is the highest and aftermost deck of a ship (Steffy, 1994, pp. 277). The name originates from the French word for stern, *la poupe*. In sailing ships, with the helmsperson at the stern, it is an ideal elevated position for both navigation and observation of the crew and sails.

Quarter deck: extends forward from the stern to the main mast. The poop is located at the hind part of the quarter deck and often serves as roof for the captain's cabin.

Forecastle: refers to a short, raised foredeck, the forward part of the upper deck, between the foremast and the stem, or the quarters below the foredeck (Steffy, 1994, pp. 271).

6 Steering and Propulsion

Oar or paddle: the main practical difference between a paddle and an oar is that an oar is attached to the boat, through an oarlock or rowlock, while a paddle is loose. Oars are also usually longer than paddles.

In rowing, a boat is manoeuvred with an oar, when paddling a paddle is used. A paddle is hence shorter and broader in the blade than an oar, and is equally employed for rowing and steering.

Sculling oar/steering oar/yuloh: 'to scull' is to cause a boat to move forward by operating a single oar over the boat's stern. A sculling oar is a kind of short oar, the loom of which is equal in length to half the breadth of the boat. A steering oar is used to steer a small vessel, either from the side or the stern. A steering oar should not be confused with a quarter rudder, which is permanently mounted and turns about a fixed axis.

The yuloh is a Chinese sculling oar. It is a large, heavy sculling oar with a socket on the underside of its shaft which fits over a stern-mounted pin, creating a pivot which allows the oar to swivel and rock from side to side. The weight of the oar, often supplemented by a rope lashing, holds the oar in place on the pivot. The sculler primarily moves the oar by pushing and pulling on this rope, which causes the oar to rock on its pivot. This system allows multiple rowers to operate one oar, allowing large, heavy boats to be rowed if necessary.

Rudder: a timber or assembly of timbers that can be rotated about an axis to control the direction of a vessel (Steffy, 1994, pp. 278). This term is used for any kind of vessel, boat, submarine or aircraft.

Various types of rudders can be seen in South-East Asia, including the Chinese axial rudder, the South-East Asian lateral rudder (or quarter rudder), the caisson helm and also some basic types of western helms.

Chinese axial rudder: Is attached to the hull by means of wooden jaws or sockets, or can be suspended from above by a rope tackle system so that it can be raised or lowered into the water.

Chinese rudders are sometimes bored with diamond shaped holes (fenestrated rudders), which are believed to decrease the force of the water on the rudder, easing the task of the helmsperson, without affecting its efficiency. The Chinese invented these stern mounted rudders almost one millennium before the pintle and gudgeon rudder appeared in Europe.

Axial caisson helm: this type of rudder is derived from the concept of the suspended sliding rudder, which slides in a water compartment. It protects the long, narrow rudder from the blows of the sea and makes it easy to retract. Pegs or crossbars enable the rudder to be fixed at a chosen depth.

South-East Asian lateral rudder: this type of rudder is mounted on the side of the boat at the quarter aft. The strength of a quarter rudder lays in its combination of effectiveness, adaptability and simplicity (Burningham, 2000).

Basic helm with braces: in the western tradition, rudders are hung on the sternpost, supported by a pintle and gudgeon rather than being suspended like the Chinese types. A pintle is a pin or bolt, usually inserted into a gudgeon, a circular fitting often made of metal, which is affixed to a surface. It allows for the pivoting of another fixture.

Tiller: is a wooden or metal lever fitted into the rudder head, by which the rudder can be moved from side to side (Steffy, 1994, pp. 281).

Helm: is a general term that usually includes the tiller, the steering wheel and the actual rudder.

Guares/centreboards/lee boards/anti-leeway devices: a centreboard, drop keel or sliding keel, is a wooden or iron plate that can be raised and lowered within a watertight housing called a trunk. The trunk is built over a slot in the keel or in the hull (Steffy, 1994, pp. 269). The centreboards help direct a vessel as it increases lateral resistance, therefore, reducing leeway when tacking or sailing off the wind.

Some seagoing rafts from Thanh Hoa (Viet Nam) were fitted with three centreboards. These particular vessels featured mixed hulls and because the basket hull could not be pierced, the centreboards were fitted in the grooved stem post, forming the unique feature of a 'bow board'.

Outrigger: the outrigger float, which could be a simple cylinder of wood or something of much more complex shape, is held out of the boat (at a distance equivalent to a third of the boat's length) by booms fastened to the hull's framing. These booms and their connectives act as transversal stabilizers. Outrigger assemblages can vary in innumerable ways and have been studied in some detail by Haddon and Hornell (1975). Their use in South-East Asia is thought to date as far back as the eighth to ninth century, as evidence of them can be seen in images found at the temple complex of Borobudur.

7 Rigging

Rigging: is the whole apparatus through which the force of the wind is used to propel sailing boats or ships forward. This includes masts, yards, sails and cordage.

Masts: the vertical pole or spar that supports the boom and sails. The mast head is located at the top of the mast.

In a three masted, square sail carrying ship each mast has a specific name. From bow to stern: foremast (the first mast), mainmast (tallest, usually located near the centre) and the mizzenmast (the shorter, third mast or the mast immediately aft of the mainmast). There are other names given to masts in ships carrying other types of rig, for example, the bonaventure mizzen (fourth mast on sixteenth century galleons) or jigger mast (the shortest, the aft-most mast on vessels with more than three masts).

The mast partners: are the ship's timbers that are fitted between the deck beams located around the opening in the deck where the mast passes through. Essentially they are under the deck planking. When the mast is stepped, it is wedged into place at deck level, the wedges going between the partners and the mast itself. This serves to stiffen the installation, so that the mast doesn't move around and damage itself or the deck.

Maststep: is the fitting in the bottom of the boat, in which the bottom or heel of the mast sits.

Yard: a spar suspended from a mast, from which the head of a square sail is suspended.

Boom: a spar attached to the foot of a fore-and-aft sail.

Shroud: a rope or wire support used to steady a mast to the side of a hull. They lead from the masthead to the sides of the vessel, to support the mast athwartships.

Deadeyes, pulley blocks and halyards: halyard is a line used to hoist and lower a yard and sail/dead-eye; a thick disk of hard wood, strapped with rope or iron, through which holes (usually three) are pierced for the reception of lanyards. They are used as blocks to connect shrouds and chain plates.

Fore-and-aft rigging: sailing rig that consists of sails set along the line of the keel, rather than perpendicular to it. Fore-and-aft rigged sails include stay sails, Bermuda sails, gaff sails, gunter rig, lateen sails and lug sails.

Evidence from South-East Asia indicated the use of fore-and-aft sails of unspecified form, set on two or more masts since third century at the latest (McGrail, 2001, pp. 309). The canted rectangular sail first appeared in the eighth or ninth century and continued to be in use until recent times. From at least the sixteenth century they were matted or made from woven rattan (Manguin, 1980, pp. 272).

Gaff rigged sails: this kind of sail is four cornered, fore-and-aft rigged and hoisted at the head by a gaff. The sail's upper edge is supported is by a spar (pole) called the gaff. The gaff enables the sail to be four sided, rather than triangular.

Gunter rig: similar to a gaff rig, except that the spar forming the gaff is hoisted up to an almost vertical position, extending well above the mast.

Lateen sail: triangular sail set on a long yard, mounted at an angle on the mast (very characteristic of Arabic civilization).

Lugsail: a four sided fore-and-aft sail, supported along the top by a spar and fixed to the mast at a point some distance from the centre of the spar.

Square sails: primary driving sails that are carried on horizontal spars, which are perpendicular or square to the keel of the vessel and to the masts.

Battened sail: is a type of sail where rigid members, called battens, span the full width of the sail and extend the sail forward of the mast. They appear to have been mainly, if not exclusively Chinese, from the twelfth century onwards.

Canted rectangular sail: one of the most primitive forms of fore-and-aft sail is the rectangular Indonesian canted (tilted) sail which is rectangular in shape.

Patent reefing gear: is a manoeuvre that facilitates the reefing of the sail (Paris 1942, pp. 395). A cross handle on the guy enables the crew to roll down the sail. This feature may originate from Indonesia, where sails made of palm are more easily lowered by a simple turn of the handle, which winds the foot of the mainsail onto the boom (Pietri, 1943, pp. 7).

8 Accessories and Other Related Terminology

Balance board: consists of a plank laid athwartships and projecting a considerable distance out to either side. It can be connected with outrigger boats and can provide stability to crafts that are otherwise too narrow or unstable, to attempt long voyages.

Anchors: there are three main types of anchors found in South-East Asia, each corresponding to a different period of time (see Kimura *et al*, 2011).

Stone weight anchors are often little more than a simple stone weight with a hole for the anchor line. Compound anchors are made of a wooden body and one or two stone stocks. The compound anchors can also be sub-divided into two groups: anchors with a single stone stock and anchors with two separate stone stocks. Both feature a stone stock in the middle of the shank (Kimura *et al*, 2011, pp. 365). 'Compound anchors became prominent during the Song to the Ming Dynasties (960-1644 CE) and compound anchors with both separated and non-separated stocks coexisted throughout the thirteenth century'. The compound anchor was gradually replaced by anchors with a round wood (or possibly iron) stock placed lower in the shank. Usually compound stone stock anchors are formed by a minimum of four elements: the shank (shaft of the anchor), the arms that end with flukes (or palms, that are pointed or chisel shaped and are designed to dig into the seabed) and by a stock. The stock is the crossbar at the top of the shank, positioned at right angles to the arms. Evidence for iron grapnel anchors is also found in Asia and South-East Asia during the same period. It is generally understood that seafarers along the northern Chinese coast preferred iron grapnel anchors, while wooden variants were the anchor of choice along the country's southern coast (Kimura *et al*, 2011, pp. 370).

Windlass: is a horizontal cylinder supported by bitts or brackets, used to haul anchors and hawsers.

Length Overall: often abbreviated as (LOA, o/a, o.a. or oa). This measurement refers to the maximum length of a vessel from two points on the hull, measured perpendicular to the waterline.

Overall lengths can vary enormously depending on the type of vessel. A small coaster or fishing vessel from the coast of Viet Nam reaches a length of between 10 to 25 meters, while the Javanese jongs of the sixteenth century had a length of about 50 meters. In comparison, the treasure fleet of Zeng He had a length that supposedly reached 125 meters.

Loaded Waterline Length (LWL): or the waterline length, is a measurement that denotes the length of the vessel at the point where it sits in the water. It isn't equal to the total length of the boat as it excludes various parts of the vessel, such as features that are out of the water. Most boats rise outwards at the bow and stern, so a boat may be quite a bit longer than its waterline length. This measurement is essential in determining many of the vessel's properties, such as how much water it displaces, where the bow and stern waves are, hull speed, amount of bottom-paint needed, etc.

Breadth or beam: the width at the widest point. This can also vary depending on the type of vessel. A small boat has a beam of 5 meters, while the treasure fleet of Zeng He supposedly had a beam that reached up to 50 meters.

Displacement: refers to the ship's mass when it is loaded to its maximum capacity. A ship's displacement is its mass, generally expressed in metric tonnes or long tons. Using the same examples, a small boat has a tonnage of 25 to 100 tons, while the Javanese jongs of the sixteenth century had an average burthen of about 300 to 500 tons. In comparison Zeng He's ships had a displacement that could supposedly reach 1,500 tons.

Net tonnage: often abbreviated as NT, N.T. or nt. Is a calculated representation of the internal volume of a ship's cargo hold. It is expressed in tons, which are units of volume defined as 100 cubic feet.

Draft (draught) and drag: the draft is the depth to which the hull is immersed (the vertical distance between the waterline and the lowest point of the hull), while the drag is the difference between the draft of a vessel's stern and it's bow.

Expressing distances and speed: Distance at sea is always measured in nautical miles. Speed at sea is measured in nautical miles per hour called knots.

1 nautical mile = 1.85 km
0.1 nautical mile = 100 fathoms = 200 yards
20km/h = 10.8 knots

9 Boat Constructions

Boats are built using different construction sequences which vary from region to region. Often boats in Europe are built frame first, while in South-East Asia, boats are often built shell first. It is, however, not possible to generalize from region to region.

Frame first/skeleton built: as the name suggests, the skeleton of the vessel is built first, which means the framework of keel, posts, and frames is set up and fastened before the planking is fashioned.

Shell first/plank first: process by which all or part of the outer hull planking is erected before the frames are attached to it. In pure shell built hulls, outer planking is self-supporting and forms the primary structure; the framework fastened to it forms the secondary or stiffening structure.

It seems that in South-East Asia, there is a predominance of shell first constructions over frame first, despite shell first being more difficult to achieve as it requires advanced skills, due to the finer tolerances that need to be maintained.

Clinker/reverse clinker: a way of setting the planks so that the outer planking overlaps and is fastened to the plank immediately below it. When planks overlap with the ones above them the procedure is known as reverse clinker. This method is seen notably in Bangladesh (McGrail *et al*, 1999).

Carvel planking: means that the seams are smooth or aligned, as opposed to clinker built.
Northern European scholars reserve 'carvel built' for frame first forms of constructions. Note that this term is confusing and best avoided, as it is sometimes taken to be synonymous with frame first building using flush-laid strakes (McGrail, 2001, pp. 467).

Flush-laid: planking in which adjoining strakes are butted edge-to-edge without overlap.

To caulk: is an essential phase in boat construction. It consists of inserting material between two members and rendering the junction watertight. Whether this is done before or after planking is fastened, may be an important diagnostic trait (McGrail, 2001, pp. 467). Caulking materials and recipes are essential in identifying the available materials to a shipbuilder.

10 Joining Methods

Iron nails: are used to fasten the planks, edge to edge. The use of iron nails for fastening the planking is a major difference between the Chinese and the South-East Asian shipbuilding traditions. Nails appear with the Portuguese in Indian traditions (late fifteenth century).

Bolt: a cylindrical metal pin used to fasten ships timbers together.

Treenails: (pronounced 'trunnels') are round or multisided pieces of hardwood, driven through planks and timbers to connect them. They are used in a variety of forms: with expanding wedges or nails in their ends, with tapered or square heads on their exterior ends, or completely unwedged and unheaded. When immersed, treenails swell to make a fit.

Tenon and mortise: a tenon is a wooden projection cut from the end of a timber or a separate wooden piece that is shaped to fit into a corresponding mortise (a cavity cut into a timber designed to receive a tenon).

Pegs: are tapered wooden pins driven into a pre-drilled hole to fasten two members or lock a joint. Pegs come in a variety of sizes and tapers: square, round or multisided cross sections. The important difference between dowels and pegs in ancient construction is that the former were of constant diameter and lightly set, while the latter were tapered and driven with appreciable force. The most common use of pegs in ancient construction was to lock mortise and tenon joints.

Wooden dowels: are cylindrical pieces of wood (of constant diameter) used to align two members by being sunk into each. Unlike treenails and pegs, dowels served an alignment function only, additional fastenings being necessary to prevent separation from the joint.

Scarf: an overlapping joint used to connect two timbers or planks without increasing their dimensions.

Lashed lugs and stitching method: there is a difference between stitched boats and sewn boats. Many examples of stitching can be found in South-East Asia. For example, in Viet Nam three techniques are described in the written accounts, yet the main principle remains the same. Essentially, holes are drilled in the planks through which threads pass to lash the planks together. A pad is placed on the seams, ensuring that the hull is water tight. Bamboo laths are then laid longitudinally over the pads. Flat wedges are inserted between them and the straps, overlapping each other like tiles, in order to compress the pad. The gaps are then sealed with a mix of tree bark and coal tar or mangrove bark, or a compound of resin and ground bamboo. The holes can be made in different ways (see Manguin, 1985).

The most common South-East Asian ship building technique is known as the 'lash-lug tradition', which is when lugs or cleats protrude and the lashing is fastened around them. Treenails support the fastening by maintaining the strakes edges to edge (see the Pontian boat, dated to between the third and fifth century). This technique evolved towards the later typical South-East Asian technology, where only wooden pegs maintain the strakes together, fully dowelled.

Suggested Reading

Burningham, N. 2000. Indonesian Quarter-rudder Mountings. *International Journal of Nautical Archaeology,* Vol. 29, No. 1, pp. 100-119.

Haddon, A. C., and James Hornell. 1975. *Canoes of Oceania,* Vol. 1 (Polynesia, Fiji and Micronesia), Vol. 2 (Melanesia, Queensland and New Guinea), Vol. 3 (General Survey). Honolulu, Hawaii, Bishop Museum Press.

Kimura, J., Randall S. and Long, V. T. 2011. Historical Development of Asian Anchors, as Evidenced by Two Wooden Anchors Found in Northern Vietnam. *International Journal of Nautical Archaeology,* Vol. 40. No. 2, pp. 361-373.

Manguin, P.-Y. 1980. The Southeast Asian Trading Ship: a Historical Approach. *Journal of Southeast Asian Studies,* Vol. 11. No. 2, pp. 253-269.

McGrail, S. 2001. *Boats of the World: From the Stone Age to Medieval Times*. Oxford, Oxford University Press.

McGrail, S., Blue, L. and Kentley, E. 1999. Reverse Clinker Boats of Bangladesh and Their Planking Pattern. *South Asian Studies,* Vol. 17, pp. 221-223.

Paris, P. 1942. Esquisse d'une Ethnographie Navale des Pays Annamites. *Bulletin des Amis du Vieux Hué,* Vol. 4, pp. 352-450.

Pietri, J.-B. 1943. *Voiliers d'Indochine*. Saigon, Société des Imprimeries et Librairies Indochinoises (SILI).

Steffy, R. 1994. *Wooden Ship Building and the Interpretation of Shipwrecks*. College Station, Texas A&M University Press.