BOATS OF THE WORLD

FROM THE STONE AGE TO MEDIEVAL TIMES

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Sources and Themes

1.1
Maritime Archaeology and Boat Archaeology

The principal subject of this study is water transport, that is, rafts, boats, and ships. Research into water transport, a subject sometimes known as 'boat archaeology', is just one aspect of the maritime subdiscipline of archaeology which may be defined as 'the study of the nature and past behaviour of Man in his use of those special environments associated with lakes, rivers, and seas' (McGrail, 1989*a*: 10). In addition to water transport, this research area includes the study of landing places and harbours, as well as the study of the building, use, and performance of rafts, boats, and ships (Fig. 1.1). It also includes: anchors and fishing gear; overseas colonizations and trade routes; trade and cargo handling; changes in past climates, sea levels, and coastlines; and early seafaring and navigational techniques (McGrail, 1995*c*: 329). A study of all aspects of maritime archaeology by a single author would necessarily be uneven in quality with some parts at an elementary level: such a task would better be tackled by a group of specialist authors. The present work leaves to one side much of maritime archaeology (although every aspect is at least touched upon in some part of the text) to focus on rafts, boats, and ships. Moreover, although planked vessels are dealt with in some detail, emphasis is placed on rafts and non-plank boats whenever the evidence allows, since in all regions of the world these are the craft most likely to have been used in earliest times about which we know least. The aim is to present a history of water transport as it has developed over millennia in the regions of the world, in as much as the evidence available at present allows.

Fig. 1.1. Diagram to illustrate the scope of maritime archaeology (Institute of Archaeology, Oxford).

1.2
Sources of Evidence

This study is based whenever possible on archaeological evidence, in particular the excavated remains of water transport. Outside Europe such evidence is rare, and even within Europe there are no excavated remains of logboats before the eighth millennium BC, or of plank boats before the second millennium BC. In later times such finds as there are, are usually isolated

in time and space, and it is only from the late Roman period onwards that sufficient numbers of similar plank boats and ships have been excavated to justify the definition of boatbuilding traditions in certain periods and regions. Remains of other types of water transport are virtually negligible worldwide. Thus other forms of evidence have to be used, often standing alone rather than in conjunction with archaeological remains. The recording, examination, and post-excavation analysis of boat and ship remains is a specialized task, outside the scope of this present work: the reader is referred to publications by Steffy (1994), by Olsen and Crumlin-Pedersen (1967), and by Crumlin-Pedersen (1977).

I.2.1 INDIRECT EVIDENCE FOR SEAGOING VESSELS

Evidence for early overseas voyages, and therefore the existence of seagoing vessels, before the time when there is direct evidence from shipwrecks, comes from the distribution patterns of artefacts, and of those ideas which become archaeologically visible as 'monuments', as 'ritual', and as technological innovations. However, not every exotic artefact or structure is a sure sign of seafaring: in continental land masses some goods and ideas may indeed have travelled by sea on coastal routes, but others may have been transported on land routes, albeit including the use of rivers. Only in the case of islands, or between continental land masses, which were demonstrably surrounded by water at the time in question, must people, artefacts, animals, and ideas necessarily have arrived by sea.

Evidence for possible early seafaring must be examined critically and, in the case of non-islands, the balance of probability struck. Even when an overseas voyage seems likely, it does not follow that there was direct contact by sea (Spain to Ireland, for example). Unless there is other evidence, the minimum conjecture must be that a coastal cabotage route was used (Spain, France, Britain, Ireland).

I.2.2 ICONOGRAPHIC EVIDENCE

Representations of boats are the only evidence available in earliest times. Furthermore, sails and rigging rarely survive to be excavated, but they are sometimes depicted on stone carvings, engravings on seals, and on pottery decorations. Such representations can therefore be invaluable, but they cannot be accepted without rigorous analysis and interpretation. The bow and stern need first to be identified and the problem of scale tackled. There are several examples in this study of ship and boat depictions which have been the subject of vigorous and lengthy academic debate about how they should be interpreted—for example, the Thera frieze (4.7.2.2). Earlier examples, such as depictions from ancient Egypt (2.4, 2.6.3) and Mesopotamia (3.2), are stylized and even more difficult to interpret.

Without the control imposed by comparisons with contemporary examples of excavated boats, the interpreter of early iconography may allow imagination too much scope. Furthermore, it has to be borne in mind that these depictions are not naval architects' plans: they are (usually) a two-dimensional representation created by someone from a distinct culture, working to specific artistic conventions, who may have only indifferent knowledge of nautical matters. However, systematic analysis of individual elements of a boat depiction, and comparisons between representations from the same artistic environment, may lead to working hypotheses about conventions used: for example, vertical lines across a depicted 'hull' possibly represent the bindings of a bundle raft; vertical lines above a hull may represent the crew; vertical lines extending below a hull may represent paddles or oars; horizontal lines along a hull may represent planking; and short vertical lines or devices, across these horizontal lines, may represent plank fastenings. But these are guidelines rather than rules, and it may be necessary to admit that some representations cannot be interpreted or, at best, it may only be possible to suggest, from the context, that they depict some unspecified type of water transport. On the other hand, a model of a boat can be potentially rewarding since the cross-section, generally unseen in two-dimensional depictions, provides much information about the boat's potential when afloat.

A series of representations from a particular period and place can thus be very useful to the archaeologist in the absence of, but particularly in addition to, excavated evidence, providing the evidence is critically evaluated. It is to be noted, however, that the iconography available probably does not represent the full range of water transport in use: for example, boats,

unlike ships, are very seldom found on medieval town seals. Compounding such difficulties is the problem of dating early representations such as the Scandinavian rock carvings: the margin of error in the dating methods used is insufficiently stressed.

1.2.3 DOCUMENTARY EVIDENCE

Documentary evidence ranges from inscriptions mentioning shipping, and early law codes listing harbour dues, to detailed technical reports written and illustrated by explorers and travellers. The principal aim of most of the authors of the earlier documents was seldom to record the building or the use of water transport; thus the nautical information in them may frequently be inconsequential. To obtain reliable information from such documents even if it is a mere scrap, it is first necessary to determine the standpoint, the reliability and the nautical competence of the observer; and the document must be given a precise provenance in time and space. Translators with an inadequate knowledge of nautical and marine affairs can easily add to inherent difficulties in understanding texts, as may the fact that no twentieth-century English word may now exist to describe a particular feature or operation. As with iconographic evidence, documentary evidence of water transport is unlikely to be comprehensive or unbiased: objects and events that are commonplace to the observer will be noted briefly, if at all, whereas the unusual, which may be in no way representative of its day, will be discussed in some detail.

1.2.4 ETHNOGRAPHIC EVIDENCE

The documentation of traditional rafts and boats still in use in non-industrial, generally illiterate, small-scale societies can also suggest the sort of water transport those societies may have used in earlier times, providing some form of cultural continuity can be demonstrated. Should there also be excavated remains of early craft, a symbiotic relationship between the two forms of evidence may ensue, as seems to have happened in Norway, leading to a fuller picture of early nautical life than obtainable solely from archaeology.

Such ethnographic evidence may also be useful in a broader sense in the interpretation of excavated remains. A knowlege of a wide range of solutions to specific boatbuilding and boat-use problems (for example, how to close the ends of a boat; how to get the desired shape of hull; and how to steer) enable the archaeologist to escape the constraints of his own culture, and perhaps come closer to understanding the early technology he is investigating. There are undoubtedly problems in using analogies cross-culturally, but the more alike in environmental, technological and economic terms two cultures (one ancient, one recent) can be shown to be, the greater the likelihood that ethnographic studies will be of relevance to the investigation of early nautical technologies and boat use.

Ethnographic studies can thus be of great value in the interpretation of early boats, their structure and their use. There is not, however, necessarily a one-to-one relationship between ethnographic documentation and the incomplete, fragmented, and distorted remains of an ancient boat. Ethnographic evidence can suggest the sort of questions to be asked of the ancient boat and may prompt a range of answers, but, as Grahame Clark (1953: 357) said nearly fifty years ago, '. . . only archaeology, in conjunction with the various natural sciences, can give the right answers'—with the rider that, in the present state of knowledge, no answer may be possible, and any answer will be probabilistic rather than definitive.

The fact that ethnographers have documented the recent use in the west of Ireland of simple forms of water transport such as the hide boat (Hornell, 1937–8) and the bundle raft (Delaney, 1976) does not validate a claim that they must have been used there millennia ago. The possibility is certainly brought to our attention, but, since there is no direct evidence for such early use, it will be necessary to trace evidence back to the protohistoric period. If this can be done, and it can be further shown that appropriate raw materials and analogous tools and techniques were available and used in prehistoric times, then a hypothesis may be formulated that such craft may have been built and used in the Bronze Age or even earlier. Evidence may subsequently be sought to support, or refute, such a hypothesis.

The 'first contact' reports by fifteenth to eighteenth-century European seamen concerning the water transport they encountered in the 'new found lands' of the

Americas, Australia, and the South Pacific are especially valuable in that many of these craft were documented (though not always in the detail one would wish) before European technologies had influenced them.

1.2.5 DATING EVIDENCE

Until relatively recently, remains of water transport were generally dated by reference to the archaeological context in which they were found, or from the cargo or other finds associated with them. Such methods are not always satisfactory and, in any case, the margin of error is often unacceptably great since such methods depend ultimately on the most recent stylistic dating of artefacts such as pottery. In recent years, however, direct dating of boats has been undertaken by radiocarbon assay and, latterly, by dendrochronology with its much greater precision. Those boats excavated before the advent of scientific dating must be considered only provisionally dated until definitive dendrochronological dates are published.

1.2.6 ENVIRONMENTAL EVIDENCE

In order to understand how and where water transport was used in earlier times, and to appreciate fully the problems faced by early seafarers, and suggest how these might have been solved, it is first necessary to build up a picture of the environment at a particular time and place. Things have not always been as they are today: there have been short-term and long-term climatic changes, and mean sea level has generally risen, at variable rates, during the past 18,000 years. Former weather patterns are of particular interest to our understanding of seafaring and overseas trading routes: especially important are the direction and strength of the predominant winds, and the frequency of winds from other sectors.

Of even more interest, and of fundamental importance to seafaring, is the position of mean sea level at a given time and place, since, in conjunction with other factors, this determines:

- the general form of the coastline;
- river gradients, and hence rates of erosion and deposition;
- the presence or absence of archipelagos, shoals, sands, reefs, skerries, tidal races, spits, and bars.

Mean sea level also indirectly influences local tidal regimes which are, to a degree, determined by the configuration of the coast. Before we can suggest how both Greater Australia and the Americas could have been first settled, mean sea level has to be determined for the period when these migrations are thought to have taken place—see Chapters 7 and 11.

Changes in sea level and in weather patterns are discussed in some detail in the chapters on the Mediterranean (see Ch. 4) and on Atlantic Europe (see Ch. 5), regions for which environmental data is readily available. The reconstruction of earlier coastlines, coastal waters, river channels, and earlier weather experienced at a particular time and place, is a complex matter since the effects of a number of interacting variables have to be estimated. Maps have been published for certain parts of the world showing sea levels and coastlines at intervals of time during past millennia; in the present state of research these must be considered as general guidance for the maritime archaeologist, rather than definitive, and the conclusions drawn by archaeologists about ancient seafaring and navigation from such data are, at best, probabilistic.

When the evidence for the direction, strength, and frequency of a predominant wind in former times in a particular region is well established, it is possible to estimate, in a relative way, whether passages between selected harbours were feasible by using a theoretical 'standard ship' which could be sailed with the true wind one point forward of the beam (leeway being discounted). In monsoon-type climates, where the wind remained in a fixed quarter for much of the sailing season, as in the eastern Mediterranean and in the Indian Ocean, such estimates are probably realistic. In temperate regions, as in Atlantic Europe, winds were probably much more variable and estimates will therefore be less reliable. In several regions of the world, however, there are periods at the beginning and the end of the main sailing season when winds can be fair for passages which cannot be made at other times.

Weather data for earlier times is either derived from dendrology and similar palaeo-research and is therefore generalized, or it is based on averages and extrapolations of observations made in past centuries. The

actual weather experienced, in earlier times, over a particular period of, say, three or four days (sufficient for many passages in the Mediterranean and coastal Atlantic waters) could well have been different from these averages. Thus, once again, it is necessary to talk in terms of probability and likelihood of what could be achieved in prehistoric times.

1.3
The Reconstruction and Interpretation of Excavated Vessels

The reconstruction and interpretation of the remains of an ancient vessel is the key phase in a research project (Figs. 1.2, 1.3). The record made during excavation, the post-excavation research documentation, environmental data, and the results of sample analyses are brought together and evaluated in the light of known facts about ancient water transport and other comparative data from iconographic, documentary and ethnographic sources. Hypothetical reconstructions of the original full form and structure of the vessel are built up, either as measured drawings or as small-scale models—see Steffy (1994: 189–298) and McGrail (1981*a*: 9). Two or more reconstructions may be compatible with the evidence. From these reconstructions, predictions of performance can be made (McGrail, 1998: 192–202): stability in various conditions (a sine qua non); payloads at certain drafts; the likely range of speeds; and achievements when tacking if it has proved possible to reconstruct the sailing rig. Only if the reconstruction is authentic, the data accurate, and the arguments rigorous will the predicted perfor-

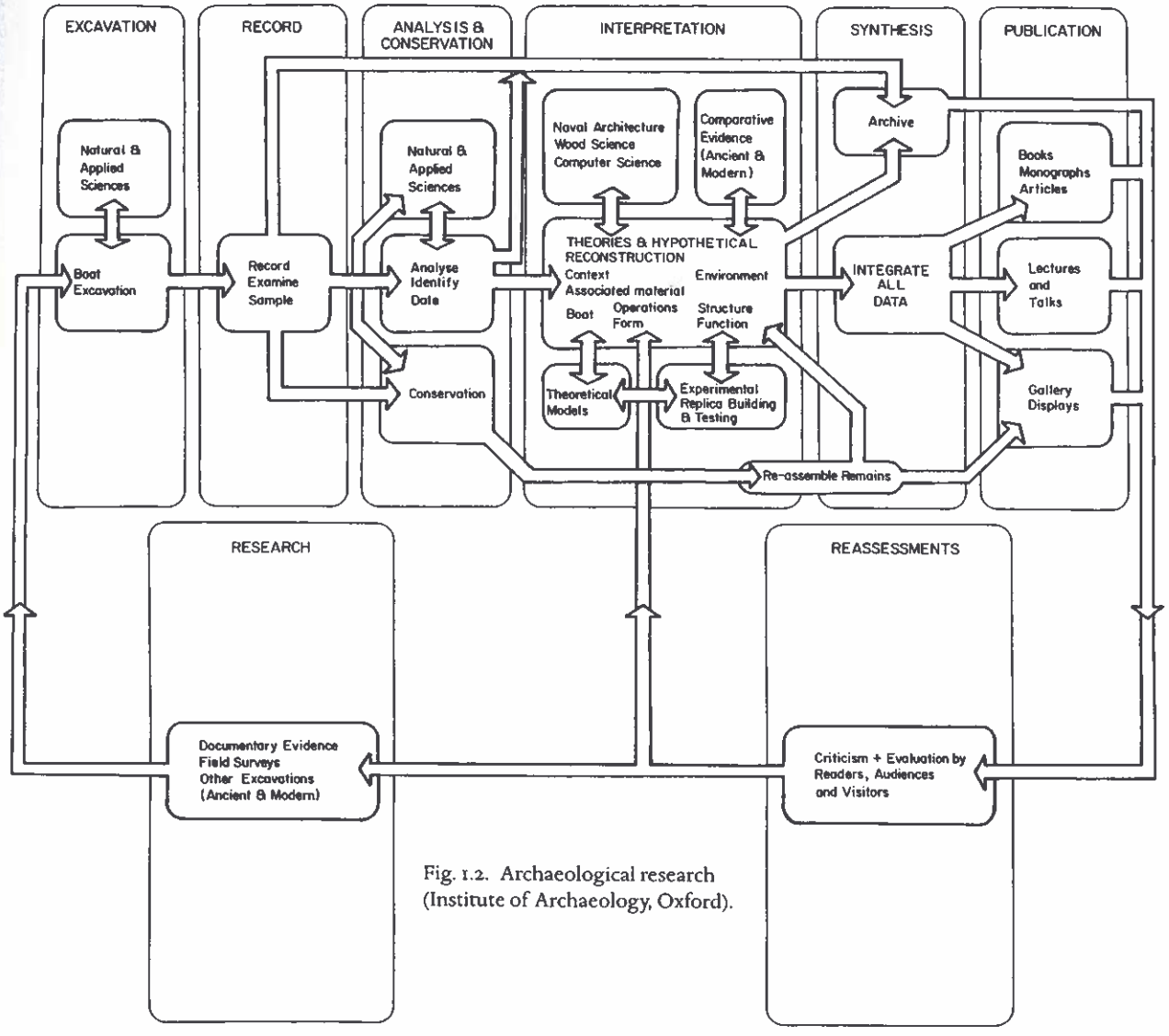

Fig. 1.2. Archaeological research (Institute of Archaeology, Oxford).

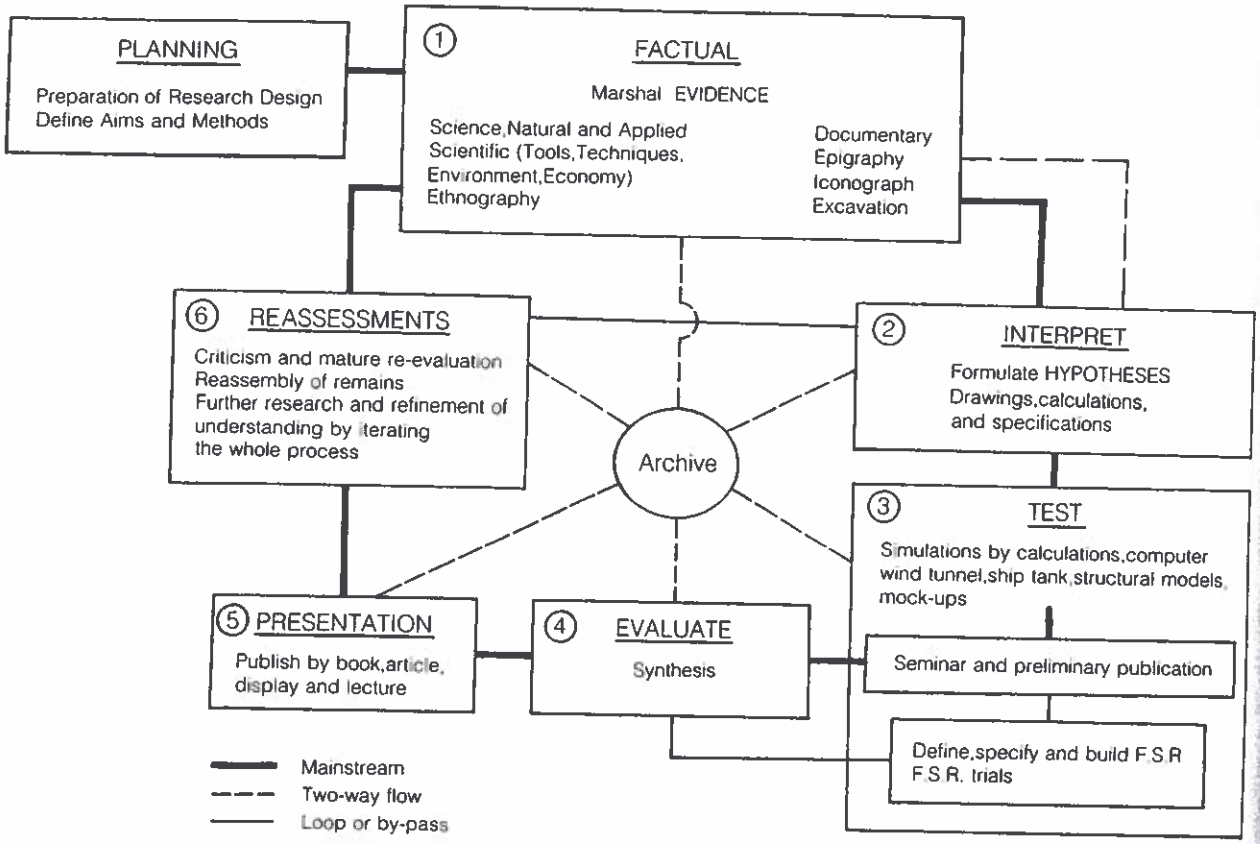

Fig. 1.3. Experimental boat and ship archaeology (Institute of Archaeology, Oxford).

mance be credible. Cargo-carrying abilities may be presented either in the form 'at a draft of *n* metres *x* tonnes of amphorae filled with wine may be carried' or in the form 'if *n* tonnes of wine-filled amphorae were carried the draft would be *x* metres'.

In such estimations of performance it has to be ensured that the vessel would have adequate freeboard (however that is defined), and that she would be stable when carrying the designated loads, using cargo storage factors in the calculations when necessary (McGrail, 1989*b*). For international comparisons it is customary to assess the tonnage that vessels could carry at drafts equivalent to 60 per cent (cargo vessels) and 50 per cent (warships) height of sides amidships, such drafts being considered (on the evidence of medieval Icelandic laws see McGrail, 1998: 199) to give safe freeboard for the two classes of vessel.

Ways of distinguishing cargo vessels from fighting vessels are discussed in 5.8.1.3.5. Another important assessment of a vessel is to determine whether or not she would have been seagoing. By 'seagoing raft or boat' is meant the sort of craft which, without special preparations or additional fittings, could be relied upon to carry a reasonable load on a sea passage of some duration in the weather and sea conditions generally experienced at that time and place, not just on one or two occasions of perfect weather. Evaluating whether an ancient vessel would have been seagoing is an art as well as a science since a number of interacting factors have to be considered (McGrail, 1993*a*: 202–4). The strength, durability, and integrity of the hull have to be taken into account, as do freeboard at operational drafts, stability, and reserves of buoyancy. An open boat below a certain size is unlikely to have been seagoing but a decked vessel, *ceteris paribus*, could have been. Shape is also of importance: a 'boat-shaped' underwater hull, and a sheerline rising towards the ends suggest a seagoing vessel. Manœuvrability, controllability, sea-kindliness, and dryness have also to be considered.

Many of these characteristics contribute towards the safety of vessel and crew, and it is impossible to

know now what was the approach to risk assessment in earlier times: in this event it seems best to assume that the ancient mariner was also a 'prudent mariner'. Nowadays the Atlantic Ocean is crossed by adventurers in the most unlikely vessels, and it may be that mavericks similarly put to sea in the past. Nevertheless, as in other aspects of the past, we should deal with the general picture, in averages and in probabilities, when evaluating whether a vessel would have been seaworthy or not. Some boats assessed as 'non-seagoing' may nevertheless have been operable within estuaries in testing conditions—this is because, in the event of trouble, the crew would have the possibility of returning to their base or of running ashore on a nearby beach before some catastrophic failure.

After excavated boat timbers have been conserved it is essential that they are re-examined to confirm any doubtful measurements and assessments, and to seek answers to questions not formulated until conservation had begun. Much may also be learned during the reassembly of the timbers for display. As a result of these two phases of research, the hypothetical reconstruction may need to be amended and performance re-estimated (Fig. 1.2).

After hypothetical reconstructions of an ancient boat have been investigated, it may prove possible to build a full-size reconstruction and undertake sea trials (Coates *et al.*, 1995). Whether such a project should in fact be undertaken depends on the extent it is expected that such an experiment would expand understanding of the building and the use of the original vessel: it is very rare, however, for this to be the only consideration.

An authentic reconstruction can be based on excavated remains of a specific boat and other appropriate evidence; or one can be based mainly on documentary and iconographic sources concerned with a general class of vessel (McGrail, 1997*c*: 313–15). Both methods are valid ways of finding out more about the past: individual projects should be judged on their merits. What can be learned from full-scale reconstruction depends upon: the quality of the evidence; the rigour used in interpreting that evidence, in building the reconstruction, and in the trials; and the clarity of the subsequent publication (Coates *et al.*, 1995: 295). In other words, what can be learned about the original vessel from such an archaeological experiment depends upon authenticity, rigour, and the use of the scientific method. There have been a handful of experiments which have matched these standards and significantly increased knowledge of the nautical past: these are discussed in the appropriate chapters.

It may prove possible to suggest that a particular wreck was a member of a tradition of building already recognized (for example, a Nordic ship); in this event, data from other similar wrecks may be used in the reconstruction process. At the same time, data from the new wreck will probably be added to the features characteristic of the tradition, possibly causing that tradition to be redefined. Occasionally it is possible to equate the remains of a medieval ship with a documented type name (for example, 'cog') and sometimes with illustrations of a distinctive type. In these cases, the conflation of the several types of evidence significantly adds to knowledge of the past. Only very exceptionally can a wreck be identified with a specific known ship, and these are invariably of a late date (for example, *Mary Rose* and *Wasa*).

1.4 Concepts behind Some of the Arguments in this Study

1.4.1 TYPES OF WATER TRANSPORT

As James Hornell observed (1946*a*), a seemingly boundless variety of 'devices' have been, and are being, used by Man in his encounter with the waters of the world. Since no early forms of water transport were mass-produced, in the ultimate analysis, each individual raft or boat is different from all others. Some sort of classification scheme is therefore needed to bring order into what at first sight may seem to be near-chaos. By such means scholars around the world can be sure that they are discussing similar forms of water transport. Furthermore, patterns may be recognized, and fundamental differences and shifts in technology may be identified. Any classification scheme is, however, a construct, an approximation or best-fit to reality: if they were other than this, they would be unwieldy. Moreover, such schemes cannot remain static: as fresh

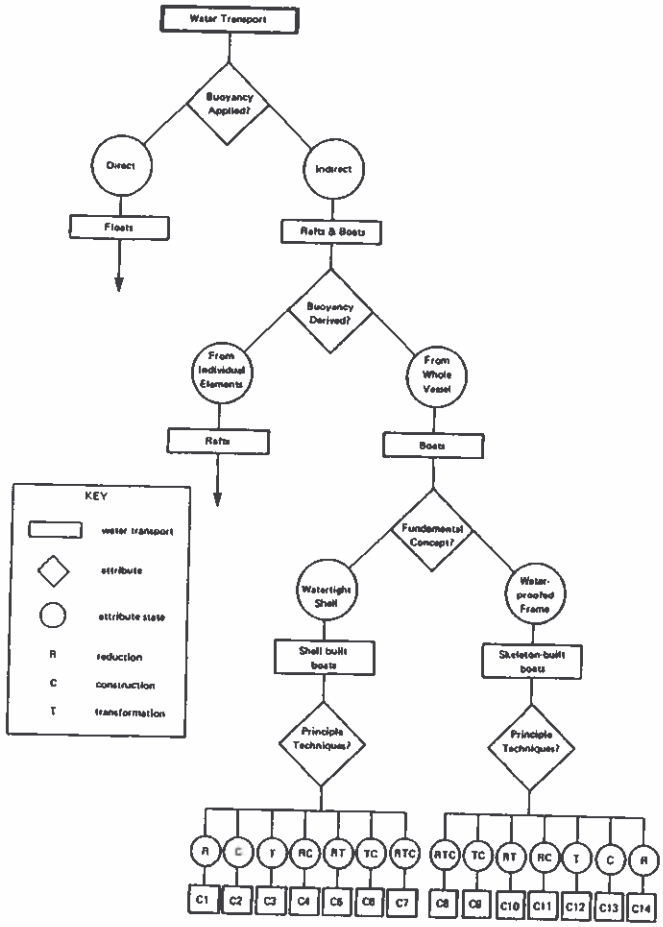

Fig. 1.4. Structural classification scheme for water transport—mainly boats (Institute of Archaeology, Oxford).

evidence emerges and new ways of analysis and synthesis are devised, the classification must be re-examined and revised where necessary.

The scheme used in this study is illustrated in Figure. 1.4. Answers to two questions separate units of water transport into three main groups (McGrail, 1985*b*; 1993*b*: 4–11). How buoyancy is applied segregates 'floats' (in which buoyancy is directly applied) from 'rafts and boats' (in which buoyancy is indirect). How buoyancy is derived divides 'rafts' (from individual elements) from 'boats' (from the whole vessel). Ships are, in general terms, merely large boats—for a more detailed discussion of the differences, see McGrail (1993*b*: 19–21).

Floats are not considered in detail in this study. Rafts and boats may each be further divided into sub-groups based on their principal raw material: thus there are bundle rafts, log rafts, and buoyed rafts; and log boats, hide boats, bark boats, plank boats, and (the rare) pot boats, basket boats, and bundle boats (McGrail 1985*b*: 289–90). Little analytical work has been done on raft structure, but boats can be further classified by reference to the sequence in which the boat is built, and, secondly, the principal techniques the builder uses when converting his raw materials into a boat (Fig. 1.4).

1.4.1.1 BUILDING SEQUENCES

A fundamental distinction has long been recognized in the way plank boats are built (Hasslöf, 1963; 1972; Greenhill, 1976: 60–88). In one case the planking is fashioned and fastened together to form the hull, then the framing is fastened to the planking; in the alternative method the framing is first fashioned to the hull shape required, then the planking is fastened to the framework. Behind these two sequences lies a more fundamental difference: the builder's concept of his boat. On the one hand, the builder visualizes the form of his boat as a watertight shell of planking which is subsequently reinforced by framing; on the other hand, as a framework or skeleton which is subsequently 'waterproofed' by planking (Fig. 1.4). This fundamental distinction between 'shell-built' and 'skeleton-built' boats can be recognized not only in plank boats but also in boats built of hides and of bark (McGrail, 1985*b*). Whichever sequence of building is recognized in examples of these three types of boat, it also reveals how the builder visualized his boat, how he obtained the hull shape he wanted, and where the structural strength mainly lay.

When dealing solely with plank craft it is now customary to use the more explicit terms 'plank-first' and 'frame-first' to describe these different styles of building. In recent centuries European frame-first ships were not planked-up until virtually the whole of the framework or skeleton had been built and faired (Greenhill, 1995*a*: 266–9), whereas with early frame-first boats, only *part* of the framework was erected before the hull was planked; or alternatively, the lower framework was erected and planked, then the upper framework was erected and planked (4.15; 5.6). To distinguish between the early and later forms of frame-first building, the term 'frame-based' has been coined

to describe the alternating forms of building, and 'frame-orientated' to describe that builder's approach (McGrail, 1995*b*, 1997*a*). The term 'plank-based' may correspondingly be used to describe boats which are built plank-first but in an alternating fashion.

1.4.1.2 PRINCIPAL TECHNIQUES

The two groups of boats—those shell- built and those skeleton-built (to use the general terms)—may each be divided according to the techniques the builder uses when converting his materials into a boat. Three main techniques may be identified (McGrail, 1998: 6–7):

(a) *reduction*: the raw material is reduced in volume as in hollowing a log;
(b) *construction*: several elements are joined together as in binding reeds into bundles, or when making a framework by weaving, plaiting, or similar processes, or fastening planks together by lashings;
(c) *transformation*: altering the shape of the material without subtraction or addition, as in the expansion of a logboat, or the bending of a plank.

One or more of these techniques may be used to make the form-determining, watertight envelope of shell-built boats, and the waterproofing outer element of skeleton-built boats. As a result of this second division of boats, fourteen theoretical classes of boat structure are identified—C.1 to C.14 in Fig. 1.4. A survey of a large number of excavated and ethnographic boats (by no means comprehensive) shows that five of the seven shell-built classes have members, and a sixth may have members. Two of the seven skeleton-built classes are known to have members and two others may have members (McGrail, 1998: table 2.1). Table 1.1 lists those classes (C.1 to C.14) in which the seven basic types of boat have members. From this table we see that all logboats are shell-built, and they are represented in classes C.1, 4, 5, and 7; that is, some are built solely by reduction, some by reduction and construction, some by reduction and transformation, and some by all three techniques. Basket boats, on the other hand, are all evidently skeleton-built, and their outer waterproofing element is produced by transforming a solid mass of bitumen or tar into a skin.

1.4.2 BOATBUILDING TRADITIONS

The scheme for dividing water transport outlined in Fig. 1.4 deals only with the early stages of classification, merely identifying the major groups of floats, rafts, and boats with some subdivision of the boats. Further work needs to be done to take classification beyond the lowest levels shown in Fig. 1.4. To do this a wide range of characteristics would have to be analysed, mostly structural attributes such as fastening methods, but also the means of propulsion and steering as well as aspects of form. As a result of this, natural groupings should be identified at a deeper level of classification. In this way sewn-plank boats which at present are virtually an undifferentiated group might be divided into meaningful sub-groups. Furthermore, traditions such as the Nordic (5.8.1.3.4) or Romano-Celtic (5.6) which have already been identified by intuitive, ad hoc

Table 1.1 Classification of boat types

Boat type	Attributes		Class
	Concept	Techniques	
Logboats	Shell	R	C1
	Shell	RC	C4
	Shell	RT	C5
	Shell	RTC	C7
Plank boats	Shell	RC	C4
	Shell	RTC	C7
	Skeleton	RTC	C8
	Skeleton	(RC)	(C11)
Bark boats	Shell	RT	C5
	Shell	RTC	C7
	Skeleton	RTC	C8
	Skeleton	(RT)	(C10)
Hide boats	Shell	RT	C5
	Shell	RTC	C7
	Skeleton	RTC	C8
	Skeleton	(RT)	(C10)
Bundle boats	Skeleton	T	C12
Pottery boats	Shell	T	C3
	Shell	(TC)	(C6)
Basket boats	Skeleton	T	C12

R = reduction
C = construction
T = transformation
C1 to C11 = classification—see Figure 1.4.
Note: Items in parentheses are doubtful.

Upper Palaeolithic to the Bronze Age (*c.*40,000 to *c.*2000 BC) and the equivalent stages elsewhere. Each type of basic float, raft, and boat has been analysed to determine the minimum tools and techniques needed to construct them. This information was then correlated with data concerning the earliest use of these tools and techniques in the manufacture of other artefacts, and deductions made as to which period specific types of float, raft, or boat might reasonably be thought to have been first made. Whether this was so at a particular time and place would depend not only on the availability of the appropriate raw materials, but also on whether the idea of using such tools and techniques in the manufacture of water transport had arisen.

The seagoing abilities of rafts and boats in Table 1.2 are based on theoretical assessments of the structures' ability to withstand the stresses imposed in a seaway. Boats, by their nature, afford some protection to the crew against the elements and therefore those with a suitable structure for seagoing may generally be used in all latitudes (subject to other constraints). Rafts, on the other hand, being flow-through structures, do not protect the crew in conditions of low air and sea temperatures which, combined with exposure to wind and wetness, can soon induce hypothermia and tax the crew beyond endurance. Rafts are thus not used at sea today beyond latitudes *c.*40°S and 40°N; in former times there would have been corresponding limitations. Table 1.2 therefore differentiates between higher

Table 1.2 A theoretical assessment of early water transport

Technological stage	Water transport	Use in Mediterranean types of maritime environment	Use in NW European types of maritime environment
Palaeolithic	Log float	S?	IW
	Bundle float	S?	IW
	Hide float	S?	IW
	Simple log raft	S	IW
	Simple hide-float raft	S	NT/IW
	Simple bark boat	NT/IW	NT/IW
	Simple hide boat	IW	IW
Mesolithic	Complex log raft	S	IW
	Multiple hide-float raft	S	NT/IW
	Bundle raft	S	IW
	Simple logboat	IW	IW
	Multiple hide boat	S	S
	Basket boat	S	NT/S
Neolithic	Pot float	S?	NT/IW
	Pot-float raft	S	NT/IW
	Pot boat	S?	NT/IW
	Stabilized logboats	S	S
	Paired logboats	S	S
	Extended logboats	S	S
	Simple plank boats	IW	IW
Bronze Age	Expanded logboats	S	S
	Bundle boats	S	NT/S
	Complex bark boats	NT/S	NT/S
	Complex plank boats	S	S

S=seagoing (includes possibility of inland use) IW=inland waters only NT=no known tradition

Sources: For definition of types see McGrail (1985*b*; 1998: 4–11.) See also Johnstone (1988: pp. xiii–xiv). For technological evidence see McGrail (1981*b*: 12; 1998: 53–4, 85–7, 96–7, 171–2, 185–7, 191).

methods may be confirmed as valid by this logical approach, or it may be found that their present definition has to be altered to become consistent with the general scheme.

A boatbuilding tradition may be formally defined as: the perceived style of building generally used in a certain region during a given time range. As with any classification it has its drawbacks. For example, it is a theoretical construct which may or may not be similar to the concepts of the people who actually built and sailed such boats. Furthermore, for our purposes, traditions must be given arbitrary start and stop dates, although it may well seem that their earliest and latest phases merge into other traditions. Similarly, spatial boundaries have to be given to such traditions, but these must necessarily be fuzzy, and in some cases it may not be clear whether the boats of a particular area (say, the southern Baltic) should be included within a regional tradition (i.e. the Nordic). There are also problems in giving names to traditions: the solution here is to consider such names as codewords without cultural or ethnic implications. Notwithstanding these and other drawbacks (McGrail, 1995*b*: 139–40), the concept of a tradition has proved useful in maritime studies both archaeological and ethnographical: it can continue to be so providing that definitions of individual traditions are modified when acquisition of new data demands it.

Within a particular tradition it is not necessary that all boats have all characteristics in common. Each boat has to share with every other boat in the tradition a large number of characteristics, but no one characteristic *has* to be possessed by all boats. Such groups are known as *polythetic* (Doran and Hodson, 1975: 160) and, in not requiring 100 per cent conformity, they reflect an intuitive understanding of the real world.

1.4.2.1 THE ORIGINS OF A WRECK

A ship may be wrecked, abandoned, or dismantled outside those waters where vessels of her tradition predominate, and within waters usually sailed by ships of another tradition. Even when wrecked within 'traditional' waters, a ship may be far from where she was built. As the definition of shipbuilding traditions in terms of structural characteristics is refined, including the recognition of temporal and regional variants, the identification of a wreck's region of origin should become increasingly practicable. In the long run, it may prove possible to narrow origins down to a particular 'shipyard' where some master builder had given a recognizable personal touch to his ship's structure or her decorative features.

The 'nationality' of the crew (as deduced from their personal possessions), and the nature of the cargo carried, have both been used in the search for a wreck's origins. The crew's likely origins may be one of several clues to be considered in such research, but the sources of the cargo may be misleading: the latter can, however, be of use in tackling a related problem—the route of the ship on her final voyage.

Cargo ships generally need ballast, often of stone, which can be: permanent, embarked when fitting out; temporary, loaded or unloaded many times at different harbours during a ship's life to match the cargo density of the goods embarked; or saleable, embarked on a particular voyage to serve two purposes (McGrail, 1989*b*). If permanent ballast can be recognized and its source identified, this may be another clue to the regional identity of the ship. The identification of the timber species used in a hull may also help, as can the dendrological examination of hull timbers which may not only date the ship's construction, but may also link the timber to a specific region.

These clues to origins need to be evaluated and integrated with any other pertinent information, so that a likely 'home port' for the wreck may be identified.

1.4.3 EARLIEST WATER TRANSPORT

There is no direct evidence for water transport until the Mesolithic period even in the most favoured regions, and it is not until the Bronze Age that vessels other than logboats are known. Nevertheless there is sound evidence for the use of lakes and rivers and for overseas voyages from earlier times: for example, the settlement of Greater Australia from 40,000 BC or even earlier (7.2). To investigate which form of water transport was used on these and other early voyages, we can, at present, only have recourse to informed speculation. Table 1.2 is based on theoretical assessments of the types of water transport that could have been used in different technological stages from the European

and lower latitudes, taking Atlantic Europe and the Mediterranean as being representative of those two regions. The table also takes into account whether there is any known tradition of the use of each type of raft or boat in those regions.

1.5
Presentation of the Evidence

The aim of this study is to use all forms of evidence, especially archaeological, to present an account of how rafts, boats, and ships were built, propelled, steered and generally used, from earliest times to somewhere in the period AD 1400–1800. When in that period the study ends depends upon circumstances in a particular region, but generally speaking, it coincides with the introduction of frame-first building and the formal design of ocean-going ships. Where the evidence justifies, methods of navigation, means of exploration, and principal overseas trading routes are also discussed.

For the purposes of exposition, the seafaring world has been divided into ten regions (Chs 2–11). The reasons for defining some of these regions are clear: for example, the early Americas had negligible overseas contact with the rest of the world, apart from the circumpolar zone, from first settlement until the late fifteenth century AD. Australia was similarly virtually isolated until post-medieval times; pre-Hellenic Egypt and early Mesopotamia can also be reasonably dealt with as individual maritime zones, although in both cases documented overseas voyages were undertaken at an early date. The Mediterranean forms a convenient maritime unit up to Classical times when maritime interaction with both Atlantic Europe and the Indian Ocean became increasingly common.

Atlantic Europe, on the other hand, cannot be recognized as an entity in maritime terms until the medieval period although there clearly were maritime contacts within, and sometimes between, each of its subregions (Baltic, North Sea, British and Irish archipelago and the Channel, Biscay and Iberia). The form of the evidence is such, however, that it is convenient to discuss this environmentally disparate region in one chapter.

The Indian Ocean, extending east and west rather than north and south and united in some sense by monsoonal winds, has, on the other hand, been a link between Arabia, east Africa, south Asia, and south-east Asia for millennia. Nevertheless the pattern of evidence dictates that these regions be dealt with separately, but with detailed cross-references where themes overlap. China has extended its cultural/technological boundaries greatly over the millennia, yet it has had periods of enforced isolation from overseas influences. Furthermore, as an entity, it has a relatively well-documented protohistory, unlike surrounding regions. China is thus sufficiently different in culture and in general technology to have its own chapter. Nevertheless, it is clear that there were maritime links between China and south-east Asian countries throughout documented times, and, indeed, the late medieval wrecks recently excavated from Chinese and south-east Asian waters have proved to have similar hull structures. Oceania also has a chapter to itself. There seems to have been much maritime interaction from early times between south-east Asia and Near Oceania. Remote Oceania (east of the Solomon islands), on the other hand, appears to have had a degree of cultural/technological homogeneity since the second/first millennia BC, and its prehistory did not end until the post-medieval European oceanic voyages.

In what sequence to place the chapters has proved difficult to decide. Boatbuilding and seafaring did not originate in one region and spread neatly around the world: all chapters thus greatly overlap chronologically. The solution has been to deal first with Egypt and Arabia, where much early evidence for water transport has survived; then to describe the European evidence in two chapters; followed by south Asia and a generally eastwards progression from south-east Asia to the Americas, via Greater Australia, the South Pacific, and China.

Individual chapters differ in their layout and in the general approach adopted, depending on the strengths of the various types of evidence available within a region. Generally, the environmental setting is described first and then a range of evidence is discussed chronologically by centuries, or by archaeological/historical periods. However, certain themes, such as 'rafts

and non-plank boats', and 'navigational techniques', are usually considered for the whole time range within one section.

Underlying all chapters in this study is the theme that rivers and seas connect continents and cultures: it is possible to travel by water from the Swiss Alps to the heart of Ethiopia, or from the Himalayas to the Indonesian archipelago or even the West Indies. Individual people or boats may not have undertaken such voyages until recent times, but ideas can travel great distances in a series of discrete passages. For example, the use of the mariner's compass is thought to have spread from the China Sea to the North Sea within the short space of 100 years (3.8.2.2.1, 5.10, 10.11). Other aids to navigation, hull forms, shipbuilding techniques, and sailing rigs, may have been similarly transmitted about the world, but remain undocumented. The spatial bounds of each chapter are purely for convenience of exposition: it is necessary to bear in mind the interaction (often unknown to history) between different cultures that water transport, especially the sailing boat, facilitates and indeed, encourages.