UNIVERSITY OF SOUTHAMPTON

THE ROMAN CHANNEL CROSSING OF A.D. 43:

THE CONSTRAINTS ON CLAUDIUS'S NAVAL STRATEGY

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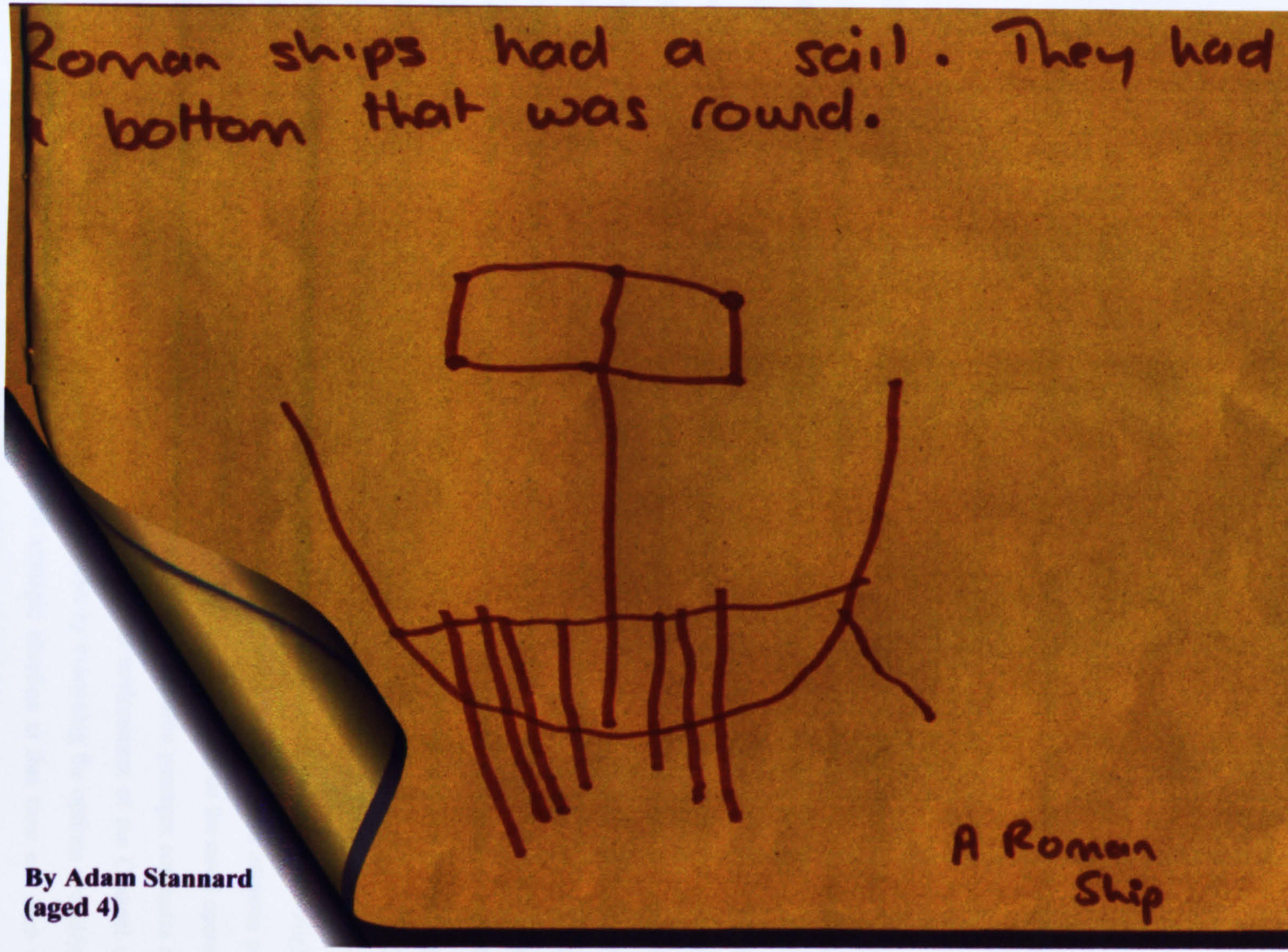
Thesis Submitted for the Degree of
Doctor of Philosophy

FACULTY OF ARTS

DEPARTMENT OF ARCHAEOLOGY

March 2001



By Adam Stannard
(aged 4)

Frontispiece A child's view of a Roman ship.

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ABSTRACT

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The academic consensus that the Roman invasion of A.D. 43 landed at Richborough, Kent, has been challenged in recent years. Proponents of the alternative hypothesis that it took place at or near Fishbourne, West Sussex, have claimed that this makes better sense of the admittedly garbled account in the ancient sources of the land campaign in Britain. This thesis asks what sense the Fishbourne hypothesis makes in terms of the options for the naval strategy of the crossing. After considering the respective archaeological and topographical contexts of Richborough and of Chichester Harbour, the thesis discusses the type of ships which would have been available to the Roman invasion forces and assesses the evidence for their performance. It concludes that the transports would have been square-rigged ships of the Romano-Celtic tradition with extremely limited windward performance and sluggish speed potential. The constraints imposed on ships of such limited performance by the maritime environment are discussed, including the significance of the tidal régime in the Dover Strait and the English Channel, the statistical frequency of the prevailing winds and the nature of the navigational hazards. On the basis of information given in Caesar's account a century earlier, an estimate is made of the number of ships required to transport the whole invasion force across the Channel at the same time and the conclusion is reached that this figure might be in the order of 725 to 1,050 vessels, including escorting warships. Drawing evidence from invasion passages made at other times in the Channel, the thesis investigates the constraints imposed on the naval operation by the number of ships involved. Further study of the conduct of these invasion passages concludes that the option chosen for each is heavily influenced both by the maritime environment of the Channel and the politico/strategic context of the invasion. The thesis concludes by examining the options available to the Roman naval planners of A.D. 43 and argues that the strategic situation at that time was such that an invasion landing anywhere in the Solent area was out of the question. The most likely scenario is that the invasion forces crossed from Boulogne in three groups to land at a secure beachhead at Richborough.

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Preface

This thesis has given me the opportunity to explore a number of personal interests, some of them going back over half a century, some of them more recent.

It has been a delight to revisit - and to understand in greater depth - the account given by Julius Caesar of his expeditions to Britain, over which I laboured, like so many schoolchildren, as I prepared for 'O' level Latin. My interest in sailing dates back even earlier to a time when, as a child, I looked out from the cliffs at Leigh-on-Sea over the Thames estuary to watch and wonder at the last working Thames barges as they plied their trade to and from Bell Wharf. My interest in Latin - and other languages - which led to a first degree in Modern Languages, has encouraged me to go back to the original texts of the sources and to appreciate that linguistic enquiry can give particular insights into the past. Sailing became a family hobby, tentatively at first with holidays on the Norfolk Broads and then with more adventurous cruises in our own yacht, which members of the family recall with varying degrees of pleasure. These cruises brought me personal experience of passage-making under sail in the English Channel and the southern North Sea, including many passages across the Dover Strait and across the Channel into and out of Chichester Harbour. It is experience such as this that intensified my interest in seamanship, shiphandling under sail and navigation in past times and my wonder at the ancient skills involved.

A more recent interest - recent for me and for everyone - is computing. It is no more that fifteen years ago since a computer was put on my desk at work on the grounds that everyone else had one. At that time I did little more than send the occasional internal email. It is fair to say that the completion of this thesis owes a considerable amount to the personal computer in my study. It is not simply the ease with which I could revise draft after draft of text. I have been able to work and rework graphics, run and rerun innumerable spreadsheets, print off the results in graph form and surf the web. The web is a marvellous resource: it has given me access to academic libraries and to correspondence by email with scholars in this country and abroad, usually with very rapid responses. In some cases a web search has given me a significant lead: all the material that I have drawn on to write up the Humber Keel came initially from a search which took me to the web site of the Humber Keel and Sloop Preservation Society; plate X was downloaded from their web page.

The academic study of the past is another recently developed interest. It dates back to the early nineties when my wife Christine invited me to collaborate with her in a paper to be given at the Institute of Historical Research in London on the Norman Invasion; my contribution was to deal with the naval and navigational aspects of the invasion passage. This study, which was eventually published (1993; 1996), was my first attempt at formal academic study since undergraduate days more than forty years ago. It gave me the realisation that seafaring in the past could be an object, not only of wonder, but also of enquiry.

In no age does seafaring take place in a vacuum. It is a technology. Like other technologies, it is resourced by society and responds to its needs, political, military and, above all, economic. Equally the limitations of available maritime technology will impose constraints on the extent to which those needs can be met. The study of these limitations can provide a particular insight into the interpretation of the past. This, I would claim, is certainly the case with the subject of this thesis, the debate as to where the Roman invasion force of A.D. 43 landed.

The past can only exist in terms of our experience of it and of the way in which we communicate that experience to others. For me it has been a delight to share my developing experience with my grandchildren. Adam Stannard's drawing of a Roman ship (Frontispiece) has no academic significance (though it might be taken as a fair representation of the Broighter Boat), but for me it symbolises the joy of exploring with him and his cousins so many monuments of the past, including Richborough Castle and Castle Cornet, Guernsey. More seriously it underlines the point that the ultimate purpose of research into the past is to enable the next generation to take ownership of their own history.

Lastly, this thesis is offered in dedication to my wife in celebration of forty-two years of marriage and of the interests we share in our retirement together.

Gerald Grainge
Finglesham
March 2001

Acknowledgements

I am grateful to so many people for the help, support and interest they have afforded me in completing this thesis.

First and foremost, I have benefited enormously from the advice and guidance that I have received from my supervisors, Professor David Hinton and Professor Seán McGrail. Over my years of study they have patiently read through the many reams of often irrelevant material that I have produced and been extremely constructive and encouraging in the comments and the criticisms that they have offered. I have much appreciated the advice they had to offer and shall miss it in the future. It has been a privilege to have had the opportunity of studying under their guidance.

Especially valuable was Professor McGrail's recommendation that I should present a short paper to the conference organised by the Sussex Archaeological Society in October 1999 to debate the question of the location of the Roman bridgehead in A.D. 43. It undoubtedly gave a focus to this thesis and I am also grateful to John Manley, Chief Executive of the Society, for agreeing to invite me to take part.

I have been much helped by the willingness of scholars - and others - to respond to enquiries and to offer comment on lines of interpretation that I was following up. David Bird, Surrey County Archaeologist, who read over and offered comments on a draft of what is now Chapter XII, was kind enough to share with me material that he had published on the A.D. 43 question. It was Ernest Black's paper at the conference of the Sussex Archaeological Society that first made me aware of the significance for the chronology of the Claudian invasion of the Alexandrian diobol, discussed in Chapter XII; he kindly supplied me with the reference to the article published by Professor Anthony A. Barrett of the University of British Columbia, who subsequently helpfully responded to my email seeking further comment. Detlev Ellmers of the Deutsches Schiffahrtsmuseum identified for me the passage in Tacitus in which the Celtic word *sagulum* is used apparently to mean 'sail' and explained his interpretation of the passage (Appendix VII). Jenny Hall of the Museum of London kindly showed me the exquisite Southwark *intaglio* (Plate VII), even though I arrived at the museum unannounced. Owain Roberts offered me extensive comment on the discussion of the windward performance of Romano-Celtic ships (Chapter VII). David Robinson, skipper of the Humber sloop, *Amy Howson*, supplied comment on the performance of Humber keels and sloops. Heather Sebire of Guernsey Museums and Galleries helped me obtain photographs of the model of St Peter Port 1 displayed in Castle Cornet. Professor Brian Sparkes kindly read through a draft of Chapter III and offered advice on my interpretation of Dio Cassius's Greek. Max Vinner of the Viking Ship Museum, Roskilde, responded to enquiries about the performance of Nordic replicas. Major Hume Wallace, who has dived extensively in the area, invited me to his home to discuss the reconstruction he had proposed for the configuration of

Chichester Harbour in Roman times (Fig. 4) and corrected my understanding of the mechanisms of erosion and deposition involved.

Other scholars have commented on lines of enquiry which in the end did not find a place in this thesis. Among them are Professor Jane Roberts of King's College, London, with whom I have corresponded on a number of occasions on matters relating to etymology, including the etymology of the word 'keel' and its Old English form *ceol*; and Mike Stammers of the Merseyside Maritime Museum with whom I corresponded about the possibility that this linguistic link was parallelled by a continuity in the ship-building tradition.

My appreciation for permission to use copyright material goes to Ole Crumlin-Pedersen (Fig. 13), Dr. Basil Greenhill (Plate IX), Professor Seán McGrail (Figs 6 and 23), Brian Philp of the Kent Archaeological Rescue Unit (Fig. 2), Owain Roberts (Fig. 15) and Major Hume Wallace ((Fig. 4); also to the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office (Figs. 21 and 22), English Heritage (Plate I and Fig. 14), the Humber Keel and Sloop Preservation Society (Plate X), Guernsey Museums and Galleries (Plates V and VI), the London Museum (Plate VII), the Ny Carlsberg Glyptotek, Copenhagen (Plate VIII), Skyscan Balloon Photography (Plate I) and Thames and Hudson (Fig. 10).

I was fortunate to learn my Latin with two outstanding schoolmasters: at the Royal Grammar School, Worcester, R.D. Wormald laid a sound foundation for my later studies; later W.L. Williams at Erith Grammar School, Kent, built on that foundation as he coached me for 'A' Level and Scholarship studies. I remember them with affection.

Finally I should mention two scholars, whose advice I sought on the possibility of devoting part of my retirement to academic research: they are Professor Alfred Smyth, then of the University of Kent, and Professor James Graham-Campbell of University College, London. They pointed me in the right direction.

I am very appreciative of the help and interest that I have received from so many people in preparing this thesis. But the conclusions - and the mistakes - must remain my own.

G.G.

Chapter I
Introduction

Sources and Interpretations: Where Did They Land?

In A.D. 43 a Roman invasion force of four legions and associated auxiliary units left Gaul to invade Britain, following up the expeditionary raids of Julius Caesar a century earlier. The success of this campaign led to the incorporation of the greater part of Britain into the Roman world until the end of the fourth century. Although estimates of the size of the invasion force vary, it was in all probability the largest army ever to invade the British Isles, exceeding by far the armies involved in the Norman Invasion of 1066 and the Descent of William of Orange in 1688. However, the documentary sources for the campaign give little detail and, in particular, do not say where the invasion fleet landed, nor where it embarked.

The principal ancient source for the campaign is Dio Cassius's *Roman History*, LX, 19-22, written in Greek. This is supplemented by a page in Suetonius's *Life of Claudius*, 17 and a brief comment in his *Life of Vespasian*, 4. Archaeology provides evidence of very early Roman military activity in Britain, particularly at Richborough (Cunliffe, 1968) and in the Fishbourne/Chichester area (Down, 1988, 7-16; Cunliffe, 1998, 25-32), while excavations at Maiden Castle and Hod Hill are testimony to assaults by the Romans on Celtic hill forts in the south-west (Wheeler, 1943, 61-8; Richmond, 1962, 31-3).

According to Dio, the following are the main details of the invasion campaign. A certain Berikos (identified as Verica, king of the British Atrebates who had settled in a region focused on West Sussex, Hampshire and Wiltshire), who had recently been expelled from Britain, persuaded Claudius to undertake the invasion. A senator named Aulus Plautius was put in charge of the invasion force and one of his legionary commanders was Vespasian, the future emperor. The soldiers were initially reluctant to embark, but were persuaded to do so when addressed by the freedman Narcissus, a senior member of Claudius's personal staff. The landing was unopposed and at first the invading forces failed to make contact with the Britons. After an initial engagement, in which the Britons were defeated, the invasion force advanced to a river, which may or may not have been the Medway. In a two-day battle, in which the Britons were again defeated, the Romans crossed this river and advanced to the Thames. Here the Romans halted and consolidated their position. Plautius, says Dio, had become afraid of the strength of the British opposition. He had been instructed to send for Claudius from Rome if he encountered any particularly stubborn resistance and this he now did. Claudius arrived with extensive equipment, including elephants, took over command of the troops and defeated the Britons opposing the crossing of the Thames. He advanced to capture Colchester and received the submission of numerous British tribes. He then handed command of the army back to Plautius, instructing him to pacify the remaining districts, and returned to Rome. Claudius had been away from Rome for six months, of which sixteen days had been spent in Britain. Dio concludes his account with a description of the honours heaped on Claudius by the Senate.

To this Suetonius adds that Claudius was motivated by a desire to achieve a military triumph and that the campaign was occasioned by the disturbances caused in Britain by the Romans' refusal to return certain refugees. In his *Life of Vespasian* he lists the activities of Vespasian in the south-west as including the fighting of thirty battles, the subjugation of two tribes and the capture of more than twenty *oppida*, no doubt hill forts, as well as the whole of the Isle of Wight.

In addition there is a brief reference in Tacitus (*Agr.*, 14) to the continuing loyalty to Rome of a King Cogidumnus to whom the Romans had handed over certain tribes and whose existence and royal rank in the Chichester region is corroborated under the name of Togidubnus by a dedication stone found in Chichester (*R.I.B.* 91; Cunliffe, 1998, 21-3, 108-9).

There are only three details which might be significant for an interpretation of the Channel crossing itself. First Suetonius informs us that Claudius embarked from Boulogne (*Claud.*, 17). Secondly Dio states that the invasion force made the crossing in three divisions, 'in order that they should not be hindered in landing - as might happen to a single force' (Dio, LX, 19; Cary, 1924, 416-17; see also Ireland, 1986, 45). Other translations suggest that the division of the invasion force into three was to avoid an 'opposed' landing (Hind, 1989, 6; see also Salway, 1998, 82). Thirdly Dio reports that:

> In their voyage across they first became discouraged because they were driven back in their course, and then plucked up courage when a flash of light rising in the east shot across to west, the direction in which they were sailing (Dio, LX, 19; Cary, 1924, 416-17).

Other translations offer a 'shooting star' (Hind, 1989, 6) or a 'bolt of lightning' (Ireland, 1986, 45).

In spite of this paucity of evidence for the crossing, the mainstream of academic opinion has until recently been that the invaders embarked at Boulogne and landed at or near Richborough (Cunliffe, 1971, 22; Frere, 1987, 48-9; Detsicas, 1983, 11-12; Peddie, 1997, 47-65; Webster, 1999, 95-7; but see Cunliffe, 1998, 21). The reference to three divisions has, however, stimulated speculation among scholars that the invasion force may have landed at three different points, for example, Richborough, Dover and Lympne (Richmond, 1955, 20), rather than at Richborough in three waves. Moreover, the claim by Dio Cassius that Claudius was persuaded to order the expedition by Verica has led some to postulate that one of the divisions of the invasion force landed in the Chichester area (Salway, 1998, 82-3). This hypothesis has been associated with the Fishbourne Roman Palace and with the significant, if shadowy, figure of the British puppet king of the Atrebates/Regni, Togidubnus, whom we have already noted and seemingly installed in Verica's place. It may be seen as drawing some force from the evidence for the campaign undertaken by the *Legio II Augusta* under the command of Vespasian in the south-west in the period immediately following the invasion. Hind (1989) has introduced a new element into the academic debate by proposing that all three divisions of the expeditionary force landed near Chichester, arguing that this makes possible a more satisfactory interpretation of the record of subsequent events in the campaign. Bird more recently (2000) has also argued for this hypothesis, although his interpretation of Plautius's line of advance differs from Hind's to allow for the impracticality of advancing from the Chichester area towards the Thames across the Wealden clay.

The debate has of necessity been inferential. Landings at Richborough, Dover and Lympne of units which came together at Canterbury have been inferred from the Roman roads linking these places to Canterbury; but the road network scarcely existed before the Roman Conquest (Frere, 1987, 49). A hoard of thirty-four Roman gold coins, including four issues of Claudius minted in A.D. 41 and 42, found near Sittingbourne and interpreted as the savings of a Roman officer buried for safe keeping before the battle on the Medway, has been seen as confirming the Roman line of advance along the North Downs from a landing in east Kent; but the find spot is too far from the Medway to be accepted realistically as a location for a hoard made in such circumstances (Detsicas, 1983, 14; Frere, 1987, 50; Hind, 1989, 10-11; Webster, 1999, 100). The British 'melted into woods and marshes' which cannot have been in Kent, because Caesar does not mention marshes until he is north of the Thames (Hind, 1989, 9), yet marshes have always been one of the distinctive features of Kent geomorphology (Everitt, 1986, 57-65). Plautius is said, when he received the capitulation of part of the Dobunni tribe, based to the north-west of Silchester, to have left behind a garrison on their territory for their protection (Hind, 1989, 16); but Dio says nothing to require the assumption that the Dobunni made their capitulation on or near their own territory, only that it was made, unsurprisingly, after the defeat of the British leaders, Caratacus and Togodumnus (see *B. Gall.*, IV, 21; V, 21 for similar remote capitulations during Caesar's campaigns, one of them being cross-Channel). Nor does Dio say anything to allow us to be certain that the purpose of the garrison was to protect the Dobunni, rather than to protect the Roman supply lines and/or bridgehead wherever it was.

An Alternative Approach

Dio's account of the campaign is the only substantive one we have, given that what might have been the principal documentary source for A.D. 43, Tacitus's *Annals*, is not extant for this period; however, with his obscurities and ambiguities Dio is not wholly satisfactory. The interpretations advanced by Hind and Bird have sought to make better sense of the ancient accounts of the land campaign than they believe is possible if one accepts the Richborough hypothesis. The question that then remains is what sense they make of the naval operation.

The alternative approach which I put forward in this thesis is to exploit the resources of maritime archaeology to examine what constraints the capabilities of the ships available to the Romans would have imposed on naval operations in the Channel in the summer of A.D. 43. What I seek to do is to attempt an insight into the thinking of the Roman senior commanders as they planned the naval operation. For operations such as this the Romans used two distinct types of ship, warships and transports; we need to establish the practical limits of the performance of each under operational conditions, both in terms of their speed potential and of their ability to make progress to windward. Ships operate in a specific maritime environment; we shall explore the influence on any naval operation in the Roman period of the weather and Channel tides in a typical British summer. This was a fleet operation and sailing in a fleet imposes constraints on the ships making up the fleet; we shall attempt an assessment of the number of ships involved and investigate how those constraints would have influenced the conduct of the naval operation.

Finally we can seek parallels in a discussion of other attempts to invade Britain during the age of sail. This will show that one factor which has a heavy influence on the options available to an invading force is the strategic context in which the invasion is planned; that context will largely determine where the invasion force embarks and where it seeks to land. This examination of other attempts to invade reveals what is perhaps a surprising fact: very few invasion landings on the British mainland have been opposed, Caesar's landing in 55 B.C. being a notable exception.

Armed with the results of this study we can set out what considerations would have been in the minds of the Roman naval planners as they deliberated the recommendations they should make to Aulus Plautius for the conduct of the crossing.

Before considering these matters, however, I should like first to review the archaeological and topographical evidence from a short list of likely landing places and to consider certain matters arising from Dio Cassius's Greek text.

Chapter II

Richborough, Dover, Lympne and Fishbourne

Dover and Lympne

The locations which have been most seriously advanced by modern scholars as possible landing places for the Roman invasion force are Richborough, Dover, Lympne and the Solent, possibly at Fishbourne or nearby (Fig. 1). The suggestion advanced in the nineteenth century by Airy that the invasion force might have landed somewhere in Essex is now generally discounted (Hind, 1989, 8-10).

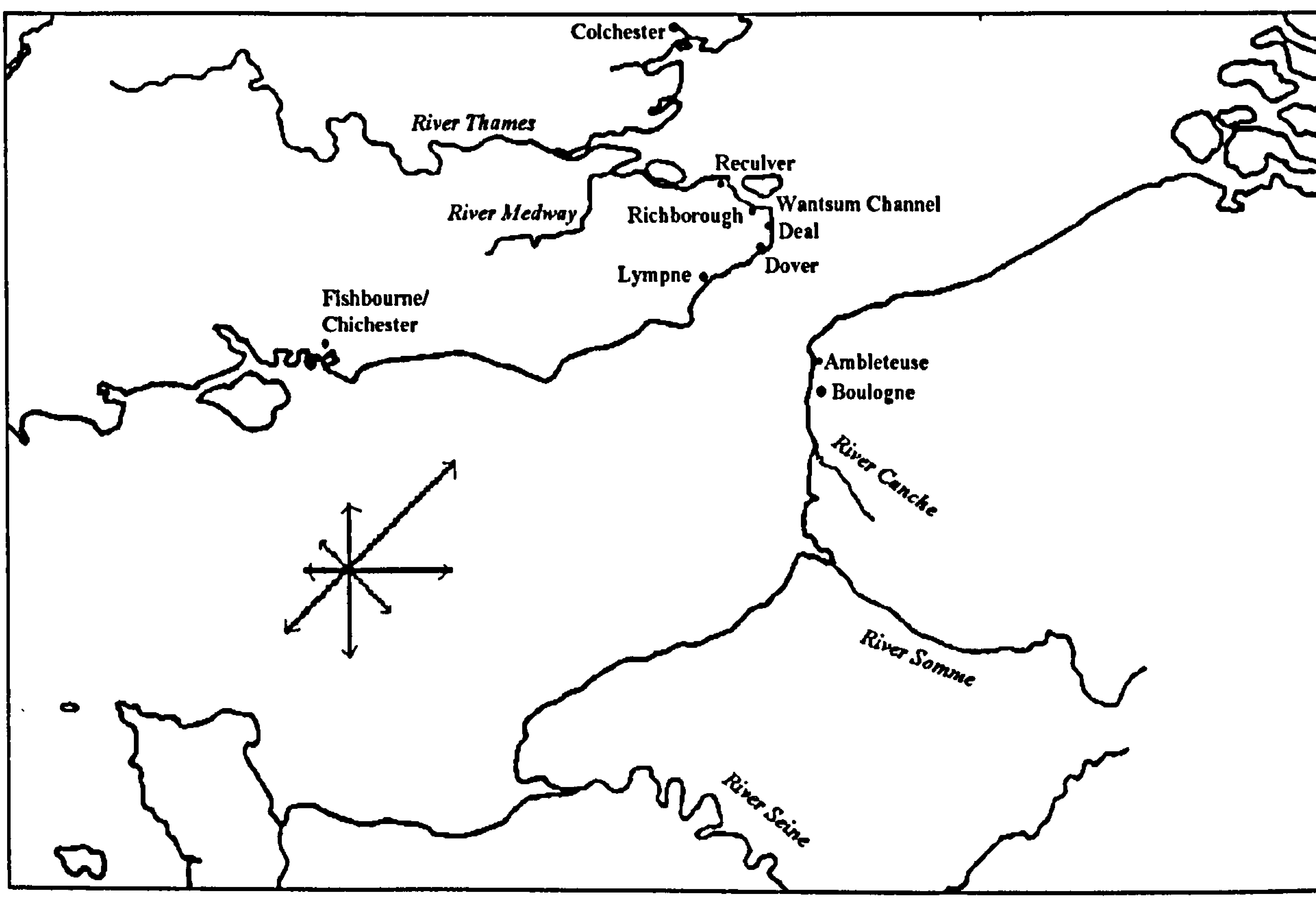

Fig. 1 Sketch map of the theatre of naval operations in A.D. 43, showing places of major strategic significance. The length of the arrows shows the relative frequency of winds from various directions in the months April to September - arrows fly with the wind (Appendix XI; NP 28, 1977, 39, 41-2, 46; NP 27, 1977, 50, 57).

Dover and Lympne, considered from the point of view of a commander planning for the possibility that his landing might be opposed, are scarcely promising. Certainly Dover was to have a major rôle as a base of the later *Classis Britannica* and as a Fort of the Saxon Shore (Philp, 1981, 91-118). However, the lack of coin and ceramic material from the pre-Flavian period in the excavations of the two *Classis Britannica* forts at Dover suggested to Philp that there could hardly have been a significant Roman presence here before *c.* A.D. 75 at the earliest. Linking the archaeological findings with attested events in the historical record he proposes a date of shortly before A.D. 117 for the building of the first fort and of A.D. 130-140 for the second. Philp conjectures a link between the fortunes of Dover and Richborough which I discuss below in connection with Richborough.

Even without archaeological evidence for Roman activity at Dover earlier than the mid 70s its topography eliminates it on military grounds as a possible landing site. It simply is not conceivable that any commander in his right mind would contemplate landing at Dover with the possible need to fight his way up the steep Dour Valley. Caesar says as much when in 55 B.C. he decided that an opposed landing in the Dover area was not acceptable (*B. Gall.*, IV, 23).

The same is true of Lympne: any invasion force landing here would be confronted with an immediate 80-metre climb up the scarp of the North Downs. Again, like Dover, there is evidence of its later rôle as a base for the *Classis Britannica*; the presence here of a prefect of the fleet is attested by an altar stone dated to the second century A.D. (*R.I.B.*, 66;; Detsicas, 1983, 20-1). But like Dover it must be discounted on the grounds of its topography.

Richborough

There is strong archaeological evidence for supposing that Richborough had a major rôle from a very early stage in the Roman occupation (Plate I). In fact the archaeological record can be read as pointing strongly to the establishment at Richborough of an invasion bridgehead in A.D. 43.

> The earliest Roman occupation on Richborough hill is represented by two parallel defensive ditches which run for 2,100 ft. across the promontory. On the north they terminate in the marsh now bordering Richborough stream, a tributary of the River Stour: their southern end must originally have been on the estuary, but at the present time the ditches, having curved eastwards, are cut off by the artificial cliff created by railway workings (Cunliffe, 1968, 232).

The area enclosed by these defensive ditches has been considerably eroded, not only by the railway cutting, but also by the Wantsum Channel itself, later the River Stour, deflected southwards by the Stonar Bank (Plates II and III; Hawkes, 1968, 228, 231), which undermined the eastern walls of the later fort. Even eroded as it is today, the extent of this initial defended precinct is clearly much larger in area than the fort and, since the degree of the erosion, which Cunliffe puts it at a minimum of 500 feet (1968, 233), is unknown, it is difficult to assess claims that a Claudian bridgehead at Richborough was too small to accommodate the four legions of the invading force (Detsicas, 1983, 12; Frere, 1987, 49; Hind, 1989, 14-5, 19). Detsicas's suggestion that the invasion force arrived in three waves and that, as each one moved forward, it was replaced by the following one, so that only one third of the invaders had to be accommodated within the defended precinct at any one time, is not unreasonable as a response to this possible difficulty. However, it assumes that the purpose of the defensive works was to protect the invaders, rather than their fleet and their supply lines. It is worth recalling the parallel case of William the Conqueror, whose first act after landing at Pevensey was to have fortifications raised to protect his ships before moving forward (*Gest. Guil.* 9; *Gest. N. Duc.*, xiv).

These defensive works were very quickly replaced by what has been seen as a supply base dated to A.D. 44-85 (Cunliffe, 1968, 234-7). The greater part of the buildings identified in this phase are considered to be granaries of a type identified with the Roman army, a total of at least nine. Some time before A.D. 70, two of the granaries were demolished. While Cunliffe (1968, 236-7) draws the inference that 'during the thirty years following the invasion supplies of corn were extracted from the British province with increasing efficiency', it does lead to the surprising conclusion that for a very considerable period after the conquest, virtually a generation, the invaders continued to rely on imported grain in a territory whose exports had been seen as including grain. This cannot be without significance in any discussion of the ancients' assessment of the economic benefits actually achieved by the annexation of the British province (Strabo, IV, 5, 3; *Agr.*, 12; Frere, 1987, 32).

It is of course possible that the military authorities very quickly began to use Richborough as a central collection point for British, rather than imported grain, redistributing it back along the same road network as was used to collect it. The need for well-fortified collection points for grain is emphasised by Vegetius in his *Epitome of Military Science* (Veg. *Mil.*, III, 3). The possibility that Richborough was an assembly point for British grain has recently been taken further (Bird, 1999, 331-4). His approach is to question the idea that Richborough was a supply base to serve the Roman occupation forces. He notes that uniquely in the case of Richborough Romanists have abandoned the rule that 'whenever possible everything was moved by water in the Roman world'. He therefore puts forward the alternative that Richborough may have served as a depôt for the export to the continent of grain from the 'rich cornfields' of north-east Kent. I shall argue in Chapter XII (150-6) that one of the prime motives for the occupation of Britain was to secure the continued supply of staple products, including grain, required for the Roman army on the Rhine, exported, however, to the Rhine from Colchester. It could well be that following the Roman occupation, particularly with the disruption of the Boudiccan rebellion, exports of corn began also to flow through the new military base of Richborough.

One difficulty of Bird's proposal is that it does not account for the abrupt shut-down of the Richborough granaries in the 80s. A possible explanation may tentatively be sought in the link that Philp sees between the decline in the military rôle of Richborough and the rise of the significance of Dover as a base of the *Classis Britannica* (1981, 99-100). The archaeological record shows that intensive military activity at Richborough ceases around the end of the first century and does not revive until the second half of the third century, with a marked reduction in what was probably by then civilian occupation between *c.* A.D. 150 and *c.* A.D. 250 (Cunliffe, 1968, 243; Philp, 1981, 99). Cunliffe suggests that the reason for the decline of Richborough was probably economic with the capture by emerging trading hubs, such as London and Dover, of Richborough's trading links with the continent. Philp sees this more specifically as coinciding with the establishment and growing importance of the new naval base at Dover. The structures identified at Dover include two granaries, which, with others yet uncovered, might well have replaced those at Richborough. While Dover must be ruled out as an invasion landing site because of its topography, its location opposite Boulogne would have made it an ideal haven for passages to and from Gaul, once the south-east of Britain had been secured. Military inertia would have retained Richborough for a generation or more, but eventually the advantages of Dover would have become apparent.

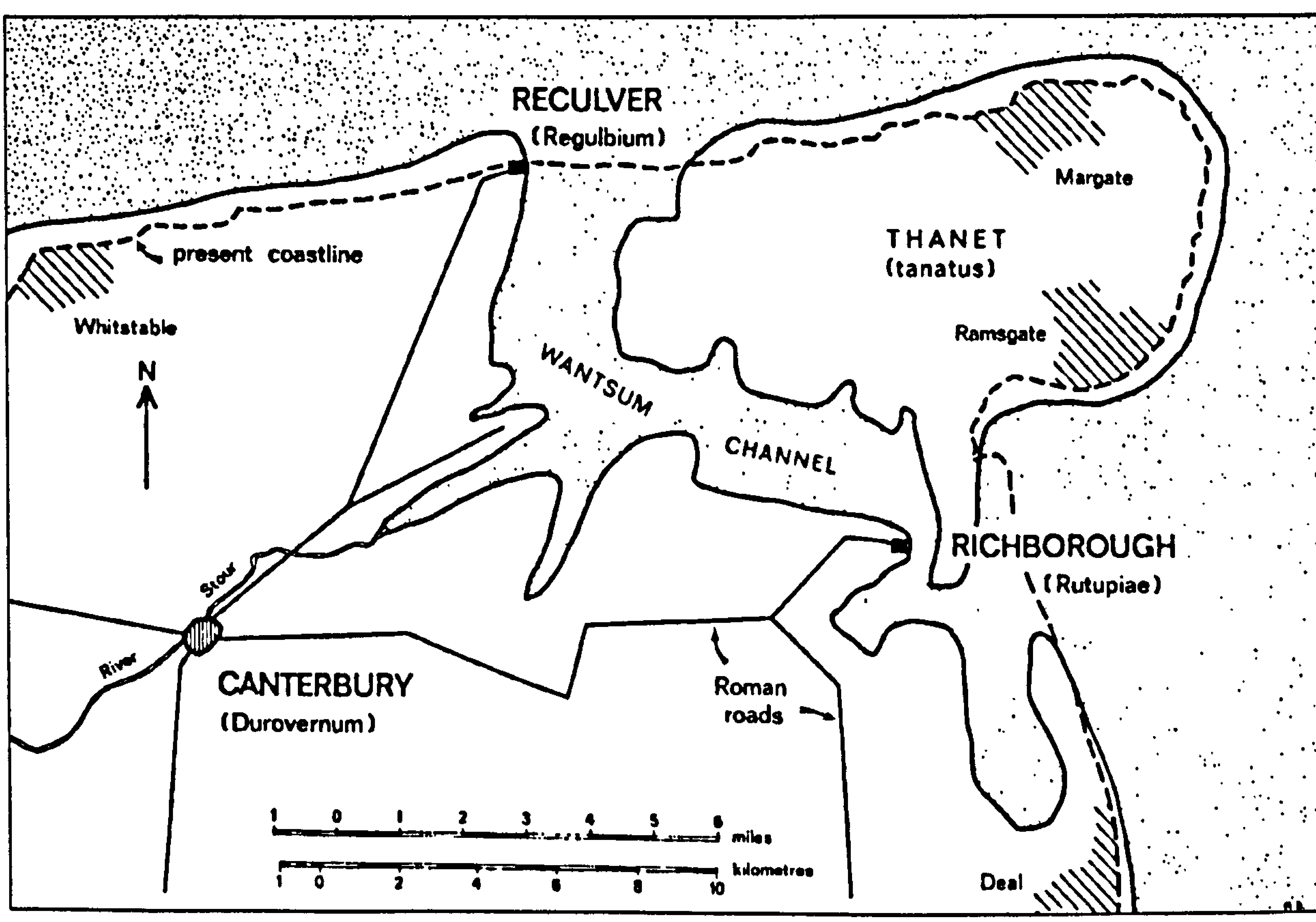

Fig. 2 North-east Kent in Roman times, showing the location of Richborough sheltered from the east by the Stonar Bank extending south from the Isle of Thanet (Philp, 1996, 2. Reproduced with the permission of Mr. Philp and the Kent Archaeological Rescue Unit). The area immediately to the south of Richborough, approximately one nautical mile by one nautical mile, was probably shallow, drying at low tide, and would have served to moor the Roman invasion fleet. The shoreline immediately to the north of Richborough would also have served.

To appreciate fully the significance of Richborough as a potential bridgehead and an actual supply base (and/or export depôt) in the first century A.D. it is necessary to attempt an assessment of the configuration of the contemporary shoreline and associated inshore waters (Fig. 2; Hawkes, 1968, 224-31). Hawkes was undoubtedly right to underline the uncertainty of our knowledge of the precise configuration of the Wantsum Channel in Roman times; but it is nevertheless possible to identify with some confidence certain features which suggest that Roman Richborough would have provided an extended sheltered haven, even from winds from the easterly quadrant; these are thought twice to have caused substantial damage to Caesar's fleet a century earlier, but, as I suggest in Appendix II, on at least one of these occasions the wind was probably from the north or north-west.

The coastlines of north-west Europe, in particular the English Channel and the southern North Sea, are still evolving under the impact of a major sea-level rise in the order of some thirty metres or more (the Flandrian Marine Transgression) following the end of the last Ice Age (Briquet, 1930, 4, 43-49, 396; Devoy, 1990, 17-18). Such a marine transgression initially creates a highly irregular, indented coastline as the sea invades river valleys, creeks and low lying coastal plains and floods up to the lowest contours of rising ground. This is followed by a process of regularisation which by silting, erosion and longshore drift creates even, straightened shorelines. The first of these processes created the host of natural havens and inshore channels, such as the Wantsum Channel, which continued to be important into the Middle Ages, while the second left them either far inland or represented by shadows of their former selves, in the case of the Wantsum, by the Stour flowing into Pegwell Bay and by the River Wantsum, which today is no more than a drainage ditch emptying into the Thames Estuary between Reculver and Minnis Bay.

There was a further, but rather less significant marine transgression at the end of the Roman period, the Romano-British (or Dunkirkian) Transgression. While this no doubt temporarily reversed the process of regularisation of the coastline following the Flandrian Transgression, it nevertheless appears that that regularisation was not complete by the beginning of the Roman period and, in particular, river estuaries were still wide and deep (Briquet, 1930, 399-400). The Wantsum was a significant channel in the Roman period and its importance in the eyes of the Roman military authorities is attested by the two military bases at either end, Reculver and Richborough.

The features of Richborough at the eastern end of the Wantsum Channel which defined its qualities as a sheltered bridgehead for a large invasion force are the following:

1. Separating the Isle of Thanet from mainland Kent, the Wantsum offers good shelter from winds from most quarters. The high ground of Thanet provides a lee from winds between the north-west

and north-east, while mainland Kent provides protection from any wind blowing between the north-west and south.

2. The Stonar Bank at the eastern end of the channel is generally believed to have come into existence before Roman times (Plate IV; Hawkes, 1968, 228-9). As such it would have provided protection at Richborough from easterly storms. On the basis of its measured rate of growth Hawkes argues that the shingle spit formed by longshore drift north from Deal outside the Stonar Bank would not yet have obstructed the entrance to the Wantsum at the southern end of the Stonar Bank; this meant that the entrance was still effectively scoured by the tide, maintaining at that point an open deep-water channel, which would have allowed good access to Richborough and the Wantsum generally (Fordham and Green, 1980, 13-14).

3. Richborough was either an island or a peninsula joined to the mainland by a strip of clay marsh, where a causeway was laid in Roman times (Ogilvie, 1968, 37-40; Hawkes, 1968, 231). Either way this would have increased the shelter offered between the high ground of Richborough itself and the Stonar Bank, probably in the extensive area of marshland lying today to the west of Sandwich and to the south of Richborough. Because it would have been out of the main tidal currents, this area is likely to have been shallow and may well have dried at low water, but this would not have been an obstacle to its use as an area to moor ships able to take the ground.

It is worth dwelling on the quality of Richborough as a secure natural haven, because Caesar's experiences of the coast of Kent a hundred years earlier have been advanced as a reason why Aulus Plautius would have avoided using Richborough as a landing place in A.D. 43 (Hind, 1989, 13, 20). But Caesar, who suffered severe damage to his fleet when at anchor in both 55 B.C. and 54 B.C. did not land at Richborough. His dispatches make it clear that in both years he landed on an open shore (*B. Gall.* IV, 23; V, 9). For his first expedition Caesar states explicitly he had virtually no information about Britain and none about its harbours and could get none from the merchants he questioned (*B. Gall.* IV, 20). He sent one of his officers, Gaius Volusenus, to reconnoitre, but he seems to have had nothing of value to report; Caesar reports with barely disguised irony:

> Volusenus observed all the country so far as was possible for an officer who did not dare to disembark and entrust himself to the rough natives, and on the fifth day returned to Caesar, and reported his observations in Britain (*B. Gall.* IV, 21).

Having arrived at about ten a.m. under the cliffs in the vicinity of Dover and deciding that he could not land there, Caesar moved some seven (Roman) miles further on, where he found an acceptable landing place on an open and level shore probably in the Walmer/Deal area. The layout of the land that Caesar found becomes very clear from the end of Deal Pier. To the south, the cliffs of Dover and the South Foreland give way to a low shoreline around the present site of Walmer Castle. From here on there is a firm shingle beach and a low hinterland not presenting major obstacles to the invader. Caesar's narrative suggests that he was not sure where he was going to land, as he coasted northwards. He took the first reasonably acceptable opportunity to land and the impression that he intended to do so is strengthened by his order to his commanders to be prepared to act on no more than a hint from himself (*B. Gall.* IV, 23).

Not knowing the layout of the coast, Caesar's first objective must have been to find somewhere his legions could land. Finding a haven where his ships could lie safely at anchor would have been a secondary concern. Even so the Romans were caught out by their inexperience of Channel tides, when the fleet was damaged in a storm which coincided with a spring high tide. It is not that they were not aware of the rise and fall of the tides - indeed in his narrative of the campaign against the Veneti in 56 B.C. Caesar gives an accurate account of the tides in Brittany (*B. Gall.* III, 12) - but rather that they did not understand just how high a spring high tide, perhaps in surge conditions, could be in the southern North Sea (NP 28, 1977, 23):

> That same night, as it chanced, the moon was full, the day of the month which usually makes the highest tides in the Ocean, a fact unknown to our men (*B. Gall.* IV, 29).

The warships, which had been hauled ashore and were no doubt lying on their beam ends, filled before they could float, while the transports, lying at anchor, lost 'cordage, anchors and the rest of their tackle' and several 'went to pieces' (*B. Gall.* IV, 29). The reference to the loss of anchors is perhaps the clue. With the tide rising higher than expected and with insufficient cable let out, some of the vessels dragged their anchors, causing the loss of some and damage to all.

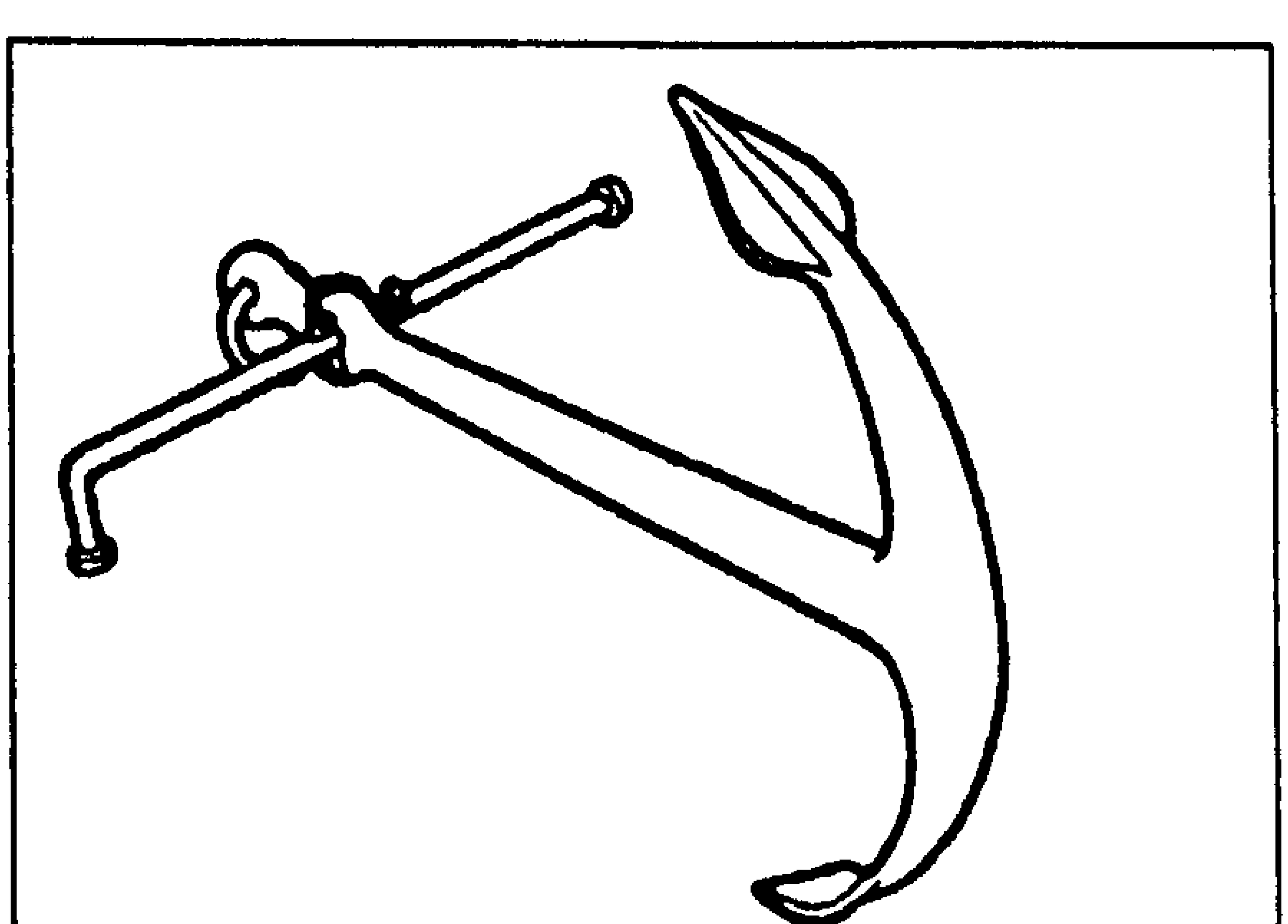

Fig. 3 A fisherman's anchor.

Iron fisherman (hook-shaped) anchors (of a type used even today) deployed with a cable made up at least in part of chain seem to have been known in north-west Europe in the Roman period (Fig. 3; Cunliffe, 1972, 300-2; McGrail, 1987, 253-5). The evidence, however, is slight and how wide-spread their use was cannot be certainly established. Perhaps Caesar's ships were equipped with stone sinkers and warps, known in the Mediterranean from the second millennium B.C. and still in use at the end of the second millennium A.D. (McGrail, 1987, 252; Marzari, 1982, 175-6); perhaps with iron fisherman anchors without chain. The fact that the previous year he had found it worthy of note that the Veneti used chain with their anchors 'rather than warps' (*B. Gall.* III, 13) suggests that the Romans regarded the use of chain as unusual.

The point is important because the use of chain increases many times the holding power of anchors of any design (Riley, 1976A, 209-10). We cannot be sure, but the obvious interpretation of Caesar's account is that, whatever the type of anchor used, some of them dragged in the storm, when the high tide was abnormally increased by surge conditions, because chain was not used.

With the benefit of his experiences in 55 B.C. Caesar landed the following year at what he describes as 'the best place of disembarkation' (*B. Gall.* V, 8), but it was still not Richborough. He says that he left the fleet on a soft (*mollis*), open shore and that he was, therefore, easier in his mind about it. 'Open' would not seem to be descriptive of the shelter of Richborough.

Although Edwards translates *mollis* as sandy (1917, 244-5), sand can be quite hard and it is much more likely that Caesar is referring to soft alluvial mud. Caesar's description of the passage is consistent only with a landing somewhere between the South Foreland and North Foreland: after being carried too far by the tide during the night, he sighted Britain on the port side. Had he been carried by the tide along the south coast, he would have sighted Britain to starboard. A landing on a muddy shore would seem therefore to indicate a point north of the longshore shingle drift from Deal, which at that time would not have extended as far north as it does today (Hawkes, 1968, 223, 228-9), but south of Richborough.

Once again the fleet was damaged in a storm and once again the prime cause was that the anchors did not hold and the ships were driven ashore (*B. Gall.* V, 10). Caesar's report is entirely consistent with ships anchored off an open shore dragging their anchors in an easterly gale and being driven ashore.

Richborough then would have provided good shelter for the ships of an invasion fleet, has been associated archaeologically with the very earliest days of the Roman occupation and shows archaeological evidence of being an invasion bridgehead.

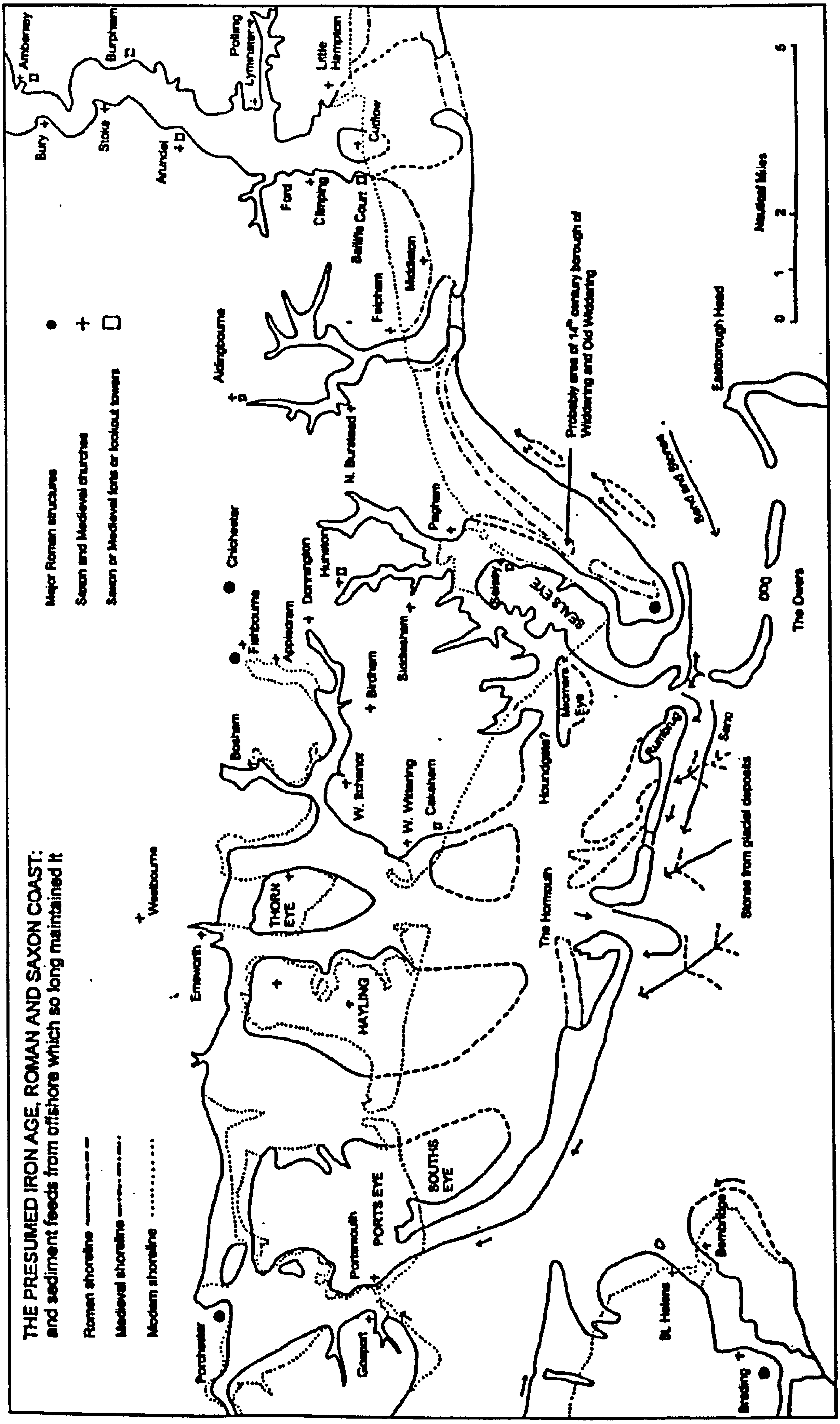

Fig. 4 Reconstruction of Chichester Harbour in the Roman period (Wallace, 1990, 8-10; 1999, 2. Reproduced with permission of Hume Wallace).

Fishbourne (Chichester Harbour)

Like Richborough, Chichester Harbour also would have provided good shelter for an invasion fleet in winds from all directions. Today it is one of a number of natural harbours on the Solent, sheltered from the prevailing winds by the Isle of Wight. Although its precise configuration in Roman times was undoubtedly different, there is no reason to suppose that it was not then just as sheltered as it is today.

A reconstruction of the harbour and adjoining coastline in Roman times has been proposed by Hume Wallace (Fig. 4; Wallace, 1990, 8-10; 1999, 3). The prime feature of this reconstruction is the barrier beach some three miles to seaward of the present shoreline, running from Seals Eye (Selsey) to Ports Eye (Portsea), which would have created a sheltered lagoon. This beach was identified by Wallace and colleagues in sub-aqua diving and has been traced over 75% of its length. Interpreted as initially a fringing beach and eventually becoming a genuine offshore barrier beach, Wallace dates it from *c.* 1800 B.C. to *c.* A.D. 1200. To continue in existence for such a long period a mechanism must have been in existence to replace the material that would have been eroded, in other words the rate at which beach material accumulated must have been equal to or have exceeded the rate at which it was being eroded. Wallace considers that the beach derived originally from the moraine fill of the Solent valley immediately to its south and possibly from the Medmerry Bank. Latterly, as the sea-level rose, Wallace believes that material must have come ashore through what he describes as the 'Selsey Shingle Trap', contributing to longshore drift westwards and eastwards from Selsey Bill (1990, 10-15; 1996, 2-4-7).

Wallace verifies his conclusion by combining eustatic data for world-wide sea-level changes with recorded data for the sea-level rise at Portsmouth over the eighteen years 1962-1980 (1996, 5-8). These data show a much higher rate of sea-level rise at Portsmouth than elsewhere in the U.K., 5.6 mm. *per annum* as compared with 1.5 mm. *per annum*, for example, at Sheerness.

Whilst accepting that data for such a short period may reflect a short-term acceleration in a more slowly moving long-term subsidence, Wallace considers that they can be explained by a local geological anomaly. He authenticates this by reconciling his proposed curve for sea-level rise in the region for the past 2,500 years with datable archaeological markers which at the relevant dates must have been, as the case may be, either above or below sea-level (1990, 5-6; 1990, 8-11).

There must of course be uncertainties in any such reconstruction and Wallace recognises the need for further research to verify his conclusions (1990, 53-8). But his hypothetical reconstruction is closely argued and even if it should fail to be accepted, it nevertheless confirms that Hampshire/West Sussex coastal plain would have provided an extensive area of sheltered water in Roman times. However, we should note that access to the harbour through the barrier beach is likely to have been difficult, though by no means impossible with local knowledge, and that Wallace's reconstruction confirms that in Roman times there would have been offlying hazards to the west of the entrance in the shape of the Owers (see Chapter X, 121).

The earliest buildings at Fishbourne, like those at Richborough, belong to the period immediately following the Roman invasion and two, identified as granaries, are very similar to the earliest buildings at Richborough, while a third, which differs only slightly in the archaeological trace, is also considered to be a granary (Cunliffe, 1971, 27-32; 1998, 25-31). Part of a ditched enclosure has been found 'which could have been used as a kraal for livestock' (Cunliffe, 1971, 32). We should not assume that the legionaries lived by bread alone; meat would also have been an important requirement for military supplies. There is also some evidence of Roman harbour works close to the Fishbourne site and in particular of dredging (Cunliffe, 1971, 26-7).

Modern buildings on the site have prevented extensive excavation and it may be that only a small proportion of an extensive military supply base has been identified. There is no trace of a defensive bridgehead of the kind found at Richborough, but given the assumption that a landing here would have been in the territory of a tribe friendly to Rome, perhaps this is not to be expected.

The evidence for early Roman military activity at Fishbourne is supplemented by similar evidence for Chichester. Again excavations were constrained by the fact that they were in a built up area, but enough has been found to suggest a major military presence. This includes timber-framed structures interpreted as legionary barracks, a number of finds of military equipment, including a Roman *gladius* found under the Central Girls' School in Chapel Street, and two defensive ditches (Down, 1988, 7-14). Dating depends on finds of Roman pottery which are ascribed to the later years of Augustus, rather than to Claudius. This can only be explained, perhaps unsatisfactorily, as forty-year old quartermaster's stock or as Roman goods imported by native traders well before the invasion and traded with Roman legionaries when they arrived (Down, 1988, 14-16). However, there is no reason to doubt an early Roman presence at Chichester, which may well have been the base of Vespasian's *Legio II Augusta* in their campaign in the south-west. As such Chichester has been identified as *Noviomagus*, the new capital of the Regnenses.

One interesting find is the legionary's helmet recovered from Chichester Harbour near Fishbourne and now in the British Museum (Cunliffe, 1971, 32-4; 1998, 28-9). Cunliffe suggests that 'it is tempting to think of it being dropped overboard by a legionary about to disembark', but it cannot of itself be evidence of a major invasion bridgehead at Fishbourne.

Summary

There are only two realistic candidates for the Roman invasion landing, Richborough and Fishbourne. Both would have provided easy access to the shore for the invasion force and both would have afforded an expanse of sheltered water for the invasion fleet. Both are supported by archaeological evidence of early Roman activity on a substantial scale.

Richborough is not as exposed to storms from the east as advocates of the Fishbourne hypothesis have suggested and we should note at this stage that Chichester harbour may have offered difficulties, as it does today, to anyone attempting the entrance without local knowledge. The passage to Chichester harbour would have been more complex than the passage to Richborough, but that is a matter for Chapter X.

Chapter III

Significant Phrases in Dio Cassius's Greek

Three Divisions

There are three points in Dio's account of the invasion where our interpretation of what he is saying has a material significance for our understanding of the invasion passage (Dio, LX, 19). The first is the phrase he uses to denote the organisation of the invasion force which has been variously translated (or understood) as 'divided into three squadrons' (Hind 1989, 6), 'in three divisions' (Cary, 1924, 417; Ireland,1986, 45), or 'in three waves' (Detsicas, 1983, 12-13).

Dio's Greek phrase is 'τριχῇ νεμηθέντες'. Grammatically this is an adverb qualifying a passive participle and might literally be construed as 'distributed in threes' - in three parts - or in three ways (Liddell and Scott, 1997, 528, 820). What is clear is that Dio is not referring to some formal and regularly recognised way of organising the troops. The phrase indicates something vague, informal and *ad hoc* and there is no necessary implication in the text or otherwise that the invasion force landed at three separate points. Detsicas's concept of 'three waves' is perhaps as close as any, but even that is being more precise than the vagueness of Dio's original text.

The Opposed Landing?

Dio explains why the invasion fleet was organised in this way in a phrase which is usually understood as meaning that this would ensure that the invaders were 'not hindered in landing - as might happen to a single force' (Cary, 1924, 417; see also Ireland, 1986, 45). Cunliffe and Hind offer an alternative: 'to avoid having an opposed landing, which might hold up a single force' (Cunliffe, 1971, 22; 1998, 21; Hind, 1989, 6). If this were a valid translation, it would actually give strength to the case for three landing points (rather than the one - at Fishbourne - that Hind is advocating).

The key word in Dio's text is 'κωλυθῶσί' Following Liddell and Scott (1997, 459), the normal meaning to be ascribed to this word is 'hinder'; to infer from Dio's text a reference to the possibility of an opposed landing is stretching interpretation to the extreme. Dio is saying that too many troops arriving at the bridgehead together would create a traffic jam and that the commanders wished to avoid this by staggering the landing. There is no need to postulate three separate bridgeheads to account for Dio's Greek.

The Bolt of Lightning

The third point concerns the 'bolt of lightning', 'shooting star' or 'flash of light' which heartened the invasion force during their crossing. The word used by Dio is 'λαμπάς'. Its basic meaning is that of 'pine torch', such as would be used outside, but Liddell and Scott do record its use by the Athenian playwrights as a metaphor for the sun, for example in the phrase 'ἡ ἐπιοῦσα λαμπάς' for the coming day (1997, 464). They record none of the other meanings offered in the different translations of Dio's text. In fact it should be appreciated that the English versions offered are not so much translations as interpretations of an incident which is frankly not well understood. Moreover, we should remember that Dio's original oral source, either direct or indirect, would have been speaking Latin, not Greek. If his narrative reflects something that really happened, the eyewitness would have used a Latin word which Dio translated as 'λαμπάς'. Possibilities for that word might be *lampas*, *fax* or *lumen*.

lampas is a borrowing from Greek and as such tends to be restricted to poetic use. In such use it can mean both 'day' and 'meteor' (Smith and Lockwood, 1976, 389). However, one might doubt whether the Roman reporting the event would have used a word of Greek origin with poetic associations. The native Latin words are *fax* and *lumen*. The basic meaning of *fax* is 'torch', but among its other meanings it includes 'meteor' (Smith and Lockwood, 1976, 266-7). The alternative *lumen* has the basic meaning of 'light', but can mean 'torch'; more significantly it also has the meaning 'daylight' (Smith and Lockwood, 1976, 410-11).

It is entirely possible that Dio did not completely understand the event that he was reporting. Given that the eyewitness may have used the word *lumen*, it is at least as plausible that he was referring to daybreak, an event which certainly would have raised the spirits of men who had spent an uncertain night at sea, as any one who has done so can confirm, and is consistent with something which went from east to west. Dio's comment that this direction coincided with that in which they were sailing should not be taken as inconsistent with a passage from Boulogne to Richborough. At the time of the phenomenon they were being 'driven back in their course'. On the passage from Boulogne to Richborough, this could mean that a combination of a north-west wind (or a failing wind) and a north-east going tide was taking the fleet rapidly offshore; eastwards from Kent and the Isle of Thanet. Their intended course would then indeed lie east to west. This happened to Caesar on his second expedition when the wind failed and the tide took him offshore; it was at sunrise that the Romans realised what had happened and took to their oars (*B. Gall.*, V, 8).

Conclusion

Taken together, Dio's description of the invasion as organised 'in threes' and his explanation of the reason why it was so organised must mean that the commanders wished to avoid too many troops arriving at the beachhead at the same time. It simply does not make sense that they organised it in that way in order to avoid an opposed landing. Dio's account is entirely consistent with a single beachhead.

Whatever may be the reality of the phenomenon lying behind Dio's use of the word 'λαμπάς', his statement that, having been set back in its course, the fleet was then sailing from east to west is not at all incompatible with a passage from Boulogne to Richborough. The parallel with Caesar's second expedition is striking.

Chapter IV

Aulus Plautius's Ships

Warships: the Mediterranean Tradition

In this chapter I look at the evidence for the types of ship used by the Romans in the invasion of A.D. 43; in the three following I shall offer an assessment of their likely performance. Since there is no direct evidence for the ships used by Aulus Plautius, inferences have to be drawn indirectly from the archaeological and iconographic record; by analogy we may also draw inferences from Caesar's account of his expeditions to Britain a century earlier.

Caesar reports using for his expeditions ships of two types, transports and warships, and at various places in his account gives much circumstantial information about them (*B. Gall.*, III, 9, 13-5; IV, 21-3, 25-6, 28-29, 36-7; V, 1-25, 7-8). The warships were built locally. For example, for his campaign against the Veneti in 56 B.C., Caesar had warships built on the Loire, ships which he would also use for his expeditions to Britain. In the details that Caesar records for his warships, the Mediterranean influence is clear. They were armed with a ram and in combat at least relied on oars for propulsion. For the British campaign in 55 B.C. they are recorded as fitted with catapults, while archers and slingsmen operated from their decks. No mention of such equipment is made in the campaign against the Veneti, when it might have been a decided advantage.

In his campaign against the Veneti, Caesar used his warships to engage the ships of the enemy at sea; in his expeditions to Britain, the warships seem to have served two functions: firstly they were allocated to the general staff and senior officers; secondly they were deployed to provide supporting fire for the legionaries as they disembarked (*B. Gall.*, III, 13-5; IV, 22, 25-6). Caesar himself comments that the warships were more easily manoeuvrable than the transports and allocating them to senior officers would have made it easier for them to move around the fleet to maintain control.

In contrast to the flatter bottoms of ships built in the local tradition which could easily take the ground, the Roman warships had deep V-shaped lower hulls; Caesar says as much in his description of the ships of the Veneti and, as I have suggested in Chapter II (21), this is why the warships hauled ashore in Kent in 55 B.C. were lying on their beam ends to be swamped as the surge tide rose. The crews, specifically the oarsmen, helmsmen and deck hands, were not regular legionaries, but were seamen drafted in for the purpose (*B. Gall.*, III, 9).

Caesar's account of his warships is supplemented by various depictions on coins and other media, the find contexts of which suggest that they represent Roman warships as used in north-west European waters. A common feature of many of these depictions is that they show the warships being rowed. Whilst this might well be a conventional way of depicting a warship, it nevertheless is likely that this conventional image was underpinned by the reality that oars, particularly in battle, were the main means of propulsion of warships and that sail was secondary.

A coin of Allectus, minted in Britain at the end of the third century A.D., includes a single rigged mast, but without sail or yard depicted. The vessel is being rowed and the inference is that the mast cannot be lowered, although the yard and sail can be handed (Marsden, 1972, 115-6). Marsden notes that earlier depictions from the first and second centuries A.D. show an *artemon*, a bowsprit-like feature from which a foresail would have been rigged, but do not show a main mast. Since the vessels are being rowed and certainly could not have sailed with this rig under foresail alone, it is possible to conclude that the main mast does not appear because it is lowered.

A Roman *intaglio* found on the foreshore at Southwark and dated to the second or third century A.D. does not show a main mast; Henig and Ross (Plate VII; 1998, 325-7) identify its prow as carrying a figurehead in the shape of the head and neck of a swan, but the structure appears far too massive to bear such an interpretation; moreover, a swan neck and head appear to form part of the *aplustre* at the stern of the vessel. It is tempting to regard the structure on the prow as an *artemon* or even as a catapult, since such are mentioned by Caesar, but neither interpretation is satisfactory.

Other depictions include a model warship prow and the gold medallion commemorating the arrival of Constantius Chlorus in London in A.D. 296 following the third Roman invasion of Britain (see Chapter XI, 125-9; Frere, 1987, Plate 32; Marsden, 1994, 17, 105, 107). The warship depicted on the latter shows neither main mast nor *artemon*. Marsden comments that, since the medallion was struck in Trier, it is unlikely that the designer had seen the warships involved. It is difficult to imagine, however, that there would have been a significant difference in design between Roman warships in British waters and those on the Rhine and its tributaries, especially since Constantius's warships were in all likelihood built on the continent.

In fact there is considerable iconographic evidence from the first century A.D. for the presence on the Rhine - and the Danube - of Roman warships of Mediterranean design (Höckmann, 1986, 390-3). Höckmann identifies these as liburnians, the work horse of the Roman navy (Casson, 1971, 141-2). His conclusion is that, until the middle of the third century A.D., when they were replaced by a new design, specifically adapted to the needs of river defence, these liburnians were identical in design and method of construction to Roman warships built in the Mediterranean.

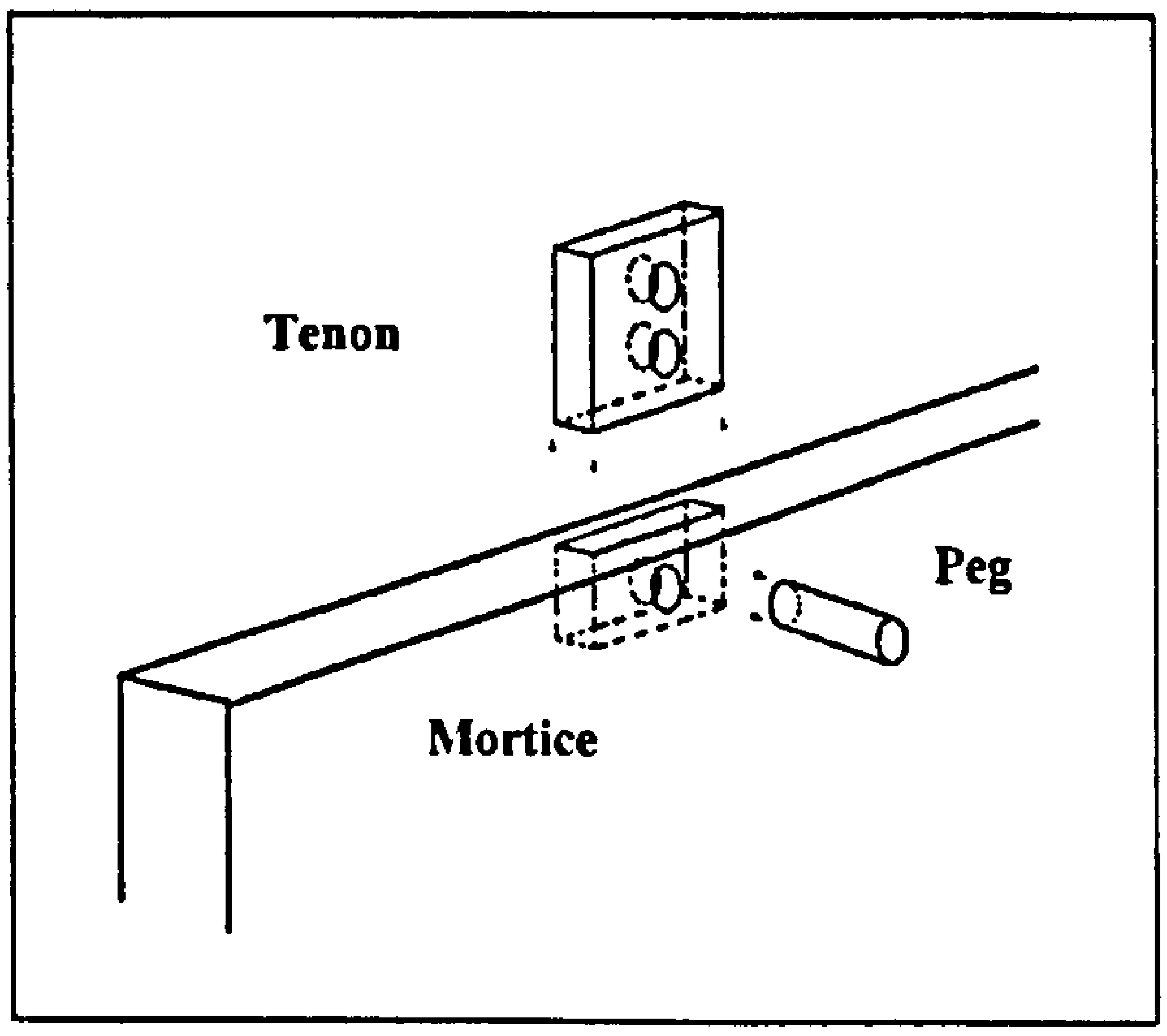

Fig. 5 A mortice-and-tenon joint; once the tenons have been inserted into the mortices, the mortices of the next plank can be offered up.

This method of construction was to build the shell of the hull first before inserting the frames. Shell-first methods of construction, which were widely used in ancient times, depend on some method of securing each plank to its neighbour: in many traditions stitching with some form of natural twine was used; in the clinker-built tradition of Scandinavia and its neighbours the planks were overlapped and secured to each other with iron rivets. The special characteristic of the Graeco-Roman method of construction was the use of mortice-and-tenon joints to secure each plank to its neighbour (Fig. 5). A series of narrowly spaced slots (mortices) were cut in the edge of each plank. Into each mortice was inserted a tenon (a rectangular tongue of wood) and the next plank was offered up so that the mortices in its lower edge matched up to the tenons already in place in the lower plank. Once the two planks had been tightened up the joints were locked by a wooden peg driven through a hole in each end of each tenon (Casson, 1971, 201-13; Katzev, Katzev and Tzalas, 1987, 7-8). The result was a strongly built carvel hull which would be waterproof without caulking (Katzev, Katzev and Tzalas, 1987, 8). It was, however, a method which was expensive in time and required craftsmen trained in the technique, who would have had to be recruited from Mediterranean shipyards.

Supporting archaeological evidence for the use of this ship-building technique in north-west European waters is provided by Marsden's reassessment of the County Hall Ship, originally excavated in London in 1910 (1994, 109-29). This ship was shell-built with the planking edge-joined with mortice-and-tenon joints; the dendrochronology fits with tree-ring sequences typical of south-east England. The ship is dated to the end of the third century (Marsden, 1994, 124-5; Tyers, 1994, 205). Although when she was originally found, she was hailed as one of Allectus's warships (see Chapter XI, 127), Marsden is unable to reach any firm conclusion as to her function (1994, 125-7).

The evidence for Mediterranean-style warships in Caesar's fleet strongly suggests that they were built by shipwrights drafted in from the Mediterranean; it is difficult to imagine the adaptation of the local ship-building technology, described in the next section, to the specific features of these warships, in particular the design of the ram. When *c*. 260 a new, smaller, type of warship was introduced on the Rhine/Danube frontier, the evidence of the Mainz type A ships is that the Mediterranean ship-building methods were replaced by what may well have been an adaptation of local practice with planks nailed to frames; according to Höckmann, these ships featured no more than a vestigial ram, ill suited to anything more than the capsize of a logboat (1986, 392-5).

Transports: the Romano-Celtic Tradition

Caesar's warships were to prove useful in his first British expedition by providing covering fire for the legionaries as they landed against the opposition of the Britons, much in the manner of cavalry in a land battle being brought to bear where the legionaries were hardest pressed. However, they were ineffective in combat against the ships of the Veneti (*B. Gall.*, IV, 25-6). The latter were far more seaworthy in the open sea conditions off the Atlantic coast of Brittany and too stoutly built to be damaged by the rams of the Roman ships. The superior freeboard of the Venetic ships made them difficult for the Romans to board. In the event it was the reliance of the Venetic ships on sails and the wind which gave the Romans victory. The Romans managed to disable several of the Venetic fleet by cutting their halyards, using the unlikely but effective expedient of sickles fixed to the end of long poles. When the rest of the fleet turned downwind to flee, it was becalmed in the dying wind and the ships were picked off by the Romans one by one (*B. Gall.*, III, 13-5).

Caesar's description of the ships of the Veneti and the archaeological evidence that has been associated with them reveal a tradition of ship-building which has been designated Romano-Celtic (Marsden, 1994, 166-8; McGrail, 1995, 139-45; Ellmers, 1996, 52, 68-71). The remains of ships and boats built in this tradition have been found the length of the Rhine, in the Netherlands, at St Peter Port, Guernsey, in London and in south Wales, while Caesar's narrative suggests that the range of the type extended to the Atlantic coast of Brittany (Plate V; Rule and Monaghan, 1993; Marsden, 1994, 33-95; Nayling, Maynard and McGrail, 1994, 596-603; McGrail and Roberts, 1999, 133-46). Since Caesar did not build transport ships for his first expedition to Britain, but requisitioned them in Gaul (*B. Gall.*, IV, 21), it is a reasonable assumption that they were built in this tradition. This assumption is corroborated by his report that his warships were less familiar in appearance to the Britons than his transports (*B. Gall.*, IV, 25). For his expedition of the following year he had some six hundred new transports and twenty-eight warships built, as well as having the old fleet repaired (*B. Gall.*, V, 1-2). Leaving his Mediterranean shipwrights to build the warships, it is a reasonable assumption, given the huge number of ships required, that Caesar used local craftsmen to build the new transports. He did, however, order modifications to the design: his new transports were to be beamier and of lower freeboard, and were to ship oars, as well as sails.

A further indication that Roman commanders in north-west European waters would look to the resources of the local ship-building tradition can be discerned in Tacitus's description of the fleet built in A.D. 15 for Germanicus's naval expedition from the Rhine to the Ems:

> A thousand vessels were considered enough, and these were built at speed. Some were short craft with very little poop or prow, and broad-bellied, the more easily to withstand a heavy sea: others had flat bottoms, enabling them to run aground without damage; while still more were fitted with rudders at each end, so as to head either way the moment the oarsmen reversed their stroke. Many had a deck-flooring to carry the military engines though they were equally useful for transporting horses or supplies (*Ann.*, II, vi).

These craft seem not to be in the Mediterranean tradition. Indeed the very fact that Tacitus described them in some detail suggests that they were not. As we shall see, some of the features mentioned by Tacitus, in particular the ability to take the ground, are reminiscent of the Romano-Celtic tradition. One detail the translator has got wrong (Jackson, 1962, 390-3): the rudders were not fitted 'at each end', but 'at each side' (*utrimque*); Tacitus is describing two side rudders fitted to the port and starboard quarters.

The key features of ships of the Romano-Celtic tradition include a hull constructed of stout planks laid edge to edge and secured to very characteristic 'massive and closely spaced framing timbers' (Plate VI; McGrail, 1987, 143-4; 1995, 140). These frames are either asymmetric grown timbers spanning the bottom and one side of the hull, alternately port and starboard, as in craft excavated at Zwammerdam, Bevaix and Krefeld-Gellep, or separate floor and side timbers, as in Blackfriars 1 and St Peter Port 1, or a combination of the two, as in the Barland's Farm Boat (Rule and Monaghan, 1993, 14-28; Marsden 1994, 45-8; Ellmers, 1996, 66-7; McGrail and Roberts, 1999, 133). The hulls are either flat-bottomed without a keel or with a central plank keel, thicker than the remaining planking (Rule and Monaghan, 1993, 29; Marsden, 1994, 38-9; McGrail, 1995, 140, 143; McGrail and Roberts, 1999, 133-4).

An important feature is that the planking was fastened to the framing timbers, not edge-joined, a feature which is significant for reconstructing the building sequence. During the Roman period the planking was secured exclusively by massive iron nails which passed through both frame and plank and were bent back on themselves (hooked - see Fig. 6) so that the point was hammered back into the wood (McGrail, 1987, 146; Marsden, 1994, 33-95; Gilmour, 1994, 181-7; Ellmers, 1996, 62, 66-7; McGrail and Roberts, 1999, 135-6), Ellmers points out that the introduction of iron fastenings did not come about with the Roman occupation of Gaul, but with the establishment of the Celtic *oppida* culture in the second and first centuries B.C., a point confirmed by Caesar's report of iron nails as thick as a thumb in his description of the native ships of the Veneti.

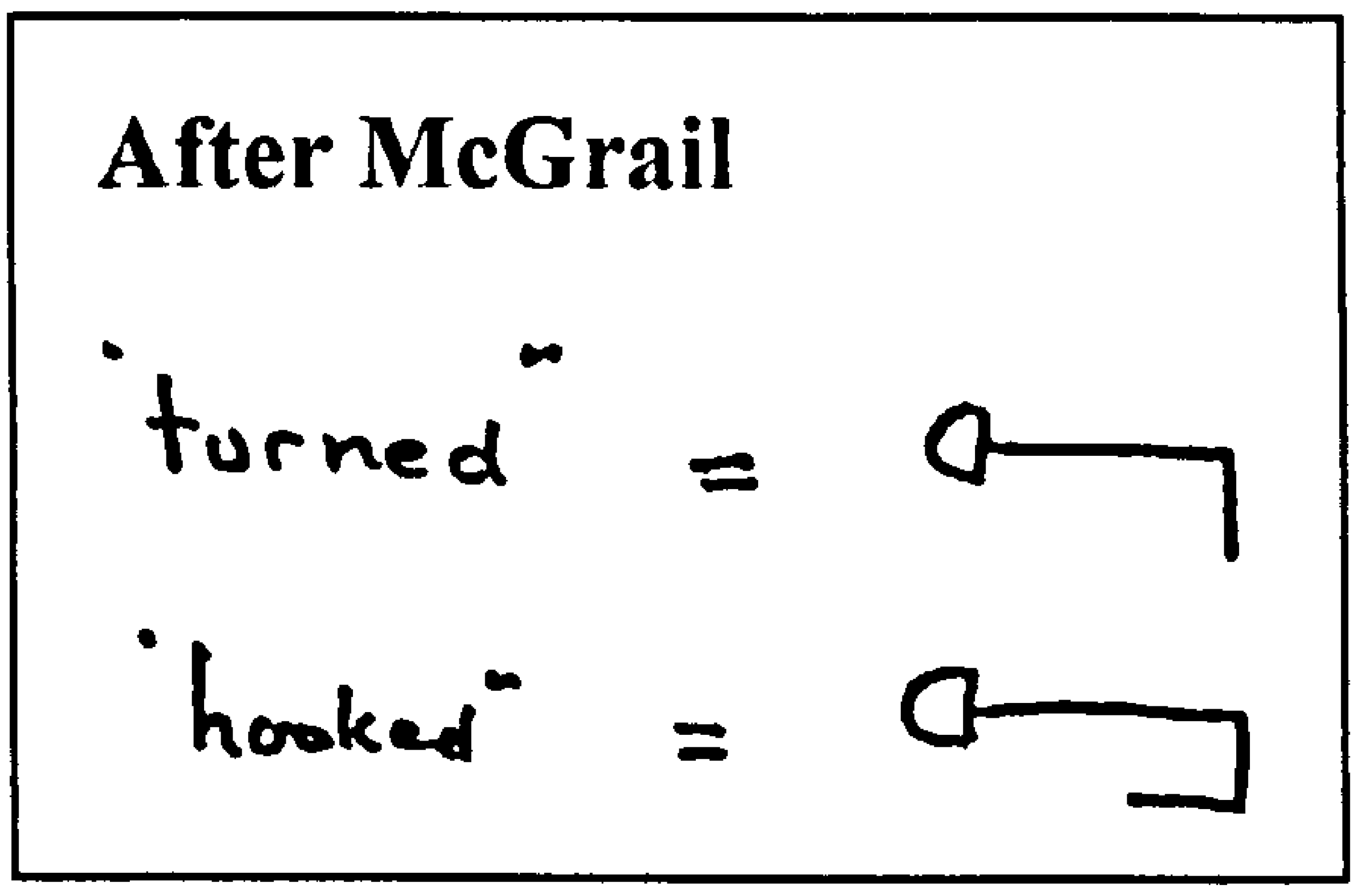

Fig. 6 Turned and hooked. (Reproduced with permission)

In fact the use of iron fastenings may go back earlier. Arnold (1999, 40-42) proposes that iron fastenings for Romano-Celtic ship construction were in use earlier, although 'there are no examples of Iron Age boats assembled by nailing'. Evolving from Bronze Age craft, such as North Ferriby 1 and 2 and the Dover boat, he sees the ship-building methods north of the Alps gradually abandoning the use of stitching, with pegs in mortised cleats, in favour of the use of nailing with a strong framework to cross-brace the hull. As a parallel, he points to the use of turned and hooked iron nails to fix iron tyres to wooden wheels by the middle of the first millennium B.C.

Another significant feature characteristic of the Romano-Celtic tradition is that the single mast step was located in the forward part of the ship, at a significant distance forward of amidships. This is a feature which it shares with other craft, including the Roman-period *codicaria* of the Tiber and the modern-day Humber keel.

It is to the massive solidity of the construction of the Venetic ships that Caesar ascribes their ability to ride out the storms of the Atlantic coast of Brittany. But this is not the only way of achieving sea-keeping ability. The much lighter and more flexible hulls of the ships built in the later Nordic tradition also had an awesome reputation for seaworthiness in the most extreme conditions of the open waters of the North Atlantic. That Nordic hulls could be and were constructed of much thinner planking depends on the fact that they were clinker-built. This meant that the caulking between the individual planks required to make the hull waterproof was held at the point where they overlapped and were fastened to each other. By contrast methods of carvel (edge-to-edge) construction required thicker planking. This is true both for the Romano-Celtic method of construction where the planking was secured to frames (frame-based) or for the Mediterranean where the shell was built first, each plank being secured to its neighbour by mortice-and-tenon joints. Some form of caulking was undoubtedly required for the Romano-Celtic method and although caulking was not used in the Mediterranean method, because of its 'close-set joinery' (Morrison and Coates, 1986, 185-7; Casson, 1971, 209; 1994, 34-5; 1996, 42), a minimum thickness of planking was required to accommodate the mortice-and-tenon joints. The stoutness, and weight, of ships of the Romano-Celtic tradition was a necessary corollary of the use of edge-to-edge planking.

The concept of a ship-building tradition is an abstract construct used by maritime archaeologists to explore and interpret the evolution of boats and ships and the methods used to build them (McGrail, 1995, 139-40).

In reality it is represented on the one hand by real craft, which existed in the past (a very few of which survive to the present day) and on the other by a set of visual concepts, skills and technologies shared by boat-builders and evolving as it is passed on from one generation to the next, like any other cultural element of human society. There is thus room for scholars to differ as to the interpretation of the scope, whether geographic or temporal, of a particular tradition. Arnold traces the Romano-Celtic tradition back to Bronze Age craft and Ellmers (1996, 66-7) identifies four stages in the tradition from the sixth/fourth century B.C. to the High Middle Ages, flourishing from western Europe as far east as Ljubljana, Slovenia. McGrail (1995, 139), on the other hand, while accepting that further finds, both earlier and later, might remain to be discovered, sees the tradition as much more focused on the Roman period, from the first to the fourth century A.D. What is important for our purposes is that it is identifiably different from the Mediterranean tradition of the Roman period and that within it one can recognise two sub-groups, which differ both in function and details of construction, the inland water craft centred on the Rhine and its tributaries and the sea-going vessels of the southern North Sea, the English Channel and the Atlantic coast of Gaul (McGrail, 1995, 143). It is the latter which is relevant to a consideration of the ships that might have been used by a Roman invasion force.

The suggestion that a ship-building tradition can be understood as a set of 'visual concepts, skills and technologies' implies that, although expressed in the individual ship or boat, the tradition has a life wholly independent of it, existing in the mind of the boat-builder and available to be drawn on to build craft which do not comply with the normal features of the tradition. Thus when Caesar laid down the design of his new transports, we must suppose that the shipwrights drew on and modified the techniques of their ship-building tradition to achieve the results that Caesar had ordered, rather than seeking a new solution to every construction problem that arose. Much the same must have happened with King Ælfred's 'long ships', about which so much ink has been spilt. The *Anglo-Saxon Chronicle* for the year 896 records that these new ships were 'almost twice as long as the others', faster and of higher freeboard (*ASC*, 896; Whitelock, with Douglas and Tucker, 1986, 57; Swanton, 1999, 16-21, proposes 'more responsive' for 'higher freeboard'). It can scarcely be supposed that Ælfred created a new ship-building tradition *ex nihilo*. He can only have dictated his requirements as to length, freeboard, etc. and left his shipwrights to get on with it as best they could within the resources of their ship-building tradition.

Summary.

I shall adopt as a working hypothesis that for his invasion fleet of A.D. 43, Aulus Plautius required the same types of vessels as used by Caesar, warships and transports. That Roman warships in north-west European waters were built in the Mediterranean tradition and conformed to the design known as liburnian is well established by iconographic and other evidence. The existence of the Romano-Celtic tradition is also well established in the archaeological record and confirmed by Caesar's description of the ships of the Veneti. It is an assumption that the transports of the Claudian invasion fleet were built in this tradition, possibly modified, as Caesar's were, for the purposes of the invasion, but a reasonable one.

Chapter V

Performance: Evidence from Caesar

In considering the options open to them for the passage of the invasion fleet, the Roman Naval Staff of A.D. 43 will have taken into account the performance of their ships, both transports and warships. Performance is to be understood as meaning not only the likely speed that the ships could attain, but also how far a successful passage would depend on having favourable wind and weather conditions. Commanders would not have relied on the ships' achieving their maximum potential speed. The vagaries of wind and weather mean that such a speed is possible only under exceptional circumstances. Moreover, as we shall see in Chapter IX (93-6), sailing in a fleet imposes limits on the speed that can be achieved.

Once again on this question no data are available for the ships of the actual invasion fleet itself, but certain general conclusions can be advanced both from the detail of Caesar's account of his two expeditions of the previous century and from other sources, which include other documentary evidence, theoretical calculations in respect of excavated ships and actual results from experimental archaeology. In this chapter we shall examine the conclusions that can be drawn from Caesar's evidence; in Chapters VI and VII we shall look at archaeological, theoretical and other evidence, first for general speed potential and then for windward ability.

Caesar's account is valuable, not only for the information which it gives about the performance of his ships, but also because we can detect indications of the preferred weather and tidal conditions. It is in his account that we can get closest to the mind of the Roman Naval Staff.

From Caesar's account five hypotheses may be formulated:

1. His warships were faster, and probably more manoeuvrable, than his transports and Romano-Celtic ships generally, at least when they were under oars; they certainly were less seaworthy;

2. His passages between Boulogne and east Kent were not particularly fast;

3. Of a total of seven recorded attempts at a cross-Channel passage by his fleet or parts of it, two were unsuccessful and did not arrive at their destination; in addition part of the fleet intended for both expeditions failed to arrive at the port of embarkation (*B. Gall.*, IV, 22, 28; V, 5, 23);

4. Caesar's preferred winds were not only favourable, but also very light, sometimes becoming a dead calm; he also seems to have preferred night crossings, possibly with a moon;

5. Caesar showed some understanding of the tidal streams in the Dover Strait and worked his tides.

Let us amplify these points in order. In comparing his warships with the Venetic ships, Caesar recognised that his ships excelled only in 'speed and oarsmanship'; he is explicit about his own ships' unsuitability for the local weather conditions (*B. Gall.*, III, 13). Later in his crossing of 54 B.C., when the wind died, he praised his legionaries who were hard pressed in rowing the 'heavily built transports' to keep up with the warships (*B. Gall.*, V, 8). The design of these transports had been modified for the purposes of the invasion. Lower freeboard allowed easier loading and unloading and the ships were fitted with oars as well as sails; Caesar noted that this was much helped by the lower freeboard (*B. Gall.*, V, 1). There is, therefore, no necessary implication that unmodified Romano-Celtic sea-going ships were fitted with oars, though they may have been.

As for his passage times, Caesar gives details of three passages in terms of the time of departure and arrival. There is some slight uncertainty because he gives the times in terms of the Roman hours of the day (*horae*) and watches of the night (*vigiliae*). These divide the day into twelve hours and the night into four watches and respectively measure the time elapsed since sunrise and sunset. Therefore the actual time elapsed will depend on the season.

For his first expedition Caesar records that he weighed anchor 'about the third watch' and reached Britain the next morning, probably off the South Foreland 'about the fourth hour of the day' (*B. Gall.*, IV, 23). Assuming sunrise at about half past four (Universal Time - UT), as it might be in the first week in August, this would imply a departure between midnight and quarter past two in the morning UT and an arrival between half past nine and quarter to eleven, again UT. The distance over the ground is some twenty-five sea miles and the minimum time taken (seven hours fifteen minutes) implies an average speed over the ground no greater than three and a half knots. If Caesar was working his tides, a point I discuss below (42-4) and in Appendix III, then his speed through the water would have been considerably less.

We may assume that, given its more serious nature, Caesar's expedition to Britain the following year left rather earlier in the year, let us say around the beginning to the middle of July. At this time of year, relatively soon after the solstice, the sun is not changing its declination very fast and consequently the time of sunrise/sunset does not vary sensitively with the date as it does close to the equinox.

On this occasion the fleet left at sunset, say eight o'clock UT; the wind failed at midnight and the fleet was carried too far by the tide; at sunrise (four o'clock UT) Britain was sighted afar off on the port side (*B. Gall.*, V, 8). The tide turned, the troops rowed and the fleet reached the shore of Britain at around midday. Assuming the landing was just north of Deal, the distance made good over the ground was some thirty sea miles and the speed made good in sixteen hours was under two knots.

The last occasion for which when we have details of Caesar's passage times is his return from his second expedition. This was close to the equinox so we may assume that sunrise and sunset were close to six o'clock UT. The fleet left at 'the beginning of the second watch' (nine o'clock in the evening) and arrived at dawn - six o'clock the following morning (*B. Gall.*, V, 23). Again the speed over the ground was low, covering the thirty sea miles from Deal to Boulogne at an average of some three and a third knots. It seems likely that the fleet was rowing because Caesar records a complete calm.

A passage of nine hours from Deal to Boulogne must have involved adverse tidal streams at some stage, because the tidal streams change direction every six and a quarter hours. But it would still be possible to exploit the tidal streams to the maximum, by ensuring that the fleet enjoyed the advantage of the full six and a quarter hours' worth of favourable streams. However, even if the tidal streams were taken at the greatest disadvantage, the likely speed through the water could not have exceeded five knots. This can be demonstrated by working up a navigational plot taking account of tidal stream data from a modern navigational chart (Appendix I). Assuming the tides were worked, the likely water speed on this passage would have been well under three knots.

In Caesar's report we can trace nine separate attempted passages. Seven of these were across the Channel and taken together they give an indication of the difficulty posed by any successful crossing of the Channel, given the technological resources available to the Romans. They are all fleet movements and no account has been taken of movements by individual ships, whether recorded, like the reconnoissance of Volusenus, or implied, as when Caesar sent orders back to his headquarters in Gaul (*B. Gall.*, IV, 21; V, 11, 23). The individual fleet movements are:

1. Assembly of the fleet at Boulogne for the first expedition. Eighteen transports failed to arrive, being 'detained eight miles off by the wind' (*B. Gall.*, IV, 22). This was the fleet assigned to the cavalry.

2. Successful crossing of the main body of the first expedition. The weather is said to be fair and the wind favourable (*B. Gall.*, IV, 23). This was a night crossing, reported to be four days before the full moon (*B. Gall.*, IV, 28-9).

3. Unsuccessful attempt by the cavalry fleet to join Caesar in Britain (*B. Gall.*, IV, 28). They left with a gentle breeze, but when within sight of their destination a violent storm arose and they were driven back to Gaul. An analysis of the nature of this storm is given in Appendix II.

4. Successful return from the first expedition (*B. Gall.*, IV, 36). The fleet weighed at about midnight. The autumn equinox was 'close at hand' and Caesar says that he took 'advantage of a spell of fair weather'. This, together with the report that two of the transports could not make Boulogne, being carried further down the coast, perhaps to the Canche estuary, suggests anticyclonic conditions with an easterly or north-easterly wind which kept them offshore, while the tidal stream carried them down the coast.

5. Assembly of the fleet at Boulogne for the second expedition. Sixty ships which had been built in the country of the *Meldi* (Meaux on the Marne, a tributary of the Seine) failed to arrive; they 'had been driven back by the weather so that they could not hold on their course, and had therefore returned to their starting-point' (*B. Gall.*, V, 5). These ships would have needed a spell of easterly winds to bring them downriver to the Seine estuary, where the prevailing westerlies would have brought them to Boulogne.

6. Successful crossing of the second expedition. Again this was a night crossing (*B. Gall.*, V, 8). The fleet weighed with a gentle south-westerly which failed about midnight. After being carried off course by the tide, the fleet reached the shore at about midday.

7. Successful return of the first group of the expeditionary force to Gaul. Because of the hostages taken and the loss of forty ships in a second storm, Caesar determined to make the return in two journeys. We are given no details of the passage, but the ships arrived safely (*B. Gall.*, V, 23).

8. Failure of most of the fleet (and of the ships that Caesar had ordered Labienus, his commander in Gaul, to build to replace those he had lost) to return to Britain to pick up the last of the expeditionary force (*B. Gall.*, V, 23). We are again not given details, but we are told that they 'were driven back'.

9. Successful return of the remainder of the expeditionary force to Gaul. Caesar 'packed' his troops into the few ships available to him (*B. Gall.*, V, 23). Yet again this was a night crossing. The fleet weighed 'at the beginning of the second watch' and arrived at dawn. Although the equinox was 'nigh at hand', there was a complete calm.

Caesar claims, with an eye perhaps to the impression that his report will make in Rome, that in neither year in any of the voyages made was a single ship carrying troops lost (*B. Gall.*, V, 23), although one suspects that his spin fails adequately to report the losses among the cavalry in the first year. It is true that, by highlighting, in the assembly of the fleet at the embarkation point, the failure of ships to arrive, Caesar gives us no indication of the number of successful movements of those fleet components that did arrive at the port of embarkation. It is also arguable that the failure of the cavalry to arrive for the first expedition was because risks were taken at a time when the cavalry commanders were under pressure to cross to support the legions. Indeed Caesar's comment that 'they took somewhat too long to despatch the business' (*B. Gall.*, IV, 23) reveals the impatience that he felt. However, the fact remains that of the cross-Channel movements 29% failed and this on a route to which McGrail ascribes a relative reliability factor of 98% (1983, 333).

Caesar's preference for night crossings is clear in the detail recited above. In the case of five of the cross-Channel passages we have sufficient information to know or to infer the time of the crossing and in the case of four a night crossing is involved, with the fleet weighing after dark. The advantages are obvious: a full day would be available for embarkation and there would be a reasonable expectation that the fleet would arrive early enough the next day to complete an orderly disembarkation and cope with any resistance in daylight. In the case of the one daylight crossing, the abortive crossing of the cavalry in 55 B.C., the circumstances may have been exceptional. We have suggested that the cavalry may have felt under pressure to follow quickly to bring support to the legions. It seems likely that Caesar's orders to their commander (*B. Gall.*, IV, 23) implied a measure of urgency and that he took a risk on too narrow a weather window. It is also possible that, at the end of the expedition in 54 B.C., Labienus, the commander Caesar left in Gaul, feeling under pressure to bring back the remainder of the army, also took a risk on the weather or on the wind direction, for the ships he sent were 'driven back' (*B. Gall.*, V, 23).

Apart from these occasions, when he had no direct personal control over the timing of the departure, Caesar appears to have chosen to sail in light weather conditions. On two occasions he describes the weather as fair, on two occasions there was a calm for the whole or part of the voyage. On one occasion the wind was described as favourable and on another he says that he weighed with a gentle south-westerly, certainly a favourable wind for a crossing from Boulogne to east Kent. The importance of a favourable wind is marked by the fact that the departure of the second expedition was delayed for some twenty-five days by a persistent north-westerly (*B. Gall.*, V, 7).

Caesar is popularly supposed to have been ignorant of Channel tides, coming as he did from the supposedly tideless Mediterranean. The range of the tide at Naples is around one foot and comes close to 0.4 metres at springs (prediction for the 25th November 1999 based on the Admiralty's Simplified Harmonic Method of

Tidal Prediction; Keys, 1982, 150-3; NP 159A v. 2.0, 1990; NP 160, 1990, 19). The belief is based on the damage caused to his fleet, particularly the beached warships, by the storm surge during his first expedition. But Caesar is explicit as to the limits of the ignorance of his people. In the passage quoted in Chapter II (21), he says no more than that they did not know that the highest tides occurred at full moon; and we may add that he would not have known about the relatively infrequent phenomenon of storm surges.

It is in fact inconceivable that, given the care which he devoted to accumulating information in preparation for the expedition (*B. Gall.*, IV, 20-1), he should not have acquired a good working knowledge of the tides and tidal currents in the Dover Strait and English Channel. This can be demonstrated by the detail in his account. In his campaign against the Veneti, he accurately describes the twelve-and-a-half-hour cycle of the flooding and ebbing of the Atlantic tide among the promontories of West Brittany and shows his understanding of its significance for the defence of the Venetic *oppida* (*B. Gall.*, III, 12).

Caesar is also clearly aware of the tidal streams. On two occasions during the expeditions against Britain, Caesar describes their effect. On his first crossing to Britain, after waiting at anchor at the South Foreland, the fleet moved further up the coast 'with a favourable wind and tide' (*B. Gall.*, IV, 23). The next year the fleet set sail with a gentle south-westerly, but the wind failed and they were carried offshore by the tide during the night (*B. Gall.*, V, 8). With daybreak the tide turned and his men were able to reach the shore by rowing. We shall look in more detail in Chapter X (104-12) at the tidal streams in the Channel and the Dover Strait, but Caesar's description is consistent with a north-east-going tide taking the fleet some way offshore north and east of Thanet and then reversing to bring them back inshore. On the return from Britain in 55 B.C. two transports were carried beyond Boulogne (*B. Gall.*, IV, 36). It is a reasonable supposition that they were carried by the tide.

The effect of a favourable tidal stream on the speed made good over the ground can be considerable, compared with an adverse one. It is, therefore, important, for efficient passage-making in these waters, to 'work the tides' (Hiscock, 1965, 348; Sleightholme, 1970, 145-6; McGrail, 1987, 266, 280), i.e. to time one's passage so as to exploit the available tidal streams to the maximum advantage. If Caesar was aware of the significance of this, we can reasonably assume that he would have endeavoured to 'work his tides'. But can we go beyond assumption to find evidence?

The analysis in Appendix II of the abortive passage of the cavalry in 55 B.C. suggests that they set sail from Gaul with a favourable tide. That assumption is based on Caesar's statement that it was the day of the full moon, when High Water Dover would have been at around eleven o'clock, from which we can deduce that the north-east-going stream in the Dover Strait would start an hour or so earlier. A departure around midday or later would see the fleet losing much of the favourable tide; moreover, a departure as late as this with what was termed a gentle breeze would have reduced the probability of its arriving, as it did, off the east Kent coast while it was still light. The fleet must have left earlier and would have carried a favourable tide for most of its passage.

We have noted Caesar's preference for night crossings and also that on one occasion the crossing was shortly before full moon. The moon could have been important to ensure that the fleet was kept a safe distance off the coast during the night (McGrail, 1987, 280). However, the departure times of these night crossings are all different:

Passage	Time of departure
Passage to Britain in 55 B.C.	about the third watch
Return from Britain in 55 B.C.	about midnight
Passage to Britain in 54 B.C.	about sunset
Return from Britain in 54 B.C.	at the beginning of the second watch

It seems clear that these different times do not reflect the ordinary routine of legionary life, nor would the naval commanders have decided on the spur of the moment that the conditions of wind and weather were now appropriate; that decision would be taken earlier in the day. The much more likely explanation is that the time chosen for the departure reflected the tidal conditions.

We know enough about the passage to Britain in 55 B.C. to make an assessment of the tidal streams that would have affected the fleet on that occasion. First, Caesar reports that it was four days before full moon; secondly we know that the fleet waited at anchor until the ninth hour, when it had a favourable tidal stream to take it further along the coast to Deal. With these two reference points we can make a judgement of the tidal streams during the whole passage. The analysis in Appendix III shows clearly that on this first passage to Britain the Romans were indeed working the tides.

Summary

This chapter has been devoted to examining the evidence for the performance of the ships Caesar used for his raids against Britain, in the light of five hypotheses which I put forward at the opening of the chapter. These hypotheses may fairly be considered to be supported by the evidence. It is of particular relevance to a discussion of the Claudian invasion crossing to note Caesar's reliance on favourable winds and tides, his preference for light winds, leading to low ground speeds and extended passage times and, above all, the evidence for the unreliability of passage-making in the English Channel in the Roman period.

Chapter VI

Performance: Speed

In this chapter I wish to supplement Caesar's account by assessing other evidence for the speed that might have been attained by the ships, warships and transports, of the Claudian invasion force. For the warships we can draw both on the evidence of classical documentary sources and on the experimental data from the trials of the reconstruction of an Athenian trireme. For the transports the approach must be rather more inferential; there has been no reconstruction of a sea-going Romano-Celtic ship and, apart from the evidence of Caesar's narrative, there are no documentary sources. However, drawing on the data from Marsden's study of Blackfriars 1 (1994, 193-9) and on comparisons with ships of the Nordic tradition, for which there are experimental data, we should be able to make a broad assessment of the speed potential of the Claudian transports.

We have noted that the primary motive power of the warships was their oars. For the transports, it was their sails. The archaeological evidence leaves considerable room for debate as to the type of sail that would have been rigged on Romano-Celtic sea-going ships. The type of sail rigged can have a significant influence on the way a ship handles and, in particular, on its directional stability and windward ability. Discussion of such issues is left to Chapter VII.

Warships

A prime source of data for the performance of ancient oared warships of the Mediterranean is *Ὀλυμπιάς*, the reconstruction of an Athenian trireme (Coates, Platis and Shaw, 1990). Speed trials showed that she was capable of up to eight knots under oars for short periods. While ancient crews with more experience than the crews of the Trireme Trust or the Hellenic Navy might well have been able to maintain speeds of this order for much longer periods (Coates, Platis and Shaw, 1990, 23-4), one may doubt whether such speeds could be maintained indefinitely. Speeds under sail of more than seven knots, up to a maximum of eight and a half knots, were recorded with following and quartering winds of Force 6 (Appendix XII). Although her windward ability remained to be properly evaluated, courses in the order of 85° to the true wind were recorded (Coates, Platis and Shaw, 1990, 33-6). Her manoeuvrability was impressive: turning circles in the order of one hundred metres in diameter were achieved, while, with the oarsmen on one side backing water, the ship could be turned in her own length; she could even be made to go sideways if the oarsmen on one side used their oars to scull (Coates, Platis and Shaw, 1990, 29-31).

During 1988 a number of relatively short passages were made, ranging in length from thirteen to twenty-two nautical miles. Average passage speeds achieved ranged from 2.7 to 4.6 knots. When possible the sails were set; on other occasions, usually because of adverse winds, oars were used, but it was normal practice to use only two of the three banks of oars, so that at any one time a third of the crew were resting; on occasion, oars were used to supplement the sails (Coates, Platis and Shaw, 1990, 38-48).

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Transports

For the speed of transports built in the Romano-Celtic tradition the only evidence is theoretical, although it may be validated by data from experiments with reconstructions of Nordic vessels (McGrail, 1987, 196-8). As it moves through the water a hull creates two wave patterns, one each from the bow and stern. Once the wave length approaches the value of the waterline length of the hull the wave-making resistance begins to increase exponentially. At this point, one when the speed in knots approximates to 1.34 times the square root of the waterline length in feet ($V/\sqrt{L}=1.34$; where V = water speed in knots and L = waterline length in feet), the hull is supported by a wave crest at the bow and by another at the stern with a trough in between. Further increase in speed, say to $V/\sqrt{L}=1.4$, will raise the bow as the wave length increases and the crest of the stern wave moves astern, so that effectively the hull is trying to climb uphill (McGrail, 1987, 196, Fig. 11.3; Marsden, 1994, 198, Fig 169). This is the theoretical maximum speed of a hull in displacement mode. A hull can only exceed this speed if it begins to plane.

McGrail (1987, 198) tabulates the theoretical maximum speed of a number of ancient craft calculated on this basis, including:

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> Comparison with other early northern European ships and boats shows that the Blackfriars ship was rather slow. It was potentially faster than Ferriby boat 1 and Brigg boat 2, although these were probably not sailing vessels. It was probably a slower speed design than the following vessels: Hjortspring, Sutton Hoo 2, Gokstad 1 and 3, Skuldelev 1 and 3, and the Graveney boat (McGrail 1987, 198). These potentially faster vessels are all of the Scandinavian clinker shipbuilding tradition which appear to have been designed for greater speed, whereas Blackfriars ship 1 was apparently designed to carry considerable loads relatively slowly (Marsden, 1994, 198).

We have already noted that clinker methods of construction enable the production, size for size, of lighter hulls than the flush-planked hulls of the Romano-Celtic tradition. Displacement volume, which is determined by the overall gross weight of the vessel, is a factor in three of the five speed assessment coefficients discussed by McGrail. The less the displacement volume the more favourable these speed assessment coefficients are. This, apart from other aspects of design, explains the superior speed potential of craft built in the Nordic tradition.

Experimental work with replicas more than adequately confirms the speed potential of Scandinavian hulls. I quote four examples.

The first case is of the 1893 Gokstad 1 replica *Viking*, which was sailed from Norway to the United States and is today on display in Chicago. *Viking* was an inexact replica, in that she was rigged with a foresail as well as her square sail and the crew set improvised studding sails and a topsail. These are probably without relevance for the vessel's maximum speed, since the foresail seems to have be used to help the vessel tack (Christensen, 1986, 73), whilst the others would have been essentially light-weather sails. The 'top registered speed' was 11 knots (1986, 73), which compares with the theoretical maximum given for Gokstad 1 by McGrail of 12 knots.

The second is *Odin's Raven*, a two-thirds Gokstad 1 replica with an overall length of 50 feet built to celebrate the millennium of the Tynwald in 1979. Binns records 'one dazzling (and independently measured) occasion' when 'with a gusting wind on the quarter and low wave height' *Odin's Raven* achieved 12.5 knots (1980, 128), a figure considerably in excess of the theoretical maximum of 9.8 knots for a hull with a waterline length of 15 metres. Binns also records 'reaching up Oslofjord at a very satisfactory 8 knots in a light force 3' (1980, 169). Although this does not match the theoretical maximum speed, the wind strength reported does give the impression of an easily driven hull.

The third example is *Roar Ege*, a Skuldelev 3 replica built using tools and methods available to Viking ship-builders. Vinner reported the preliminary trials, including a best speed of 8.6 knots when running under double-reefed sail in a true wind of 32 knots (1986, 224). Subsequently a 'top speed of 8.5 to 10 knots' was reported with an average maintained of 6.5 knots under favourable conditions (Crumlin-Pedersen, 1996, 119). McGrail gives a theoretical maximum speed of 8.7 knots for Skuldelev 3.

The last case is that of *Saga Siglar* reported to have achieved up to 13 knots with a load of 15 tons (Jørgensen, 1992, 24). This is a very respectable performance for a replica of Skuldelev 1 for which McGrail gives a maximum theoretical speed of 10.0 knots. It is to be noted that Jørgensen states that this was achieved on a reach, a point of sailing when for given wind strengths the highest speeds can be achieved (Neumann, 1989, 236). The account given by Crumlin-Pedersen of the performance of this 'exhaustively tested' replica confirms this, but as a very exceptional result: he says that she achieved 13 knots in a storm in the North Sea in the lee of the Shetland Islands and up to 8.5 knots under bare poles in another storm between Greenland and Newfoundland (Crumlin-Pedersen, 1996, 119).

Although the speed potential of Nordic hulls is confirmed by these experimental findings, it is difficult to correlate them with the theoretical conclusions that Marsden offers about the maximum theoretical speed of Blackfriars 1. While certain dimensions of Blackfriars 1 compare quite closely with Skuldelev 1, the Romano-Celtic ship is much heavier. It is instructive to compare these two vessels in terms of these dimensions and of the speed assessment coefficients defined by McGrail.

	Blackfriars 1	Skuldelev 1
Midships Underwater Area (A)	5.7	4.0
Waterline Beam (B)	5.62	4.5
Waterline Length (L)	17.34	15.6
Draft (T)	1.3	1.27
Displacement Volume (∇)	66.5	34.0
Prismatic Coefficient	0.67	0.54
Slenderness Coefficient	3.08	3.47
Midships Coefficient	0.78	0.70
Block Coefficient	0.52	0.38
Volumetric Coefficient	12.75×10^{-3}	8.96×10^{-3}

(Source: McGrail, 1987, 198; Marsden, 1994, 199. Definitions quoted below are drawn from McGrail, 1987, 196-8. Dimensions are in metres, square metres and cubic metres as appropriate.)

The prismatic coefficient (∇/AL; where ∇ = displacement volume, A = area of midships underwater cross-section and L = waterline length) is useful in assessing the wave-making resistance of hulls at speeds equivalent to values of $V/\sqrt{L}$ in the range of 0.6 to 1.1. Skuldelev 1 is at the low value suggested by McGrail (0.55 to 0.53) as indicative of low resistance and high speed potential (1987, 196-7), while Blackfriars 1 is significantly outside it.

Both vessels have a lower value for their slenderness coefficient (L/B; where L = waterline length and B = waterline beam) than that suggested by McGrail as an indicator of good speed potential (> 5 - 1987, 197), but Skuldelev 1 has the marginal advantage. However, vessels intended for cargo use might be expected to exhibit values in this range. In fact McGrail suggests that a slenderness coefficient ≤ 5 is one of the criteria to be used to identify a specialised cargo vessel (1987, 201).

There is little to choose between the two ships in terms of their midships coefficient (A/BT; where A = area of midships underwater cross-section, B = waterline beam and T = draft), for both are higher than the low value indicative of good speed potential (< 0.60 - McGrail, 1987, 197). Again this is not unexpected in specialised cargo carriers, given that this coefficient measures the proportion of the rectangle defined by the waterline beam and the draft which is taken up by the midships section.

Both vessels score well on their block coefficient (∇/BLT; where ∇ = displacement volume, B = waterline beam, L = waterline length and T = draft) against the criterion proposed by McGrail as an indicator of good speed potential (a low value < 0.85 - 1987, 197-8). In fact of the nine ancient vessels considered by McGrail, only two, Ferriby 1 and Brigg 2, fail to meet this criterion. McGrail comments that their block coefficients are low compared to modern designs, say of a modern yacht with a typical value of *c.* 0.50, and attributes this in part to the 'double-ended nature of the ancient boats'. The block coefficient measures the proportion of the rectangular block defined the waterline length, the waterline beam and the draft which is taken up by the underwater body of the hull. Its theoretical maximum of 1.00 would represent a hull with a rectangular block-shaped underwater body. The value of 0.96 given for Brigg 2 must represent a slab-sided, flat-bottomed hull, with square ends, offering some but not much flare (McGrail, 1987, 194). This consideration tends to indicate a value of 0.85 as appropriate to twentieth-century bulk cargo carriers. An examination of McGrail's list (1987, 198) would suggest that for ancient ships a criterion of < *c.* 0.30 may be more relevant. While generally this does distinguish between cargo carriers and and people carriers, it leaves Sutton Hoo 2 among the cargo carriers, close to Skuldelev 1 at 0.36 and suggests that Skuldelev 3 at 0.27 would offer a fair turn of speed. A higher criterion, say of < *c.* 0.40, would distinguish all the clinker-built vessels in the Nordic tradition from ships of the Romano-Celtic tradition, if Blackfriars 1 is to be taken as typical. That this may have been so, is supported by Caesar's report that the Venetic ships had flatter bottoms than the Roman warships; such a feature would be symptomatic of a high block coefficient.

However, the selection of any criterion must be relative and its usefulness will depend on its relevance to the specific range of craft under consideration. For our purposes it is sufficient to note that the block coefficient for Blackfriars 1 is significantly less favourable in terms of speed potential than that of Skuldelev 1. This may well reflect a genuine design difference between clinker-built Nordic ships and vessels of the Romano-Celtic tradition.

Finally, it is to be noted that Blackfriars 1 also has a markedly higher volumetric coefficient (∇/L^3; where ∇ = displacement volume and L = waterline length) than Skuldelev 1. However, the value of this coefficient is chiefly in assessing speed potential at values of $V/\sqrt{L}$ in excess of *c.* 1.1 when the effect of the 'displacement trap' comes into effect. Where the volumetric coefficient is less than 2×10^{-3} a boat may exceed the limit of $V/\sqrt{L} = 1.4$ without a massive increase in propulsive power. It is this which accounts for the use of the catamaran configuration for high-speed ferries and the reputation of sailing multi-hulls for good speed potential.

The values listed by McGrail (1987, 198) for the volumetric coefficient of various ancient craft show that the value of 8.96×10^{-3} for Skuldelev 1 is substantially greater than that of most other Nordic-tradition craft apart from the Graveney Boat at 10.7×10^{-3}. Along with Skuldelev 3 at 4.77×10^{-3}, these cargo-carriers can be clearly distinguished from recognised people-carriers such as Gokstad 1, which return values close to or less than 2×10^{-3}. This would explain the ability of *Odin's Raven* so dramatically to exceed her maximum theoretical displacement speed, probably by planing.

Marsden (1994, 194) gives in his table 17 a range of displacement and draft figures for Blackfriars 1 for different cargo configurations, from 'lightship', i.e. empty and without crew, to a maximum load of 66.7 tonnes equivalent to a freeboard of 2/5 of the hull depth near amidships. Appendix IV shows the coefficients reworked for each of these configurations, while the displacement-related coefficients are reproduced in graph form in Fig. 7.

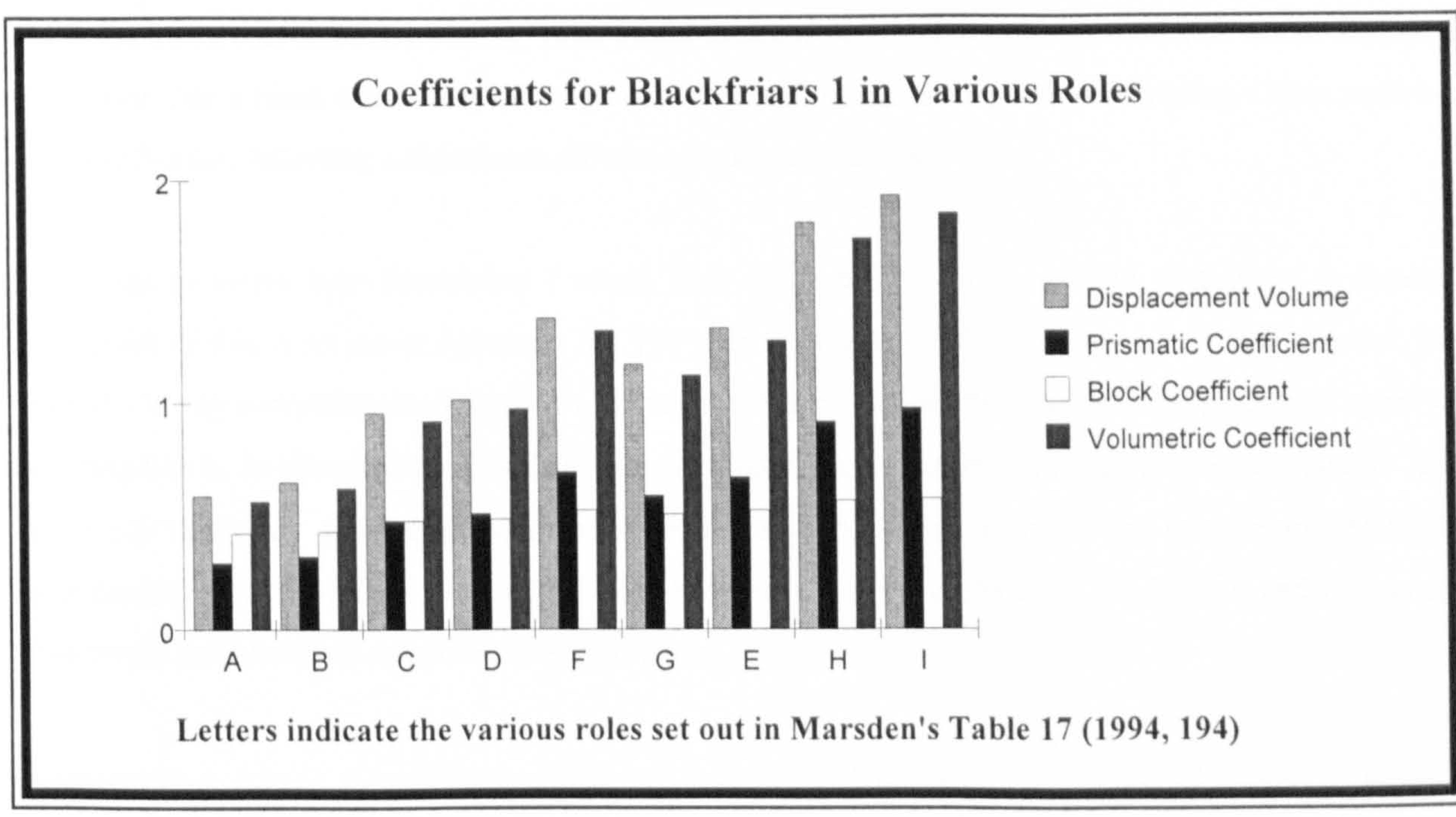

Fig. 7 Displacement-related coefficients for Blackfriars 1; the displacement volume has been divided by 50 and the volumetric coefficient multiplied by 100 to allow easy visual comparison of the different values.

The qualification needs to be made that Marsden does not show how the waterline length and waterline beam vary with increasing draft and the assumption has been made that any variation is not of great significance; thus we are not able to identify any variation in the slenderness coefficient with increasing draft. More seriously, however, the midships underwater area must increase with increasing draft, and probably at a greater rate, and the absence of data for this dimension at different drafts means that the figures in Appendix IV for the midships coefficient are meaningless, except at the displacement of 66.7 cubic metres.

These qualifications do not have a great significance for the displacement-related coefficients (Fig. 7). That the prismatic coefficient and the volumetric coefficient should increase at the same rate as the displacement volume is to be expected, given that in the relevant formula it is only the displacement volume that varies. This is not the case with the block coefficient, which also takes account of the changing draft. Here the range for Blackfriars 1 is from 0.43 to 0.58, showing a vessel which becomes steadily more sluggish as its displacement increases.

In sum, Blackfriars 1 shows up significantly less favourably than Skuldelev 1 in three of the five speed assessment coefficients. These are the three which include displacement volume (∇) as a factor and, as we have already noted, the Romano-Celtic ship is much heavier, both in terms of its weight empty of cargo and crew, 29.7 against 10 tonnes, and in terms of its cargo carrying capacity, 37.2 tonnes when drawing 1.3 metres, as opposed to the 24 tonnes of Skuldelev 1. Given that the prismatic coefficient is relevant to speeds equivalent to $V/\sqrt{L} = 0.6$ to 1.1 and the volumetric coefficient is relevant to speeds in excess of $V/\sqrt{L} = 1.1$, the block coefficient may be the most useful indicator here. Moreover, the evidence would support a conclusion that a block coefficient in excess of 0.4 to 0.45 would distinguish the Romano-Celtic tradition from the Nordic, reflecting a significant difference in speed potential.

It remains to assess how Blackfriars 1 might have responded to different wind strengths. A detailed assessment of this is set out in Appendix V. The main conclusion is that she was a very stable vessel, but unlikely, in any acceptable conditions of wind and weather to achieve her maximum displacement speed or anything like it. In the conditions likely to be acceptable for an invasion, i.e. Force 4 or less (Appendix XII) her likely maximum speed in a beam wind would have been five knots at the outside and probably considerably less. Downwind she would have been even slower, probably at the bottom end of a range from under three knots to somewhat over four knots.

Summary

The Claudian invasion fleet would have been made up of oared warships, liburnians, which would have had sails as a supplementary form of motive power. While potentially faster than the transports, their great advantage would lie in their manoeuvrability, both during the passage enabling senior officers to move around the fleet and in the case of an opposed landing to be directed to the point where covering fire was required.

The overall speed of the fleet would have been determined by the speed potential of the transports. Taking our hypothesis that these would have been Romano-Celtic ships constructed on the lines of Blackfriars 1, we may assume that the average water speed of the invasion fleet would have of the order of three knots, or less, particularly if the commanders of A.D. 43 shared Caesar's preference for passages in light winds.

Chapter VI

Performance: Speed

In this chapter I wish to supplement Caesar's account by assessing other evidence for the speed that might have been attained by the ships, warships and transports, of the Claudian invasion force. For the warships we can draw both on the evidence of classical documentary sources and on the experimental data from the trials of the reconstruction of an Athenian trireme. For the transports the approach must be rather more inferential; there has been no reconstruction of a sea-going Romano-Celtic ship and, apart from the evidence of Caesar's narrative, there are no documentary sources. However, drawing on the data from Marsden's study of Blackfriars 1 (1994, 193-9) and on comparisons with ships of the Nordic tradition, for which there are experimental data, we should be able to make a broad assessment of the speed potential of the Claudian transports.

We have noted that the primary motive power of the warships was their oars. For the transports, it was their sails. The archaeological evidence leaves considerable room for debate as to the type of sail that would have been rigged on Romano-Celtic sea-going ships. The type of sail rigged can have a significant influence on the way a ship handles and, in particular, on its directional stability and windward ability. Discussion of such issues is left to Chapter VII.

Warships

A prime source of data for the performance of ancient oared warships of the Mediterranean is *Ὀλυμπιάς*, the reconstruction of an Athenian trireme (Coates, Platis and Shaw, 1990). Speed trials showed that she was capable of up to eight knots under oars for short periods. While ancient crews with more experience than the crews of the Trireme Trust or the Hellenic Navy might well have been able to maintain speeds of this order for much longer periods (Coates, Platis and Shaw, 1990, 23-4), one may doubt whether such speeds could be maintained indefinitely. Speeds under sail of more than seven knots, up to a maximum of eight and a half knots, were recorded with following and quartering winds of Force 6 (Appendix XII). Although her windward ability remained to be properly evaluated, courses in the order of 85° to the true wind were recorded (Coates, Platis and Shaw, 1990, 33-6). Her manoeuvrability was impressive: turning circles in the order of one hundred metres in diameter were achieved, while, with the oarsmen on one side backing water, the ship could be turned in her own length; she could even be made to go sideways if the oarsmen on one side used their oars to scull (Coates, Platis and Shaw, 1990, 29-31).

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Marsden also calculates four speed assessment coefficients for Blackfriars 1, while a fifth may be calculated from his data. While not having a significant direct impact on maximum theoretical speed, such coefficients do give an indication of the speed potential of particular hulls, i.e. to put it in plain parlance, how easily driven they are. These suggest that the overall speed potential of Blackfriars 1 was low when compared with other ancient ships (Marsden, 1994, 198-9; McGrail, 1987, 196-8).

> Comparison with other early northern European ships and boats shows that the Blackfriars ship was rather slow. It was potentially faster than Ferriby boat 1 and Brigg boat 2, although these were probably not sailing vessels. It was probably a slower speed design than the following vessels: Hjortspring, Sutton Hoo 2, Gokstad 1 and 3, Skuldelev 1 and 3, and the Graveney boat (McGrail 1987, 198). These potentially faster vessels are all of the Scandinavian clinker shipbuilding tradition which appear to have been designed for greater speed, whereas Blackfriars ship 1 was apparently designed to carry considerable loads relatively slowly (Marsden, 1994, 198).

We have already noted that clinker methods of construction enable the production, size for size, of lighter hulls than the flush-planked hulls of the Romano-Celtic tradition. Displacement volume, which is determined by the overall gross weight of the vessel, is a factor in three of the five speed assessment coefficients discussed by McGrail. The less the displacement volume the more favourable these speed assessment coefficients are. This, apart from other aspects of design, explains the superior speed potential of craft built in the Nordic tradition.

Experimental work with replicas more than adequately confirms the speed potential of Scandinavian hulls. I quote four examples.

The first case is of the 1893 Gokstad 1 replica *Viking*, which was sailed from Norway to the United States and is today on display in Chicago. *Viking* was an inexact replica, in that she was rigged with a foresail as well as her square sail and the crew set improvised studding sails and a topsail. These are probably without relevance for the vessel's maximum speed, since the foresail seems to have be used to help the vessel tack (Christensen, 1986, 73), whilst the others would have been essentially light-weather sails. The 'top registered speed' was 11 knots (1986, 73), which compares with the theoretical maximum given for Gokstad 1 by McGrail of 12 knots.

The second is *Odin's Raven*, a two-thirds Gokstad 1 replica with an overall length of 50 feet built to celebrate the millennium of the Tynwald in 1979. Binns records 'one dazzling (and independently measured) occasion' when 'with a gusting wind on the quarter and low wave height' *Odin's Raven* achieved 12.5 knots (1980, 128), a figure considerably in excess of the theoretical maximum of 9.8 knots for a hull with a waterline length of 15 metres. Binns also records 'reaching up Oslofjord at a very satisfactory 8 knots in a light force 3' (1980, 169). Although this does not match the theoretical maximum speed, the wind strength reported does give the impression of an easily driven hull.

The third example is *Roar Ege*, a Skuldelev 3 replica built using tools and methods available to Viking ship-builders. Vinner reported the preliminary trials, including a best speed of 8.6 knots when running under double-reefed sail in a true wind of 32 knots (1986, 224). Subsequently a 'top speed of 8.5 to 10 knots' was reported with an average maintained of 6.5 knots under favourable conditions (Crumlin-Pedersen, 1996, 119). McGrail gives a theoretical maximum speed of 8.7 knots for Skuldelev 3.

The last case is that of *Saga Siglar* reported to have achieved up to 13 knots with a load of 15 tons (Jørgensen, 1992, 24). This is a very respectable performance for a replica of Skuldelev 1 for which McGrail gives a maximum theoretical speed of 10.0 knots. It is to be noted that Jørgensen states that this was achieved on a reach, a point of sailing when for given wind strengths the highest speeds can be achieved (Neumann, 1989, 236). The account given by Crumlin-Pedersen of the performance of this 'exhaustively tested' replica confirms this, but as a very exceptional result: he says that she achieved 13 knots in a storm in the North Sea in the lee of the Shetland Islands and up to 8.5 knots under bare poles in another storm between Greenland and Newfoundland (Crumlin-Pedersen, 1996, 119).

Although the speed potential of Nordic hulls is confirmed by these experimental findings, it is difficult to correlate them with the theoretical conclusions that Marsden offers about the maximum theoretical speed of Blackfriars 1. While certain dimensions of Blackfriars 1 compare quite closely with Skuldelev 1, the Romano-Celtic ship is much heavier. It is instructive to compare these two vessels in terms of these dimensions and of the speed assessment coefficients defined by McGrail.

	Blackfriars 1	Skuldelev 1
Midships Underwater Area (A)	5.7	4.0
Waterline Beam (B)	5.62	4.5
Waterline Length (L)	17.34	15.6
Draft (T)	1.3	1.27
Displacement Volume (∇)	66.5	34.0
Prismatic Coefficient	0.67	0.54
Slenderness Coefficient	3.08	3.47
Midships Coefficient	0.78	0.70
Block Coefficient	0.52	0.38
Volumetric Coefficient	12.75×10^{-3}	8.96×10^{-3}

(Source: McGrail, 1987, 198; Marsden, 1994, 199. Definitions quoted below are drawn from McGrail, 1987, 196-8. Dimensions are in metres, square metres and cubic metres as appropriate.)

The prismatic coefficient (∇/AL; where ∇ = displacement volume, A = area of midships underwater cross-section and L = waterline length) is useful in assessing the wave-making resistance of hulls at speeds equivalent to values of $V/\sqrt{L}$ in the range of 0.6 to 1.1. Skuldelev 1 is at the low value suggested by McGrail (0.55 to 0.53) as indicative of low resistance and high speed potential (1987, 196-7), while Blackfriars 1 is significantly outside it.

Both vessels have a lower value for their slenderness coefficient (L/B; where L = waterline length and B = waterline beam) than that suggested by McGrail as an indicator of good speed potential (> 5 - 1987, 197), but Skuldelev 1 has the marginal advantage. However, vessels intended for cargo use might be expected to exhibit values in this range. In fact McGrail suggests that a slenderness coefficient ≤ 5 is one of the criteria to be used to identify a specialised cargo vessel (1987, 201).

There is little to choose between the two ships in terms of their midships coefficient (A/BT; where A = area of midships underwater cross-section, B = waterline beam and T = draft), for both are higher than the low value indicative of good speed potential (< 0.60 - McGrail, 1987, 197). Again this is not unexpected in specialised cargo carriers, given that this coefficient measures the proportion of the rectangle defined by the waterline beam and the draft which is taken up by the midships section.

Both vessels score well on their block coefficient (∇/BLT; where ∇ = displacement volume, B = waterline beam, L = waterline length and T = draft) against the criterion proposed by McGrail as an indicator of good speed potential (a low value < 0.85 - 1987, 197-8). In fact of the nine ancient vessels considered by McGrail, only two, Ferriby 1 and Brigg 2, fail to meet this criterion. McGrail comments that their block coefficients are low compared to modern designs, say of a modern yacht with a typical value of *c.* 0.50, and attributes this in part to the 'double-ended nature of the ancient boats'. The block coefficient measures the proportion of the rectangular block defined the waterline length, the waterline beam and the draft which is taken up by the underwater body of the hull. Its theoretical maximum of 1.00 would represent a hull with a rectangular block-shaped underwater body. The value of 0.96 given for Brigg 2 must represent a slab-sided, flat-bottomed hull, with square ends, offering some but not much flare (McGrail, 1987, 194). This consideration tends to indicate a value of 0.85 as appropriate to twentieth-century bulk cargo carriers. An examination of McGrail's list (1987, 198) would suggest that for ancient ships a criterion of < *c.* 0.30 may be more relevant. While generally this does distinguish between cargo carriers and and people carriers, it leaves Sutton Hoo 2 among the cargo carriers, close to Skuldelev 1 at 0.36 and suggests that Skuldelev 3 at 0.27 would offer a fair turn of speed. A higher criterion, say of < *c.* 0.40, would distinguish all the clinker-built vessels in the Nordic tradition from ships of the Romano-Celtic tradition, if Blackfriars 1 is to be taken as typical. That this may have been so, is supported by Caesar's report that the Venetic ships had flatter bottoms than the Roman warships; such a feature would be symptomatic of a high block coefficient.

However, the selection of any criterion must be relative and its usefulness will depend on its relevance to the specific range of craft under consideration. For our purposes it is sufficient to note that the block coefficient for Blackfriars 1 is significantly less favourable in terms of speed potential than that of Skuldelev 1. This may well reflect a genuine design difference between clinker-built Nordic ships and vessels of the Romano-Celtic tradition.

Finally, it is to be noted that Blackfriars 1 also has a markedly higher volumetric coefficient (∇/L^3; where ∇ = displacement volume and L = waterline length) than Skuldelev 1. However, the value of this coefficient is chiefly in assessing speed potential at values of $V/\sqrt{L}$ in excess of *c.* 1.1 when the effect of the 'displacement trap' comes into effect. Where the volumetric coefficient is less than 2×10^{-3} a boat may exceed the limit of $V/\sqrt{L} = 1.4$ without a massive increase in propulsive power. It is this which accounts for the use of the catamaran configuration for high-speed ferries and the reputation of sailing multi-hulls for good speed potential.

The values listed by McGrail (1987, 198) for the volumetric coefficient of various ancient craft show that the value of 8.96×10^{-3} for Skuldelev 1 is substantially greater than that of most other Nordic-tradition craft apart from the Graveney Boat at 10.7×10^{-3}. Along with Skuldelev 3 at 4.77×10^{-3}, these cargo-carriers can be clearly distinguished from recognised people-carriers such as Gokstad 1, which return values close to or less than 2×10^{-3}. This would explain the ability of *Odin's Raven* so dramatically to exceed her maximum theoretical displacement speed, probably by planing.

Marsden (1994, 194) gives in his table 17 a range of displacement and draft figures for Blackfriars 1 for different cargo configurations, from 'lightship', i.e. empty and without crew, to a maximum load of 66.7 tonnes equivalent to a freeboard of 2/5 of the hull depth near amidships. Appendix IV shows the coefficients reworked for each of these configurations, while the displacement-related coefficients are reproduced in graph form in Fig. 7.

Fig. 7 Displacement-related coefficients for Blackfriars 1; the displacement volume has been divided by 50 and the volumetric coefficient multiplied by 100 to allow easy visual comparison of the different values.

The qualification needs to be made that Marsden does not show how the waterline length and waterline beam vary with increasing draft and the assumption has been made that any variation is not of great significance; thus we are not able to identify any variation in the slenderness coefficient with increasing draft. More seriously, however, the midships underwater area must increase with increasing draft, and probably at a greater rate, and the absence of data for this dimension at different drafts means that the figures in Appendix IV for the midships coefficient are meaningless, except at the displacement of 66.7 cubic metres.

These qualifications do not have a great significance for the displacement-related coefficients (Fig. 7). That the prismatic coefficient and the volumetric coefficient should increase at the same rate as the displacement volume is to be expected, given that in the relevant formula it is only the displacement volume that varies. This is not the case with the block coefficient, which also takes account of the changing draft. Here the range for Blackfriars 1 is from 0.43 to 0.58, showing a vessel which becomes steadily more sluggish as its displacement increases.

In sum, Blackfriars 1 shows up significantly less favourably than Skuldelev 1 in three of the five speed assessment coefficients. These are the three which include displacement volume (∇) as a factor and, as we have already noted, the Romano-Celtic ship is much heavier, both in terms of its weight empty of cargo and crew, 29.7 against 10 tonnes, and in terms of its cargo carrying capacity, 37.2 tonnes when drawing 1.3 metres, as opposed to the 24 tonnes of Skuldelev 1. Given that the prismatic coefficient is relevant to speeds equivalent to $V/\sqrt{L} = 0.6$ to 1.1 and the volumetric coefficient is relevant to speeds in excess of $V/\sqrt{L} = 1.1$, the block coefficient may be the most useful indicator here. Moreover, the evidence would support a conclusion that a block coefficient in excess of 0.4 to 0.45 would distinguish the Romano-Celtic tradition from the Nordic, reflecting a significant difference in speed potential.

It remains to assess how Blackfriars 1 might have responded to different wind strengths. A detailed assessment of this is set out in Appendix V. The main conclusion is that she was a very stable vessel, but unlikely, in any acceptable conditions of wind and weather to achieve her maximum displacement speed or anything like it. In the conditions likely to be acceptable for an invasion, i.e. Force 4 or less (Appendix XII) her likely maximum speed in a beam wind would have been five knots at the outside and probably considerably less. Downwind she would have been even slower, probably at the bottom end of a range from under three knots to somewhat over four knots.

Summary

The Claudian invasion fleet would have been made up of oared warships, liburnians, which would have had sails as a supplementary form of motive power. While potentially faster than the transports, their great advantage would lie in their manoeuvrability, both during the passage enabling senior officers to move around the fleet and in the case of an opposed landing to be directed to the point where covering fire was required.

The overall speed of the fleet would have been determined by the speed potential of the transports. Taking our hypothesis that these would have been Romano-Celtic ships constructed on the lines of Blackfriars 1, we may assume that the average water speed of the invasion fleet would have of the order of three knots, or less, particularly if the commanders of A.D. 43 shared Caesar's preference for passages in light winds.

Chapter VII

Performance to Windward

General Considerations: the concept of hull balance

In the last chapter we concluded on the basis of the trials of the replica trireme, *Ὀλυμπιάς*, that Aulus Plautius's oared warships would, subject to the stamina of their crews and to weather and sea conditions, be able to make progress direct to windward. No sailing ship can advance direct to windward, but by sailing close to the wind (close-hauled) and, if necessary, by changing tack, progress to windward can be made, subject to a suitable combination of rig and hull. In this chapter I propose to investigate the extent of the windward ability of Plautius's transports.

We have concluded, on the basis of Caesar's account of his own invasion fleet, that the transports would have been built in the local Romano-Celtic tradition. That such ships were single-masted sailing ships is beyond doubt. What is less certain is the type of rig and sail used and relevant evidence is sparse indeed.

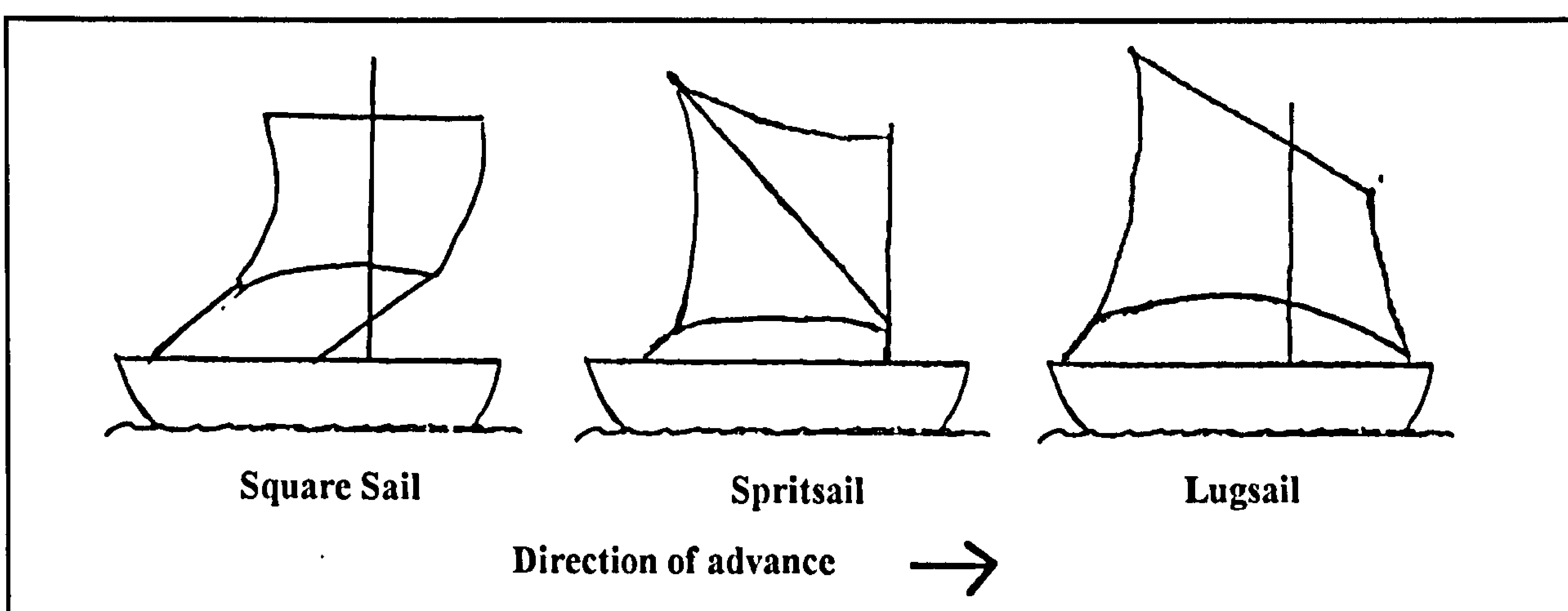


Fig. 8

The available candidates are the square sail, the spritsail and the lugsail (Fig. 8; McGrail, 1987, 218-24). The object of the enquiry is more than academic; if we can arrive at a conclusion as to the type of sail rigged, we may be able to reach an educated view about the effectiveness of these ships on various points of sailing, i.e. running, reaching or close-hauled.

The square sail is familiar to the layman as the sail commonly shown in depictions of Viking ships. It is usually rectangular, rather than exactly square, and it may even have been trapezoidal (Binns, 1980, 125-7).

Its essential feature is that it is rigged symmetrically about the mast. The relationship of its height to its width (chord) is expressed by its aspect ratio, a concept which applies to any sail and which is a significant indicator of its efficiency as an aerofoil.

The spritsail survives to the present day as the mainsail of Thames barges. Hoisted abaft the mast, it is supported by a sprit, hence the name, running diagonally from the base of the mast to the peak (the upper corner of the sail furthest from the mast). At least in its modern manifestation the sprit is controlled by two lines from its upper end, known as vangs.

The lug is in many ways similar to the square sail and represents perhaps a midpoint between the square sail and the spritsail. It differs from the spritsail in that it is supported by a yard, as is the square sail, but, unlike the square sail, it is asymmetrically deployed about the mast, with about 30% of its area forward of the mast.

Given the absence of direct archaeological evidence and the paucity of iconographic and documentary evidence for the type of sail on Romano-Celtic ships, theoretical arguments which centre on directional stability or hull balance assume significance.

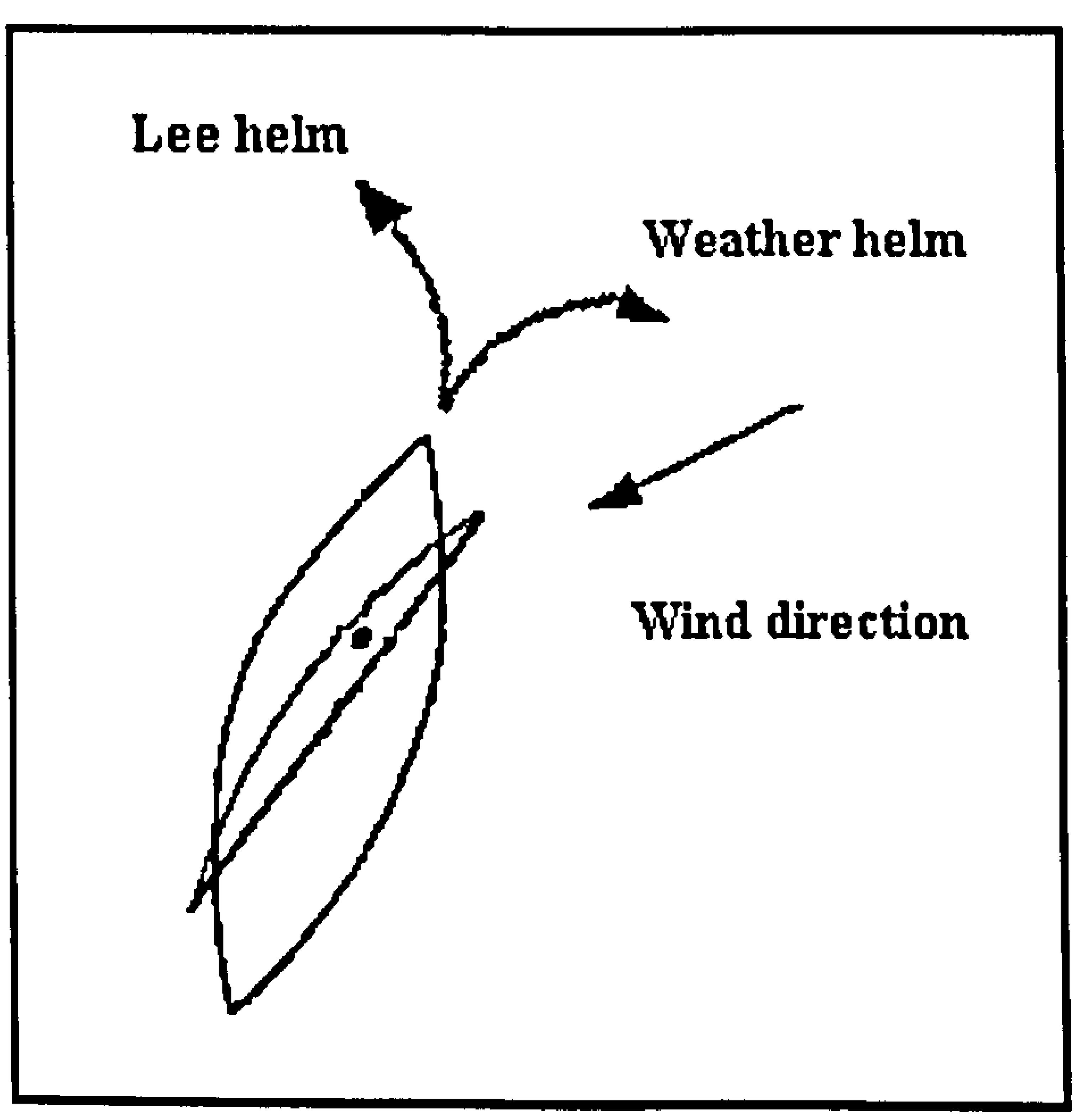


Fig. 9 A vessel exhibiting lee helm will turn in the direction of the 'lee helm' arrow when the helm is released, i.e. away from the wind; a vessel with weather helm will turn towards the wind, when the helm is released, i.e. in the direction of the 'weather helm' arrow.

Hull balance manifests itself at the helm. When under way, a sailing ship has either weather helm, lee helm or neutral helm. When the helm is released, a vessel with weather helm will turn into the wind, while one with lee helm will turn downwind. A vessel with neutral helm will maintain its course when the helm is released (Fig. 9). A modest amount of weather helm is generally considered desirable to give feel to the helm and in a sudden gust the ship will turn into the wind, thus reducing the pressure on the sail(s). In addition, weather helm contributes to the overall resistance of the hull to leeway (below, 68-9; Marchaj, 1964, 350-1). Excessive weather helm can be tiring, while lee helm is considered dangerous, since in a blow the ship will tend to turn down wind with a consequent increase in wind pressure on the sail(s). This could lead to a loss of control and in extreme conditions damage to the sail(s) and rigging.

In essence hull balance is a question of finding an equilibrium between the total aerodynamic force of the wind on the sails, as well as on the hull and superstructure, and the opposing hydrodynamic force on the underwater body of the vessel, including the rudder.

Romano-Celtic ships: the significance of the mast step

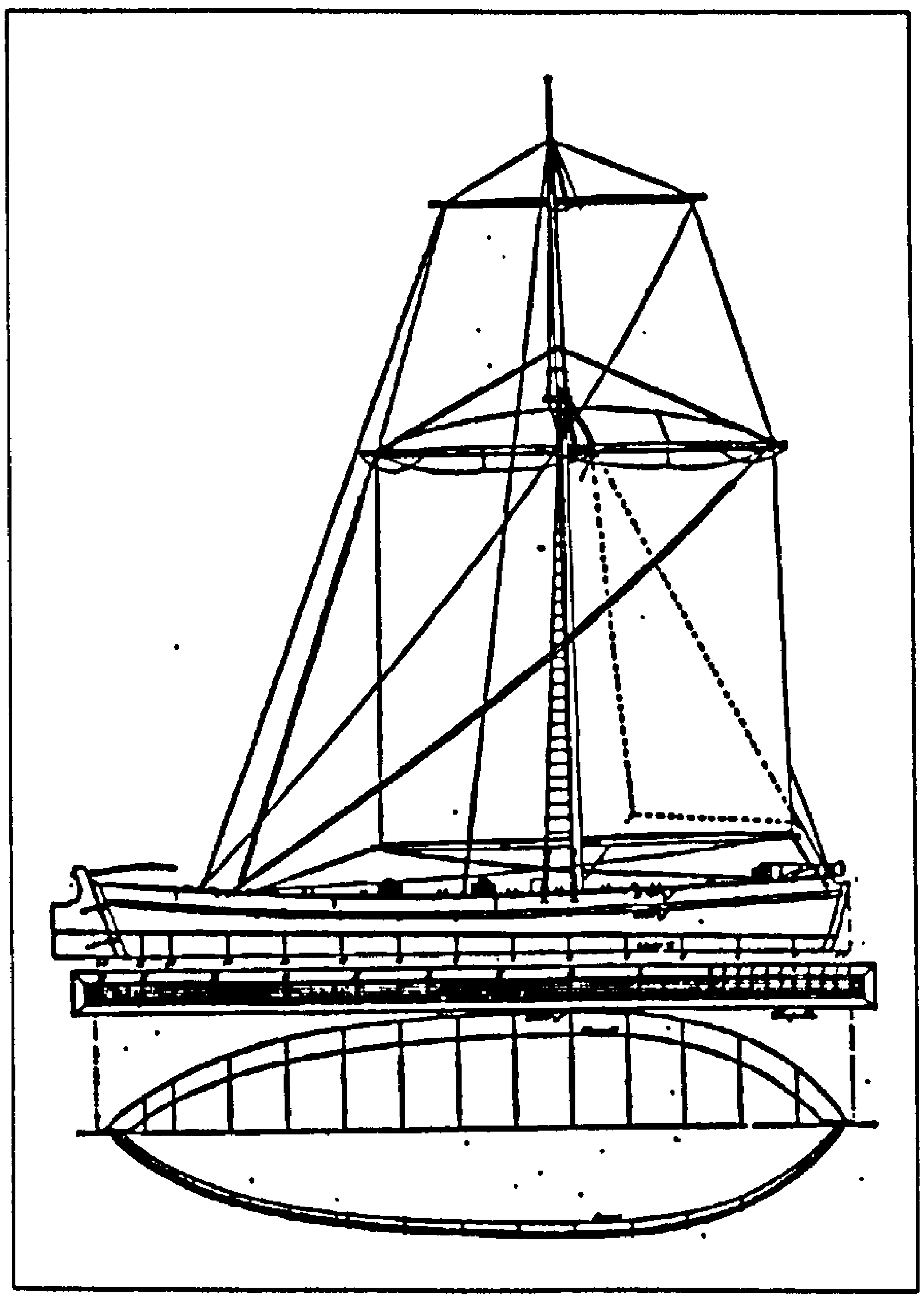


Fig. 10 Scale drawing of the gundalo *Philadelphia.* This late eighteenth-century vessel was raised from thirty-five feet of water. Restored, it is now in the Smithsonian Institution (van Gemert, 1972, 289). Reproduced with permission from Bass, G.F., ed., *A History of Seafaring based on Underwater Archaeology*, London: Thames and Hudson.

In Blackfriars 1 the position of the mast step is well forward of amidships, 'about one-third of the length of the vessel from its bow' (Marsden, 1994, 70-4). This is also true of St Peter Port 1 and the Barland's Farm Boat (Plate V; Rule and Monaghan, 1993, 127; McGrail and Roberts, 1999, 138). Iconographic confirmation that this was a common feature of the Romano-Celtic tradition is given by the Oceanus mosaic of *c.* A.D. 250 from Bad Kreuznach, which shows the mast stepped approximately one third back from the bow (McGrail, 1987, 234; Ellmers, 1996, 61-2). Masts stepped in a similar position are also a shared feature of Romano-Celtic inland craft, but these may be towing masts (McGrail, 1987, 216-7; 1995, 140); this position is appropriate for a mast used for towing a vessel from a river bank. A mast stepped forward of amidships is not unique to the Romano-Celtic tradition, being noted by McGrail in a number of *cogs*, as well as in the Kyrenia ship of the fourth century B.C. (McGrail, 1987, 225; 227). It is also a feature of the *naves codicariae*, a class of specialised Roman harbour craft (Plate VIII; Casson, 1965, 43-9), as well as the present-day Bangladeshi *balam* (Plate IX; Greenhill with Morrison, 1995, 123-4), the Humber keel (Plate X; Schofield, 1988, 8) and the square-rigged American gundalo, *Philadelphia* (Fig. 10; van Gemert, 1972, 289).

Marsden (1994, 70) suggests that steering problems might arise if a ship with a mast stepped as far forward as this attempted to sail to windward with a square sail. In their discussion of the mast step in the Barland's Farm Boat, McGrail and Roberts say that this is in 'a position suitable for a mast with a fore-and-aft sail on a seagoing vessel' and they propose a lugsail (McGrail and Roberts, 1999, 138-9).

McGrail (1987, 217, 220) discusses the theory of this which in essence is that the force of the wind acting through the Centre of Effort (C.E. - taken as a point approximating to the geometrical centre of the sail) will produce a couple acting on the Centre of Lateral Resistance (C.L.R. - in essence the point about which the hull will pivot in response to a sideways force, also taken as approximating to the geometric centre of the underwater fore-and-aft section). To ensure a degree of weather helm, which, as we have noted, is generally held to be a desirable requirement of directional stability, it is stated that this is to be achieved by having the C.E. slightly aft of the C.L.R. The theory is that with the C.E. positioned in this relationship to the C.L.R. the ship will weathercock into the wind if the helm is released.

This has led to the suggestion that ships such as Blackfriars 1, with single masts stepped well forward, would have been rigged with some form of fore-and-aft sail, such as a spritsail, so as to ensure that the C.E. is indeed aft of the C.L.R. (Marsden, 1994, 71). The problem with this is that the spritsail is not documented in north-west Europe before the fifteenth century A.D. (McGrail, 1987, 223-4).

The spritsail was, however, known in the Mediterranean from the second century B.C. There is a particularly fine example of a spritsail represented on a relief on a third-century A.D. sarcophagus (Plate VIII), which Casson interprets as telling the story of the accident which led to the death by drowning of the occupant of the sarcophagus (1994, 117; 1996, 49-51). The value of this depiction is that it is clear that the sculptor had an accurate eye for nautical detail. For example, one of the three vessels involved is shown in the act of backing her mainsail to heave to, a manoeuvre, one suspects, not readily understood by the layman, even of the third century A.D.

A second vessel is clearly shown with a spritsail mounted on a single mast. The details of the rig include the sprit, i.e. the spar running from the base of the mast to the peak of the sail, and the two vangs controlling the head of the sprit. Apart from a means of brailing up the sail, which Casson states, incorrectly, cannot be fitted to such a rig, the detail is exactly what one would expect on a Thames Barge of the modern period. The other relevant detail is the position of the mast which is stepped right forward, 9% of the waterline length from the bow (14% of the overall length). It is the waterline length which is relevant here because it is that which influences the position of the C.L.R. This mast position is much further forward than the mast step on Blackfriars 1, St Peter Port 1, the Barland's Farm Boat, the Kyrenia ship, one third back from the bows, and the *cogs* quoted by McGrail, 24% to 34% from the bow (1987, 225, 227). A mast stepped as far forward as this is typical of ships rigged fore-and-aft with a single sail, the whole area of which is abaft the mast, such as the American cat boat, the Norfolk Wherry or the modern Freedom (wishbone-rigged) yachts. On that ground alone we can rule out a spritsail for the Romano-Celtic tradition.

Elimination of the spritsail on the grounds that the mast in the Romano-Celtic tradition is not stepped far enough forward does not, however, rule out a lugsail, because that carries part of its area forward of the mast (McGrail, 1987, 224; McGrail and Roberts, 1999, 140). A suggestion has been made that the depiction of a Romano-Celtic boat in a mosaic from Bad Kreuznach shows a battened lugsail in the Chinese style (Ellmers, 1969). Ellmers has noted, however, that evidently the artist 'was used to the appearance of typical Mediterranean ships' (Ellmers, 1996, 61-2) and it is clear that his depiction leaves much to be desired; the hull actually looks somewhat akin to a sauce boat. Apart from this questionable case, there seems to be no Roman-period or early medieval evidence for the lugsail in north European waters (McGrail, 1987, 217).

Directional stability: Refining the theory

In practice and in contrast to what we have said so far, designers of modern sailing vessels nearly always put the C.E. well ahead of the C.L.R. (Hewitt and Lees-Spalding, 1990, 304). Marchaj (1964, 196) states that authorities put this 'lead' of the C.E. forward of the C.L.R. at anything from 0% to 20% of the waterline length. Moreover, it is common practice among yachtsmen, particularly in heavy weather, to sail under head sail alone. This in theory takes the C.E. well forward, but in practice there is no sign of lee helm, i.e. a tendency to turn downwind. I personally have recent experience of sailing a ketch-rigged yacht on a north-easterly course in a south-easterly Force 5, i.e. on a beam reach; the only sail we had was a double rolled headsail and the C.E. must have been well forward of the main mast, but there was no sign of lee helm.

Clearly more is involved than just the couple between the C.E. and the C.L.R. Marchaj (1964, 196) says that this 'lead' of the C.E. on the C.L.R. is to compensate for the effect of heel and the displacement of the sails from the centre line of the vessel, significant in, but not restricted to, the case of a fore-and-aft rigged ship. For example, with the vessel heeling to the wind, the forward drive component of the forces acting on the sail plan will be applied to the leeward side of the fore-and-aft centre line of the vessel, tending to turn the vessel into the wind, whatever the relative positions of the C.E. and the C.L.R.

To this needs to be added the effect of hull trim (Hewitt and Lees-Spalding, 1990, 307-8). As the vessel heels, she is likely to trim down by the bows; i.e. immerse a greater proportion of her forward sections and raise an equivalent proportion of her after sections out of the water. This will happen for two reasons, one static, the other dynamic. If the forward sections are finer and the after sections fuller, then the bows will dip as the hull heels simply because they are less buoyant than the stern. In a dynamic situation, the forward drive of the wind is also likely to force the bows down, because the C.E. is above the Centre of Buoyancy. As this happens, the C.E. will move forwards, because the rig is now raked forwards; so too will the C.L.R., as the centre of the area of the immersed centre-line cross-section moves forward. The drive of the wind will cause the hull to trim down by the bows, even when the vessel is not heeled, for example when running before the wind. Finally the trim of the hull and, therefore, the position of the C.E. and C.L.R. will be significantly affected by the lateral and fore-and-aft distribution of ballast and cargo (Godal, 1986, 201-4; Andersen, 1986, 210-12).

In addition, other forces, such as wave action, will also affect directional stability. A vessel sailing with a beam or quartering wind will encounter a wave train coming from windward. The height and energy of this wave train will to a large degree be determined by the wind strength. The force of this wave train will act on the vessel's Centre of Gravity, forming a couple with the C.L.R. If the C.L.R. is forward of the Centre of Gravity, this will tend to push the bows into the wind. In heavy weather a larger wave can cause a yaw, which can be corrected only by vicious helm action. This, say Hewitt and Lees-Spalding (1990, 308), is the classic cause of broaching.

Finally there is the question of the action of the wind on the hull, rigging and superstructure. Modern sailing yachts tend, when drifting without sail, to turn downwind; this is partly a consequence of the mast and forestay being forward of amidships and partly because of the greater profile presented to the wind by the bows which are normally higher above the water than the stern. The depiction of Blackfriars 1 on the front cover of Marsden's book (1994) shows a reconstruction with a very large deckhouse in the stern of the ship. While there is no direct archaeological evidence for such a deckhouse in Blackfriars 1, Marsden concludes that the crew accommodation was aft and considers that it was possible that this was in a deck cabin, rather than below decks (1994, 80). It has been very tentatively suggested that finds from St Peter Port 1, tiles, pottery and the remains of a hearth, also point to a deckhouse aft (Plate V; Rule and Monaghan, 1993, 128). If such a deckhouse did exist, it would undoubtedly have tended to turn the bows of the ship into the wind and thereby countered any tendency to lee helm arising from a forward-located square sail. The case is similar to sixteenth-century galleons, whose high superstructure aft would turn them into the wind; in a gale they would run downwind under fore course alone (Padfield, 1988, 75).

These factors of hull trim, wave action and wind action on hull and superstructure would have played a part in the helm balance of Romano-Celtic ships such as Blackfriars 1. An examination of the lines of Blackfriars 1 (Marsden, 1994, 90-3) suggests that, although double-ended, her after lines were somewhat fuller than those forward. As she heeled, therefore, she would trim down by the bows. This was not the case with the Barland's Farm Boat; heeled to 10° and with a displacement of 5 tonnes, computer simulation suggests that her longitudinal Centre of Buoyancy would move forward barely 1% (Owain Roberts, pers. comm.). However, this appears to be a static computation; any vessel under sail will trim down by her bows to a greater or smaller degree as the result of the forward drive of her sails being centred on a C.E. vertically separated from her C.L.R.

How far the trim of Blackfriars 1 would also be affected by the distribution of her ballast or cargo is not known, but there seems to be potential for a large variation in trim. Marsden lists a number of different cargo weights, all of which would have affected the trim of the vessel differently (1994, 194). Given that her crew accommodation was in the stern, the possibility is that the heavier her cargo, the more she trimmed down by the bows.

Redefining the C.E. and the C.L.R.

Up to now we have assumed that the positions of the C.E. and the C.L.R. approximate to the geometric centre of the sail area and of the underwater fore-and-aft section respectively. This is a useful rule-of-thumb measure for designers who have to reach a balance of compromise in designing sail plans for the different points of sailing and a wide range of differing conditions of wind and weather. We need to refine our concept of both C.E. and C.L.R. The concepts we have used so far are essentially static and two-dimensional, i.e. they are seen as acting in the vertical fore-and-aft plane of the centre line of the ship.

This will do for the C.E. as long as the pressure of the wind is exerted directly into the sail so that there is no airflow horizontally across the sail. This is the case when the vessel is running directly downwind or with a quartering breeze. As the vessel comes onto the wind, the airflow begins to be deflected around the back of the sail, which becomes a true aerofoil. On the windward (after) side of the sail pressure will rise owing to a decrease in the velocity of the airflow, while on the leeward (fore) side of the sail pressure will reduce with an increase in the velocity of the airflow. It is the combined effect of this pressure and suction which produces the drive of the sail and its effect is centred on a point horizontally displaced from the geometrical centre of the sail (Fig. 33 in Appendix V, 184; Andersen, 1986, 210). Andersen states that the point is approximately 25% from the leading edge of the sail. Marchaj (1964, 197-9) gives in graph form experimental results for the displacement of the C.E. obtained from an aerofoil with an aspect ratio of 1:5 and varying degrees of camber. As the angle of incidence of the airflow decreases from 90° to 10°-15°, so the C.E. moves forward from 50% to some 31%-37% from the leading edge of the sail. He notes two points: first that the less the camber, i.e. the flatter the sail, the greater the displacement of the C.E.; second that because the results report the displacement of the C.E. in terms of the percentage of the chord of the sail, the displacement for sails of low aspect ratio will be relatively large. Both points are important for ancient vessels, because it seems improbable that their sails could have attained the degree of flatness that the stability of modern sail cloths makes possible and because the sails of ancient craft would not have had the high aspect ratios of modern sailing craft.

It is not enough to take the position of the C.E. redefined in this way; what counts in a three-dimensional model is the direction and alignment of the total aerodynamic force acting on the C.E. As an aerofoil meets an airflow at an angle of incidence, a total aerodynamic force is created which can be resolved into the two components of lift (or crosswind force) and drag (or downwind force) (Fig. 33 in Appendix V, 184; Marchaj, 1964, 50, 63-74); it can also be resolved into the components of forward drive and heeling force. Once the angle of incidence reaches a critical point, the flow of air over the top (lee side) of the aerofoil becomes turbulent, lift decreases rapidly and drag becomes the predominant component of the total force, until at an angle of incidence of 90° drag constitutes the totality of the aerodynamic force. The latter case applies to a sailing ship running before the wind or on a broad reach, with the wind blowing more or less at right angles to the sail; the former, to one which is on the wind, close hauled or with a beam wind, when the wind is blowing smoothly across both sides of the sail.

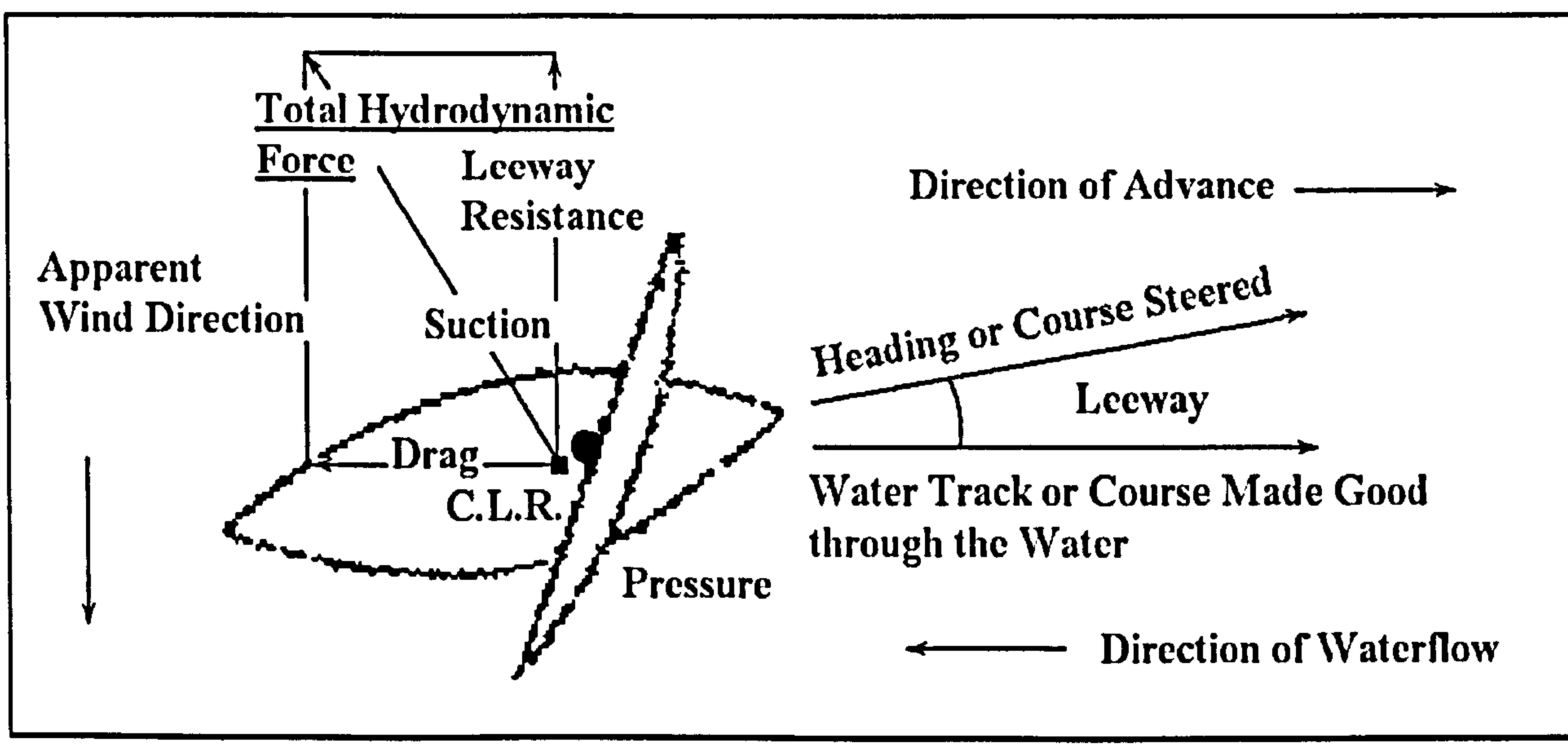


Fig. 11 Hydrodynamic resistance to leeway (Andersen, 1986, 212)

As the hull moves through the water it is subject to a corresponding hydrodynamic force. This is created in a way analogous to the total aerodynamic force. When running directly downwind this force will equate to the resistance of the hull to its forward movement. In all other cases any vessel moving forward through the water will also move sideways away from the wind and in effect becomes a vertical hydrofoil (Fig. 11). This effect, termed leeway, arises, whether the vessel is under sail or under some other form of propulsion, if the wind is not from directly astern or ahead. As the vessel moves forward this means that the water will meet the hull beneath the waterline, not from directly ahead, but at an angle of some degrees (Andersen, 1986, 210). In a manner precisely parallel to that of the airflow deflected by the sail, the water flow will be deflected by the underbody of the hull, and in particular the keel, if there is one, to produce an area of low pressure on one side and of high pressure on the other creating a total hydrodynamic force which can be resolved into the two components of sideways force countering the leeway and of resistance to the forward movement of the vessel (Marchaj, 1964, 272, 351). As in the case of the aerodynamic force created by the airflow around the sail, the effect of the hydrodynamic force created by the underwater body of the hull will be centred, not on the geometric centre of the fore-and-aft vertical cross-section of the underwater body, but on a point in the forward part of the hull.

As shown in Fig. 34 in Appendix V (185), for a sailing ship to achieve directional stability at a constant speed and heading, the total aerodynamic force acting through the C.E. must be in equilibrium with the opposing total hydrodynamic force created by the passage of the hull through the water, acting on the C.L.R. (Marchaj, 1964, 350-4; Smitt, 1984, 168-70).

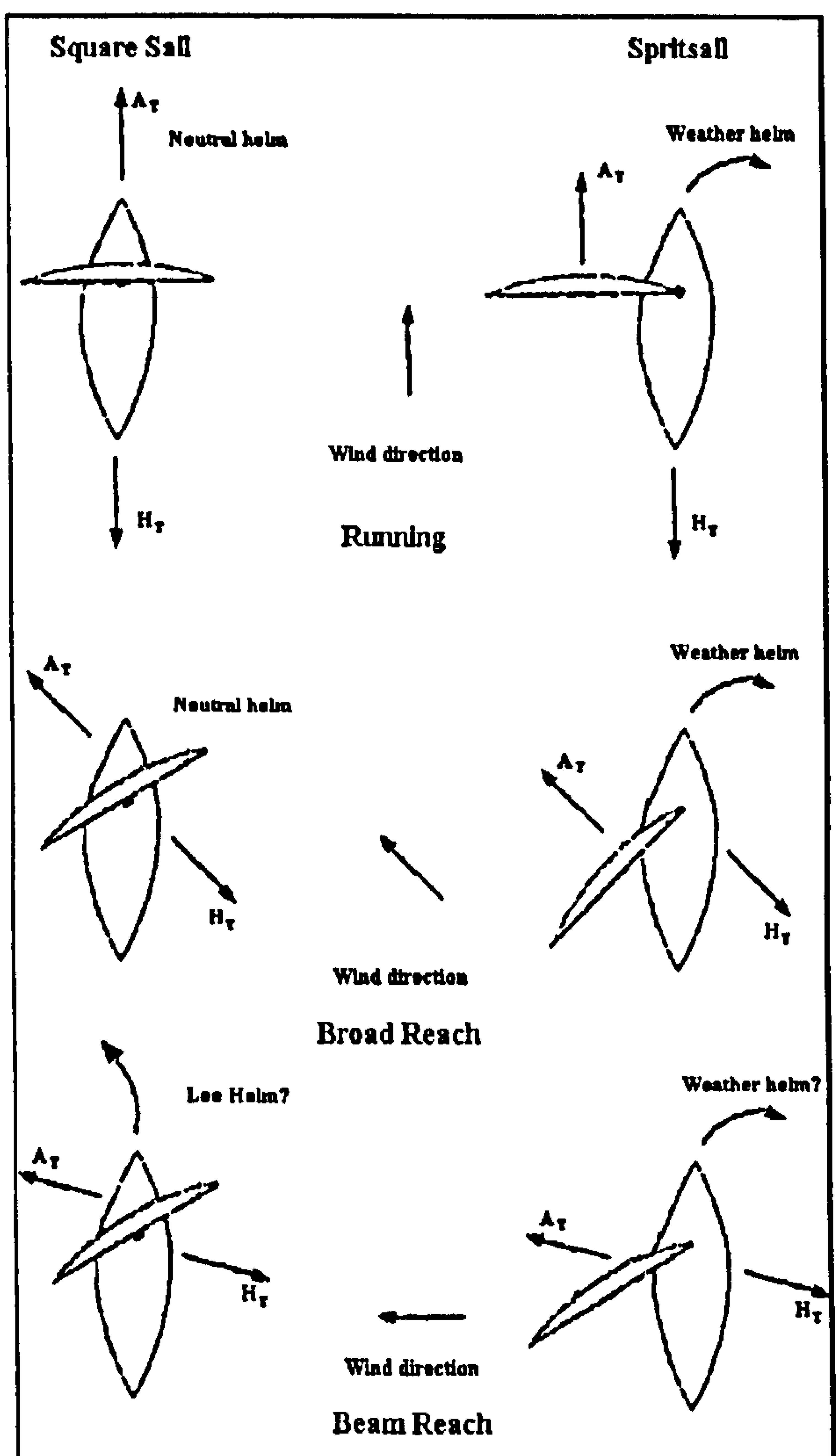


Fig. 12 A_T = total aerodynamic force; H_T = total hydrodynamic force.

We may eliminate the effect of the vertical separation of the C.E., acting on the sail from the C.L.R. acting on the underwater body of the hull. While this vertical separation creates a lever tending to capsize the hull it is opposed by the lever created by the metacentric height (McGrail, 1987, 220; for a discussion of the metacentric height, see Chapter VIII, 78-9; Fig. 17) This makes it possible to consider the interaction of the total aerodynamic force and the total hydrodynamic force in the horizontal plane (Fig. 12).

Figure 12 shows schematically a square-rigged and a spritsail-rigged vessel on three points of sailing, running, on a broad reach and on a beam reach (Marchaj, 1964, 197-8). Each vessel has its mast located, as in the Romano-Celtic tradition, about one third back from the bows. In each case the total aerodynamic force (A_T) is to be assumed to act through the C.E. and the total hydrodynamic force (H_T) through the C.L.R.

On a run in both cases, the A_T acts on the centre of the sail at 90° to its chord while the H_T acts on the centre line of the hull. In the square-rigged ship the two opposing forces are in equilibrium and the helm is neutral. This is not the case with the spritsail-rigged ship. While the H_T is still acting on the centre line of the hull, the A_T is acting through a C.E. which is way outboard. The two forces are considerably out of equilibrium and the result manifests itself as massive weather helm, an effect which is worsened by the fact that the sail is of low aspect-ratio with the C.E. proportionately further outboard than would be the case in a modern high aspect-ratio rig.

The effect continues as the two ships come onto a broad reach, with the apparent wind 45° abaft of the beam. The ships are now making leeway and the H_T is acting through a C.L.R. which is forward of amidships, possibly as far forward as the base of the mast. The A_T is acting through a C.E. which is still located near the centre of the sail. In the case of the square sail the two forces may well still be in equilibrium, while the spritsail is still subject to a degree of weather helm.

It is with an apparent beam wind that the square-rigged ship is likely to begin to show a degree of imbalance between the A_T and the H_T. In the case of both rigs the H_T is still acting through a C.L.R. forward of amidships. With the angle of incidence on the sail now considerably less than 90°, the A_T is acting on a C.E. markedly forward of the geometric centre of the sail. In the case of the spritsail this may be aft of the C.L.R. still giving a measure of weather helm, while in the case of the square sail it may now be forward of the C.L.R. manifesting itself in incipient lee helm.

The spritsail is the extreme case and a lugsail with perhaps 30% of its area forward of the mast would undoubtedly reduce the extremes of weather helm shown by the spritsail. With that qualification, the lug is likely to follow the pattern of the spritsail with a degree of weather helm on all points of sailing, with a maximum, as with the spritsail, on a run or broad reach.

Parallels: the Bangladeshi *Balam*; *Kyrenia II*; the Humber Keel

There are interesting parallels to these Romano-Celtic sea-going ships with their forward-located masts. The first, from the waters of Bangladesh, is described by Greenhill (Plate IX; Greenhill with Morrison, 1995, 123-6). Greenhill's photograph shows that, stepped like the mast of Blackfriars 1, at the after end of the foredeck, the mast is located well forward of amidships and from Greenhill's text and photographs there is nothing to indicate that the underwater profile had anything in the way of a keel to enhance leeway performance. Nevertheless Greenhill records some degree of windward ability which he attributes to the 'well cut sail' and 'long narrow hull'.

He describes the sail as a square sail, but it is interesting to note that this 'square sail' seems to be set asymmetrically about the mast and might even be described as a lugsail. This arrangement may contribute to moving the C.E. aft, but even so, it is well forward on the single-masted *balam*. The probability therefore is that these craft when on the wind experience a measure of lee helm and indeed Greenhill's report that some are rigged with a mizzen implies as much.

The second parallel is the Kyrenia Ship, which shared with the Romano-Celtic ships a mast located well forward of amidships; like them, no evidence of its rig has survived. The replica, *Kyrenia II*, was fitted with a broad loose-footed square sail. Her performance has not been published in any detail, but according to Casson (1996, 42-3) this rig functioned perfectly and she weathered some severe storms with no trouble.

However, at least initially, reality may not have been so rosy. According to one who had personal experience of her with her rig as originally set up, she 'could barely get onto a broad reach. She only wanted to point downwind and constantly overpowered her two side rudders' (Owain Roberts, pers. comm.). Roberts understands that this problem was remedied subsequently by raking the mast aft, which would have had the effect of displacing the C.E. aft. He suspects that it was also necessary to move ballast forward as well. That modifications were made as the result of sea trials is confirmed, although details are not given (Katzev, Katzev and Tzalas 1987, 11-2).

The third parallel is that of the Humber keel (Plate X). These traditional inshore cargo-carriers, plying the waters centred on the Humber estuary until the twentieth century, were characterised by a single-masted rig with two square sails, a main and a top sail. Fred Schofield, who spent a working life on keels, described the mast as located one third of the vessel's length from the stem (1988, 8).

Schofield's evidence is confirmed by the many photographs and paintings of keels that he publishes; scale drawings of Humber keels published by Finch (1976, 81) and Mannering (1997, 55) show the mast stepped 37%-38% back from the bows. A description by Moore (1970, 32) from 1915 describes a keel with eighteen cargo hatch covers, with the mast stepped at the forward end of hatch cover no. VII; Schofield's own keel was described as having twenty-nine hatch covers, with the mast stepped at the forward end of hatch cover no. X (1988, 7, 276-7). These descriptions put the mast at 31%-33.3% back from the forward end of the hold.

All this means that the C.E. was well forward. Even so, the keel could be easily handled and was well able to make to windward (Moore, 1970, 28-30, Finch, 1976, 81; Schofield, 1988, 3; 14). For windward work the keel is fitted with leeboards in line with the mast. These will have some effect on the position of C.L.R., bringing it forward to some degree.

Schofield does not discuss helm balance in his book, but he is reported to have complained privately of bruising his hip from the weather helm in a Force 3-4 (David Robinson, pers. comm.). However, he does seem to regard the square rig as ideal for sailing with a following or quartering wind (Schofield, 1988, 14).

To sum up then in terms of aerodynamics, it is apparent that with the mast placed where it is in the Romano-Celtic tradition the square sail would be best balanced sailing downwind, or with a quartering breeze, when a fore-and-aft rig would have been seriously unbalanced. It is only as it comes onto the wind and indeed close-hauled that the fore-and-aft rig might become balanced. In general, in spite of some evidence that square-sailed rigs could make progress to windward, with a forward-located mast no rig with a single sail will give perfect directional stability on all points of sailing.

The Significance of Leeway

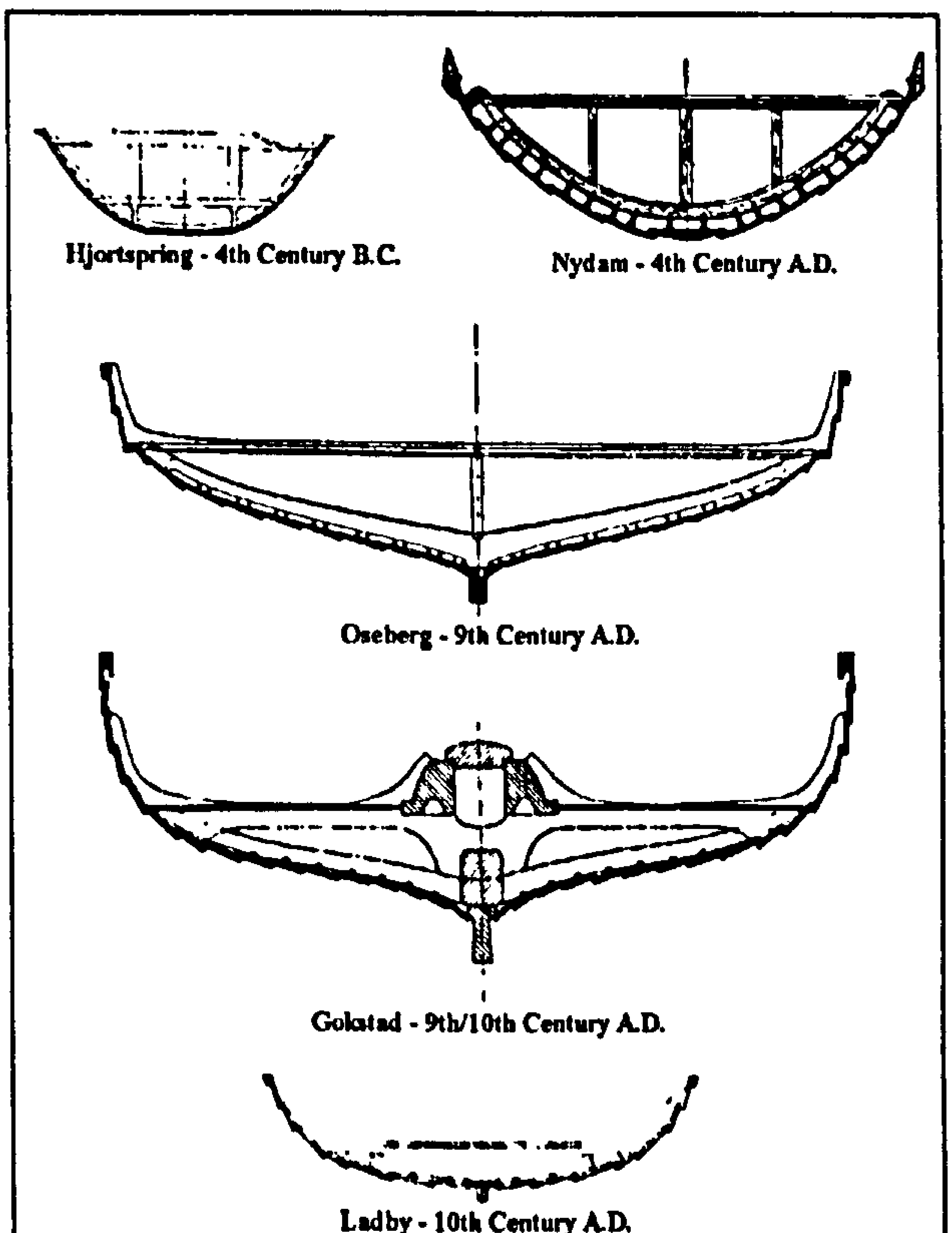


Fig. 13 Evolution of hull cross-sections in the Nordic tradition; the protruding keel, associated with a good deadrise, is fully developed in the Gokstad and Oseberg ships of the Viking Age while the Ladby ship, although late, seems to represent an intermediate stage (Drawing by Ole Crumlin-Pedersen; reproduced with his permission).

In terms of hydrodynamics, however, it seems likely that whatever their rig, when sailing close-hauled or in a beam wind, Romano-Celtic ships would experience an excessive amount of leeway. To sail effectively with a beam wind, and even more so, when close-hauled, leeway must be kept to a minimum, because leeway represents ground lost downwind; excessive leeway can make it impossible to achieve any progress at all to windward. The efficiency of the vessel in resisting leeway comes in large measure from the underwater configuration of the hull. The three characteristics which in principle make for good resistance to leeway are:

1. Good draft (Marchaj, 1964, 277-8);

2. A keel, such as the beam keels which developed in the Scandinavian tradition, associated with a significant deadrise in the garboards, giving a wineglass shape to the underwater cross-section of the hull (Fig. 13; McGrail, 1987, 111-15);

3. A deep protruding keel with a high aspect ratio, a feature limited to modern sailing craft (Marchaj, 1964, 270-81).

Leeway will vary with the point of sailing, being at its maximum when sailing close-hauled and will be exacerbated by excess windage from rigging and superstructure. It will also vary considerably with wind strength and sea state and may in extreme cases reach a value as high as 20° (Royal Yachting Association, 1981, 35). However a typical figure for an average modern cruising yacht when beating to windward would be about 5° (Hewitt and Lees-Spalding, 1990, 88). This value is so small that one suspects that most cruising navigators would ignore it as being smaller than the likely error by the helmsman in reporting his heading.

While modern cruising yachts would meet, at least to some degree, all three characteristics enumerated above, Romano-Celtic seagoing vessels could be said to comply in any degree with only the first: Blackfriars 1 was assessed for stability at a range of drafts from 0.7 to 1.7 metres, while the sailing performance of the Barland's Farm Boat was assessed at a range of drafts from 0.34 to 0.52 metres, described as 'relatively light' (McGrail and Roberts, 1999, 144). Their plank keels, even though about 1" thicker than the neighbouring planking, can scarcely be regarded as contributing significantly to the total leeway resistance of the hull, especially since they were faired into their neighbours (Marsden, 1994, 38-9, 65); in this they differed from Scandinavian ships of the Viking Age (Fig. 14).

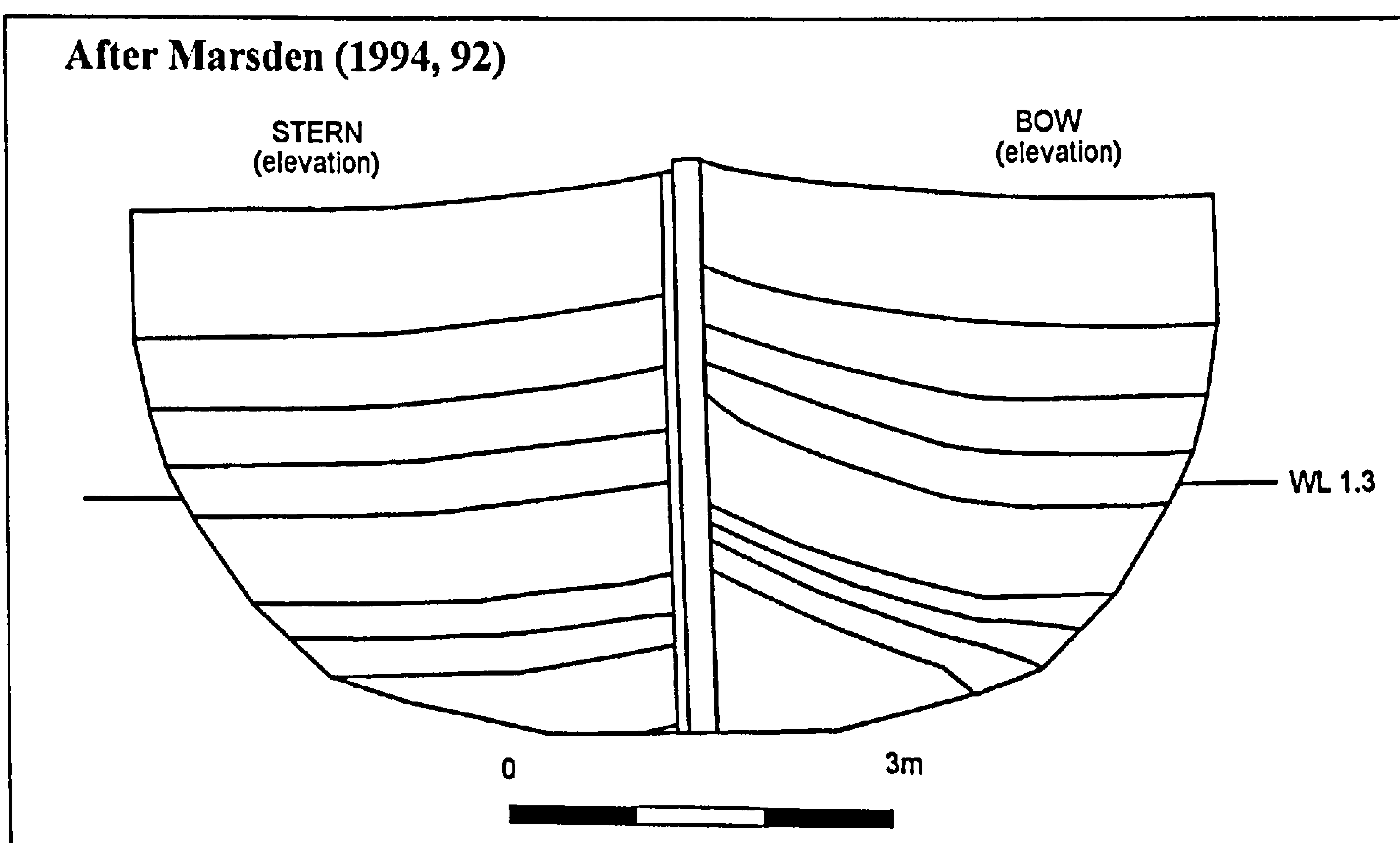


Fig. 14 Computer-drawn end elevations of Blackfriars 1. Reproduced with permission from Marsden, P., 1994, *Ships of The Port of London: first to eleventh centuries A.D.*, London: English Heritage, 92.

Owain Roberts draws attention to the rôle of rudders in enhancing leeway performance (1984, 134-40; 1995, 308-11). A rudder is a hydrofoil which, if it is set at an angle to the water flow, will create a sideways force, in exactly the same way as the hull as a whole (Fig. 11). Provided the incidence of the water flow onto the rudder is from leeward the direction of this sideways force will be the same as that of the underwater body of the hull as a whole in counteracting leeway. This will usually manifest itself in a degree of weather helm. The presence of lee helm, however, means that leeway will be considerably increased, since the contribution of the rudder to leeway resistance will be negative.

Located in the after part of the vessel, the effect of the rudder will be to displace the total C.L.R. aft. Roberts points to the particular case of the coble from north-east England. In the case of this craft the deep forefoot, which takes the C.L.R. of the hull well forward, is hydrodynamically balanced by a deep high-aspect ratio rudder (Fig. 15).

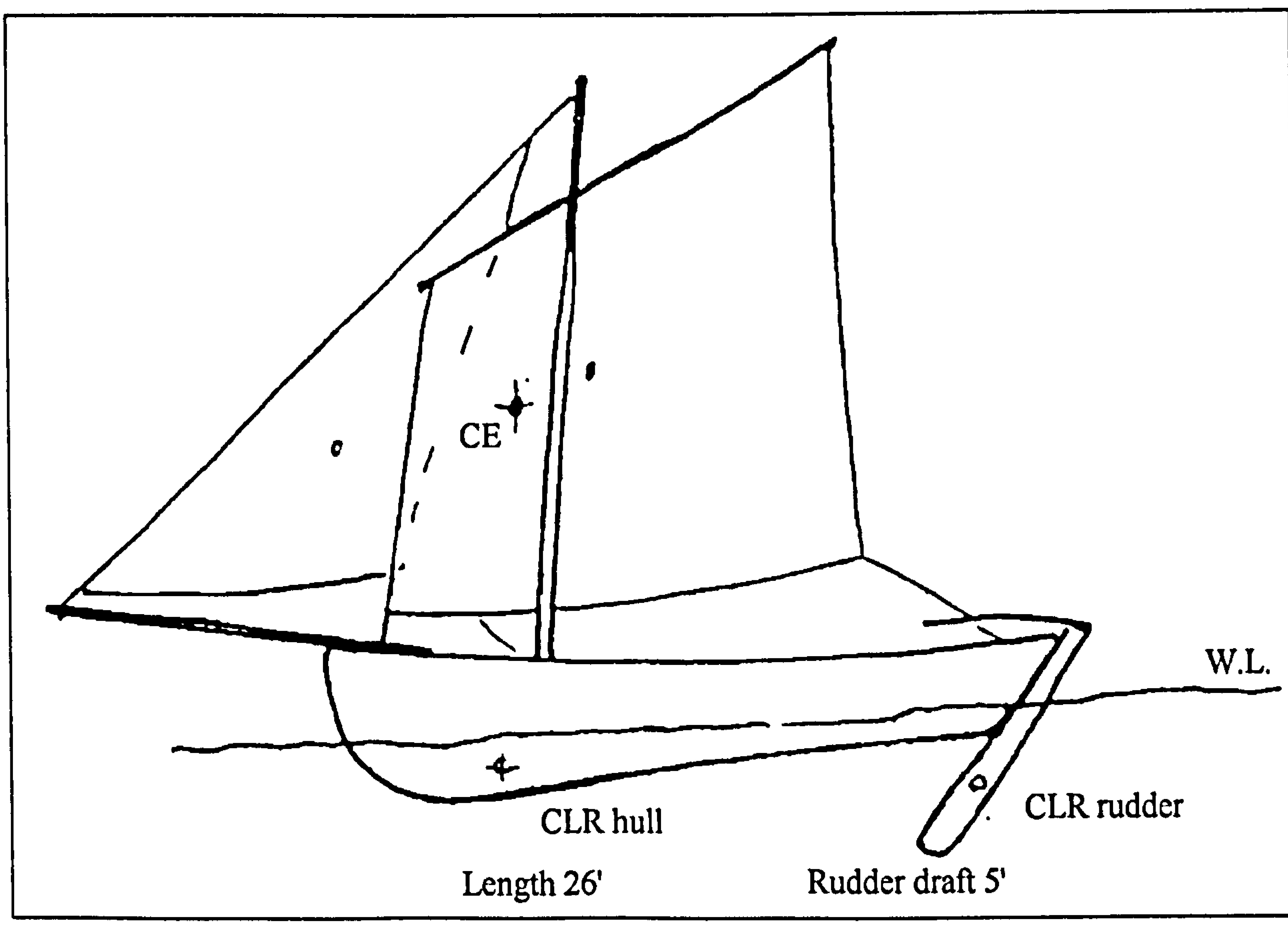


Fig. 15 From Roberts (1995, 309 after Hill, 1978. Reproduced with permission).

Another case, an extreme one, of a design in which the rudder makes a major contribution to leeway resistance is that of the *bragozzo*, a traditional fishing craft surviving in Adriatic waters into the twentieth century (Appendix VI). Unlike the coble, however, there is in the *bragozzo* no deep forefoot; the C.L.R. is, therefore, located substantially aft of amidships and balanced by the C.E. displaced aft by a two-masted lug rig, with the greater part of the sail area on the after mast.

We may assume, therefore, that the rudder (or rudders) fitted to Romano-Celtic sea-going vessels would have been a factor in their leeway performance. Although McGrail and Roberts settled on a steering sweep for the reconstruction of the Barland's Farm Boat (1999, 136-40), Roberts suggests tentatively that, with a side rudder, leeway for this vessel might have been less than perhaps 7° to 8° (pers. comm.). This is a very good figure compared with that achieved by the reconstructions and replicas discussed below.

Neither for St Peter Port 1 nor for Blackfriars 1 was any direct archaeological evidence recovered for the steering system, any more than for Barland's Farm. Drawing on the parallel of the Bruges Boat, Marsden proposes two four-metre high-aspect ratio side rudders for Blackfriars 1 (1976, 26, 29; 1994, 74-6). These would be adequate to project below the bottom of the hull and to be a factor in the vessel's hydrodynamic performance. However, as we have noted, for this to amount to a positive contribution to leeway resistance the water flow onto the rudder blades must be from leeward, normally manifested in a degree of weather helm. Lee helm would indicate that the rudder is adding to the leeway, rather than countering it.

No experimental work has been done with Romano-Celtic replicas and an accurate assessment of the leeway that would be generated by a vessel such as Blackfriars 1 could only be made with data derived from tank-testing. Even Roberts's suggestion of less than 7° to 8° leeway for Barland's Farm is no more than an estimate.

However, results obtained from experiments with replicas and reconstructions of other traditions with a similar amidships cross-section may give a sufficient indication. In discussing such results, it is necessary to make the distinction between the true and apparent wind (Fig. 16; Quarrie, 1982, 83-91).

True and Apparent Wind

As a ship moves ahead (Fig. 16), it creates a headwind (W_s) which is equal in speed and opposite in direction to its own motion (V_s). This headwind combines with the true wind (W_t) to create the apparent wind (W_a) which is observed by the crew and to which the ship responds. This happens on all points of sailing and has the effect of moving the apparent wind direction forward; if the true wind is forward of the beam, it will also have the effect of increasing the apparent wind strength (Quarrie, 1982, 83). When beating against the wind the sailor has the impression of sailing much closer to the wind than he really is. In particular, when a rig capable of sailing no closer than, say, 70° to the true wind is combined with a hull that affords little resistance to leeway, the ship may simply sail across the wind, even though the sailor believes that he is hard on the wind and making progress to windward.

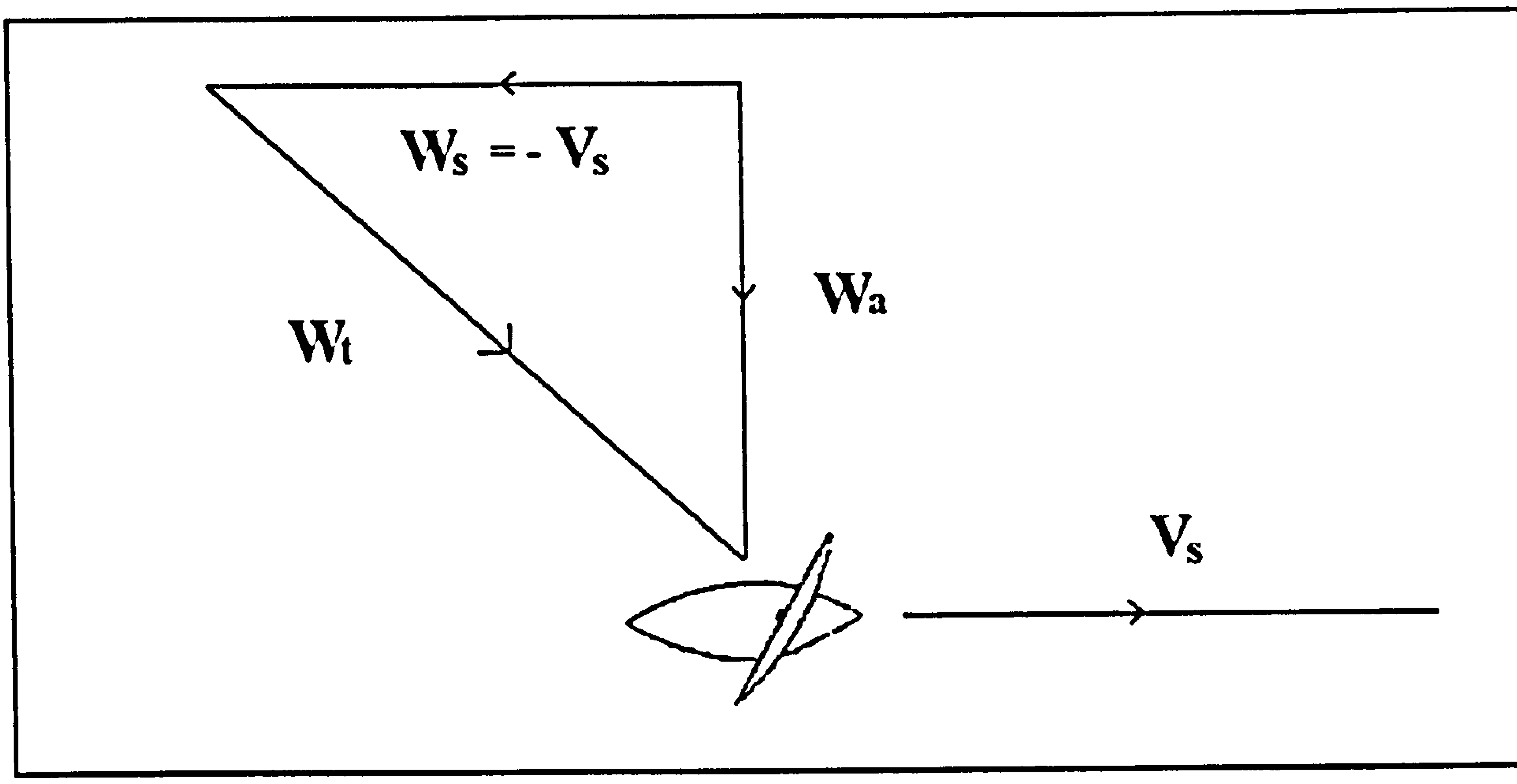


Fig. 16 V_s = ship's forward speed; W_s = headwind; W_t = true wind; W_a = apparent wind (Quarrie, 1982, 84).

Leeway in Ancient Vessels

In a survey of estimates of windward ability by various authorities, McGrail suggested that the best available evidence indicates that Viking-Age ships 'would make best progress to windward when 6 points off the [true] wind with a leeway of *c.* 1 point giving a combined effect of 7 points off the wind' (1987, 261-2). A point is a compass point and amounts to 11¼°. So we are talking of leeway of just over 10° with a track through the water of some 80° off the true wind.

A polar diagram published for *Roar Ege*, a Skuldelev 3 replica, shows her as capable of achieving a heading of 60° against a true wind of 18 knots (Jørgensen, 1992, 24). However, this diagram did not take leeway of about 10° into account. When adjusted for leeway, her track through the water against the true wind is 70° and against the apparent wind 58° (Max Vinner, pers. comm.). The figures for leeway and apparent wind accord closely with those recorded for *Odin's Raven*, a two-thirds Gokstad replica, although it seems that *Roar Ege* was capable of a track through the water against the true wind of about 10° better, 70° as opposed to 80° (Binns, 1980, 165 and 168; Vinner, 1986, 224). The figures quoted above for *Roar Ege* are the best results obtained in trials; a range of headings against the true wind of 64°-72° was recorded, it being noted that the poorest results were achieved with a reefed sail. Both the effects of the rising wind and the fact that a reefed sail would have a lower and less efficient aspect ratio would account for these poorer results.

As we have noted, there has been no replica of a Romano-Celtic ship for which experimental results are available, but we may take as a proxy results reported for trials of reconstructions of shallow-keeled ancient craft such as those of a Celtic *curragh*, *Brendan*, of the Graveney Boat and of the Sutton Hoo Ship.

Brendan was a reconstruction, designed for Tim Severin by Mudie (1986, 42-6), of a Celtic hide boat, such as was thought to have been used by St Brendan in his voyage into the North Atlantic. *Brendan* had no external keel and had a hull cross-section approximating to that of the Romano-Celtic tradition. She was sailed to North America in an endeavour to recreate St Brendan's voyage.

> Against a headwind *Brendan* would point about 50° or 60° off the wind, but leeway of 30° meant that she made an effective 90° to the wind. At F 6 and above, it became dangerous in most sea states to continue to reach across the wind, and it was safer to run downwind (Severin, 1988, 290).

Severin experimented with leeboards, although their use 'may have been anachronistic', but could not use them above Force 5-6. Leeboards reduced leeway 'by up to 10°', although Mudie, who did not sail with Severin on the voyage, reports leeway of an unlikely figure of approximately 6° (1986, 45). Such a figure would represent a good performance for a modern cruising yacht and may be discounted.

Gifford's two replica projects also provide proxy evidence. *Ottor* is a half-scale replica of the tenth-century Graveney Boat. The excavated craft was reported to have a plank keel with a minimum deadrise of the garboards - just 4° (McGrail, 1987, 114). In the initial trials of the replica, leeway of about 30° prevented windward progress, but this was later improved to about 20° when the crew number was increased to six. This performance was again improved to 10° by the addition of a 2½" deep false keel, evidence for which the Giffords see in the three plugged trenail holes in the flat-surfaced keel plank of the original (Gifford and Gifford, 1996, 139). The improvement in leeway resistance with the larger crew is ascribed by the Giffords to the 'well-known relationship between ballasting and lateral resistance'. It is of course corroborating evidence of the significance of draft as a factor in leeway resistance.

Sæ Wylfing is a half-scale replica of the Sutton Hoo Ship. This ship was also reported to have a plank keel; the deadrise was a little greater than in the Graveney Boat - 13°, but still significantly less than in Viking-age craft such as Gokstad 1, the Oseberg Ship and the Skuldelev finds in all of which a deadrise of *c.* 30° was reported - with a protruding beam keel (McGrail, 1987, 114). Trials of *Sæ Wylfing* were initially conducted with a keel projection of 20 mm. This was subsequently increased by 50 mm. over the central two-thirds of the keel length. Finally a further modification created a total projection of 40mm. over the full length of the keel (Gifford and Gifford, 1996, 143). As might be expected, the reported leeway varied considerably with the keel configuration, from 10° to 30°. The greatest variation occurred with the minimal keel projection of 20 mm. As long as the ship was sailed upright, leeway was only 10°; once the ship was allowed to heel, leeway increased to 30°.

This seems to point to a conclusion that hulls with rounded bottoms and without protruding keels, such as the Romano-Celtic ships, would not have performed well on the wind. Leeway would have been in the order of 20° to 30°, the better figure being characteristic of ships with deeper draft. With this constraint on performance, like Severin's *Brendan*, it seems unlikely that Romano-Celtic craft could ever do better than reach across the wind. This is confirmed by experience with Humber keels and Humber sloops. The Humber sloop is a version of the Humber keel, with a single forward located mast rigged fore-and-aft (Finch, 1976, 82-3; Schofield, 1988, 237-40; Mannering, 1997, 54-6).

> *Amy Howson*, a gaff-rigged sloop was absolutely hopeless sailing to windward without leeboards... the first sail after five years' restoration work ended in an ignominious grounding on the tail end of Read's Island when she merrily thrust on on a starboard tack in spite of the tiller being hard over to port...
>
> The Keel *Comrade*, however, with about 12 tons of ballast to sit the hull 3'0 deep was sailed from '76 to '83 without boards, but there was appreciable leeway sailing to windward (David Robinson, pers. comm.).

This brings us to a paradox, for on the only point of sailing on which it could have achieved reasonable directional stability with a fore-and-aft rig, i.e. when close-hauled, the Romano-Celtic ship would have been at its most ineffective in terms of leeway resistance. On all other points of sailing, on a run or on a broad reach, when leeway is of less significance, the advantage in terms of directional stability would be with the square rig. This paradox is the direct result of two characteristic features of these ships, the forward-located mast and an underwater profile which gives poor leeway resistance.

Conclusion: The Battened Square Sail

To draw any conclusions, on the basis of the available evidence, as to the type of rig used on Romano-Celtic sea-going ships, apart from the fact that they were single-masted, must be to enter the speculative. But certain points can be made.

The first is that these ships were almost certainly not rigged with a spritsail, or indeed any other fore-and-aft sail the whole area of which was rigged abaft the mast. Such a rig requires a mast right up in the bows of the ship and with the mast stepped where it was in the surviving craft it would have created excessive weather helm.

Whilst one cannot say that, rigged with a square sail, Blackfriars 1 would have been in perfect directional balance, nevertheless, she was certainly not as far out of balance as the simple comparison of static positions of her C.E. and C.L.R. would imply (Marsden, 1994, 71). Certainly a square sail would give good directional balance when running before the wind or on a broad reach; it is only when sailing with a beam wind that the possibility of lee helm might set in, but, as we have noted, if these vessels were equipped with large deckhouses or similar superstructures aft, then lee helm might well have been eliminated.

Blackfriars 1 may well have been rigged with a lugsail, but if she were she would have exhibited a significant degree of weather helm when running or on a broad reach. Always supposing that the superstructure aft did not include the deckhouse we have already mentioned, then the weather helm might be kept to an acceptable level with a beam wind, but that would be the least efficient point of sailing given the large amount of leeway which would have been created. While, therefore, the lugsail is a valid hypothesis, it does not seem to offer significant advantage over the square sail.

It is, therefore, entirely possible that Blackfriars 1 and other sailing ships of the Romano-Celtic tradition were square-rigged, but there is some hint that they did not use the loose-footed sail known in the Mediterranean and used in Northern European waters certainly from the Viking period onwards. A second-/third-century gravestone from Jünkerath, Germany, shows a square sail with a yard and two horizontal battens running across the body of the sail (McGrail, 1987, 234-5; Ellmers, 1996, 61-63). The detail at the bottom of the sail is not shown, but the mosaic depiction from Bad Kreuznach already mentioned shows a strikingly similar sail with yard, two horizontal battens and a boom securing the foot of the sail. McGrail compares it with the Chinese lugsail and indeed the similarity is striking even down to the control lines running to the end of the yard, battens and boom.

But was it a lugsail, i.e. asymmetrically rigged on the mast, so as to act more effectively as a fore-and-aft sail (McGrail, 1987, 224)? If it were, it would certainly have the effect, when sailing on the wind, of bringing the C.E. further aft and it is when sailing on the wind that the horizontal battens of the Chinese lug come into play in controlling the aerodynamic shape of the sail, while the individual control lines enable the crew to determine that shape quite precisely. But the advantages of booms and battens are not restricted to lugsails. For a start such a sail can be reefed with comparative ease. It is also likely to be more stable in a heavy beam sea than a loose-footed square sail. The point can be appreciated by studying a photograph of the replica of the Kyrenia ship under sail in a heavy sea (Casson, 1996, 43). As she rolls - and the crewmen's stance demonstrates that she is rolling - the loose foot of the square sail is free to sway back and forth, thus increasing the tendency to roll. The only effective way of restricting this swaying movement is to secure the tack of the sail to a fixed point on the ship, for example to the end of a securely rigged spar, such as the Scandinavian *beitiass*. This would be similar to the use of a pole in modern days to secure the tack of a spinnaker, itself a notoriously unstable sail (Marchaj, 1964, 143).

Thus far, while ruling out the spritsail, theoretical considerations allow as reasonable hypotheses that the Celtic sail was either a square sail or a lugsail; neither gives perfect directional balance and it is even possible that both were in use on Romano-Celtic ships. Ultimately then we have to come back to the iconography. The Bad Kreuznach mosaic could conceivably be a representation of a lugsail, but Ellmers has suggested (1996, 62) that in other respects the mosaicist was not entirely familiar with the details of the Romano-Celtic tradition. The Jünkerath gravestone is on the other hand quite incontrovertible: the sail is symmetrically disposed about the mast and is a square sail.

This is supported by a number of Celtic depictions of ships with a yard symmetrically disposed about the mast. These include the Broighter boat (McGrail, 1987, 187) and Celtic coins (Ellmers, 1996, 68). A documentary source, admittedly late, but otherwise persuasive, corroborates the point. Adomnán in his seventh-century *Life of St Columba* (II, 45) describes sailors 'raising yards up crosswise' (*instar crucis*). It is inconceivable that a Christian writer should use the image of the cross if the yard was not horizontal and not symmetrically disposed about the mast.

The only direct indication of the material of which Celtic sails were made is Caesar's description of the ships of the Veneti (*B. Gall.* III, 13). He reports that their sails were made of leather, either because the Veneti lacked a supply of flax or, more probably, because leather was more suited to the weight of the wind in the local conditions. However, the etymology of the Celtic word for sail gives an indication that elsewhere Celtic sails may have been made of wool. If this is the case, an explanation for the boom and battens in Celtic sails may be found in the need to stabilise the sail cloth. This etymology is discussed in Appendix VII.

Ultimately it is the poor leeway performance of the Romano-Celtic ships that is the telling point. Excessive leeway, as Severin testified, will nullify any attempt to go to windward, even if with a fore-and-aft rig, as the case of the *Amy Howson* demonstrates. If, therefore, the transports of the Claudian invasion fleet were built in the Romano-Celtic tradition, then we may be confident that the Roman naval commanders would have avoided any plan which relied on achieving a passage to windward.

Chapter VIII

Fleet Numbers: How Big was the Claudian Invasion Fleet?

So far we have been considering the naval operation of A.D. 43 as though it involved only single ships. It may well have been the largest invasion campaign ever mounted against the British Isles and would have involved hundreds rather than tens of ships. In this chapter, I use the evidence of Caesar's accounts of his expeditions to Britain in the first century B.C. to make an assessment of the numbers of ships that might have been required by the invasion force of A.D. 43. In the next I consider evidence as to the size of other invasion fleets launched across the English Channel and look at the impact of fleet numbers on their management.

Caesar's report gives specific figures as to the numbers of ships used in his two expeditions. While there seem to be some inconsistencies and uncertainties, they nevertheless give a valuable insight into the order of figures involved on the one hand in a lightly equipped exploratory raid and a more serious invasion task force on the other.

In 55 B.C. Caesar assembled about 80 transports to convey two legions across the Channel; of these twelve were lost at anchor off Deal. In addition eighteen transports were reserved for the passage of an unspecified number of cavalry, who in the event failed to arrive; thirty cavalrymen sent ahead with the Atrebatian chieftain, Commius, did, however, arrive, but the number of ships involved in this vanguard is not given. The transports were escorted by the warships built the previous summer, the number of which is also unspecified, which were given over to the headquarters staff (*B. Gall.*, IV, 21-2, 35).

If one takes a legion as comprising the maximum figure of six thousand men, these figures suggest that the average capacity of the transports was 150 men. Even at a lower figure of five thousand men a legion, we are still looking at an average capacity of 125. These figures are neatly confirmed by an incident on the return voyage from the first expedition: Caesar mentions that two transports did not make the same harbour as the rest and records that about three hundred men landed from these two ships (*B. Gall.*, IV, 36-7).

The following year Caesar had available some 600 newly built transports, of which 60 were prevented by adverse weather from arriving at the port of departure, as well as 28 newly built warships. To the net figure of 540 newly built transports is to be added the figure of some 86 remaining from the previous year, after taking account of the loss of the twelve off Deal, making some 626 transports in total. In all, including 'the private vessels which individuals had built for their own convenience', the fleet numbered over 800 ships when it arrived off east Kent. In spite of the reference to private vessels, the vast majority of the 175-odd ships not classed as transports are likely to have have been warships (*B. Gall.*, IV, 31; V, 2, 5, 8).

In 54 B.C. Caesar took with him five legions, say 30,000 men, and 2,000 cavalry (*B. Gall.*, V, 8). However one works the figures, the average number of legionaries per transport was considerably less than the previous year, 52 if the cavalry transports could each accommodate forty cavalrymen and their horses and 70 if the number of cavalrymen per transport were reduced to ten. Only if the number of cavalrymen per transport were as low as five, would the number of legionaries per transport reach anything like the levels of the previous year at 133. But that would imply that the previous year, Caesar had planned to take only 90 cavalry in the eighteen transports reserved for them.

The discussion thus far would indicate that the number of men per ship for Caesar's expeditions might be between 50 and 150. Bearing in mind that the size and capacity of the ships involved might not be much different from that of the Roman transports, Viking evidence also suggests a similar range of men per ship of 30 to 100, but depending on the nature of the expedition (Griffith, 1995, 126). If, however, we can determine more closely the likely number of horses that could be accommodated per cavalry transport, we might be able to arrive at a more precise estimate for the number of infantrymen per transport in Caesar's expeditions. The literature on the transport of horses and indeed of other animals by sea, particularly in the Roman period, is sparse. McGrail has six references (1987, 70; 143; 170; 184; 201; 268-9), most of which seem to relate to inland waters, while Davis in his study of medieval warhorses (1989) does not discuss the question of their transport by sea at all. However, there is a useful study of the transport of horses by sea during the Crusades (Pryor, 1968).

Horses need special arrangements, not only for accommodating them on board ship, but also for loading and unloading them:

> As anyone will realise who has seen a horse being loaded into a horse-box, horses are very fragile, and their transportation presents great difficulties. Further, it is not easy to carry animals in a rough sea without their suffering injury (Waley, 1954, 121).

Waley sees the ability to transport horses as 'an important technological factor in warfare up the nineteenth century' and argues that the Normans in their eleventh-century operations in Sicily and ultimately in the invasion of England in 1066 were drawing on the expertise of the Byzantine Empire and through it that of the ancient world (Waley, 1954, 121-5). And of course, if Caesar had needed special expertise to transport his cavalry, he could well have tapped this ancient Mediterranean source direct.

However, Waley's argument that there was a special Byzantine, ultimately Mediterranean, tradition of expertise in the transport of horses by sea is not conclusive. While he argues for the existence of a class of specially designed horse transports, he accepts that at the time he is discussing (eleventh century A.D.) there were probably very few of them and he therefore concedes that the hypothetical Byzantine expertise in the transport of horses included the adaptation and use of such ships as the Normans found in south Italy. Gillmor effectively destroyed the idea of a special Byzantine expertise, both by refuting the force of the documentary evidence advanced by Waley and by pointing to records of the transport of horses by sea by Vikings in the ninth century (Gillmor, 1985, 111-4; Griffith, 1995, 93-4). Waley undermines the credibility of his arguments by stating that, *inter alia*, the twelfth century saw the introduction into northern waters of a number of Mediterranean features, including the quarter rudder (Waley, 1954, 125; Gillmor, 1985; 113).

In fact, the idea that the capability of transporting horses by sea involved a high order of technological expertise is overstated and certainly there is no need to postulate a specific specialist ship-building tradition. Once cargo ships of adequate size are available, the requirements are six, three of which are stated by Gillmor:

> The south Italians could have adapted northern ships to accommodate horses, especially with the construction of boarding ramps as in the Mediterranean; the insertion of flooring to provide a level place for the horses to stand; the construction of stalls to prevent the horses from colliding into each other during the voyage (1985, 114).

In specifying a need for ramps, Gillmor is being too specific. Certainly a means must be available to embark and disembark the horses and a ramp will obviously serve. But other means can be found. In the Mediterranean, ports in the stern of the ship were used in conjunction with ramps to allow knights to ride straight out of the body of the ship onto the beach (Pryor, 1962, 17, 21-2, 103). The ships involved were oared transports and were designed to back onto the beach to allow the landing. However, this specifically met the needs of medieval warfare and the central part played in it by the mounted knight. For the Romans, whose legionaries would be charged with seizing the beachhead on foot, the disembarkation of horses would be a secondary priority and could be achieved, for example, by hoisting them out one by one with a derrick mounted on the mast and lowering them to the beach or into the water, a method practised in the sixteenth century by the Spanish, shipping horses out to the New World (Hyland, 1998, 192), and advised in the early twentieth-century War Office *Handbook of Animal Management* (Peddie, 1997, 38).

To the requirements stated by Gillmor should be added the preservation of stability, because the weight of the horses standing is likely to be added high in the ship. While the weight of a horse might be taken as half a tonne or so, a matter for consideration is that its centre of gravity will be at a height of the order of 1.5 metres above the floor on which it is standing.

The next requirement is a reasonably smooth or moderate sea for the crossing, to avoid frightening the horses or making them seasick! Lastly, fodder and water must be carried. In 1123 a Venetian fleet transporting horses direct to the Levant is reported to have needed to land every day to water the horses (Pryor, 1962, 15), a report that Pryor allows may well have been true. This is a factor which the Roman Naval Staff must have taken into account in A.D. 43, especially if contemplating the long haul along the south coast.

The essentially practical question of adapting an existing design has been considered from the point of view of naval architecture in relation to the Athenian trireme, known to have been converted to carry 30 horses, with their grooms and riders (Morrison and Coates, 1986, 226-8). Morrison and Coates's hypothetical conversion was achieved by removing two banks of oars and installing precisely the features cited by Gillmor. Scaling from the published plan it would appear that Morrison and Coates allowed each horse a stall measuring 0.8 by 2.2 metres, dimensions which would coincide with those offered by a modern horse box and which are close to those specified for the transport of horses by the statutes of Marseilles of 1253 (Pryor, 1962, 106).

In any conversion stability would be an issue. A key measure of stability is the metacentric height (Fig. 17; McGrail, 1987, 14; Morrison and Coates, 1986, 195, 240; Marsden, 1994, 89, 193-4, 216). This is defined as the distance between centre of gravity and the metacentre (basically the point on the vertical centre line of the hull through which the centre of buoyancy acts). For a ship to be stable, it is not necessary for the centre of gravity to be below the centre of buoyancy (indeed Fig. 17 shows it above the centre of buoyancy), but it must be below the metacentre.

Fully loaded, Morrison and Coates's converted trireme would weigh some eight tonnes more than a standard trireme with a full complement of oarsmen. The centre of gravity would be 16 centimetres higher, but in the converted trireme the metacentre would also rise, preserving satisfactory stability. In the converted trireme the rise in the metacentre results from the flare of the hull at the waterline. The question is whether a similar movement in the metacentre would adequately preserve stability in ships of other traditions. Marsden's work on the theoretical stability of Blackfriars 1 (1994, 89-91, 193-9) offers the opportunity of investigation. He offers worked examples of the metacentric height for Blackfriars 1 based on different cargoes:

cargo	displacement tonnes	C.G. of cargo metres	GM_T metres	GM_T/Beam %
empty	32.70	N/A	0.76	12
wine	48.00	0.84	0.99	16
grain	51.00	0.84	1.01	16
ragstone	69.10	0.84	1.14	18
stone (part load)	58.70	0.92	1.11	18

(GM_T = metacentric height; C.G. = Centre of Gravity.)

All these figures for the metacentric height, being positive, give a good measure of stability; negative figures for GM_T would indicate an unstable hull, i.e. that the metacentre was below the centre of gravity. The figures for the metacentric height as a percentage of the beam provide a comparative measure. Marsden notes that for large modern powered ships a figure of no more than 3-4% would be regarded as appropriate, but that for sailing ships a higher percentage would be required to counter the heeling forces of the sails (1994, 193-4). More research is required into this aspect of the stability of ancient ships, but the percentages listed seem plausible.

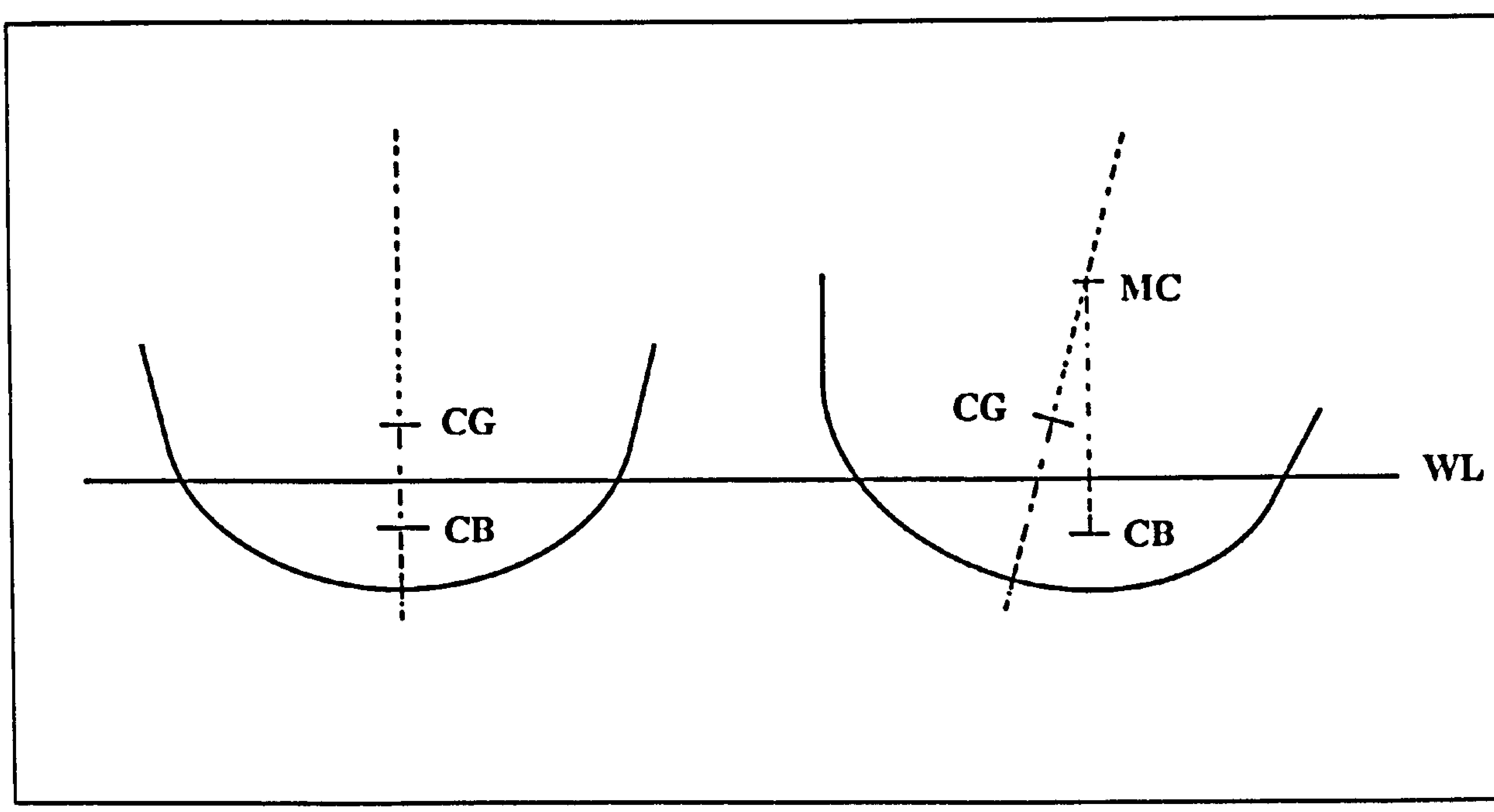


Fig. 17 The metacentric height: C.G. = Centre of Gravity; C.B. = Centre of Buoyancy; M.C. = Metacentre. The metacentric height (GM_T) is the distance between the Centre of Gravity and the Metacentre; as long as the M.C. is above the C.G. the vessel will recover from heeling.

Assuming that ten cavalrymen and their horses, together with their gear, would weigh up to ten tonnes and that one should allow a centre of gravity for the cargo of 1.5 metres, higher than the figure used by Marsden (see table above), then a reworking of his formula gives a metacentric height of 0.75 metres and a figure of 12% for the metacentric height as a percentage of the beam, at the lower end of the range of figures worked by Marsden, but still giving very adequate stability. The metacentric height with a centre of gravity of the cargo at 1.5 metres is relatively insensitive to additions to the cargo weight, being 0.79 metres for an assumed cargo weight of 20 tonnes and 0.74 metres for 30 tonnes (see Appendix VIII). Increasing the height of the centre of gravity of the cargo does reduce the metacentric height, without, however, bringing the vessel to the point of instability. An assumed height for the centre of gravity of 2.0 metres has the following effect on the metacentric height:

Cargo weight tonnes	displacement tonnes	C.G. of cargo metres	GM_T metres	GM_T/Beam %
10	42.70	2.0	0.63	10
20	52.70	2.0	0.60	9
30	62.70	2.0	0.50	8

(The calculations are shown in detail in the Appendix VIII.)

Of course the figures of 20 and 30 tonnes are purely hypothetical, chosen to demonstrate the effect that they would have on the stability of the vessel, but it is important to note that they do encompass the possibility of more than ten horses on Blackfriars 1. Morrison and Coates's hypothetical conversion of a surplus trireme as a horse transport provided for 30 horses on a length of some 35 metres, with a beam of rather less than 9 metres. By contrast, Blackfriars 1 offered a length of *c.* 18.5 metres and a beam of *c.* 6.12 metres (Marsden, 1994, 56, 89). Within these parameters, Marsden postulates a hold of at least 4.6 metres wide up to a maximum of 6.68 metres long (1994, 60). Because of the uncertainty of these figures, Marsden adopts for his own capacity calculations a hold length of 5.7 metres. Assuming that a clear space athwartships of at least four metres was available, these figures would indicate that a cargo ship in the Romano-Celtic tradition of the size of Blackfriars 1 could certainly safely transport a minimum of ten horses and perhaps as many as fifteen, facing fore-and-aft in the hold and five abreast (i.e. requiring for ten horses a space of 4 times 4.4 metres and 4 times 6.6 metres for fifteen).

Some experimental work has been done on the horse-carrying potential of ships of the Nordic tradition, but perhaps without instilling much confidence as to the conclusions. Danish sea scouts built a replica of the Ladby ship and in 1967 an experiment was conducted with the embarkation and disembarkation of horses (Greenhill with Morrison, 1995, 199). This experiment was inspired, it seems, by a supposed resemblance of the Ladby ship to the ships depicted in the Bayeux Tapestry as carrying horses. Greenhill states that the experiment was completely successful, but adds the qualification 'on the shallow, sheltered, non tidal coasts of the Danish islands'. The published photograph (Greenhill with Morrison, 1995, 198; Vadstrup, 1986, 85) provides no basis for believing that the experiment would have proved equally successful if it had involved an open-sea crossing (Gillmor, 1985, 110; 1996, 119). Five horses are shown as involved, but the ship shows no adaptation, no provision of stalls to accommodate the horses and the low freeboard gives no confidence that frightened horses might not destabilise the ship. As Gillmor says:

> The roll and pitch of the sea would undoubtedly have thrown the horses overboard because of the low freeboard which would reach only to the knees of most horses (Gillmor, 1985, 110; 1996, 119).

Crumlin-Pedersen sees this as a virtue. Discussing Skuldelev 5, he says:

> Horses could jump the low gunwale and thus be landed with ease (1972, 184).

A point of interest is that the photograph of the Ladby trial shows a line running ashore from the masthead. Such a line can have only two purposes: to keep a deep-keeled ship upright against a wall as the tide goes out (not the case here); or to pull a ship onto or towards her beam ends for some reason. In fact the photograph shows that the ship was not upright when it was taken and one may assume that this was to allow the horses more easily to step over the gunwale, low though the freeboard may have been.

But both Skuldelev 5 and the Ladby ship are more to be seen as warships; they would not appear to match the criteria proposed by McGrail for specialised cargo vessels (1987, 201-2) and we may be looking in the wrong place.

McGrail discusses load-carrying data from ten selected vessels from north-west Europe spanning some 3,000 years (1987, 199-201). These include three from the late Nordic age, Graveney, Skuldelev 1 and Skuldelev 3, all of them recognised as trading vessels. It is important to take on board the reservations that McGrail expresses about the data he publishes; he stresses that the estimates of gross deadweight (basically weight of crew and cargo as distinct from the weight of the ship) were obtained by different methods and using different assumptions. Nevertheless, some comparisons may be made:

Ship	**Gross Deadweight (tonnes)**	**Depth (metres)**
Graveney	6 or 7	1.0
Skuldelev 3	4.6	1.4
Skuldelev 1	24.0	2.1
Blackfriars 1	18.3 to 66.7	2.86

(Sources: McGrail, 1987, 200; Marsden, 1994, 193-4. McGrail defines depth as depth from sheer to keel at the position of maximum beam. For Blackfriars 1 depth is taken as the sum of draft and freeboard in Marsden's Table 17.)

Unfortunately McGrail points out that it has not been established in all cases that the ships he lists would have adequate transverse stability when loaded as shown in his table. Nevertheless, one may draw certain tentative inferences. Bearing in mind that the construction of an adequate floor inside the hull will reduce the depth of the hold within which the animals would stand, one might conclude that hulls to the general dimensions of Graveney and Skuldelev 3 could not adequately be converted to the carriage of horses, except possibly for relatively short passages in sheltered waters. Under such circumstances transverse stability might not be at risk and the comparison might be made with inland ferries with animals penned with hurdles (McGrail, 1987, 143). Moreover the gross deadweight for these vessels, bearing in mind that it includes the crew and their provisions, suggests that the number of horses that could be carried would be limited. The size postulated for the hold of these vessels points also to the same conclusion:

Ship	Length of hold (metres)	Beam (metres)
Graveney	5.2?	4.0
Skuldelev 3	3.7	3.3
Skuldelev 1	5.5	4.6
(McGrail, 1987, 200; 203)		

Since useable athwartships space must be rather less than maximum beam one might assume that Graveney would allow perhaps three metres and Skuldelev 3 some two and a half metres across the beam of the hull to accommodate horses. Taking the horse box figures of 2.2 times 0.8 metres used above, this implies that within Graveney one might be able to stall six horses, either in one row fore and aft (2.2 times 4.8 metres) or in two rows athwartships (2.4 times 4.4 metres). As for Skuldelev 3 one row only could be accommodated - fore and aft (2.2 times 3.2 metres). In either case the number of horses, four in the case of Skuldelev 3 (say two tonnes) and six for Graveney (say three tonnes), would be within the deadweight limits shown by McGrail. It is to be noted here that, unlike the case of Morrison and Coates's trireme conversion, the adaptation of these ships to the transportation of horses would not increase their loaded displacement and therefore move the centre of buoyancy and thus the metacentre upwards, but it is likely that as with the trireme the centre of gravity will move upwards thus reducing the metacentric distance (GM_T) and thereby adversely affecting the transverse stability. This would undoubtedly increase the tenderness of the ship and might go so far as to render her unstable.

> A small GM_T means a weak righting moment; a boat in this condition is said to be *tender* or *crank*, and will be slow to return upright and may become unstable at large angles of heel or loads (McGrail, 1987, 15).

Moreover, given the relatively low depth of these hulls, the likelihood is that horses might well seriously impede the proper management of the ship, particularly under sail. All in all then, whilst one cannot say outright that adaptations of ships built following lines similar to Graveney and Skuldelev 3 to carry horses would be impracticable, the probability is that such a vessel would be difficult to manage, particularly under sail, and may well have been unstable to the point of capsize in open-sea conditions.

Skuldelev 1 is a more promising candidate. Following our horse box model a hull built to the dimensions of this ship could accommodate eight horses in two rows running athwartships (3.2 by 4.4 metres) and their weight, say four tonnes, is well within the quoted deadweight, leaving a considerable margin for riders and gear. Given the greater depth of the hull, one may be confident that horses could be stalled well down in the hull and would not impede the management of the ship. Moreover one may postulate that, precisely because of this greater depth, allied to the greater displacement of the hull, horses would not have a significant effect on the position of the metacentric distance and therefore on the ship's transverse stability.

From this we can conclude that for serious open-sea transport of horses in the Nordic tradition we may look to the *knarr*, the 'Ocean-Going Cargo Ship' (Jørgensen, 1992, 13). In terms of her dimensions Skuldelev 1 is closer to Blackfriars 1 than to her Nordic sisters. At 29.7 tonnes Blackfriars 1 is of course considerably heavier than Skuldelev 1 at 10 tonnes (Marsden, 1994, 89, 194; McGrail, 1987, 198, 200), a difference resulting from the different method of hull construction, edge-to-edge, as opposed to clinker planking as discussed in Chapter IV (34-5). But the overall length, beam and depth of the two ships are relatively close:

Ship	Overall Length (metres)	Beam (metres)	Depth (metres)
Graveney	13.5	4.0	1.0
Skuldelev 3	13.3	3.3	1.4
Skuldelev 1	16.5	4.6	2.1
Blackfriars 1	18.5	6.12	2.86

(McGrail, 1987, 198; 200; Marsden, 1994, 89).

In either tradition, then, for the serious open-sea carriage of horses one is looking for substantial beamy craft with good depth. As far as ships in the Romano-Celtic tradition are concerned, this would mean ships at least of the size of Blackfriars 1, affording a carrying capacity of perhaps ten, but certainly no more than fifteen, horses each with their cavalrymen and gear. Some indication that these figures might be in the right range is given by Pryor: while for thirteenth and fourteenth centuries, at a time when the maritime states of the Mediterranean were responding in their ship design to the increasing demands of the Crusaders, his sources record loadings per ship of forty horses or more, the earliest record he quotes is of a fleet put together by the emperor Constantine V carrying no more than twelve horses per ship (Pryor, 1962, 9, 12, 19-20, 24).

If we apply these figures of ten to fifteen horses per ship to the calculations we were making a few pages back about the number of infantrymen per ship, it begins to appear that for Caesar's second expedition each infantry transport carried 60 to 70 men. These figures assume a maximum of six thousand men in a legion and clearly would be lower if the legion were smaller, for example 50 to 60 men per transport for a legion of five thousand men. The detail, which assumes 626 ships available, is as follows:

Cavalry	No. of men (and horses)	2,000	2,000
	No. per ship	15	10
	Ships needed	133	200
Infantry	Ships available	493	426
	No. of men	30,000	30,000
	No. per ship	61	70

If we compare these figures with that of up to 150 men per ship for Caesar's first expedition, we are inevitably drawn to the conclusion that there is a real and significant difference between the two expeditions. A further indication of the lower number of legionaries per transport in 54 B.C. is given by the details of Caesar's return from Britain that year, when in addition to the legionaries, he brought back 'a large number of prisoners'. This, together with the fact that he had again lost ships at anchor in a storm, some forty in number, determined him to make the passage back in two waves. Although no ship carrying troops was lost in either year, very few of the returning empty ships or of the sixty replacement ships built for him in Gaul after the storm made it to Britain for the second crossing. Caesar, therefore, crammed his troops into the few ships available to him, perhaps reaching or exceeding the loading of the previous year. To do so he may well have been compelled to abandon much heavy equipment.

In fact, the probability is that the undertaking in 54 B.C. was a much more serious affair than that of 55 B.C., involving significantly more back-up in terms of supplies and resources than that of the previous year. In specifying the design of the new ships he commissioned for the expedition of 54 B.C., Caesar mentions the need to accommodate cargo and numerous draft-animals, which had not been taken the previous year, when the legionaries had been travelling light (*B. Gall.*, IV, 30; V, 1).

The conclusions that we can draw can be applied to any Roman invasion fleet in northern waters at the turn of the millennium. We may assume that they applied to Aulus Plautius's fleet.

They are:

1. While a lightly equipped expeditionary force might be accommodated within a loading of up to 150 men per ship, a loading of 60 to 70 men per ship seems more likely for a fully equipped invasion army.

2. Cavalry would require one (suitably adapted or designed) transport for every ten to fifteen horses.

3. Warships would be required to provide catapult and other artillery cover for the landing in the way described by Caesar. While these vessels would be rigged with sail, their main means of propulsion, particularly in battle, would be oars.

4. The number of warships required would obviously depend on the assessment of the invasion commander, but if the figures given by Caesar for his second expedition are any guide, it is possible that the warships made up at least 20% of an invasion fleet, i.e. there was one warship for every four transports.

Academic consensus is that Plautius's invasion force consisted of four legions, *II Augusta, IX Hispana, XIV Gemina* and *XX Valeria Victrix*, but the evidence is circumstantial (Frere, 1987, 48, 77-8; Salway, 1998, 73-5). Salway suggests an invasion force of about 40,000 men, on the basis of a legion of 5,000 men and an equivalent number of auxiliaries. Frere identifies the auxiliary units which 'are attested in Britain before AD 70 and so were probably part of the expeditionary force'. The units he mentions I would estimate to amount to 6,000 infantrymen and 1,500 cavalrymen. Taking the legion at the higher figure of 6,000 men, we arrive at a total invasion force of 30,000 infantrymen and 1,500 cavalrymen.

Undoubtedly, however, the evidence considered by Frere did not identify all the auxiliary units. Therefore it would be reasonable to take 35,000 as a minimum figure for the invasion force, to bracket with Salway's 40,000. At the same time one needs to take account of between 1,500 and 2,000 cavalry, which might be within the overall figures of 35,000 - 40,000.

These figures point to a requirement of 580 to 830 transports, together with 145 to 210 warships, if the invasion force was to cross at the same time; the total fleet would be some 725 to 1,040 ships.

The detailed calculation is:

Cavalry					
	No. of men (and horses)	No. per ship	No. of ships		
	1,500	15	100	**100**	
	2,000	10	200		**200**
Infantry					
	No. of men	No. per ship	No. of ships		
	33,500	70	479	**479**	
	38,000	60	633		**633**
	Minimum no. of transports			**579**	
		Maximum no. of transports			**833**
	No. of warships @ 1 in 5			**145**	**208**
	Minimum Fleet Size			**724**	
		Maximum Fleet Size			**1,041**

Using a different methodology, Peddie arrives at a very similar estimate for the size of the fleet (1997, 40-1). Making a separate estimate of the number of ships required to meet the logistical needs of the invading force - draft animals, carts, heavy artillery and rations, including grain - he calculates a total requirement for 933 ships, but adds that 'the final figure would probably have been nearer 1,000'.

There are two factors which point to an even larger requirement of ships. The first is that it is known that the invasion force included an unspecified number of elephants. Although these are mentioned in the context of Claudius's arrival to take charge of the invasion, the wording seems to imply that they were already part of the original invasion force (Dio, LX, 21). It may be taken for granted that there were fewer than ten elephants in each ship allocated to them. The second factor arises from the archaeological evidence of a contemporary bridgehead at Richborough. If the invasion force, or part of it, did indeed land at Richborough and if the archaeological reconstructions are correct in showing that the ditches and ramparts thrown up were surmounted by a palisade, it seems more than a possibility that the timber required for this urgently needed construction would have been prepared in advance and imported with the invasion force.

At this point the implications of a fleet of this size are worth considering. The first point is that while Caesar could land his troops from his fleet of 800 ships on the broad front offered by the open beach in the area north of Deal, any attempt to manoeuvre a fleet of that size through the relatively narrow approach channel to Richborough would have caused, to put it mildly, some excitement, particularly if the landing was opposed. The same goes for the narrow entrance to Chichester Harbour. In fact if the landing were opposed, it would have been impossible for the warships to manoeuvre effectively to cover the landing. At once we have a possible answer to two questions: why Caesar landed on the open shore; and why Plautius divided his invasion army into three for the crossing.

The second is that if the division was in three waves, rather than to three different disembarkation points, then only a third of the number of ships would be required, say 240 to 350. In spite of the evidence from Caesar of the Romans' ability within a minimum timescale to muster and to build large numbers of ships, this would have huge implications for the resource requirements of the operation.

Chapter IX

Fleet Operations: the significance of numbers

Drawing from contemporary sources (Whittle, 1689, 31-2; de Rapin-Thoyras, 1743, 776-7) for a description of the passage of the fleet of William of Orange through the Dover Strait in 1688, Macaulay offers a picturesque vignette:

> Soon after midday he passed the Straits. His fleet spread to within a league of Dover on the north and of Calais on the south. The men of war on the extreme right and left saluted both fortresses at once. The troops appeared under arms on the decks. The flourish of trumpets, the clash of cymbals, and the rolling of drums were distinctly heard at once on the English and French shores. An innumerable company of gazers blackened the white beach of Kent. Another mighty multitude covered the coast of Picardy (Macaulay, 1883, 564).

In English and American usage a league was taken as three nautical miles (Webster, 1862, 654; Funk, 1903, 1012). The rhumb line distance between Dover and Cap Gris Nez is some 17 nautical miles. Macaulay is therefore describing a fleet advancing in line abreast over a front of some eleven nautical miles.

However, it is not simply the sheer size of an invasion fleet that is impressive, nor the length of a line-abreast formation, such as William's. The numbers of ships and men involved in serious cross-Channel operations would have had a considerable significance for the way those operations could be managed. Embarking and disembarking men - and horses and stores - took time and would be seriously hampered if adequate shore-side room was not available; the manoeuvres required to leave and enter harbour would be more complex and more time-consuming than for single-ship operations; propulsion by sail requires that fleets adopt specific formations for efficient passage-making which will impose limitations on speed.

Fleet Sizes

The exact size of William's fleet is unknown. Macaulay (1883, 563) states that there were more than fifty men of war in a total fleet in excess of 600 vessels. De Rapin-Thoyras counts a total of 500 ships, including 50 men of war, 25 frigates and 25 fire ships (1745, 776). Dalrymple's estimate of the fleet amounts to some 635 vessels, including 65 ships of war (1771, 154); he adds that only 12 warships were left behind for the defence of the Netherlands. A fleet in excess of 600 vessels for the size of the invasion force seems a considerable overstatement, but it is not out of the question. A fleet of 600 vessels advancing in line abreast in a single rank over eleven nautical miles would be spaced at average intervals of 112 feet, perhaps twice or three times the average beam. More significantly it is a gap approaching the length of the main yard. Data on frigates of the second half of the eighteenth century indicate an average beam approaching 40 feet and an average main yard of some 75 feet (Gardiner, 1992, 58-9, 88-9). Even more critically, a gap of this order would not be great enough to allow an alteration of course into line ahead.

Of course the problem of spacing would be alleviated by sailing in line abreast in more than one rank. But we show below that in fleet operations under sail there are likely to be decreases in efficiency as the number of ranks is multiplied.

We have more information about the size of the Armada of 1588 (Rodríguez-Salgado, 1988A, 31, 36; Rodríguez-Salgado et al., 1988, 154-5). On the 15th July 1588 the fleet mustered 138 ships and some 17,000 soldiers. This may itself give an indication of the improbability of the figures for the Dutch fleet, which was transporting some 14,000 to 16,000 soldiers, much the same figure (de Rapin-Thoyras, 1743, 776; Dalrymple, 1771, 154). Even allowing for the possibility that on average the Dutch ships were considerably smaller than the great galleons of the Armada, a figure of around 600 vessels for the Dutch fleet does seem excessive.

The sources have wildly different figures for the size of the Norman fleet of 1066. One can discount the figure of 3,000 ships reported by William of Jumièges, and even more so that of 11,000 given by Gaimar (Gillmor, 1985, 106; 1996, 114-15). More serious estimates seem to focus on 700 ships. Wace gives the figure of 696 ships sailing from St Valéry, 'whether ships, boats or skiffs', as one he had heard from his father when he was a young man, while *The Ship List of William the Conqueror* (MS Oxford Bodl. Lib E Museo 93 fo. 8v) lists quotas, totalling 776, of the numbers of ships 'owed him as of right' by various magnates (van Houts, 1988, 159-81). van Houts advances a strong case for recognising *The Ship List* as a contemporary document and accounts for the discrepancy between it and Wace's figure by pointing out that the one is the record of quotas of ships and the other the number that actually sailed. Wace's report is very specific: unusually for a medieval chronicler he names his source, although his father was scarcely an eyewitness, since Wace was born in 1120.

Even so, allowing for the fact that Wace's figure included small craft, 700 as an approximate figure may seem excessive, if we are to give credence to a Norman army of as few as 7,000 to 8,000 fighting men at the Battle of Hastings (Abels, 1996, 74). The sources report that William left garrisons at Pevensey, to protect the fleet, and at Hastings (*Gest. Guil.*, 9; *Carmen*, 141-2). Assuming a total invasion force of 10,000 men, this still gives an average loading of only 15 men per ship, seemingly low, even allowing for the fact that a number would have been horse transports. Nevertheless any reasonable estimate must involve a fleet of hundreds of ships.

We have no information at all about the size of the fleet involved in Constantius Chlorus's invasion of Britain in A.D. 296. But Caesar gives very specific information on the number of ships involved in his expeditions of 55 and 54 B.C. In 55 B.C. he sailed with 80 transports and an unspecified number of warships, while the following year he arrived off east Kent with over 800 vessels, including 626 transports (*B. Gall.*, IV, 22, 31; V, 2, 5, 8). Starting from Caesar's figures, we have made our own estimate in Chapter VIII that the Claudian invasion fleet might have numbered between 725 and 1,040, always supposing that the whole invasion force was transported at the same time. Such an order of numbers for a major Roman naval operation in northern waters is corroborated by Tacitus's report that Germanicus had 1,000 ships built for his expedition to northern Germany in A.D. 15 (*Ann.*, II, 4).

That these cross-Channel naval operations should involve fleets running to several hundred vessels is also confirmed by figures quoted in ninth-century sources for the fleets used by Viking armies. These figures have often been seen to result from monastic exaggeration and, allied with such claims, it has been thought that Viking armies in western Europe in the late ninth century numbered hundreds, rather than thousands, of men. However, Brooks has argued for the authenticity of the figures both on the grounds that the military operations attributed to such armies would be beyond small bands of hundreds of men and on the grounds that independent sources, Anglo-Saxon, Frankish and even Muslim, tend to agree on the range of figures given for fleet sizes (Brooks, 1979, 5-11).

Fleet Manoeuvres

There are two basic formations available to a fleet under sail, line abreast and line ahead. The formation adopted will depend in large measure on the wind direction.

Consider first a ship running before a favourable wind. Downwind, i.e. directly ahead, she will have a zone of turbulent air, a 'dead wind cone' (Marchaj, 1964, 391-5). Within this zone the sails of other vessels will not draw efficiently and their water speed will fall. Indeed, since they fall within this zone the sails on the forward masts of a multi-masted ship will not draw and her own speed will fall in consequence. Marchaj states that the influence of the zone extends up to 'ten boat lengths'.

In the case of a single ship, the sailing master may choose to come slightly on to the wind so as to fill his forward sails. While taking him off his direct downwind course, his water speed will increase and he can later correct his course by bringing the wind onto the other quarter. This tactic is known as 'tacking downwind' (Quarrie, 1982, 113-14, 152).

A fleet running downwind advances most advantageously in line abreast (Fig. 18). In such a formation no ship will interfere with the sails of any other. The fleet can advance in this formation in more than one rank, provided the gap between the ranks is sufficiently wide for the sails of the ships in the front ranks not to be blanketed by the sails of the following ranks. A modification of a line abreast formation was adopted by the Spanish Armada as it sailed up the Channel (Padfield, 1988, 104, 107, 122, 125). More than one rank was involved in this case, particularly in the centre of the fleet, where three ranks of warships covered further ranks of dispatch vessels and store hulks. The line abreast of the Armada was curved, with the divisions to both port and starboard trailing behind the centre to produce a crescent-shaped formation.

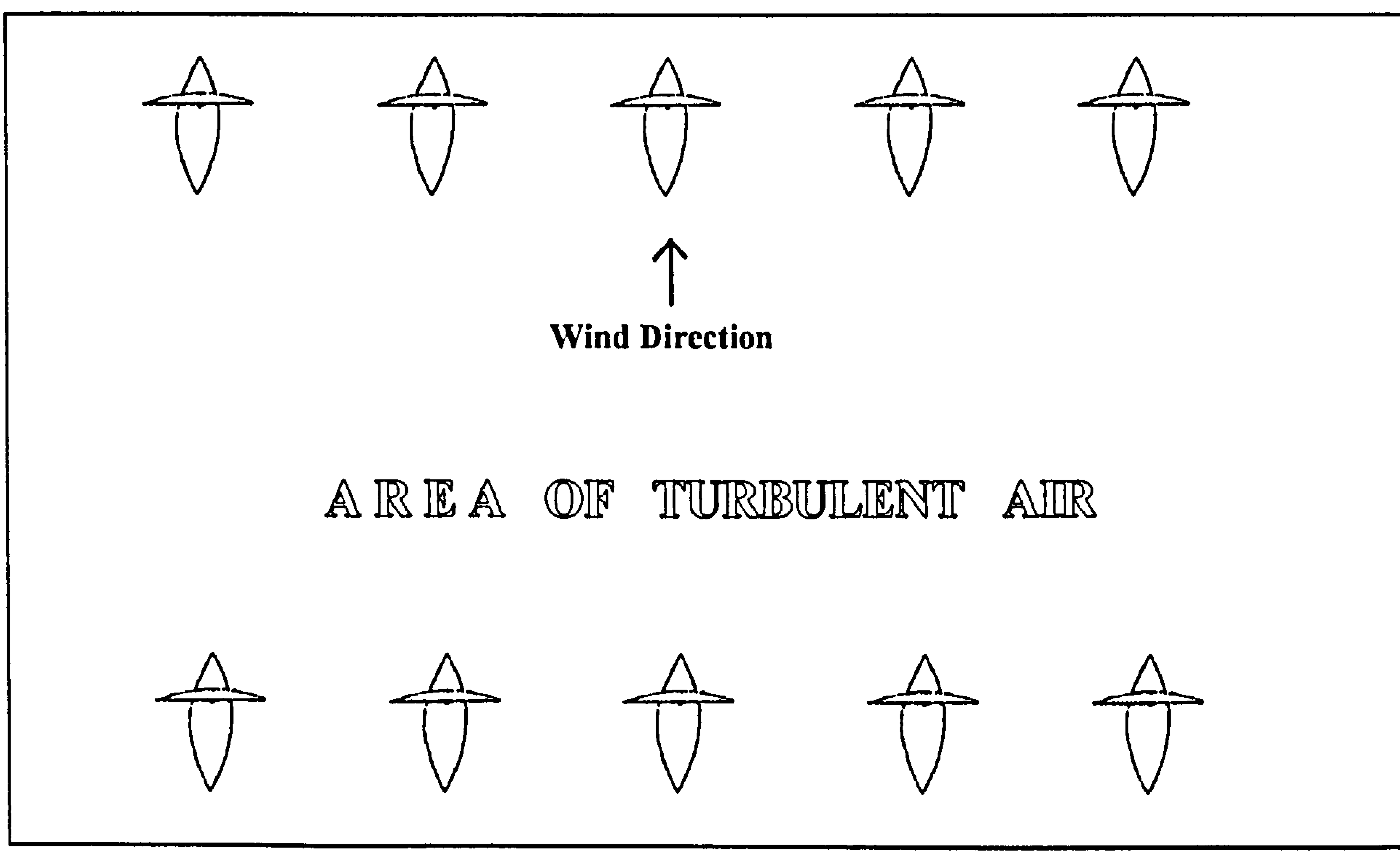


Fig. 18 A fleet running downwind in two ranks. The ranks must be far enough apart for the turbulent air from the sails of the second rank not to affect the sails of the front rank. Each ship must be far enough away from her neighbour on each side to be able to alter course onto a beam reach without colliding with her.

The interaction between a ship close-hauled and the air streams flowing over its sails is more complex (Marchaj, 1964, 388-92). The 'dead wind cone' is still to be discerned, effectively downwind of the sails, but in addition the flow of the air from luff to leach over the sails has the effect of changing the wind direction and speed in the immediate vicinity. This will most disadvantage another sailing ship following close behind. If, rather than being close-hauled, the ship has a beam wind, these deleterious effects are most to be experienced on her leeward side.

Thus a fleet with a beam wind sails most efficiently in line ahead (Fig. 19). The zone of turbulent air is now to the leeward of the advancing ships and again there is no interference between the sails of any one ship and another. Again ships can be arranged in more than one file, provided there is sufficient room between the files to prevent the airflow off the sails of one file disturbing the airflow onto the sails of the file to leeward. If the fleet comes close-hauled, then the most efficient formation would put each succeeding ship somewhat to windward of the line being followed by the ship ahead, i.e. the former would be on the latter's weather quarter.

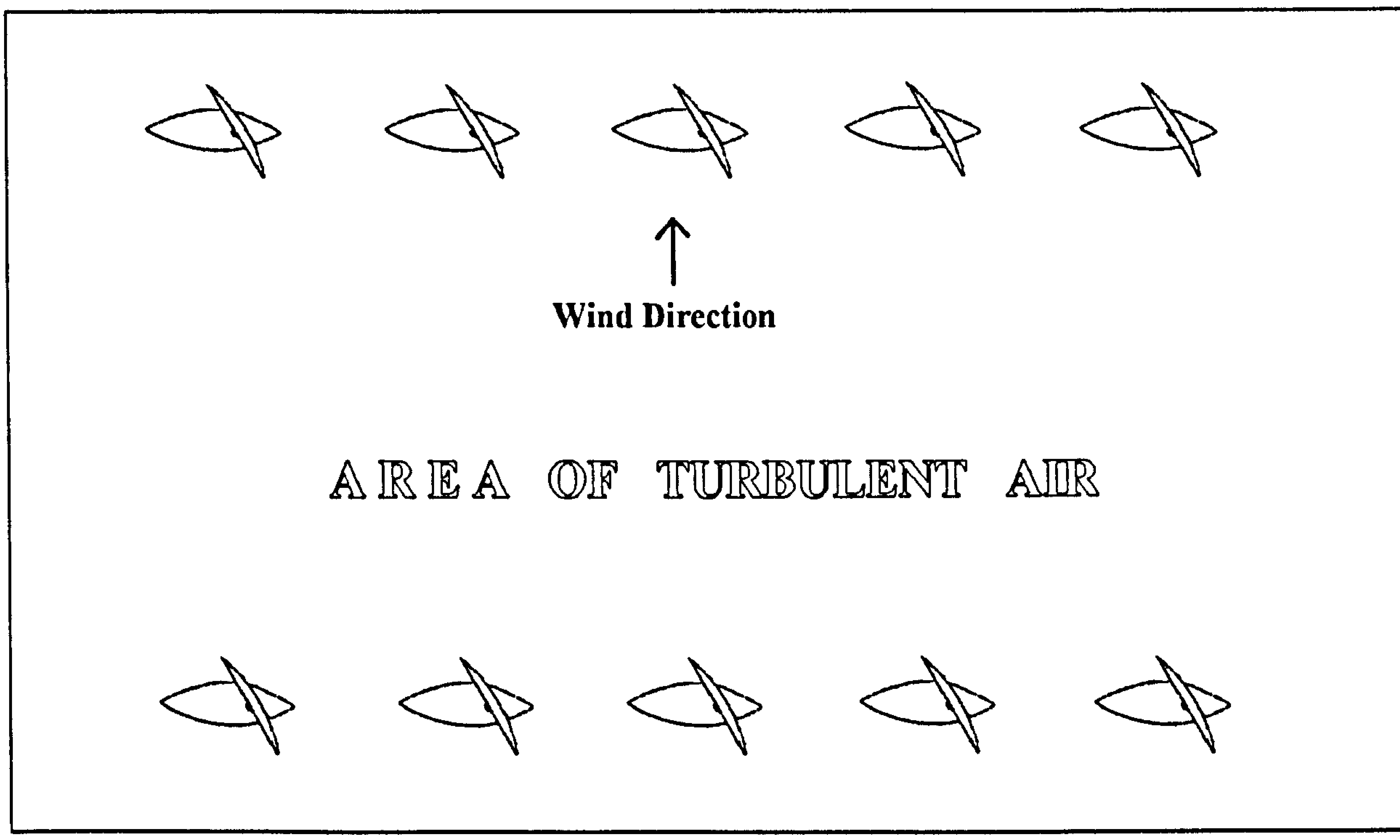


Fig. 19 The fleet has now hardened up onto a beam reach in line ahead. As in Fig. 18, the files must be far enough apart to ensure that the foul wind from the sails of the windward file does not affect the airflow over the sails of leeward file.

Keeping formation in this way demands discipline, not least in adjusting water speed so as to keep station. But providing station is maintained, the fleet can alter course as one and automatically assume the required formation for the new wind direction.

This imposes two requirements which will affect the total area covered by the fleet:

1. The distance between ranks/files must be sufficient to prevent the sails of one blanketing the sails of another immediately to leeward.

2. The distance between ships in each rank/file must be sufficient to allow each ship to come from line abreast to line ahead without interfering with one another.

These figures must depend on the general size of the ships involved, but as a general guide I would suggest that we are looking at figures in the order of one to two and a half cables (200 to 500 yards) for the first and two hundred to five hundred feet for the second.

Fleet Speeds

It is generally held that fleet speeds are lower than single-ship speeds. Neumann, drawing on data from Casson and an estimate suggested to him by McGrail (Casson, 1971, 271-8, 292-6, Neumann, 1989, 232-3), adopts ratios of 'fleet-speed-to-single-ship-speed' in the range of ½ and 7/10. However, we do need to define terms. The ratio as applied by Neumann is that actually achieved by a fleet to that of the maximum displacement speed of a defined size of single ship, in other words a ratio of actual to potential. In that sense, of course, the average speed actually achieved by a single ship on a single voyage is likely to be less than its maximum displacement speed, if only because of the vagaries of the wind. We also need to note that the definition as applied by Neumann is that of water speed, even if he does confuse it with ground speed (Neumann, 1989, 233, 239-40).

In fact to have any meaning we must be saying that a fleet will sail more slowly through the water than the individual ships comprising the fleet would sail on their own in identical conditions of wind and weather. This will be the inevitable result of the determination of the commander-in-chief to keep the fleet together in good formation (Seán McGrail, pers. comm.). To do so he will sail his flagship at less than the maximum possible speed to ensure that the individual ships can maintain strict formation with him.

While this will be the prime cause of the phenomenon, other factors that will cause a fleet to sail more slowly than the individual ships that comprise it include the following:

1. The fleet will need time at the beginning of its voyage to leave harbour and take up its formation. At the end of its voyage, it will also need time to moor up for orderly disembarkation.

2. The discipline of maintaining station will cause the fleet to advance at the speed of the slowest. But in fact the process is perhaps more subtle; as the fleet proceeds, the sailing master of each ship will keep an eye on the trim of his sails, making adjustments, not to squeeze the last possible fraction of a knot out of his ship, but so as to avoid surging ahead. Clearly the more disparate the individual vessels in the fleet, the more important this factor will be.

3. Fleet discipline may break down and ships begin to blanket each other's sails.

4. The fleet may be scattered by gales and require time to regroup. This happened to the Armada of 1588 as it crossed the Bay of Biscay (Rodríguez-Salgado and Friel, 1988, 233).

5. The fleet commander may decide to heave to, so that his captains can join him for a council, again as did the Armada off the Lizard (Mattingly, 1959, 233).

6. The speed and direction of the winds during the voyage will be a major influence in determining how fast the fleet travels as a proportion of the maximum displacement speed of the individual ships making up the fleet.

None of these factors is susceptible to mathematical analysis, though sufficient data might make a statistical approach possible. Even so, that could never achieve a precise ratio. Even a statistical average would cover a wide variation; pragmatically one can appreciate that the influence of the individual factors would vary widely in different cases.

The first factor, the time required to achieve a proper formation at the start of the voyage and to leave it at the end, may not even be taken into account if the enquirer is attempting an assessment of the average speed from the point of departure off the port of embarkation to the point of arrival off the place of disembarkation. The third, fourth and fifth factor might not apply and, if they did, the delay involved is not a matter that can be calculated. However, we do have information from which we can calculate or estimate the actual average speeds of real fleets in the Channel.

In the case of the Armada, dates, approximate times and positions recorded in contemporary sources (Rodríguez-Salgado and Friel, 1988, 233-42; Padfield, 1988, 98-131) allow the calculation of its average ground speed during its passage up the Channel. From its arrival off the Scillies to its arrival off Calais an average speed of approximately 1.6 knots was achieved (320 nautical miles over 8½ days). The passage was characterised by light winds, mainly from the westerly quadrant, and by periods of calm. As we have noted, a council of captains was called off the Lizard and the fleet's progress was interrupted by skirmishes with the English. Perhaps the best day's sailing was the 2nd/3th August, between Portland Bill and the Isle of Wight, when the average speed may have exceeded 2 knots. This was a day which opened with an unfavourable north-easterly (which gave the Spanish their only weather gage of the campaign) and involved a significant battle with the English.

From the details given by Macaulay (1883, 563-4) one can calculate the probable average ground speed of the fleet of William of Orange from the Dover Strait to Torbay as just under five knots (4.9 knots - 234 nautical miles over two days). The stage from the Dover Strait to Beachy Head seems to have been completed at a ground speed as high as 7.5 knots (60 nautical miles in 8 hours) and the speed seems to have dropped towards the end of the passage. The fast stage from the Dover Strait to Beachy Head perhaps reflects a favourable tidal stream. The weather during this passage was in stark contrast to that of the Armada. The winds were from the easterly quadrant and strong, probably up to Force 7 or 8 (Appendix XII). The passage was not interrupted by skirmishes with the enemy fleet, which was storm-bound in the Thames estuary. William did, however, hold a council of captains before passing the Dover Strait to discuss defence of the fleet against the English fleet (Whittle, 1689, 30). The speed achieved during this passage is all the more remarkable because, according to Whittle, who was on board, the fleet took in sail during the night of the 13th/14th November after passing Beachy Head (1689, 32) and lay ahull; given the strength of the easterly wind, it would still have been making progress westwards under bare poles. Macaulay relates that the fleet was in sight of the Isle of White the next morning (1883, 564).

For the Norman crossing of 1066, Christine Grainge and I adopted as a working hypothesis a water speed of five knots as one which allows a credible reconstruction of the passage of the fleet from its departure off St Valéry to its arrival off Pevensey in the light of the relatively imprecise information in the sources (1993, 269; 1996, 139). This gives a passage time of eleven hours. The water speed could have been nearer four knots, giving a passage time of some 14 hours, but the sources would make it difficult to justify a longer passage time than that. Neumann is reluctant to accept a speed of more than 4½ knots 'because we feel that it would be hard to keep a fleet comprising several hundred ships in fleet formation at high travel speed during a dark night' (1989, 233).

Caesar gives enough detail for us to reach conclusions about the ground speed of three of his cross-Channel passages. These we have analysed in Chapter V (39-40) and indicate an average ground speed for each passage of no more than 3½ knots. Given the probability that he worked his tides (Appendix III) and his preference for sailing with light winds, the actual speed through the water of his fleets was very likely considerably less.

The data from these Channel passages are not sufficient to form any conclusion about a possible statistical relationship between the average speed of a fleet and a single ship. Not only is the sample too small, but we have no reliable information about the speed potential of individual craft making up these fleets.

What does emerge from the comparisons is that, provided we discount the time taken in adopting the formation and in leaving it and provided the fleet does not heave to for any reason or fleet discipline break down, the single most important influence on the speed of a fleet is, as one might expect, the wind strength and direction. The slow progress of the Armada up the Channel, compared with the rapid progress of William of Orange in the opposite direction is entirely due to the difference in the wind strength. William had no choice, given the lateness of the season, while the Armada after its long passage from La Coruña chanced upon a spell of light winds when it reached the Channel. We have noted that Caesar showed a strong preference for light winds and any commander undertaking an invasion passage from Gaul in high summer would have the opportunity, and may be expected, to do the same.

Fleet Operations at Night

Invasion passages would continue unimpeded at night. We have noted that Caesar had a preference for making overnight Channel crossings and the 1066 crossing from St Valéry to Pevensey was also overnight.

Neumann's proposition that it would be necessary to reduce sail during the night receives some confirmation from Whittle's report that the Dutch fleet in 1688 'strake sail' on three of the four nights of its passage to Torbay (Whittle, 1689, 29, 30). This seems to have led to a breakdown in the formation, because the following morning the men of war had to usher the fleet back into line. However, given proper fleet discipline, there is no reason to suppose that ships could not continue under sail and maintain station, provided the each ship was lit.

Surprisingly it seems to have been common practice for ships not to carry lights at night, except when at anchor, until legislation required it in the mid-nineteenth century and the now familiar red to port and green to starboard lights were introduced (Senior, 1913, 257-64). However, it is unthinkable that ships in a fleet should not have been lit at night and there is good evidence for the lighting of fleets from the Roman period through to modern times, including the fleets of 1066, 1588 and 1688 (*Carmen*, 106-13; Macaulay, 1883, 564; Casson, 1971, 247-8; Rodríguez-Salgado et al., 1988, 168). In 1588, Drake attracted criticism because on one night during the Armada campaign he dowsed his lights for his own nefarious purposes (Padfield, 1988, 116).

Instead of red and green sidelights, the ships of the sixteenth and seventeenth centuries were lit with great stern lanterns, while earlier ships, both in the classical and early medieval period, were lit with torches (*Carmen*, 106-13; *Gest. Guil.*, 6; Senior, 1913, 257-64; Rodríguez-Salgado et al., 1988, 168). As we shall see in the next section, lights were shown in special patterns to distinguish particular classes of vessel, such as the flagship and warships, from the rest of the fleet.

Fleet Communications

On his first expedition to Britain in 55 B.C. Caesar ordered his senior officers to 'do everything in the nick of time at a hint from him' (*B. Gall.*, IV, 23). He then 'gave the signal' and the fleet weighed. A system of signalling had clearly been established, but quite what it was we do not know. However, given the uncertainty of the Romans' knowledge of the coastline of east Kent, there may well have been an element of 'follow-my-leader' about responding 'in the nick of time' to 'hints' from the commander-in-chief.

Vegetius defined the signals used by the Roman army as 'voiced, semi-voiced and mute' (Veg. *Mil.*, III, 5). 'Voiced' are those given by the human voice, such as watchwords; 'semi-voiced' are those given by other audible means, such as the horn, trumpet or bugle; 'mute' are in essence visual signs, such as legionary standards. Although Vegetius was describing signals to be used in land operations, we may be certain that the Romans would have established similar arrangements for signalling at sea. In addition to Vegetius's categories, we find evidence also for communications by sending boats around the fleet and for summoning councils of captains.

Unless assisted by megaphone, the human voice is ill suited to communications at sea, particularly between vessels. But that does not rule it out: as his ship, the *Mary Rose*, was sinking, Sir George Carew, Henry VIII's Vice-Admiral, is reported to have called out to his uncle Sir Gawen Carew on the *Matthew Gonson* that 'he had a sort of knaves whom he could not rule' (McKee, 1982, 27).

There is evidence for Vegetius's 'semi-voiced' signals not only in Roman times. It is not unreasonable to suppose that Caesar's signal to weigh was given by a trumpet or other such instrument. According to William of Poitiers, Duke William also used a trumpet as a signal to his fleet to weigh off the Somme estuary, supplementing it with a torch raised to his masthead (*Gest. Guil.*, 6). By the time of the Armada such 'semi-voiced' signals were given by firing a cannon (Padfield, 1988, 111, 117, 122, 128, 130). The context of the signal guns implies that the general meaning was 'follow-my-leader'; sometimes the meaning was: 'Alter course with me', sometimes: 'Come back into formation' and once: 'Anchor here with me'. The same underlying meaning of: 'Do what I am doing' seems to be behind the signal given by William of Orange when his fleet altered course for the Dover Strait from its initial northerly heading (Chapter XI, 143: Macaulay, 1883, 563). Whether it was given by firing a gun, we do not know, but most likely it was.

In Vegetius's definition 'mute' signals also imply 'follow-my-leader'. Their purpose in land operations is to distinguish one side from another and to mark out the senior officers. In modern naval warfare they are the battle ensigns, large enough to ensure that they are not mistaken, and the flag officer's pennant, to mark out the flagship. The custom goes back to classical antiquity when warships flew standards to identify their allegiance to country and/or fleet and flagships flew their admiral's pennant (Casson, 1971, 246). The *Mora*, Duke William's ship, was similarly recognizable; apart from the torch raised at her masthead, she carried a golden figure representing an infant pointing towards England - one source says holding a bow and arrow (van Houts, 1988, 166, 168). She is also shown in the Bayeux Tapestry with what appears to be a distinctive banner at her masthead. The Dutch fleet of 1688 was divided into three divisions, the ships of which flew red, white and blue flags respectively, while William's ship flew the flag of England and his own arms (Whittle, 1689, 28; Dalrymple, 1771, 155).

At night flags cannot be seen; indeed modern flag etiquette requires ensigns to be struck at sunset (Hewitt and Lees-Spalding, 1990, 217). Lights then serve as Vegetius's 'mute' signals. Livy records that in the second Punic War Scipio Africanus ordered his warships to carry one light, his transports two and his flagship three (Casson, 1971, 247-8). The fleet of William of Orange was marked out at night in a remarkably similar way: his flagship carried three stern lanterns, his warships two and the rest of the fleet one (Whittle, 1689, 18, 28). A sixteenth-century triple stern lantern from an admiral's flag ship is on display in the Museo Storico Navale in Venice.

More precise communication could be achieved by sending instructions round the fleet by pinnace, a procedure much used by the commander-in-chief of the Spanish Armada (Padfield, 1988, 117, 124, 129). These could be general instructions to the captains of the fleet as a whole or written messages to individual captains, or even to the commander-in-chief of the Spanish army in the Netherlands. The general instructions were backed up by the presence in the pinnace of an executioner and the threat of hanging in the case of non-compliance, a threat actually carried out in one case (Padfield, 1988, 165-7).

Finally there is the council of captains called aboard the flagship. This was much used by both the English and the Spanish during the Armada campaign (Padfield, 1988, 100-1, 111, 129). At one such council Howard knighted captains who had distinguished themselves.

In general one may expect that for short invasion passages and perhaps those which did not involve interception by the enemy, the more sophisticated procedures of sending messages by pinnace round the fleet or calling councils of captains were not necessary, although Caesar seems to have called such a council off the South Foreland before moving up to his beachhead near Deal; perhaps that was only because the opportunity offered when he anchored there.

Leaving and Entering Harbour: taking up formation

In principle for a single ship there is a relatively short period when it is often most advantageous to leave harbour. For example, craft leaving harbours such as the Kent or Essex rivers, flowing into the Thames Estuary, or St Valéry, several miles up the Somme from the sea, will find that the ebb flow of the tide helps them on their way if they leave at or soon after High Water, subject only to the need to pick up a favourable tidal stream once they have reached the open sea. In the case of harbours such as Boulogne, Dover and

Calais, opening directly onto the open sea, it will be most beneficial to leave as the coastwise tidal stream starts to run in the desired direction.

However, a fleet numbering hundreds of vessels cannot all leave harbour at the same time. Clearly the operation will take a period of time running into hours. This will be especially true when the fleet is constrained by the configuration of the harbour to leave in single file. Sir John Dalrymple recorded the length of the fleet of William of Orange approaching the Channel from the north as formed up in 'a line of twenty miles in extent' (Dalrymple, 1771, 158). The wind direction at the time from the east would have dictated a line-ahead formation. If the fleet was making five to six knots, a likely speed in the conditions, leaving the Maas estuary in line ahead would have taken three to four hours. In 1066, it may well be that the Norman fleet also had to leave St Valéry in something approaching single file; certainly today there is a single narrow meandering channel leading from St Valéry to the open sea and, although in the eleventh century the silting up process had not yet choked the channel to the same extent, the fleet would still have been constrained by sandbanks obstructing the estuary as far as the open sea. Be that as it may, the fleet anchored as soon as it reached the open sea. According to William of Poitiers, this was for fear of reaching England before daybreak; after an overnight passage a dawn approach is considered to be the optimum, so that the landfall can be identified (Sleightholme, 1970, 162). But anchoring would also allow the fleet to achieve the required formation, which is explicitly mentioned in *The Song of the Battle of Hastings* (*Carmen*, 102-3, 114-7; *Gest. Guil.*, 6; Grainge and Grainge, 1993, 269; 1996, 139).

The case of the Spanish Armada was even more extreme. The fleet started to move down river to the mouth of the Tagus on the 9th May 1588, but was prevented by adverse weather from putting to sea until the end of the month. It then took two days to get the whole fleet out to the open sea. In this case the operation was hampered by the inability of the more unwieldy ships to weather the shoals to the south of the estuary (Padfield, 1988, 49; Rodríguez-Salgado, 1988A, 30).

Although we may be sure that time would be required for a fleet to leave harbour and form up, it would be futile to attempt to put a precise measure on it; much would depend on the prevailing conditions and the size of the fleet. The two days spent by the Spanish Armada clearing the Tagus were clearly unusual. Excluding that case, all we can say is that leaving harbour and forming up might take several hours. We may also assume that the same would apply to entering harbour at the end of the voyage.

Embarkation and Disembarkation

One can discern a significant difference between the practice adopted by the Normans and by later invaders. Where in the case of the Normans embarkation and disembarkation seem to have taken place in a single day, later invaders completed the process over several days.

Thus the invasion force of William of Orange started to embark, both men and horses, in late September 1688; the operation was not complete until the end of the first week of October. Because of the weather the fleet could not sail until the end of October, when it was forced back to port and finally sailed on the 11th November (Lindgrén and Neumann, 1985, 640). The same protracted timetable applied to the embarkation the Armada. When it was inaugurated on the 25th April 1588 in Lisbon Cathedral, most of the troops were already on board, but it would be a fortnight before the Armada was ready to move off (Padfield, 1988, 49; Rodríguez-Salgado, 1988A, 30).

By contrast the embarkation of the Norman fleet seems to have been a rather rushed and perhaps even disorderly affair. William of Poitiers speaks of most of the men as 'fearful of being left on shore' (*Gest. Guil.*, 6). However, from the detail provided by both William of Poitiers and by *The Song of the Battle of Hastings*, we can discern that the embarkation of both men and horses was triggered by the favourable wind and took place during the single day (*Carmen*, 72-101). We may envisage the Duke waking up that morning to the new wind and ordering the embarkation, which took all that day and was complete in time to allow the fleet to sail with the evening High Water.

Given the failure of the Armada, we have no data for its disembarkation as an invasion force, but Macaulay records that the disembarkation of William of Orange's fleet took only two days owing largely, it seems, to a calm window in the weather. The unloading of the horses was expected to take several days, but in the calm weather on the second day the ships were brought to within sixty feet of the beach and the horses swam ashore (Macaulay, 1883, 566).

Of all the invasion landings discussed here Caesar describes the only opposed landing, that of his first expeditionary force. It is in fact remarkable that, apart from 55 B.C. few, if any, major invasion landings in Britain have been opposed over the last two thousand years.

This occasion seems to have involved a fierce skirmish, which Caesar opened by sending in his warships with their catapults and other missiles to clear the beach of the enemy. After some hesitation the troops disembarked, but clearly were at some disadvantage because they were not able immediately to take up their normal legionary formation. However, with reinforcements sent in boats to the points where the Britons pressed most fiercely, the Romans managed to drive them off (*B. Gall.*, IV, 24-6).

This is the only disembarkation that Caesar describes in any detail. It clearly was completed before the day was out. From hints in the accounts of the other passages described by Caesar it appears that embarkation and disembarkation would have been completed within the day of sailing; for example on his second expedition, he set out before daybreak the day after landing in pursuit of the British forces (*B. Gall.*, V, 9). This in part explains his preference for night passages; this would give the troops the best part of the day before the crossing to embark and they would still have a good number of hours of daylight to disembark after the crossing. Perhaps the exception to this was the crossing of the cavalry in 55 B.C. They left in the morning to make a daylight crossing and it seems likely that the horses would have been embarked the day before.

Thus it would seem that Roman practice was the same as the Norman in embarking and disembarking in a single day. We may detect the reason in the design of the ships involved. With their open ships, which were probably easier to board, the Normans, and we may assume the Romans, found it preferable to camp on shore and to embark animals and men immediately before sailing. By contrast, the ships available to the later invasion fleets were more habitable and soldiers and seamen were more easily billeted aboard.

Space Required for Embarkation and Disembarkation

Caesar's opposed landing with two legions in 55 B.C. gives us the opportunity to consider the space required to achieve disembarkation. We may assume that his eighty transports came into the shore bow first to allow the legionaries to jump down into the water and fight their way ashore (*B. Gall.*, IV, 24). The beam of Blackfriars I, which we have taken as the paradigm of the transports used in the Roman invasions, is 6.12 metres (Marsden, 1994, 89). Assuming that the ships came inshore at 10-metre intervals this would imply a landing over a front of somewhat under half a nautical mile. A 20- or even a 30-metre interval seems more likely, given that the soldiers would need room between the ships to jump down into the water. In such a case one is looking at a landing over a front of up to a mile and a half. These figures compare with those given by Vegetius for the front presented by an army of 10,000 men, which might correspond to two legions: if drawn up in six lines, it would occupy one Roman mile - 0.8 nautical miles; in three lines two Roman miles - 1.6 Nautical miles (Veg. *Mil.*, III, 15).

However, in the case of larger invasion forces, such as Caesar's second expedition, if all the transports came inshore at the same time to disembark their troops, there would be something of a tactical problem; at 10-metre intervals, the 626 transports of 54 B.C. would have required a front of three and a third nautical miles, while a 30-metre interval would have produced a landing over a front of some ten nautical miles. In terms of east Kent, that is a front stretching from the South Foreland almost to Ramsgate in Thanet, including stretches of cliff-lined coast where a landing would have been impossible. The probability then is that the army would have been disembarked in phases.

The room required for mooring up or anchoring is also considerable. One August Bank Holiday I counted seventy yachts at anchor in Stangate Creek, a popular anchorage in the Medway, and there was little room for any more. Stangate Creek is some two nautical miles long and varies in width between 100 and 200 yards.

A ship at anchor needs room to swing to her anchor, as the tide ebbs and flows (Fig. 20). The room required is a circle with the anchor at the centre and the stern of the yacht at its circumference; its size is defined by the depth of the water, the length of the ship and the amount of anchor cable let out.

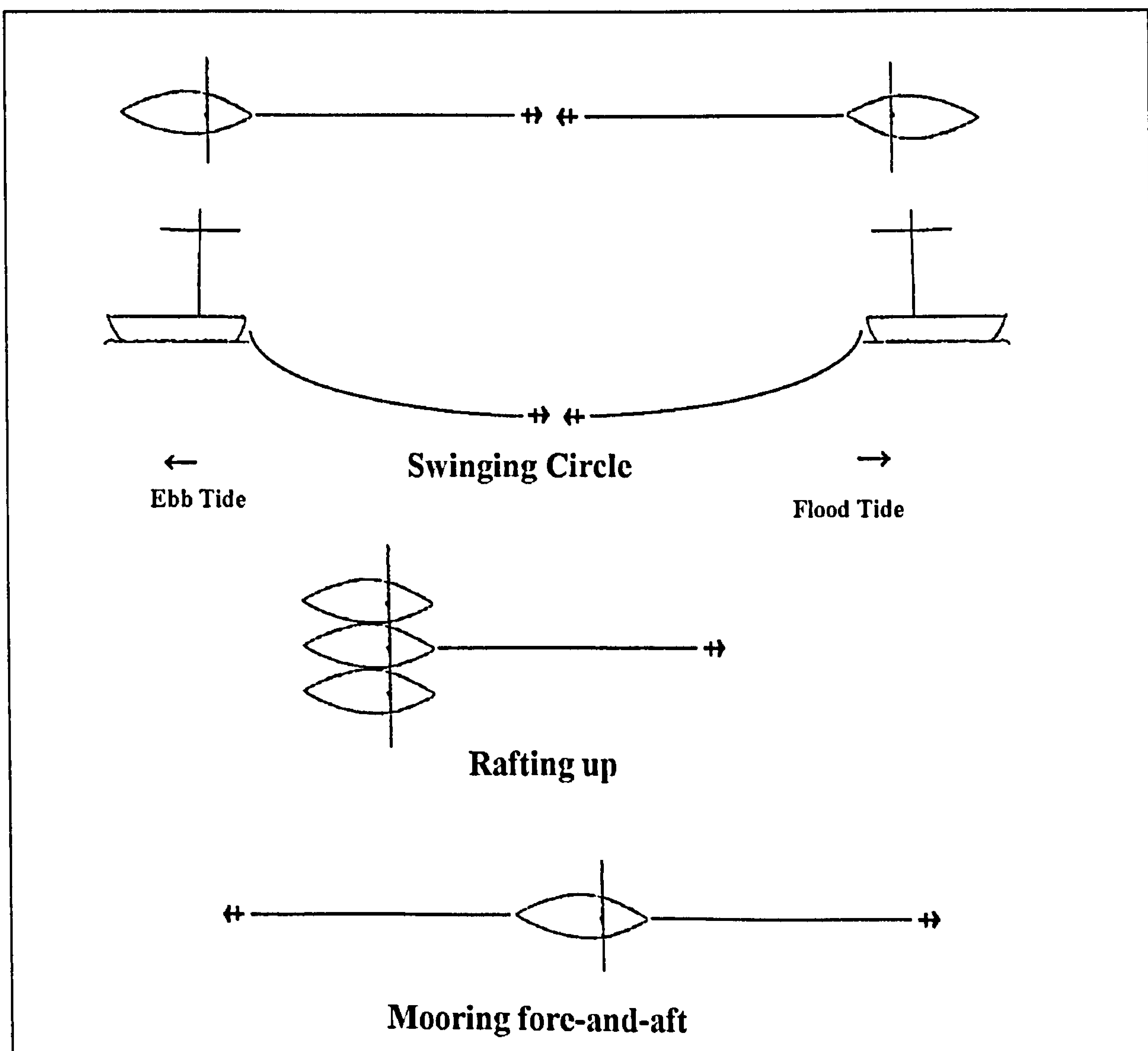


Fig. 20 Different methods of anchoring and mooring up.

Ways can be found of reducing the amount of room required. First, because ships at anchor will tend to lie to their anchors in the same direction, swinging circles can be allowed to some degree to overlap. Secondly, craft can be rafted up, i.e. several can be lashed together as they lie at anchor. Thirdly, craft can be moored up fore-and-aft, so that their swing is greatly reduced. Fourthly, they can be brought ashore at high tide, though the scope for this will be limited by the weight and draft of the individual ship; Caesar seems to have been able to bring his warships ashore, while his transports had to be left at anchor (*B. Gall.*, IV, 29). The Bayeux Tapestry shows in one scene a crewman wading through the shallows to carry the anchor ashore, while another scene shows a ship moored bows-to with the anchor secured ashore; a third scene shows the Norman fleet brought ashore at Pevensey and arranged closely gunwale to gunwale. Vergil in *Aeneid* (VI, 901) describes a method still in use in the Mediterranean: 'Bow-anchors out, the ships are lining the shore with their sterns' (Lewis, 1966, 315).

Provided means such as these of reducing the area required to moor up the ships were exploited, there is no reason why the Roman fleet of A.D. 43 could not have been accommodated in the Wantsum off Richborough Hill. There is an area of about one nautical mile square to the south of Richborough and to the west of Sandwich which in Roman times probably offered a stretch of sheltered shallow water, perhaps drying (Fig. 2 in Chapter II, 18). Any ships not accommodated there could have been accommodated along the shore of the Wantsum to the north-west of Richborough.

Conclusion

The size of the fleet to be deployed is a factor to be taken into account in planning a cross-Channel invasion. If it is not carefully managed, the sheer size of the fleet will hamper the operation: allowance must be made for the factors which will slow down the passage, such as the requirement to adopt the appropriate formation; time must be allowed for orderly embarkation and disembarkation; and provision must be made for the mooring-up of the ships. It is in this context that the decision of the Romans in A.D. 43 to 'cross in threes' ('τριχῇ νεμηθέντες') makes good sense (Dio, LX, 19). Dio clearly explains why the Romans did this: so as not to be hampered in disembarking, 'as might happen to a single force'. As we have noted in Chapter III (27), there is no need to postulate landings at three separate points to explain Dio's account. The obvious tactic was to send across the advance force to seize and fortify the beachhead and then send across the rest of the force in two groups, as and when tide and wind served. This would not only make the naval operation more manageable, it would provide a sound basis for securing the supply lines that the invading army would need and it would also reduce at a stroke the requirement for ships to one third.

Chapter X

Maritime Context of the Invasion Passage

In planning the invasion passage of A.D. 43, like any seafarer, ancient or modern, Aulus Plautius's naval commanders needed to take account of the environmental factors which would influence the success of their voyage. The most relevant of these factors would be the tides, the weather, including the likely wind direction and strength during the passage, any navigational hazards to be encountered and available havens. Although only the most extreme conditions would prevent the master of a modern power-driven ship from setting out, his passage will still need to be planned to take account of all these factors. The modern yachtsman, on the other hand, will find that these factors will influence the timing of his passage and may well lead him to defer departure. The seafarer of the Roman period, who operated without the support of modern services, such as weather forecasts or ubiquitous seamarks, and whose ship was even less handy than a modern sailing yacht, would be even more at the mercy of these factors.

Tidal Régime in the Channel and the Dover Strait

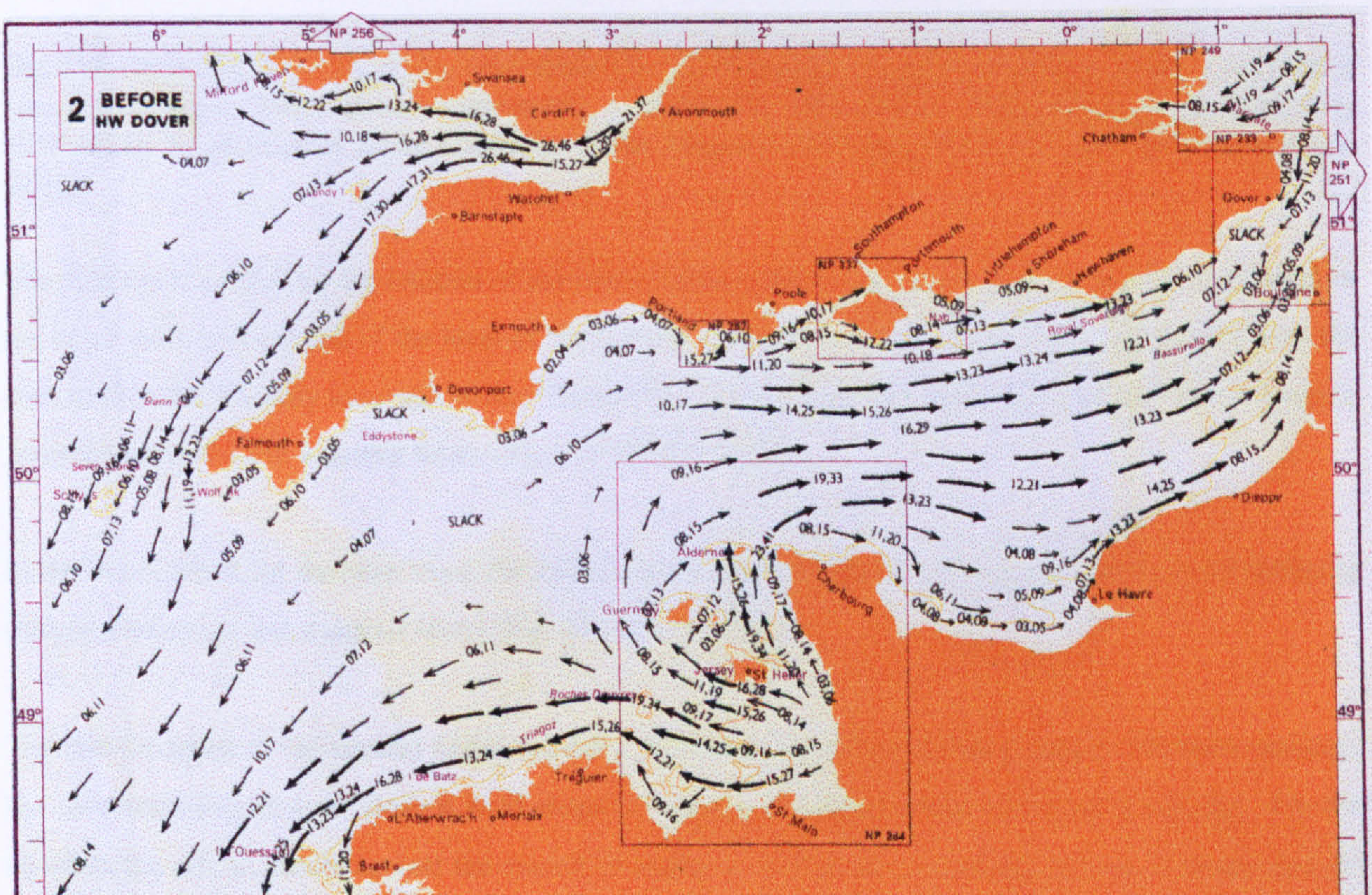


Fig. 21A Tidal streams in the English Channel at 2 hours before High Water Dover

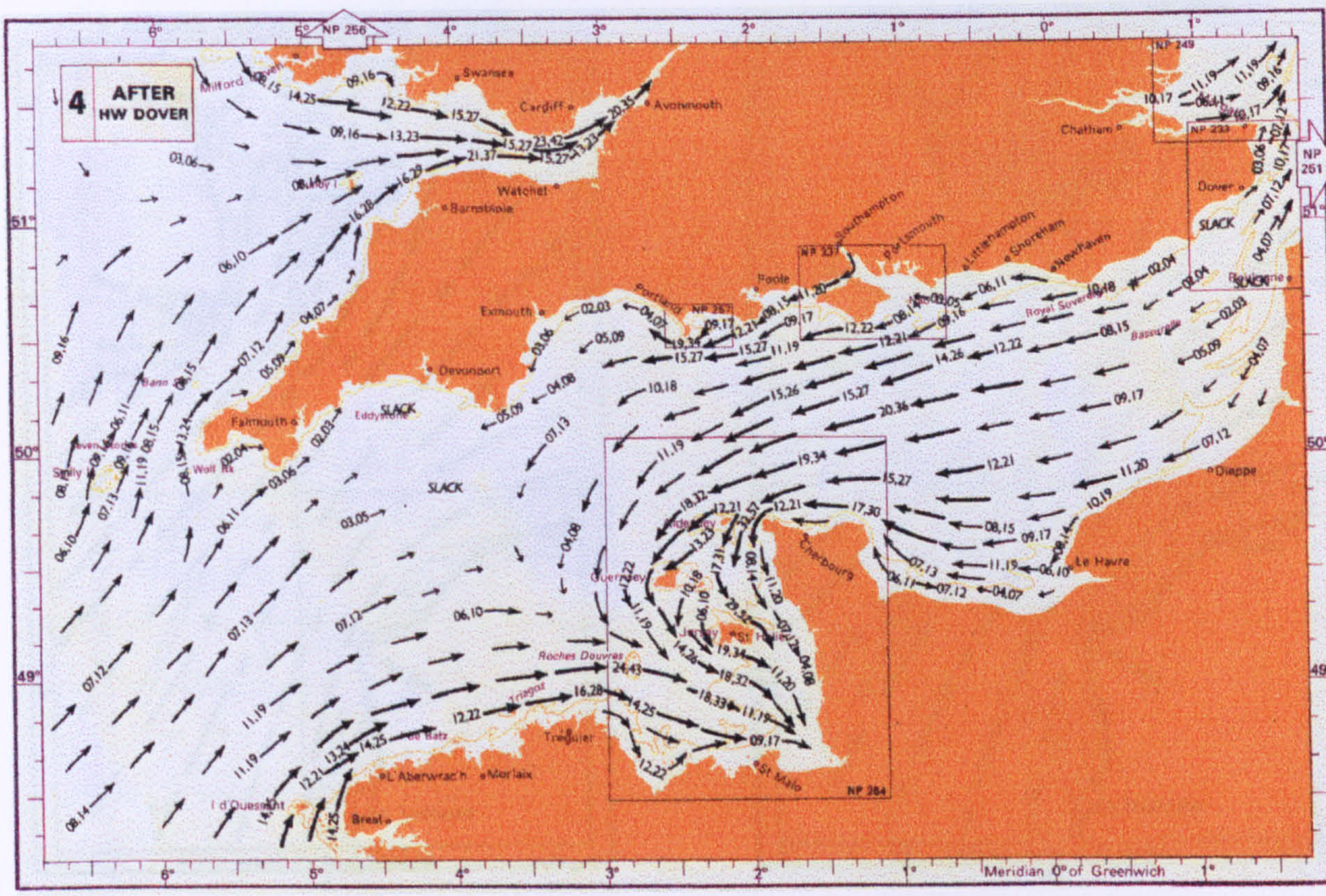


Fig. 21B With Fig. 21A this shows tidal streams in the Channel at 2 hours before High Water Dover and 4 hours after High Water Dover respectively. (From NP 250, 1973. Reproduced from Admiralty Publications by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office).

The tidal cycle created by the rotation of the moon and sun about the earth manifests itself in two ways, in the twice daily rise and fall of the level of the sea and in the tidal streams which vary continually with the state of the tide. Broadly speaking, in the Channel the tidal streams flow alternately east and west, changing direction every six and a quarter hours (Fig. 21; NP 250, 1973).

In the Dover Strait, on the other hand, the streams run alternately north-east and south-west, again changing direction every six and a quarter hours (Fig. 22; NP 233, 1963).

The rate (or speed of the stream) varies not only with the state of the tide (how long it has been running), but also according to how close it is to neaps or springs, the fastest rates occurring at springs. On the chartlets the rate is shown against the arrows in tenths of a knot, the first being the rate at neaps and the second at springs. Examination of the details will show that in the areas restricted by headlands, for example, between South Foreland and Cap Gris Nez, or between the Cherbourg peninsula and the Isle of Wight the rates are higher than elsewhere.

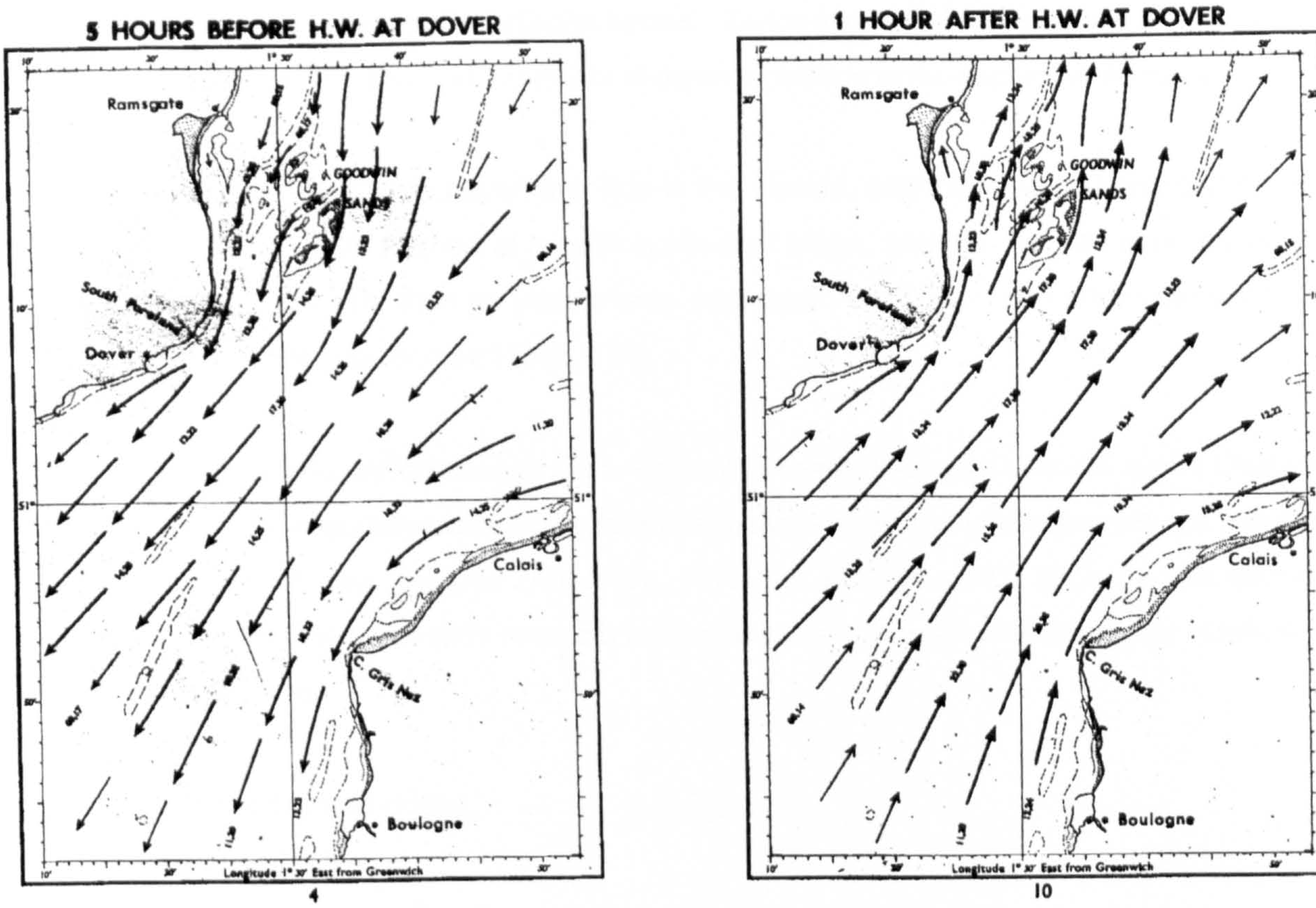


Fig. 22 Tidal streams in the Dover Strait Channel at 5 hours before High Water Dover and 1 hour after High Water Dover respectively. (From NP 233, 1963. Reproduced from Admiralty Publications by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office).

Certain caveats need to be entered. The first is that the lower sea-level and the more heavily indented coastline of the Roman period would undoubtedly have meant that there were local variations from the pattern of tidal streams as shown in modern tidal atlases; these would not, however, have altered significantly the general pattern of tidal streams shown in Figs 21 and 22, changing direction every six and a quarter hours (McGrail, 1987, 259).

The second caveat is that there is no suggestion that the Romans had access to tidal data of the sophistication available nowadays, but, as we have shown, the Romans were well aware of the effect of tides in these waters and a century earlier Caesar had understood the importance of working the tides (Chapter V, 42-4; Appendix III).

In fact it is an error to suppose that in an age of non-instrumental navigation sophisticated data were necessary. All that one needs to know is how many hours after high (or low) water at a particular haven the tidal streams start to run in one's favour. Alternatively the onset of a favourable stream may be expressed in relation to the azimuth of the moon. Taylor (1956, 121) quotes 'The English Rutter' on tides: 'a south Moon maketh high water within Wight' and 'all the havens be full at a west-south-west Moon between the Start and the Lizard.' It is in terms as simple as this that the lore of vernacular seamanship could express and record the change in tidal streams off particular havens. Taylor quotes sailing directions for crossing the Dover Strait which give clear advice as to the time to depart in relation to the azimuth of the moon:

> If ye be bound to Calais haven and ride in the Downs, and the wind be west-south-west, ye must rere (raise anchor) at a north-north-east Moon, and get you into your marks, the steeple into the fan, then go your course east-south-east over, and after your wind and your tide serve your course (1956, 133).

McGrail draws attention to the importance of rote learning in transmitting such data and quotes Chadwick as underlining the high importance accorded by the Celts 'to the development of an advanced oral technique for the transmission of their thoughts' (Chadwick, 1971, 45; McGrail, 1987, 277); he also quotes a fisherman's rhyme reported in the early twentieth century to be well known on the East Coast which, in its most correct variant, goes:

> High water London Bridge,
> Half ebb in the Swin;
> Low water Yarmouth Roads,
> Half flood at Lynn (*Mariner's Mirror*, 3, 287, 319; McGrail, 1983, 319).

Pacific Island navigators, for the most part illiterate, draw on a vast store of knowledge which is entirely memorised (Lewis, 1994, 40).

Unless a high speed through the water can be reliably achieved, it would be important to work the tides (Sleightholme, 1970, 145-6; McGrail, 1987, 260, 277, 280). To appreciate the point, it is only necessary to consider the case of a vessel making five knots through the water: if she is stemming a two-knot tidal stream, she will achieve no more than three knots over the ground; conversely, if she has a favourable two-knot tidal stream, her effective speed over the ground will be seven knots. She may be able to carry a favourable tide for the whole passage. For example, a ship leaving Boulogne just as the tide starts to run north-east will have the advantage of a favourable tide from two and a half hours before High Water Dover off Boulogne until four hours after High Water Dover off Ramsgate (Hanson, 1971, 83, 354) - a total of six and a half hours, quite sufficient to complete the passage if an average of 5 knots through the water can be maintained (Fig. 22; Hanson, 1971, 83, 354). If a lower speed through the water is anticipated, then the tide must be stemmed at some stage, perhaps preferably at the start of the voyage.

In other cases the length of the passage will be such that at some time during the passage the tide will turn, perhaps several times. In the English Channel two specific cases can be identified. First there are the cross-Channel passages, evidence for whose use in the late first millennium B.C. has been investigated by McGrail (Fig. 23; 1983, 299-337).

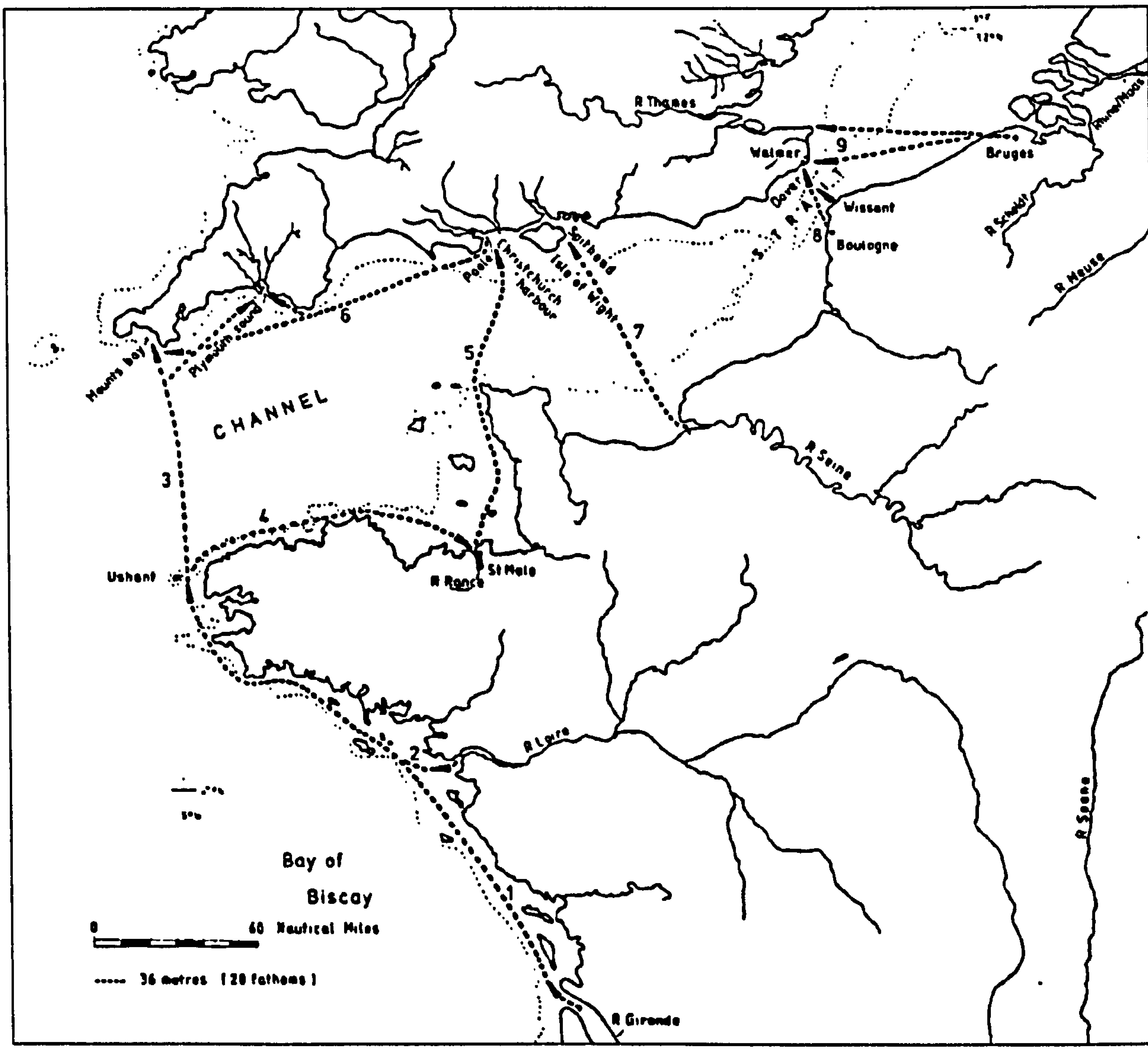


Fig. 23 McGrail's nine Channel routes (1983, 309; 1987, 272. Reproduced by kind permission of Professor McGrail). McGrail points out that the routes are approximate and do not show precise tracks.

McGrail identifies from archaeological and other evidence five cross-Channel routes in use immediately before the opening of the Roman period. These routes seem to be remarkably persistent over time. In the twentieth century Riley gives passage notes for yachtsmen for fourteen cross-Channel passages in the area surveyed by McGrail (Riley, 1976B, 50-79). Of these all but three may be seen as variants of McGrail's five routes. The three exceptions are Newhaven to Dieppe, Dungeness (from places further east) to Dieppe and Newhaven (from places further west) to Boulogne. It is also to be noted that, with one or two exceptions, McGrail's five routes are those of the main modern ferry crossings, again with Newhaven-Dieppe a notable addition. Given this persistence, we may reasonably suppose that in the period immediately following McGrail's survey, i.e. at the moment of the Claudian invasion of A.D. 43, his five routes were the normal routes of communication between Britain and the continent. They would be the cross-Channel routes of which ancient seamen had traditional experience.

We have already noted that in tidal terms McGrail's route 8, Boulogne to the Downs, is a special case, being controlled by the north-east/south-west-going tidal streams through the Dover Strait and being short enough to be completed, given adequate boat speed, within a single tide. So too is his route 9, Bruges to Kent, being controlled by the coastwise ebb and flow along the Flemish coast. However, unless we adopt the unlikely hypothesis advanced by Cottrell that Plautius's legions made their passage direct from the Rhine to east Kent by river and by sea along the Flemish coast (1961, 100), route 9 has no bearing on our analysis of the options open to the Roman naval staff.

The other cross-Channel routes include that from the Seine to the Solent, which might have well been of interest to Aulus Plautius's naval staff as a candidate for an invasion crossing, if a landing in the Fishbourne area was a strategic requirement (Hind, 1989, 13). Basically south/north, these routes are subject to tidal streams bearing alternately on one beam or the other. This brings no special benefit in terms of speeding the vessel towards her destination, but it does not set her back on her track. What it does is to cause her to follow an elongated S-shaped track over the ground as the tidal streams run alternately east and west (for a worked example from the Somme to Pevensey, see Fig. 24; Grainge and Grainge, 1993, 270; 1996, 138). In principle, if the passage lasts an even multiple of six and a quarter hours or thereabouts, the net effect of this tidal stream offset will be cancelled out; in any event it is likely, except in extreme cases, to be relatively small. In the case of the passage from the Somme to Pevensey quoted above the net offset after a passage of 11 hours was less than a mile to the south-west. In a worked example for a 13-hour passage from the Solent to Cherbourg, Keys gives a net lateral offset to the west of 5.29 nautical miles, together with a net southwards lift due to the tide of 4.39 nautical miles (1982, 84-9); of this some 50% arose in the last hour.

For each of his cross-Channel routes McGrail assigns a figure for an offset described as the 'theoretical displacement, during passages out of sight of land, due to current and tidal stream (assuming departure on ebb tide)' (1983, 309, 330). The highest displacement figures are given for the routes in the western approaches, up to 17 nautical miles to the north-east, but for the mid-Channel routes, which are closer to our interest, the displacement figures are lower, 6 to 7 nautical miles to the nor' nor' east for the route from the Seine to the Solent.

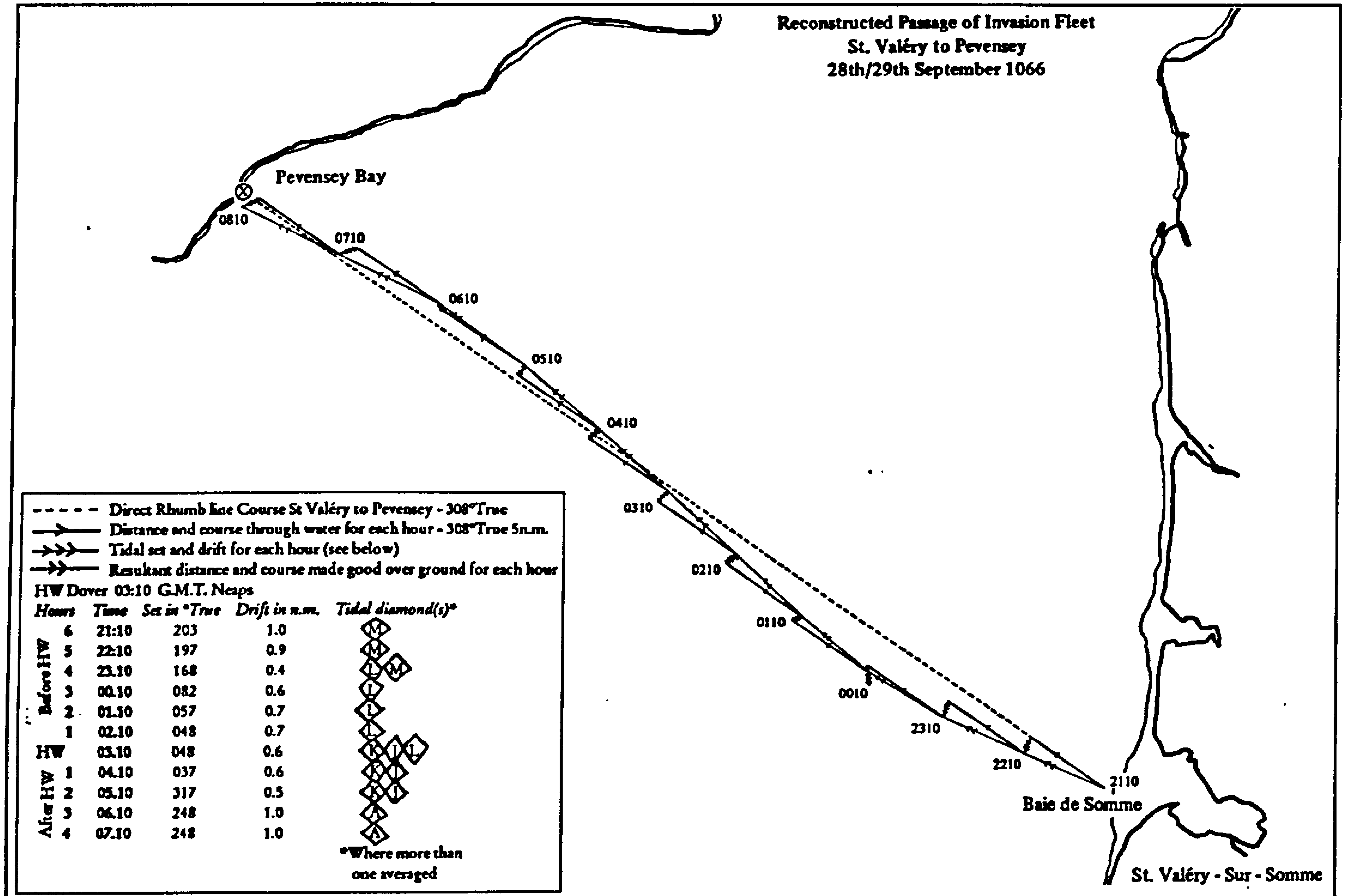


Fig. 24 As the invasion fleet of 1066 travelled across the Channel, the tidal stream initially offset its ground track to port and then to starboard and again to port during the 11-hour passage. The assumed speed through the water is 5 knots (Grainge and Grainge, 1993, 270; 1996, 138).

Assuming, therefore, that an accurate heading may be maintained, if the passage time is close to an even number of tides, then the likelihood is that the effect of the tidal streams will cancel out, as in the 11-hour example of Fig. 24, or nearly so, as in the case of Keys's 13-hour Solent/Cherbourg passage. In fact the distances involved in these two passages (Solent/Cherbourg - 57.87 nautical miles; St Valéry/Pevensey - 55 nautical miles) are such that if a speed through the water approximating to five knots can be maintained the passage will be completed within this time frame; we assumed for the latter a water speed of 5 knots, while for his Solent/Cherbourg passage Keys assumed 4.45 knots. This will not be so in the case of the passage from the Seine to the Solent, some 80 nautical miles. In this case a boat speed of 5 knots would bring the ship to the offing of the Nab Tower in 16 hours which would imply some net offset from the effect of the tidal streams. An indication of the maximum absolute impact on a ship's position of tidal streams may be taken from Keys's worked example for the Solent/Cherbourg crossing. The total absolute offset westwards, i.e. discounting any eastwards offset, was 14.86 nautical miles (1982, 87). That would, however, be an extreme case and would imply a passage which takes a time close to an odd number of tides, i.e. 6¼, 18¾ hours, etc. It is a reasonable assumption that, provided a reasonably accurate heading is maintained, a landfall will be made within a few miles of the required destination.

Let us now turn to the other category of passage which will involve one or more turns of the tide. These are the coastal passages, whose length is such that they cannot be completed in one tide. McGrail catalogues four such passages of between 95 and 250 nautical miles (Fig. 23), but they do not include the passage along the south coast of Britain east of the Solent which is central to Hind's hypothesis for the A.D. 43 invasion (1989, 12-3). This is not to say that on that account such a passage would not have been feasible, but it is to say that McGrail did not find evidence that Channel mariners of the period would have been familiar with this particular stretch of coastline.

In fact three of the four possible invasion routes proposed by Hind come into this category, at least in part, since they would involve following this stretch of the south coast of Britain, for some part of the passage. Apart for the Boulogne/Solent route, these are those to the Solent from the Canche and the Somme. (The fourth, that from the Seine, has already been discussed, as a wholly open-water cross-Channel passage.) After a leg across the Channel a fleet leaving these havens would have picked up the south coast of Britain at some point, from Boulogne and the Canche, probably in the vicinity of Dungeness and, from the Somme, no further west than Beachy Head and then followed the coast westwards from there. In fact the passage from Boulogne, given the proximity of the departure to the British coast, is to all intents and purposes a coastal passage.

Unlike the open-water cross-Channel passages, these extended coastal passages will of necessity involve stemming foul tidal streams at some point (McGrail, 1983, 315, 321, 322, 325; 1987, 280) and this might involve anchoring to await the turn of the tide. We should not assume that anchoring an invasion fleet was not a feasible option; in 55 B.C. Caesar anchored off the South Foreland to wait out the tide (*B. Gall.*, IV, 23) and Duke William is also recorded as having anchored his fleet during the invasion passage of 1066, apparently to avoid arriving off Pevensey in the dark (Grainge and Grainge, 1993, 269; 1996, 139). Hind observed that the distance from Boulogne to the Solent is much the same as that from Le Havre to the Solent (1989, 13). It is in fact close to 100 nautical miles from Boulogne (96 to the Nab), as opposed to 80 from Le Havre. The fact, however, of the regular onset of adverse tidal streams makes it an entirely different proposition.

I have examined in a worked example (Appendix IX) the way in which such a coastal passage would have been affected by tidal streams. The detailed conclusions are given in the Appendix, but in general one may say that, unless the fleet were able to maintain a constant speed of some 5 knots through the water, it would have been very much at the mercy of the changing tidal streams. Our examination of the speed potential of Romano-Celtic ships, such as Blackfriars 1, suggests that they were sluggish vessels and that a more likely average speed might have been in the order of 3 knots or less. Certainly that assessment is in line with the records of Caesar's crossings. At a steady speed in the order of 3 knots, it would appear that, anchorage to anchorage, a passage time of 36 hours or more would be required. However, such a steady speed is dependent on a steady favourable wind. Moreover the fact that this would have been a fleet passage, rather than one involving a single ship, would considerably extend the time involved; total passage time from embarkation to disembarkation might well have been in the order of two and a half to three days, as a minimum.

Wantsum Channel

While we have suggested that the tidal régime at the beginning of the first millennium A.D. was in broad terms very similar to that which obtains today, that cannot be true of the Wantsum Channel and the immediately adjacent waters, if only for the reason that they no longer exist. The crucial question for us is whether the Wantsum Channel was a haven or a dangerous stretch of water. We have suggested earlier that the configuration of the Wantsum created a sheltered body of water from winds in all directions, but did the tides and tidal streams make any difference?

Hind, for example, has suggested that the Wantsum 'might well have been treacherous, if open to tides at both ends' (1989, 14). The question does not appear to have occurred to other scholars and the consensus seems to be that the Wantsum played an important part in communications and trade between Britain and Gaul both in Roman times and in the Anglo-Saxon period; indeed, as far as the Roman period is concerned, Hind concedes as much. In fact the continued existence of Richborough at the eastern end of the Wantsum in a variety of rôles throughout the Roman period, in its final days as a Fort of the Saxon Shore, and the establishment the Roman fort at Reculver at the other end in the early third century bespeak the importance of the Wantsum, not only for Roman communications with Gaul, but also for Germanic pirates and settlers. While the tradition that the first of Gildas's 'pack of cubs' in their three keels landed at Ebbsfleet in Thanet in A.D. 449 is perhaps of doubtful historicity (Gildas, 23; *ASC*, 449), the richness of the archaeological record in east Kent is eloquent testimony to the significance of the Wantsum for the arrival of migrants, such as the Jutes, and for their links of gift exchange or trade with Francia (Hawkes, 1982, 70-6). Hawkes remarks on the density of population in this period in north-east Kent with a 'noticeable preference for sites near harbours along the coast and the shores of the Wantsum Channel' (1982, 74). On the basis of the evidence of toll charters, by the middle of the eighth century, kings of Kent were levying tolls at Sarre on the Thanet shore of the Wantsum and at Fordwich on the Stour, from which the houses of Minster-in-Thanet and Reculver were granted exemption (Kelly, 1992, 6-11). Hawkes, suggesting that Sarre 'was an obvious place for a royal toll station', considered that it was 'strategically placed where vessels using this inner route had to put in to wait on the double tide', perhaps on the analogy of Southampton (1982, 76; Tatton-Brown, 1984, 17-8).

Against this sort of evidence of the importance of the Wantsum as a waterway, any thought that it might be regarded as a treacherous stretch of water needs to be treated with some caution. In Appendix X, therefore, I attempt an assessment of the tides and tidal streams in the Wantsum Channel. The detailed conclusions are set out in the Appendix, but in broad terms they are:

1. The tidal streams flowed alternately east and west. The eastward flow lasted longer than the westward flow, continuing for some two or three hours after the onset of the flood;

2. The rates of the tidal streams were significantly greater at springs than at neaps. However, although it is not possible to give them a numerical value, rates appear to have been moderate;

3. There would appear to be no evidence for a double high tide.

In particular there appears to be no basis for arguing that this was a treacherous stretch of water. Comparison with other inshore channels points to moderate and predictable tidal streams and there is no reason to suppose that they would have presented a problem for an experienced mariner. This is not to say that local knowledge would not have been required; this would have been so in the case of most havens in days before the regular dredging and marking of channels and certainly would have been the case at, for example, Chichester Harbour. Any suggestion that the Romans would have preferred this latter to the Wantsum on that account is unsustainable.

Wind and Weather

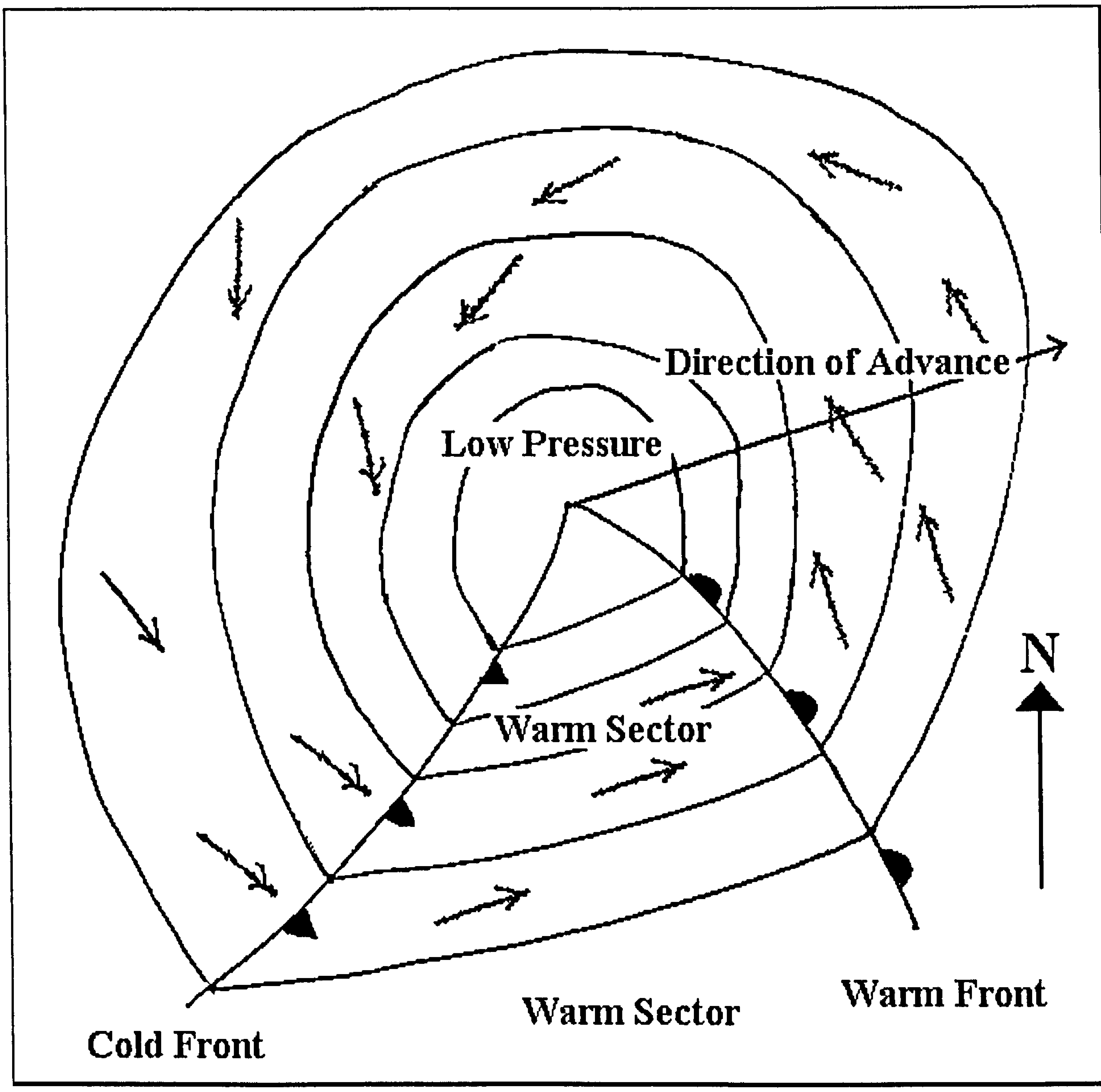


Fig. 25 Schematic model of an Atlantic Depression showing the anti-clockwise circulation of winds and the cold and warm fronts; note the sharp bend in each isobar as it crosses each front; this causes a distinct wind shift which is a clear indication to the observer on the surface that a front is passing overhead (Singleton and Best, 1979, 7-8; Best, 1990, 230-1).

The weather patterns which would have affected the naval operation of A.D. 43 are those characteristic of the Atlantic low, modified from time to time by the effect of anticyclones. In broad terms we have prevailing winds from the westerly quadrant, created by depressions originating in the North Atlantic and travelling in an easterly/north-easterly direction across north-west Europe, giving way from time to time to winds from other directions generated by anticyclones (regions of high pressure). Depressions are low pressure systems with winds circulating (in the northern hemisphere) anti-clockwise; in this they are to be contrasted with anticyclones, the wind circulation of which (again in the northern hemisphere) is clockwise,

The prevailing winds created by depressions are reasonably predictable and, as the depression moves east, there is a characteristic and marked windshift as each front passes over the observer (Fig. 25). The usual pattern is that, as the new depression approaches from the west, it will be heralded by winds from the south or south-west, even on occasion from the south-east; as the warm front passes over, the wind will veer quite sharply to the south-west or west, and again to the west or north-west, as the cold front passes over. The wind will then back to the south-west, south or south-east, as the next depression approaches. This regular sequence of windshifts has important implications for any understanding of options facing ancient seafarers making cross-Channel passages under sail.

The passage of a depression is marked by a characteristic weather sequence, which is of considerable significance for single-observer weather forecasting and which is well known to mariners. Where modern yachtsmen have the benefit of sequential series of photographs of the changing weather pattern of a passing depression (e.g. Singleton and Best, 1979, 22-3), this weather lore was in former times passed down from generation to generation of seamen, often in the form of easily remembered jingles (Hiscock, 1965, 265-8; Sleightholme, 1970, 186-8; Best, 1990, 247). For example:

> Backing winds and mares' tails
> Make tall ships carry low sails.

is an accurate and concise description of the weather associated with an approaching depression. The wind sequence of a depression coming up behind one which has just passed over is concisely recorded in the jingle:

> When the wind shifts against the sun
> Trust it not for back it will run.

Seafarers could form some idea of the rapidity of changes to be expected:

> Long foretold, long last,
> Short warning, soon past.

The weather associated with anticyclones is much more stable (Hiscock, 1965, 263; Sleightholme, 1970, 191; Singleton, and Best, 1979, 6-7; Best, 1990, 232). Anticyclones tend to move slowly or to remain stationary for some days. In summer they are associated with fine settled dry weather, sometimes with thin hazy cloud with winds often from directions other than the west; at other times of the year the sky may be uniformly overcast, sometimes with light drizzle, and in winter and early spring the winds can be bitterly cold. Because pressure gradients tend to be slacker, winds are usually not very strong; indeed in the centre of an anticyclone, there is often a large area of calm. However, on the outskirts of the system, where it may interact with a depression, winds may be strong. For example, an anticyclone to the south of a depression will combine with it to produce a strong westerly airflow between them.

Single-observer forecasting was all that was available until the advent in the modern age of instantaneous communication and no doubt it would have been exploited to the full by Aulus Plautius's naval staff. Riley (1976A, 114-5) suggests that only three factors are of significance in single-observer forecasting:

1. Observation of pressure changes with a barometer;

2. Direction and strength of the wind;

3. Cloud formation and movement.

Before the age of instrumentation, only the second and third were available to mariners. The limitations of single-observer forecasting need to be borne in mind. First, the weather lore we have just described is restricted in its validity: the weather sequences described are those which are experienced in that part of north-west European waters which normally lie to the south of the track of the centres of passing Atlantic lows; the weather sequence associated with a depression whose centre passes south of the observer is quite different (Singleton and Best, 1979, 7-8; Best, 1990, 247). This would not have been a problem for Aulus Plautius's naval staff; the centres of depressions usually track well to the north of the English Channel and southern North Sea.

The second limitation is that of timescale. Riley suggests that no forecast the mariner makes on his own can be valid for more than five or six hours (1976A, 114). This may be unduly pessimistic except in a rapidly changing meteorological scenario; Hiscock points out that the cirrus cloud portending an approaching depression may be seen in the western sky when it is as much as 300 miles away and may give 12 or even 24 hours' notice of an approaching depression (1965, 265). But what the single observer cannot see is the second and third depression forming out in the Atlantic. Linked with this is the uncertainty for the single observer of the potential longevity of an anticyclone. In 1879 Captain Andrew Shewan spent twelve days beating up-Channel in his clipper *Norman Court* in the teeth of a strong easterly wind generated by an anticyclone; he was informed by a fleet of Salcombe fishermen that the easterly had been blowing for six weeks (Shewan, 1996, 37). On the other hand, although its stability will usually mean that one can count on at least a few days of settled weather, an anticyclone can decay in as little as twenty-four hours (Sleightholme, 1970, 191). For the passage of some twelve hours planned by Duke William that was not a problem, but for Aulus Plautius's naval staff that would have introduced a degree of uncertainty if the planned passage extended, say, to three days or more.

The third limitation is reliability. Modern authorities emphasise the importance of using single-observer forecasting only as an adjunct to official meteorological services (Sleightholme, 1970, 186; Riley, 1976A, 114-5; Best, 1990, 247). What single-observer forecasting does in the modern context is to enable the mariner to add what might be termed local colour. Official marine forecasts parcel out weather predictions in terms of formal sea areas of thousands of square miles and inevitably there is a measure of local variation and to appreciate this the mariner can use his own local observations.

Of course it is very probable that, in an age when seafarers had only their own observations to rely on, their sensitivity to minute distinctions in weather patterns was much greater than ours. Even so, any forecast they made was inevitably local. They would not be able to state what the present weather was a hundred miles down Channel, let alone forecast what it would be in that locality two or three days later.

To all this we must add our own uncertainty about the weather patterns two thousand years ago. This is not to suggest that climate change has been so dramatic as to invalidate our picture of a contemporary climate controlled by Atlantic depressions and anticyclones. But if we wish to use modern data to make a statistical assessment of the prevalence of winds from particular directions, we need to be reasonably assured that the climatic conditions were similar enough to allow the comparison.

Lamb (1995, 152-4) identifies the period 800 to 400 B.C. as one of 'unmatched wetness in the west' of Britain with 'an unequalled predominance of westerly winds'. Around 500 B.C. the climate became wetter in eastern areas of England as well and winds became less predominantly from the west. By the beginning of the first millennium A.D. until around A.D. 400. there was a continuing recovery of warmth and dryness in Europe generally (Lamb, 1995, 156-7, 165). The vine and the olive could be cultivated farther north in Italy than had been the case in previous centuries and the beech, which around 300 B.C. grew in Rome, was by Pliny's time regarded as a mountain tree. Lamb expresses the view that the persistent west to north-west winds which delayed Caesar's expedition in 54 B.C. 'was certainly nothing that would be unusual today' (1995, 157). On that basis we may tentatively take modern meteorological data as proxies for the prevalence of winds in the first century A.D.

Appendix XI sets out alternately in numeric and graph form modern data on wind direction and average speed drawn from the *Channel Pilot* and *Dover Strait Pilot* (NP 28, 1977, 39; 41-2; 46; NP 27, 1977, 50; 57). The data cover the months April to September as representative of the Roman sailing season (Veg. *Mil.*, IV, 39).

The selected stations are:

Station	Comment
Boulogne	Putative port of embarkation for the Roman invasion force.
Dover	Indicator of winds in the Dover Strait.
Manston	This is the modern airport on the Isle of Thanet; taken as a proxy for Richborough, although it should be borne in mind that wind strengths are likely to be less at Richborough because it is in the lee of Thanet and of mainland Kent.
Newhaven	Close to the mid point of the hypothetical Roman invasion passage from Picardy to the Solent.
Thorney Island	Taken as a proxy for Fishbourne and the Solent area generally.
Le Havre	Taken as a proxy for a hypothetical alternative port of embarkation for Roman invasion force in the Seine area.

These are of course land stations and offshore average wind speeds are likely to be stronger (McKee, 1983, 21); nevertheless they can be taken as a reasonable indication of the likely conditions that would have been encountered by the invasion fleet on any of the hypothetical passages.

From the data and the Pilots the following conclusions emerge:

1. That the winds are predominantly from the westerly sector, mainly from the south-west, is confirmed by the data from all the stations (NP 28, 1977, 32). Aggregation of the data shows that nearly a quarter (23%) of winds are from the south-west and as much as 48% from the westerly sector generally.

2. Winds from the easterly sector (north-east, east and south-east) constitute in aggregate only a quarter of the total (26%), although there is a marked increased frequency in winds from the north to north-east between February and May (NP 28, 1977, 32). This shows up in the graphs for all the stations, except Thorney Island, and is particularly marked at Dover and Boulogne, with the

implication that as the season progressed the probability of a fair wind to the Solent would decrease.

3. There is a marked funnelling effect created by the Dover Strait which increases the frequency and strength of south-west and north-east winds in the Strait (NP 28, 1977, 24, 32). The *Dover Strait Pilot* states that this effect can cause Force 5 to 6 winds from the south-west or north-east to result in gale force winds in the narrowest part of the Dover Strait, giving rise to higher seas on the Dover to Calais route than would be inferred from the gradient wind speed. These higher seas appear to be greater with north-east winds.

4. Wind speeds average Force 4 (11 to 16 knots), except at Thorney Island with average values at the bottom end of Force 3 (7 to 10 knots), no doubt because this station is in the lee of the Isle of Wight and the South Downs. Clearly the average covers a wide variation, but the average number of days per month with gales (Force 8 or above - 34 knots plus) at all the stations is one or fewer.

5. The mobility of the depressions coming in from the Atlantic means that the region often experiences marked variations in wind speed and direction. However, in late winter and early spring, if an anticyclonic system becomes established over central and north-east Europe, east to north-east winds may persist for several days, occasionally for two or three weeks (NP 28, 1977, 32). This was no doubt the meteorological scenario in January 1879, when the *Norman Court* battled up-Channel against a strong easterly that had been blowing for six weeks (Shewan, 1996, 37-9).

Hazards and Havens

In planning the invasion passage the Roman naval staff would have taken account of both hazards and alternative havens. Indeed Vegetius makes it clear that it was their duty to acquaint themselves with precisely these matters (Veg. *Mil.*, IV, 43). Hazards might be offlying, such as sandbanks or rocks, or the shore itself, if because of the wind direction it lies to the lee of the fleet. Offlying hazards do not have to break the surface of the water, since waves can break heavily over such features, even when they are several metres deep. It is important to consider alternative havens in case a deterioration in the anticipated weather conditions rules out making the original destination.

On the route across the Dover Strait there is only one offlying hazard and one which today has an awesome reputation, the Goodwin Sands (NP 28, 1977, 91-4). Lying some five nautical miles off east Kent and drying at low water, they offer a formidable threat to any ship that goes aground on them. However, a fleet from Boulogne which made a landfall at the South Foreland and then followed the coastline northwards should have been able to give them ample clearance. There is of course the danger that a wind shift to the north-west as a cold front passes over might make holding a course close inshore difficult. However, there would the opportunity to anchor in the lee of the high ground of east Kent in the Downs, an important anchorage throughout the days of sail.

A matter which might warrant further research is whether the Goodwins existed in Roman times. The essential mechanism for the creation of sandbanks is that, as the tidal stream slows down, sand particles being carried along by the water begin to drop out. One reason for the deceleration of a tidal stream is the widening of the narrows through which it has just passed and that is of course the context of the Goodwins to the east of the Dover Strait; there are also sandbanks to the west. Once established, sandbanks tend to be self-generating, because the tidal stream flows more slowly in shallow water than it does in deep. The process has clearly been going on for millennia, but it is possible that it was influenced by the silting up of the Wantsum Channel since the Roman period, which must have altered the tidal régime in the locality.

There appears to have been a popular tradition which associates the Goodwin Sands with Earl Godwine, dating their origin to the eleventh century (Wilson, 1866-69, 790). According to this tradition the Sands were once part of mainland Kent and formed an estate belonging to the earl which was submerged in an eleventh-century storm following the robbing of the stones of its protecting seawall. This seems as unlikely as the alternative explanation that the Sands existed until the eleventh century as the remnants of an offshore island, which one might have expected to have entered the documentary record one way or another, given its proximity to a busy cross-Channel route.

Be that as it may, the association of the Sands with the name of Earl Godwine seems firm enough. It may simply be that the slow build-up of sediment on the Sands over the centuries did not make itself felt as a navigational hazard until the eleventh century. It is certainly true that the *Anglo-Saxon Chronicle* records considerable naval activity in the eleventh century focused on Sandwich, much of it involving Earl Godwine and his sons (*ASC*, 1044-1049, 1052).

On the route coastwise from the ports of Picardy to the Solent there are two hazards to be mentioned. The first, some seven miles eastward of Beachy Head, is the group of shoals centred on the Royal Sovereign Shoal (NP 28, 1977, 77). While, on the basis of modern charted depths, it is unlikely that the Roman transports would go aground here, the chart is marked with overfalls here and the *Dover Strait Pilot* reports that the sea breaks heavily in bad weather. There are also overfalls close inshore of Beachy Head. We cannot be sure that the charted depth would not have been greater in the Roman period, but the Royal

Sovereign Shoals are reported to be of rock and we may wonder whether with the lower sea level of Roman times, they might not then have been more of a threat than today.

The second and more serious hazard on this route is the foul ground and extensive rocky patches going under the collective name of the Owers (NP 27, 1977, 210-11). Standing across the apparent entrance to the Solent, they extend 3 miles south, 6 miles south-east and 4 miles east of Selsey Bill. Again we cannot know for certain how they were configured in the Roman period, but given that they are of rock and that the sea level was lower then, it is likely that they presented an even more serious hazard. Indeed, if we accept Hume Wallace's reconstruction of Chichester lagoon as it was in the Roman period (Fig. 4 in Chapter II, 23; 1990, 9-10; 1999, 2), there can be no doubt of it. The danger is increased because Selsey Bill is a low headland, not one from which it is easy to judge distance off, creating the possibility of running onto the Owers, before the pilot has realised how close inshore he is.

The danger here is essentially one which would have threatened craft coasting westwards, rather than completing a cross-Channel passage from, say, the Seine. The latter would have the high ground of the Isle of Wight on the port bow as a mark to guide them away from the Owers. The danger would be greater if the coasting craft is on the port tack, i.e. with a wind in the southerly quadrant because then Selsey Bill would be a lee shore. In fact the seafarer running close-hauled on the port tack with the tide along the Sussex coast would face the same choice as the ninth-century Viking Egill did, as he coasted south towards the Humber: to go aground on the off-lying hazard or drive his ship ashore (*Egil.*, 59; Binns, 1968, 111-116).

Describing the surroundings which influenced the evolution of traditional working craft in Britain, McKee distinguishes four types of coastline: the lee shore, the exposed shore, the sheltered shore and the weather shore (1983, 23-26, 229). He classifies coastlines on the basis of the aspect they offer to the prevailing south-westerly winds. For our purposes we may note that McKee classifies virtually the whole of the south coast of Britain, from Selsey Bill to the South Foreland as an exposed shore, with the stretch between Rye and Dungeness as a lee shore. McKee is interested in the impact of prevailing conditions on the design of working boats, whereas what counts in passage-making and ship-handling is the actual direction of the wind in relation to the shore during the voyage. Indeed a Roman invasion fleet would almost certainly not have attempted a passage along the south coast to the Solent with a south-westerly wind. But winds from the south or south-east, which would be favourable for the passage, would also make this coastline a lee shore.

The most obvious danger of a lee shore is that the wind may drive a ship ashore and that the pounding of the vessel, as it is lifted and dropped by the waves onto the ground, will break it up. Life will also be at risk if the crew cannot scramble safely ashore; the chalk cliffs along much of the coast from Beachy Head westward would make it impossible for crew members to reach safety. The less obvious danger of a lee shore would be that the wind could well hamper the vessel in trying to keep to windward of off-lying dangers, such as the Owers and the Royal Sovereign Shoals. This is precisely what happened in the recent tragic case of the *Maria Assumpta*. This brig was wrecked on a lee shore outside Padstow and three crew members were drowned. The skipper did not allow himself sufficient room to tack and was subsequently convicted of manslaughter.

Inhospitable though much of the present coastline of Sussex appears, it is likely that in the Roman period there were a number of substantial natural havens, which are now silted up or kept open by dredging. Pevensey Bay, the site of the Norman landing, in the lee of Beachy Head, is perhaps the best known. In addition there are the four river valleys of West Sussex, the Cuckmere, now heavily silted, the Ouse, with the modern port of Newhaven at its mouth, the Adur, with the commercial harbour of Shoreham, both of them kept open by dredging, and Littlehampton on the Arun, which now is open only for some six hours in each tidal cycle (Hanson, 1971, 73-7). In the Roman period all would have served as shelter for a substantial fleet, but would have been open and uncomfortable in southerly gales, precisely the conditions which would make the Sussex coast a lee shore.

Pilotage and Navigation

The ability of seafarers in an age of non-instrumental navigation to orientate themselves, to maintain an accurate heading and to make an estimate of their position, when out of sight of land, has been well researched by a number of scholars, including Lewis (1994) for the Pacific Island navigators, and by McGrail (1983) for the area of our immediate concern. We need not go into great detail. We can, however, note that in the case of all the options for the invasion passage, but one, the task facing the naval commanders was one which McGrail has defined as pilotage, that is to say: 'the art and science of conducting a vessel within waters restricted by the proximity of land and which are generally shallow' (1983, 301). This would certainly be true for the Richborough option and would also be true for the suggested passage from Boulogne to the Solent. The exception would be a passage from the Seine estuary to the Solent.

If the passage did take the fleet out of sight of land it would certainly have been possible to maintain orientation by a whole variety of visual and other signs such as the run of the sea and the directions of the wind and of the sun and stars. Pilots in a non-instrumental age would have exploited these with a high degree of directional awareness.

Coastwise passages or short Channel crossings such as that from Boulogne (or Quentovic) to the Wantsum will normally have been conducted in conditions in which visual orientation was possible throughout the passage. For example, on the 24th August 1991, I left Boulogne on passage to Ramsgate in a lively south-westerly; the South Foreland was visible throughout the passage and we did not rely on formal navigation. The passage was a fast one taking only six and a half hours with an average speed through the water of five and a half knots. Similarly, during longer coastwise passages, such as that along the south coast to the Solent, the seafarer can maintain his orientation by visual reference to the coastline. The critical thing is to be able to maintain visual contact with the coastline and it might be necessary to anchor, for example, at night, if there was no moon (McGrail, 1987, 280).

In any coasting passage, and offshore too, it would have been necessary to keep an eye on the sea so as to identify submerged offlying dangers, such as those off the Sussex coast, which we have just rehearsed. From clues such as the colour of the sea, the way the waves form and break under the influence of wind and current or where the calm patches are, the experienced pilot can read the nature of the dangers presented by the sea-bed, be it sand bars, shallows or rocks (Sleightholme, 1970, 107-12). As we have noted in regard to reading the weather, seafarers who did not have the advantages of charts would undoubtedly have been much more sensitive than we are to such signs. And the importance of local knowledge would be crucial.

There does seem to be evidence that in northern waters coastwise pilotage was much exploited. Of the nine regular Channel routes used by mariners in the late first millennium B.C. four were coastwise routes (McGrail, 1983, 319-32). Later, the significance of Dorestad lay in its position at the junction of the coastwise route north-eastwards towards Scandinavia and westwards towards Francia with the network of the Rhine and its tributaries leading southwards into Central Europe (Lebecq, 1983, 273). In Scandinavia Ohthere sailed along the coast of Norway northwards into the Barents Sea and southwards to Kaupang and Hedeby (*O. E. Or.*, I, i) and we have already noted the case of Egill (121; *Egil.*, 59; Binns, 1968, 111-116). Even though Egill's aim on his voyage south was to avoid landing in the territory ruled by his enemy Eiríkr Blóðøx, king of York, his close following of the coast caused his shipwreck precisely in that territory.

Providing weather conditions were appropriate for the passage, there is no reason to suppose that navigation/pilotage would have presented a problem, particularly for the passages which did not include a leg out of sight of land.

Conclusion

It is not my wish at this stage to compare the various possible routes open to the Roman invasion fleet in A.D. 43. That should await a consideration of the way in which the choice of options might have been influenced by other factors such as ship performance, the size of the invasion force and the ultimate objectives of the campaign (Chapter XII). We may at this stage remind ourselves of the importance of the prevailing winds and the significance of the tidal streams for any coastwise passage down-Channel. Any passage will be influenced by the characteristic weather patterns of Atlantic lows, alternating with occasional anticyclones, and the single observer's constraints on forecasting. We have noted the hazards which might threaten an invasion fleet and which are particularly significant along the Sussex coast. Finally we have discussed the nature of contemporary pilotage and concluded that none of the potential invasion routes would have presented the pilots with an impossible problem.

Chapter XI

Other Naval Operations in the Channel

A.D. 296: The Third Roman Invasion

In this chapter we consider four other naval operations in the English Channel and southern North Sea during the age of sail involving attempts at the invasion of Britain, in the hope that we may be able to identify common features which may inform our understanding of the thought processes of the Roman naval commanders as they came to plan the naval operation of A.D. 43. The first is the third Roman invasion of Britain under the leadership of the *Caesar*, later *Augustus*, Constantius Chlorus and his praetorian prefect, Asclepiodotus. The objective was to re-integrate Britain into the Empire.

The source material includes coins, contemporary or near-contemporary accounts and panegyrics; the latter by their allusive, rather than narrative, style tend to obscure, rather than reveal. It is unfortunate that for the naval operations we have to rely on the panegyrics (*Pan. Lat.*, VIII(V); X(II)). Useful interpretative accounts include Frere (1987, 326-31), Haywood (1991, 37-40) and Salway (1998, 288-90, 295-313). The significance of the episode for the discussion of the naval campaign of A.D. 43 is that it has been advanced in support of the Fishbourne hypothesis as an example of a Roman landing in the Solent area (Hind, 1989, 14).

In 286 the Menapian, Carausius, who had been put in charge of the Roman naval defences along the coasts of northern Gaul and southern Britain against German pirates, learnt that his execution had been ordered by Maximian, the *Augustus* in the West. The charge against Carausius was that his practice was to allow the pirates in, catch them on their way out and embezzle their booty, neither returning it to the original owners nor handing it over to the Emperor. Whatever the justice of this accusation, Carausius took the only step open in such circumstances to a self-respecting Menapian: by a unilateral declaration of independence, he set himself up as a third *Augustus* alongside the two existing legitimate *Augusti*, Diocletian in the East and Maximian, with whom Diocletian had formally shared imperial power, in the West.

In addition to Britain, Carausius held significant parts of the coast of northern Gaul, including the important naval base of Boulogne (Fig. 26). This seems to have enabled him to deny the English Channel to Maximian (Haywood, 1991, 39). For the action now taken by Maximian against Carausius we have evidence only from two panegyric poems. The first, dedicated to Maximian, includes vague allusions to an invasion which he is about to undertake (*Pan. Lat.*, X(II), 12). The second, a much later one addressed to Constantius Chlorus, makes a veiled reference to what appears to have been the failure of this invasion, due, so the panegyricist claims, to stress of weather, although he does allow that the rebels claimed that the failure was because Maximian's troops were afraid of them (*Pan. Lat.*, VIII(V), 12). It is a fair guess that Maximian's fleet embarked from the Rhine, since this may have been his only access to the sea, but what actually happened is beyond knowledge. Haywood (1991, 39-40) suggests that the correct conclusion may well be that Carausius was well prepared for Maximian's fleet, given that the defences of Britain were specifically designed to deal with marauders approaching from the Rhine area, and drove Maximian off; but this is no more than a guess. These new defences included not only refurbished forts at Richborough and Reculver, defending east Kent, but also the superbly sited Bradwell and Walton Castles, the latter now lost to coastal erosion, defending the Essex rivers (Fig. 26).

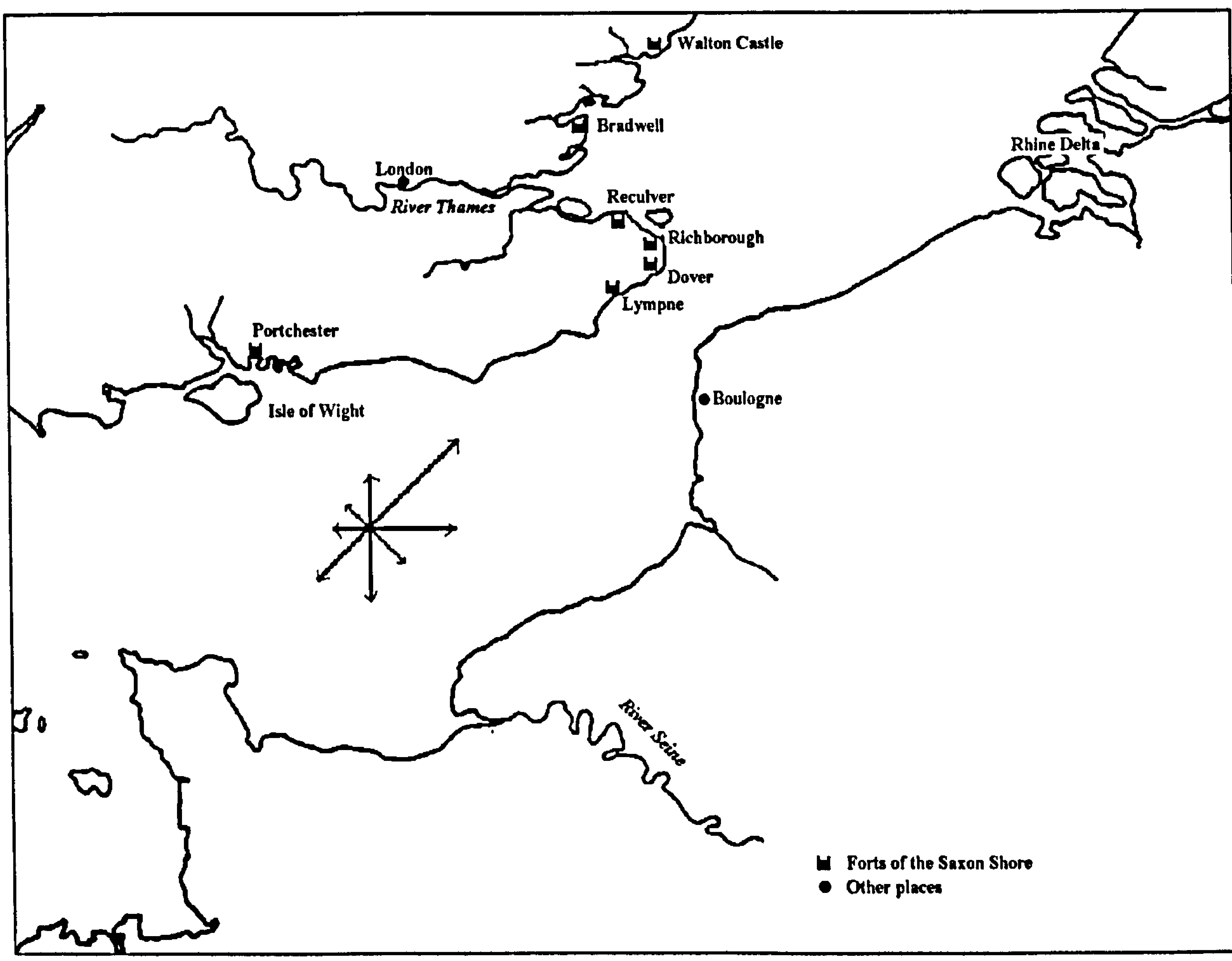


Fig. 26 Sketch map showing places of strategic significance for Roman naval operations A.D. 286-296. While dating evidence for individual Saxon Shore Forts is in some cases deficient, it has been argued that most of the system was in place by A.D. 286; however, a gap in occupation at Portchester has been taken to mean that this fort was abandoned during this decade (Cunliffe, 1975; Salway, 1998, 320-1). The length of the arrows shows the relative frequency of winds from various directions in the months April to September - arrows fly with the wind (Appendix XI; NP 28, 1977, 39, 41-2, 46; NP 27, 1977, 50, 57).

Meanwhile, Diocletian had further reorganised the top management of the Empire. In 285, Diocletian had taken Maximian as his deputy with the title of *Caesar*. The following year he promoted Maximian to share with him the rank of *Augustus* and to be responsible for the West (Salway, 1998, 287-91). Now in 293 he introduced the Tetrarchy: each of the two *Augusti* was to have a deputy, styled *Caesar*. Maximian's *Caesar* was Constantius Chlorus, father of Constantine the Great.

The bâton was now passed to Constantius. In 293 he took Boulogne by building a mole which closed off the harbour (*Pan. Lat.*, VIII(V), 6). This may well have compromised Carausius's control of the Channel, but more importantly for him, it cost him his life; he was assassinated by his partner in secession, Allectus, who took his place as pseudo-*Augustus* (Frere, 1987, 328; Salway, 1998, 305).

According to the panegyricist (*Pan. Lat.*, VIII(V), 13), Constantius now spent the next three years building ships and pacifying the Franks in the lower Rhineland. In 296 his fleet was ready for the invasion. For the invasion, we rely once again almost entirely on the panegyricist (*Pan. Lat.*, VIII(V), 14-9). The key facts - I must enter the proviso: as recorded by him - appear to be:

1. The fleet was organised in two groups, one under Constantius sailing from Boulogne, the other under Asclepiodotus sailing from the Seine.

2. Both fleets sailed in extreme conditions of wind and rain and, not having a favourable wind, 'tacked across it'.

3. Allectus's fleet was on station at the Isle of Wight, but failed to see the arrival of that of Asclepiodotus because of fog.

4. Because Asclepiodotus's fleet is said to have bypassed that of Allectus in the fog, it is assumed, not unreasonably, that it landed in the Solent area. They destroyed their ships after they landed.

5. There is no clear indication from the panegyricist where the fleet from Boulogne landed, or even if it landed at all. Allectus is said to have fled from the sight of it towards Asclepiodotus who defeated him and his Germanic mercenaries. There is a reference to some of Constantius's troops being separated from the rest in fog (another fog?) and finding their way to London, which they successfully defended against Allectus's Germanic mercenaries, an action apparently commemorated in a magnificent gold medallion minted at Trier, the Arras Medallion (Chapter IV, 31; Frere, 1987, Plate 32: Marsden, 1994, 105; Salway, 1998, 310-12).

In considering what the panegyricist reports, I start by discounting his comments about the weather. A commander who has waited three years to prepare his invasion forces is simply not going to risk the successful outcome of his campaign by sailing in bad weather and with adverse winds. It is of course possible that Constantius, like William the Conqueror (Grainge and Grainge, 1993, 268; 1996, 137-9) and later William the Descender (Lindgrén and Neumann, 1985, 640-2), felt compelled to set sail in marginal conditions because the season was getting late and the prospect of favourable conditions that year was diminishing by the day. But, as we shall see, each of the Williams, the Invader and the Descender, failed in their first attempts to cross the Channel.

The second point which merits comment is the panegyricist's report that once they had landed Asclepiodotus's men 'set fire to all their ships' Salway describes this as 'the traditional gesture of confidence' (1998, 308) and certainly this is what the panegyricist says. However, there seems little in the act that is traditional. The traditional thing seems rather to prepare a fortified base for the protection of the fleet. This seems to have been done by Caesar, is what the archaeological record shows was done at Richborough in A.D. 43 and was certainly done by William the Invader (*Gest, Guil.*, 9; *Gest. N. Duc.*, XIV). The only tactical reason for burning one's boats must be to deny them to the enemy, but this not only cuts off one's own retreat, but also denies the possibility of reinforcements of both men and supplies. Frankly the gesture is incomprehensible and, if it is to be credited, can only mean that Asclepiodotus's force was lightly equipped, fast moving and not large enough to spare a garrison to protect the ships.

Thirdly, the length of time taken to build the fleet is worthy of comment. By the standards of Caesar and later of William the Conqueror, three years seems a long time. For his second British expedition Caesar commissioned some 628 new ships, the construction of which was achieved during the winter of 55/54 B.C. (*B. Gall.*, V, 2). William the Conqueror assembled his fleet of several hundred ships in a similar time scale, certainly building some of them (Gillmor, 1985, 105-22; 1996, 114-28). As for Plautius's fleet of A.D. 43, given that, as we shall see in Chapter XII (155-6), tension had been mounting since the emperor Gaius's failed attempt to launch an invasion against Britain, it is likely that it had been assembled over several years.

Considered in depth, the third Roman invasion of Britain does not bring the support to the Fishbourne hypothesis that its advocates might wish. Firstly, it is not part of the critique of the Fishbourne hypothesis that an invasion landing in the Solent would not have been envisaged in A.D. 43; only that such a landing would not have been attempted from a port of embarkation as far east as Boulogne. But at a more profound level to argue support for the Fishbourne hypothesis from a landing in 296 in the Solent region is to ignore the fact that the strategic contexts of the invasion of A.D. 43 and of that of 296 were entirely different. In A.D. 43 a landing at Richborough and the establishment there of a secure beachhead was entirely feasible; in 296 it would have been out of the question. By then the system of the Forts of the Saxon Shore was well established (Frere, 1987, 329-30). A frontal assault from the sea on Richborough was not to be contemplated and there is no evidence that Constantius attempted it, though he may have made a show of force off the east Kent coast. Haywood opines that Constantius simply sailed for London (1991, 40) and Frere that Constantius 'contented himself with a demonstration which was perhaps diversionary in intent' (1987, 330), while Salway concurs in the possibility 'that Constantius' own use of the short crossing was a deliberate feint, particularly sensible if a substantial part of the Second legion was now garrisoning the new fortress at Richborough' (1998, 308). Be that as it may, in 296 a pincer advance by two fleets made good strategic sense, just as the straightforward crossing and landing in three waves at Richborough made good strategic sense in A.D. 43.

1066 and All That

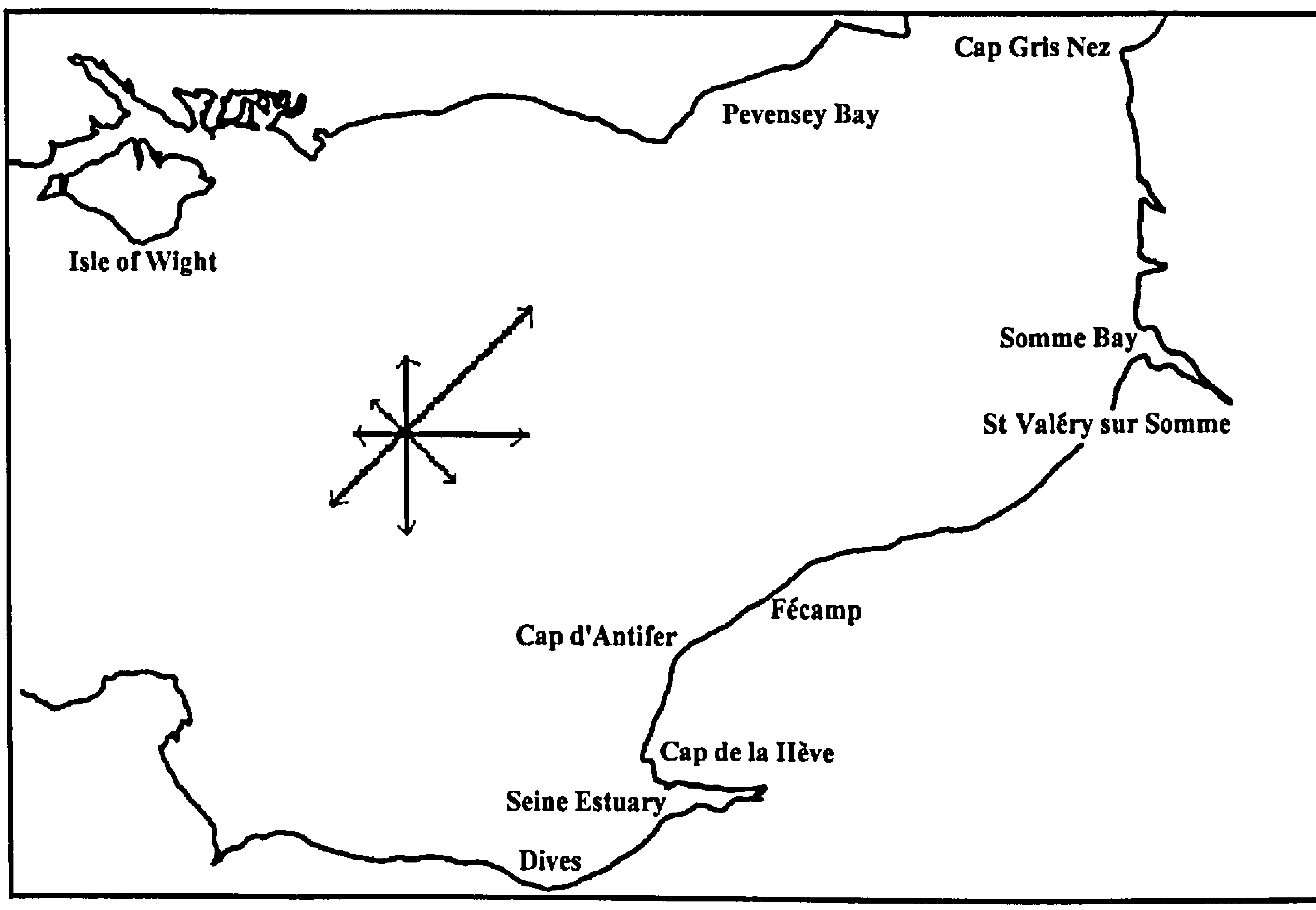


Fig. 27 Sketch map of the English Channel (east) showing the location of places significant in the naval operation of 1066. Winds shown as in Fig. 26.

The outline facts of the Norman Invasion are well established. Edward the Confessor died on the eve of Epiphany 1066 and Harold Godwineson took the throne. William, Duke of Normandy, assembled an invasion fleet at Dives and at neighbouring harbours on the Bay of the Seine (Fig. 27). Harold as a defensive measure stationed his fleet at the Isle of Wight. It remained there all summer, until it stood down on the 8th September. After a delay of perhaps a month or six weeks waiting at Dives for a favourable wind, the Norman fleet moved in mid-September along the coast to St Valéry sur Somme. After a further delay a favourable wind set in on or about the 28th September. The fleet sailed for England on the evening tide and arrived at Pevensey the following morning. On the 14th October the Normans met and defeated the Anglo-Saxons at Battle. Harold was killed and William became king. He was crowned at Westminster on Christmas Day 1066.

The principal contemporary records relevant to the events of 1066 are the Bayeux Tapestry, believed to have been commissioned by Odo, Bishop of Bayeux; the *Gesta Normannorum Ducum* written by the monk William of Jumièges around 1070; the *Gesta Guillelmi ducis Normannorum et regis Anglorum* written between 1071 and 1077 by William of Poitiers, who served Duke William as a knight and later as chaplain; the *Carmen de Hastingae Proelio* (*The Song of the Battle of Hastings*), thought by some to be by Guy, Bishop of Amiens; the *Anglo-Saxon Chronicle*; and the intriguing *Ship List of William the Conqueror* which may or may not record the number of ships (and men) contributed by each of William's magnates (MS Oxford Bodl. Lib E Museo 93 fo. 8v; van Houts, 1988, 159-81). Collections of these (apart from the *Ship List*) and other sources have been published by Morillo (1996); Morillo also includes a number of articles by various scholars on various aspects of the campaign.

Studies of the naval operation have been published by Gillmor (1985), Neumann (1989) and Christine Grainge and myself (1993 and 1996).

Neumann's study focuses on the crossing from St Valéry to Pevensey and produces conclusions about the wind strength and direction, the speed of the ships, the effect of the tides on the route sailed and its length. His conclusions are uncontroversial and add little to an understanding of the naval operation or of its politico-strategic context.

In the second part of her paper (1985, 122-31) Gillmor addresses the conduct of the crossing from Dives *via* St Valéry to Pevensey. Gillmor's interpretation of the Norman naval operation turns on her belief that the standing down of the Anglo-Saxon fleet from its station at the Isle of Wight on the 8th September meant that the Normans could now sail from Dives in safety (1985, 124). Up to that date the Anglo-Saxon warships had been waiting to 'pounce on the unescorted Norman convoy'. She also opines that William's 'mariners were doubtless aware of the west winds in Lower Normandy at this time of year and must have advised William to move up the coast where the chance of a south wind would be greater'.

Neither point can be substantiated. Interception on the high seas was, given the limited capability of the ships of the period, virtually impossible and blockading of enemy ports out of the question (Haywood, 1991, 4).

The idea that William moved east in search of favourable winds is not tenable either. Gillmor quotes an authority (Sauvage, 1911, 248) for her claim that 'the western winds along the Lower Norman coast are particularly noted for their violence and long duration, especially between the equinoxes' (Gillmor, 1985, 124). In the absence of data for St Valéry, let us take as proxies Boulogne and Dieppe. The mean wind speed recorded during September at Le Havre is 13 knots, compared with 12 knots at Boulogne and 11 knots at Dieppe, all generally within the bottom end of Force 4 (Fig. 28; NP 28, 1977, 45-6; NP 27, 1977, 57). As to direction, it is true that at Dieppe, but not at Boulogne, there is a significantly greater probability of a wind from the south (18% as opposed to 10%), but this is offset by a marked reduction at Dieppe in winds from the south-east which would also serve (3% as opposed to 9%). As to the frequency of westerly winds, taking the totals for the whole of the westerly quadrant (south-west, west and north-west), we arrive at:

Le Havre	37%
Dieppe	48%
Boulogne	53%

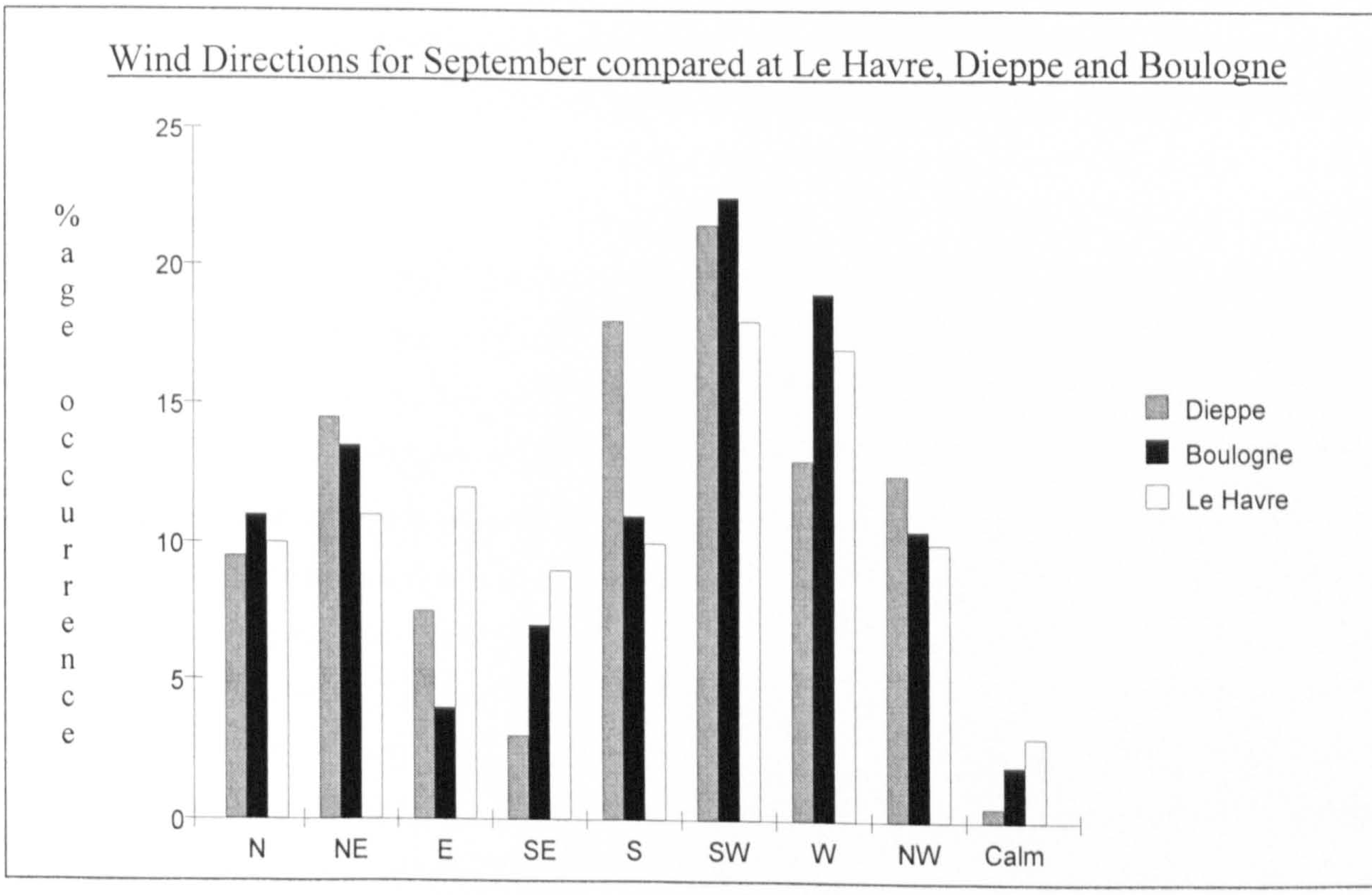


Fig. 28 Percentage occurrence of winds in September from various directions at various points on the north coast of France (NP 28, 1977, 45-6; NP 27, 1977, 57).

A key consideration in the understanding of the passage to St Valéry is that the coast of Ponthieu stretching north from the Somme is a lee shore. The men of St Valéry had the right of *lagan*, of holding to ransom ships driven onto its shores (Morton and Muntz, 1972, 4-5; Grainge and Grainge, 1993, 263; 1996, 131). It is not to be supposed that this might have realistically applied to the Norman fleet, but it is a strong indication of the dangers of the area which the locals exploited; it was traditional wreckers' territory and hardly an area where William would have willingly risked his invasion fleet.

The fact of the matter is that the documentary record is clear enough. After a lengthy delay during August and the first two weeks of September waiting for a favourable wind, the Norman fleet set sail and reached St Valéry. Both William of Poitiers and *The Song of the Battle of Hastings* state clearly that St Valéry was not the intended destination (*Gest. Guil.*, 6; *Carmen*, 46-7). We must suppose, therefore, that the intended destination on leaving Dives was England and that William took a risk on setting sail in marginal conditions, because the lengthy wait and the advancing season made it appear that the choice was between sailing in such conditions and not sailing at all that year. There is no need to postulate the standing down of the Anglo-Saxon fleet or the greater probability of favourable winds further east to explain his move.

At St Valéry the pressure on William continued and is vividly depicted in *The Song of the Battle of Hastings* (*Carmen*, 54-63). At the end of the day it was a matter of the leader facing up to the challenge and winning through. For Christine Grainge and myself one of the fascinating outcomes of our reconstruction of the invasion crossing was the insight into William's charisma and strength of purpose under stress (1993, 271-2; 1996, 141).

It remains to consider the strategic context of 1066. The chain of the Forts of the Saxon Shore had long since fallen into disuse. The long years of the Viking raids, invasions and wars had eventually led to the creation by Ælfred and his son, Edward the Elder, of the *burhs*, fortified places established at strategic points throughout southern England whose defenders were systematically supported by the countryside through the system of the *Burghal Hidage* (Hinton, 1977, 30-41; Smyth, 1995, 135-8; Abels, 1988, 68-78; 1998, 195-207). The *burhs* constituted an integrated system whose purpose was 'to provide refuges, to block rivers and to guard river crossings' (Hinton, 1977, 40). Most of the sea inlets along the south coast were covered, but not all; a notable exception appears to have been Pevensey. To supplement the system, Ælfred divided his army into two rotating contingents, so that at any time there was a mobile standing force able to respond to any Viking threat and to act in conjunction with the garrisons of the *burhs*, thus creating a system of defence in depth (Abels, 1988, 63; 1998, 195-6).

However, the system was expensive, not only to establish, but also to maintain (Abels, 1988, 76-7). The record of the *Burghal Hidage* required a total of 27,071 men to garrison the *burhs*, quite apart from the standing army. Abels estimates that this amounted to 6% of the total population of Wessex and a quarter of the adult male population (1998, 207). The likelihood is that by the eleventh century the system had been allowed to fall into disuse and that perhaps only key points, such as Portchester, defending the route to

Winchester, may have been manned. Defence of the kingdom would have depended largely on the armies raised by the king and his magnates.

Armies on both the Norman and Anglo-Saxon sides had evolved considerably from primitive Germanic warbands, based on the bond between a man and his lord. Although the details varied, the obligation to military service was becoming closely tied to land tenure (Abels, 1996, 58-77; Chibnall, 1996, 80-92). While the chief magnates might have had a personal obligation to respond to the king's summons, among lesser folk the obligation was that a specified number of armed men should be provided by a given estate; in Anglo-Saxon England this obligation was closely related to the hidage of the place concerned, but in no sense did it amount to a universal obligation to respond to the royal summons (Abels, 1988, 175-9).

Although the kings were surrounded by their immediate retinue of permanent household troops, ('housecarls' on the Anglo-Saxon side - Abels, 1988, 167-70), these armies did not amount to the professional armies that the Romans had known. Numbers were far fewer and armies came together very much as the occasion demanded and disbanded when the need had passed. Based on the size of the battle field, there seems to be an academic consensus that the armies that met at Battle can have numbered no more than about 6,000 to 8,000 men on each side (Abels, 1996, 74).

The evidence of the Bayeux Tapestry shows that ships in north-west European waters were now generally built in the Nordic tradition, at least for military purposes. These are likely to have represented a considerable technological advance on the Romano-Celtic transports available to the Romans, being lighter, faster and more seaworthy. However, as we have already noted, the limitations of naval technology were still such as to rule out the effective interception of an enemy fleet at sea. Inshore skirmishes, where the enemy's freedom of manoeuvre was constrained by shore line and shallows, are indeed documented, but they are few, for example, Ælfred's engagement of sixteen Viking ships on the Essex Stour in 885 or his action in 896 with his newly designed ships against six Viking ships in the Solent (*ASC*, 885, 896; Binns, 1968, 105-10; Abels, 1998, 172-4, 305-7). Open-water interception would not become a reality until weapons had evolved to make it possible to lay down a long-range barrage; the long bow, which was to prove so effective in doing so at Agincourt, had yet to be developed and in any event could not have been used with the same effect at sea, because of the unsteadiness of the ship as a platform and because the archers could not be massed in sufficient numbers. When they occurred, naval battles were close quarter affairs and a favourite tactic was for one side to lash its boats together, thus creating a larger platform on which its warriors would have room to move and fight what was virtually a land battle (Griffith, 1995, 196-202). In this, size and above all height of freeboard gave an advantage and these are precisely the qualities that the *Anglo-Saxon Chronicle* identifies in Ælfred's new ships of 896.

The political geography had moved on as well. From the point of view of the Normans it made good sense to amass their invasion fleet in harbours in Lower Normandy. The Seine as well as the rivers of Lower Normandy would have served as a vital link in the transport system in assembling their supplies and, of course, in getting their ships from the construction sites on inland rivers. The coast further east, cliff-lined, was far less hospitable and more exposed than the Bay of the Seine and offered fewer suitable harbours (Grainge and Grainge, 1993, 263; 1996, 131; British Admiralty Chart 2451). St Valéry sur Somme, which William eventually was forced to use, was outside his jurisdiction, lying in the county of Vimeu (*Carmen*, 46-52; Morton and Muntz, 1972, 4-5), while Boulogne, well suited, as we have seen, for a landing in east Kent, had William intended one, was within the province of Ponthieu.

In Dives and the harbours nearby the Normans were well placed for the planned crossing to the south coast of England; this was after all a base from which they could exploit the by now well established trade route from the Seine to the Solent, the eleventh-century equivalent of McGrail's route 7 to which he gives a relative reliability rating of 71% (McGrail, 1983, 309, 333). In addition to the Solent, they would have the alternative of the numerous harbours available on the coast of Sussex which are now silted up, from Littlehampton through to Rye. Did William intend to land in the Solent or further east, or indeed did he have no fixed view of where he should land, simply leaving that to be determined on the day? We cannot know. But the Solent would have opened the way into the heartland of Wessex and its ancient capital, Winchester.

On the Anglo-Saxon side, it seems clear that Harold expected that the Solent would be William's intended landing point. This is where he stationed his fleet (Grainge and Grainge, 1993, 271; 1996, 140). Otherwise, except perhaps for east Kent, where Sandwich was beginning to emerge in the documentary record as a place of strategic significance, the south coast was wide open.

Once again then the strategic situation is significantly different from that which applied in A.D. 43 and in 296. The Invader was denied the full range of options available to Plautius and to Constantius for the embarkation of his army and in particular he did not have access to Boulogne. This meant that a crossing of the Dover Strait was not on the agenda and in any event the strategic location of Sandwich may have made that an undesirable option. The Bay of the Seine was the logical place to assemble his fleet and from there the options for landing were wide, including the possibility of an opposed landing in the Solent, if William so chose.

1588: 'Jehovah Blew and They Were Scattered'

(Inscription on Dutch medal - Rodríguez-Salgado et al., 1988, 276).

The defeat of the Spanish Armada stands as the high-water mark of the power of Elizabethan England, celebrated by contemporaries in pamphlets, medals, music and paintings, such as the magnificent 'Armada' portrait, one version of which is on display at Woburn Abbey (Rodríguez-Salgado et al., 1988, 271-85). It created the myth of the impregnability of the British Isles behind the barrier of the English Channel:

> This precious stone set in a silver sea,
> Which serves it in the office of a wall
> Or as a moat defensive to a house,
> Against the envy of less happier lands (*Richard II*, Act II, Scene I).

and, along with Trafalgar and with King Ælfred's design of ships 'twice as long' and 'both swifter and steadier and also higher than the others' (*ASC*, 896; Abels, 1998, 305), ranks among the foundation legends of the Royal Navy. It is also a tale of unremitting tragedy and gruesome suffering as the Armada struggled back to La Coruña, many of the great ships leaving their bones and those of their crews on the coast of Ireland.

The contemporary documentary sources and the archaeological evidence have enabled a much more detailed understanding of the events of 1588 and of their strategic context than is possible for the two campaigns we have just considered. Two comprehensive accounts of the 'Enterprise of England', as the Spanish called it, and its background were published to celebrate its four-hundredth anniversary (Padfield, 1988; Rodríguez-Salgado et al., 1988). Especially important for an understanding of the running naval battle in the Channel and the southern North Sea are the Armada Charts by Augustine Ryther published in 1590 and based on charts by Robert Adams, ultimately drawing on Howard's own record of the engagement (Rodríguez-Salgado et al., 1988, 243-8); of particular interest is that for each stage of the battle the wind direction is shown (Fig. 29).

Naval technology had moved on considerably since the days of the open ships of the Scandinavian tradition (Padfield, 1988, 66-77; Friel, 1988B, 151-3; Barkham, 1988, 158-63). Multi-masted, ocean-going ships were now the norm; with their decked hulls, they offered their crews a modicum of shelter that would have been unthinkable half a millennium earlier. During those five hundred years interception at sea had become possible and more common; shipbuilding trends had reflected this with the evolution of huge fore- and sterncastles to give crews the advantage in grappling and boarding attacks. More recent and more significant was the emergence of the naval gun (Padfield, 1988, 80-93: Martin, 1988, 173-5; Loyn, 1988, 175-6).

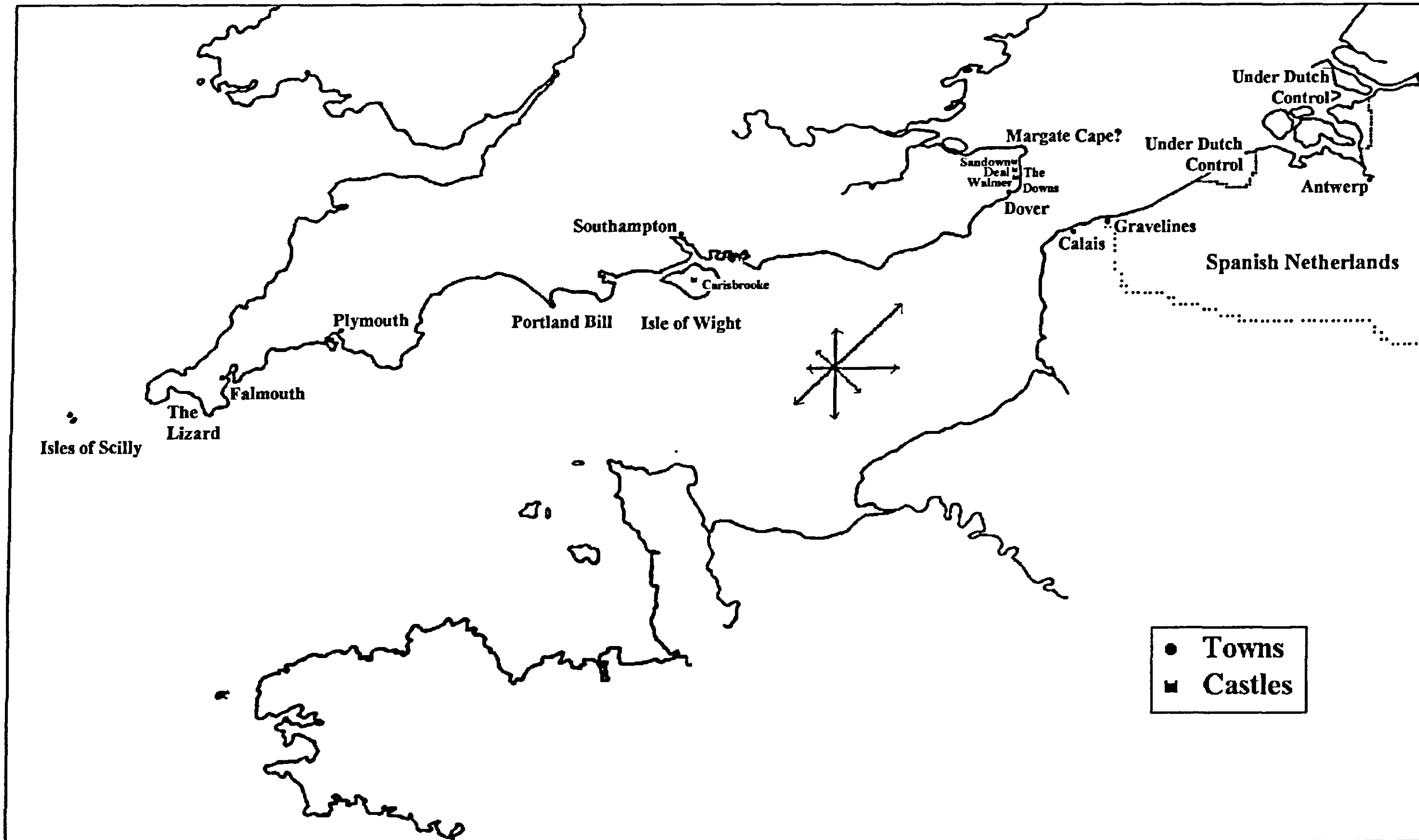


Fig. 29 Sketch map showing places significant in the Armada campaign of 1588. The extensive shoals along the Flemish coast running from Gravelines to the Schelde/Rhine Delta are not shown. For the detail of the Spanish Netherlands see Rodríguez-Salgado (1988C, 110). Winds in the eastern Channel as in Fig. 26.

The core of the Armada was its 44 galleons and *naos* (Rodríguez-Salgado et al., 1988, 154-5). The basic hull proportions of these ships followed a shipbuilding rule giving the keel and overall length as twice and three times the beam respectively (Barkham, 1988, 162). Built to give maximum cargo capacity for the Atlantic trade, such ships with the high windage from their superstructure without doubt did not point well into the wind and were cumbersome in coming about (Padfield, 1988, 76-7), but this would not have been a problem on the Atlantic trade route, when they exploited the north-east trade winds for the voyage out and the westerlies for the return passage, sailing free both ways. However, in the context of the Channel engagement, their poor windward ability would be a crippling disadvantage.

By contrast in the second half of the sixteenth century, English warship design had evolved to produce the so-called 'race-built galleon' (Padfield, 1988, 69, 114-15; Friel, 1988B, 152-3). The design change, credit for which has been given to John Hawkins during his time as treasurer to the Admiralty, but which must have involved contributions from the Queen's master shipwrights, such as Matthew Baker, involved a drastic reduction in the height and size of the castles and a change in the proportion of beam to length, which now centred around 1:4. The change in this ratio produced an underwater profile with less water resistance and greater leeway resistance, while the reduced windage from the lower superstructure enabled the ships to point higher, both combining to produce an enhanced windward performance, an ability to change tacks more quickly and generally greater manoeuvrability (Padfield, 1998, 76-7). The trade off was of course that if it came to a grappling and boarding action the English warships would be at a disadvantage.

In their gunnery the English had a complementary advantage. The Spanish had more guns, heavy enough to inflict real ship damage (464 to 423). However, Padfield suggests that the distribution of the guns meant that on average the Spanish ships would have each mounted eleven heavy guns and the English ships twenty-one each. If we exclude Perier-type guns intended for very close-range fighting, then the English had an absolute advantage of 385 to 267 pieces (Padfield, 1988, 63-5). The English guns were mounted on compact dedicated naval gun carriages, rather than on the bulky field gun carriages or the shipboard adaptations of them used by the Spanish (Martin, 1988, 173-4; Loyn, 1988, 176; Rodríguez-Salgado et al., 1988, 179). The sheer bulk of the carriages used for the Spanish guns seriously reduced the space around them and would have impeded the rapid reloading drills developed by the English. In any event it seems that the Spanish did not consider such drills necessary. In Spanish tactics a broadside was a preliminary to a boarding attack; it would be delivered at virtually point-blank range to confuse the enemy immediately before the troops went over to board. The soldiers who had helped to set the guns up would be part of that boarding party, leaving the gun captains to discharge the broadside on their own (Martin, 1988, 173).

Thus, if it came to close action with grappling and boarding, the advantage would have been with the Spanish with their high fighting castles, superiority in anti-personnel weapons and their sixteen thousand or more soldiers. With their greater manoeuvrability, however, the English were able to make sure that it never came to a boarding action, much to the frustration of the Spanish admiral, the Duke of Medina Sidonia. Throughout the whole of the engagement, from the initial sighting of the Spanish fleet off the Isles of Scilly on the 29th July, through the Battle of Gravelines on the 8th August until the English broke off the engagement on the 12th August off the east coast of Scotland, the only boarding actions were undertaken by the English and then of ships which, by reason of being disabled, had been abandoned by the Spanish (Padfield, 1988, 116).

There is no need here to go into a day by day account of the running battle; it has been analysed in detail both by Padfield (1988, 98-168) and Rodríguez-Salgado and Friel (1988, 233-42). The tactic of the English was to engage in a series of stand-off gunnery skirmishes. This depended on winning and retaining the 'weather gage', i.e. getting to windward of the enemy fleet and staying there. As soon as the Armada was sighted off the Isles of Scilly, the English fleet worked out of Plymouth against the westerly wind to get to windward of the Armada and, apart from one occasion off Portland Bill when the early morning land breeze brought the wind into the north-east, they retained the weather gage throughout the two weeks of the engagement (Padfield, 1988, 117-18). In this position they were able to shadow the Armada, deny Medina Sidonia the close action he so much desired and engage in naval artillery duels as and when they chose. The procedure was for the English ships to run down in line ahead towards the target ship, harden up one by one on to a beam reach as they came into range, discharge their broadsides and then come close-hauled to leave. When all the ships in the attacking squadron had done this, they were then able to tack and return on the other gybe towards the target ship to discharge the broadside from the other beam (Padfield, 1988, 106-7).

The formation adopted by the Armada was a modified line abreast in the shape of a crescent (Padfield, 1988, 103-4, 124-5). In this formation they could advance up Channel before the westerly winds without unduly hampering each other's wind (Fig. 18 in Chapter IX, 91). It also enabled them to swing on to a beam reach when under attack so that they could bring their broadsides to bear (Fig. 19 in Chapter IX, 92).

Although the English did not know it (Friel, 1988A, 125), it was not Medina Sidonia's intention to land direct on the English coast. His instructions from Philip were to effect a junction with the Duke of Parma, the Spanish commander in the Netherlands, and to provide cover for him to cross to England with his army (Padfield, 1988, 17, 100, 132-44). The plan was that the Armada should anchor in the Downs, 'off Margate Cape'; from here the fleet would be able command the Dover Strait while Parma came across in small ships, which were all that were available to him - a sort of Dunkirk Little Ships in reverse (Padfield, 1988, 138). The recent sixtieth anniversary passage of the Dunkirk Little Ships showed one weakness in this plan, of which Parma was well aware (Padfield, 1988, 134). The Little Ships were unable to make the anniversary passage on the intended date because of high winds and equally Parma recognised the need for settled weather for his crossing.

He also recognised the need for an unchallenged passage, since his vessels were 'too small for fighting'. Philip seems to have believed that this would be achieved by the mere presence of the Armada in the Downs. The Downs would have been an uncomfortable station; Henry VIII had built Walmer, Deal and Sandown Castles to meet precisely such an eventuality and they were state of the art gunnery platforms (Fig. 29). Moreover, the Armada had failed to neutralise the English fleet. Medina Sidonia, therefore, felt constrained to anchor off the exposed coast off Calais and make contact from there with Parma, from whom he had not heard since entering the Channel eight days earlier (Padfield, 1988, 101, 128, 129, 131, 132). The English fleet anchored some two miles further west to windward. The drama of the Armada was about to reach its catharsis.

In the early hours of the 8th August, with a favourable wind and tide, the English sent in their fire ships. With the loss of only one ship, the galleass, *San Lorenzo*, which lost its rudder in a collision and went aground, the Armada slipped their cables and made off on the port tack to avoid the shoals downtide and downwind off the Flemish coast (Rodríguez-Salgado and Friel, 1988, 240-1; Padfield, 1988, 144-53). At first light the English ships came in to open what was to be the Battle of Gravelines. Although, as in the earlier encounters, the English avoided boarding action, by all accounts they now came in very close to deliver their broadsides. It may well be that after the actions during the run up the Channel, the Spanish galleons were running out of shot; it may well be that the English now felt that they had the measure of the slow and ineffective Spanish fire (Padfield, 1988, 152). At any event by the end of the day, after a considerable mauling and with mounting concern about the shoals under his lee (Rodríguez-Salgado and Friel, 1988, 242; Padfield, 1988, 159-63), Medina Sidonia was constrained to accept that he had no other option but to return to La Coruña round the north of Scotland, even if the spin he put on the decision for his master was that he would have returned to Calais if the wind had served.

Whatever Philip's overall strategic objectives, those he set for his commanders-in-chief lacked clarity and practicality. Parma was to transport his army across the Channel under the protection of the Armada, but no account was taken, in spite of Parma's discrete protestations, of the threat posed by the Dutch rebel seamen, known as the Sea Beggars. As for Medina Sidonia, he was to rendezvous with Parma, command the Channel during Parma's crossing and deliver to him the siege trains he was transporting together with six thousand troops, but how he would command the crossing was entirely vague. Although the general intention seems to have been that this should have involved anchoring in the Downs, there are also references to anchoring in the Thames, a station from which commanding the crossing would have been out of the question. Crucially there was no pre-arranged plan for the rendezvous; Medina Sidonia was simply left to try and make one up on the hoof as he sailed up the Channel.

In like vein, the way the Spanish exploited their intelligence was very poor. Padfield suggests that it would have been unreasonable to expect Philip 'with his vast responsibilities' to have known about English tactics of stand-off naval gunnery (1988, 140). The fact is, however, that he had the resources to find out about something which would prove to be of crucial importance to the success of the Armada, and given the personal interest he gave to the planning of the Enterprise, he should have asked himself what the English tactics would be. In fact he may well have done so. Rodríguez-Salgado (1988A, 34) says that in his instructions to his commanders Philip did warn them that the English would avoid boarding and rely on their guns. Whatever the truth of the matter, in all the painstaking planning of the Armada, no one found a way of countering the English tactics; even Medina Sidonia's anguished request to Parma for 'flyboats to catch the enemy fleet and force them to fight' (Padfield, 1988, 129) was too late and would have scarcely answered the problem. Similarly, Philip should have taken account of the danger posed by the Sea Beggars, of which he was aware and which he failed to share with Medina Sidonia. The failure to neutralise these two dangers, more than anything else, accounted for the failure of the Enterprise of England.

In addition to these, there is one other staggering failure of intelligence in Parma's plan (Rodríguez-Salgado, 1988A, 19). His flotilla of little ships would land on the English coast between Dover and Margate, 'a fertile strip with good landing points'. John Speed's map of Kent of 1612 shows that, although a shadow of its former self, the Wantsum would still have offered a formidable obstacle, thus ruling out a landing on Thanet. So these landing points must have been in the Downs - under the guns of Sandown, Deal and Walmer Castles.

It remains to consider the strategic significance for the Enterprise of the Isle of Wight (Fig. 29). As in the case of Asclepiodotus's invasion crossing, the Armada has been taken as supporting the Fishbourne hypothesis on the grounds that 'the commanders of the Spanish Armada considered the use of the Solent for an invasion and therefore thought of capturing the Isle of Wight' (Bird, 2000, 92).

In fact the Isle of Wight figured in Spanish planning in two ways. First, Philip recommended Medina Sidonia to consider seizing the Isle of Wight, but this was only if he failed to join Parma or secure his crossing (Rodríguez-Salgado, 1988B, 125; Padfield, 1988, 137). However, Philip does not seem to have regarded it as a place from which an invasion of England could be mounted; he decided not to instruct Medina Sidonia to take Southampton on the grounds that while the island might be held, the recovery of the port by the English could not be prevented. Second, at a council of captains off the Lizard, Medina Sidonia decided to anchor off the Isle of Wight to wait to hear from Parma (Mattingly, 1959, 233; Padfield 1988, 100-103).

Quite what Medina Sidonia might achieve on - or off - the Isle of Wight, apart from having a sheltered port to await news from Parma, remains uncertain and Philip did not spell it out. Carisbrooke Castle was a considerable fortification which would not have been taken without a major siege and without it the Spanish would scarcely have secure control of the island. In any event Spanish thoughts about taking the Isle of Wight scarcely justify Bird's interpretation that the Spanish considered using the Solent 'for an invasion'. The sources appear clearly to indicate that the Solent would be used solely as a place to wait to hear from Parma, before proceeding further east to support his passage across the Dover Strait, or after the Armada's main objective had failed.

Taken with the vagueness of the Spanish plans, this must mean that in 1588 an invasion beachhead on the Solent was not a seriously considered objective.

There were two further Armadas in 1596 and 1597, one to Ireland and one to land at Falmouth (Padfield, 1988, 198-9). Neither was ready until late in the year. Philip against naval advice insisted that both should sail. Both encountered Atlantic gales and were scattered before they could reach their destination. Falmouth is to windward of the English fleet bases. The Spanish had learnt the importance of the weather gage. The irony is that, had the Armada sailed in 1588 with the objective of putting an army ashore at Falmouth, the Enterprise of England might have been a very different story.

1688: 'Praying for a Protestant Wind' (Macaulay, 1883, 558).

Englishmen do not like to think of the Descent of William of Orange in 1688 as an invasion, preferring to call it a revolution, the Glorious Revolution which preserved their ancient liberties. Nevertheless, it had many of the characteristics of an invasion: it was the sovereign act of a foreign power, pursuing its own legitimate interests, it involved the assembly and transport across the Channel of an army of some 16,000 soldiers, including some 3,300 cavalry, and it resulted in the replacement of the legitimate sovereign by a foreign prince with a questionable claim to the throne. In this, apart from the fact that the rightful king, James II, realising that his support was draining away, did not stand and fight, but deserted his kingdom, it is scarcely to be distinguished from the invasion of Duke William of Normandy. As we shall see, there are also close parallels between the actual invasion passages of Duke William the Invader and Prince William the Descender.

The background to the invasion is given by Speck (1988). Other useful accounts are Ashley (1954, 165-78) and Hill (1980, 166-71). Macaulay (1883, 209-655) is perhaps only for the long-distance reader, but he does have some useful passages on the naval operation. Lindgrén and Neumann (1985) have written up the meteorological background to the invasion. Contemporary or near-contemporary sources include a diary by John Whittle, a priest on board the Dutch fleet (Whittle, 1689) and two histories of England (de Rapin-Thoyras, 1743; Dalrymple, 1771); de Rapin-Thoyras states that he too was on board William's fleet (1743, 776-7).

The three years of the reign of James II were dominated by growing hostility towards him among many of his subjects because of his use of extra-parliamentary measures to promote the interests of fellow Catholics, who were barred by the Test Acts of 1673 and 1678 from holding office under the crown (Speck, 1988, 31-2). Matters came to a head when James issued a general Edict of Toleration, which suspended all penal laws against Non-Conformists and in 1687 and 1688 when he issued two Declarations of Indulgence, suspending the Test Acts and granting freedom of public worship (Hill, 1980, 170; Speck, 1988, 141-3). The constitutional issue was 'where the sovereign power lay: with the prerogative or with statute; in the king, or in the king and parliament' (Speck, 1988, 62).

As the husband of James's elder daughter, Mary, heir presumptive to the English throne, William was concerned to protect his wife's claim to the English throne (Ashley, 1954, 175; Speck, 1988, 75) and to advance his own. As hereditary Stadholder or governor of the Dutch Republic, his strategic interest lay in preventing an alliance between England and France under Louis XIV to the disadvantage of the Republic and in bringing England into the anti-French bloc (Ashley, 1954, 175). However, although the States General gave its approval to the assembly of an expeditionary force in the summer of 1688, there was concern that its departure might leave the Republic open to a counter-offensive from Louis (Macaulay, 1883, 550-1). That danger was removed when in September Louis sent his army against Phillipsburg, a fortress on the Rhine, some 200 miles beyond the Dutch border. The States General gave their consent to the departure of the fleet (Ashley, 1954, 173-4; Lindgrén and Neumann, 1985, 635-6; Speck, 1988, 76-8). Horses and men were embarked at Hellevoetsluis in the estuary of the river Maas, but this was not completed until the 6th or 7th October (Lindgrén and Neumann, 1985, 640). It was late in the season.

There is considerable evidence in contemporary records that the autumn months of 1688 were dominated by winds, often violent, from the westerly quadrant (Lindgrén and Neumann, 1985, 638-40). These include a 1691 publication by a London astrologer, Gadbury, of 21 years of daily meteorological observations. According to his record for the autumn of 1688, until the 10th November, with one exception, the wind was consistently in the west, north-west or south-west. No formal means existed yet for measuring wind strength, but accounts of the damage done to the fleet at anchor in the Maas and the report of structural damage ashore suggest that during October there may well have been winds of Force 9 or more (Appendix XII, 234). The French ambassador to The Hague recorded on the 19th October that the 'tempest' had been raging for 13 days. The significance of the wind direction was well understood both in England and in Holland (Lindgrén and Neumann, 1985, 636-38). Macaulay describes crowds in Cheapside gazing at the weathercock on the steeple of Bow Church and 'praying for a Protestant wind' (1883, 558).

Towards the end of October the wind turned to the east and the fleet prepared to sail, leaving on the 29th. The fleet was scarcely at sea, when a storm blew up from the west (Macaulay, 1883, 561; Lindgrén and Neumann, 1985, 640-2; Speck, 1988, 84). The fleet was scattered and blown back to the Dutch coast. William himself arrived back at Hellevoetsluis on the 31st October.

The severe westerly winds kept the fleet storm-bound for another eleven days. On the 11th November it was under way again, heading north-west with the intention, so it was believed, of landing in the north of England (de Rapin-Thoyras, 1743, 776; Macaulay, 1883, 563-4; Lindgrén and Neumann, 1985, 642-3; Speck, 1988, 84-5). Lindgrén and Neumann state that on the 9th the wind had changed to the east-north-east and that its violence had abated. But it is not until the 11th that Gadbury notes a wind from the east in London. After some progress on its north-westerly heading the fleet altered course to the south. Macaulay simply says: 'All at once, on a signal from the Prince's ship, the whole fleet tacked, and made sail for the British Channel'; Lindgrén and Neumann opine that there may have been a shift of the wind to the north; Speck considers that the north-westerly heading was a feint to deceive James's supporters about the fleet's ultimate destination. All are agreed that James's fleet was unable to leave its anchorage in the north of the Thames estuary, Macaulay and Speck saying that this was because they were pinned down by the easterly wind and Lindgrén and Neumann, because the flood tide was against them. Macaulay reports a revealing detail: that James's ships were forced to 'strike yards and topmasts'. The device of being able to lower topmasts and indeed topgallant masts was an innovation attributed to John Hawkins during his time as treasurer of the Navy (Padfield, 1988, 72-4). However, it was intended to be used only in extreme weather; whatever the wind direction, east or north, it must have been gale Force 8 or more.

William now had the benefit of a favourable wind which took him through the Dover Strait and down the Channel to Torbay, where he landed on the 15th November (Macaulay, 1883, 564-6). In fact, according to Macaulay, the fleet overshot Torbay and was in danger of being carried into Plymouth, where it was feared that the garrison might oppose the landing. However a 'soft breeze sprung up from the south' to bring the fleet into the harbour at Torbay. Disembarkation took two days; although hampered by rain on the first day, it was greatly eased on the second when the weather cleared and 'the water in the bay was as even as glass'. Once disembarkation was complete, a 'fierce gale' arose from the west.

This weather also affected the pursuing English fleet under Lord Dartmouth. Having extricated itself from the Thames estuary, it was following William's fleet down Channel when it was becalmed off Beachy Head (Macaulay, 1883, 566). After drifting without wind for two days Dartmouth was able to continue westwards as far as the Isle of Wight, but was compelled to take shelter in Portsmouth by a 'tempest'. At that stage he was some 130 nautical miles east of the Dutch fleet at anchor in Torbay and, therefore, was never in a position to intercept it. The inference from Macaulay is that the two days the English fleet spent drifting off Beachy Head were the two calm days during which William disembarked and that the 'tempest', which drove Dartmouth into Portsmouth, was the 'fierce gale' which arose from the west at Torbay. At Torbay Macaulay implies that the gale set in immediately after the two calm days, while from his description of the progress of the English fleet one must infer that a further period of perhaps twelve hours of easterly wind intervened. The two accounts do not quite tally, but the discrepancy is perhaps not significant.

William was concerned to avoid, if at all possible, hostile action between his fleet and that of James. Memories were too recent of Dutch naval action against England and animosities of English against Dutch sailors would have run high. William, according to Macaulay, entrusted the command of his fleet to the English Admiral, Herbert, in the hope that the sailors of the English fleet, hailed by an admiral in their mother tongue, would believe that his fleet was manned by Englishmen and would be reluctant to fight. Herbert was instructed to avoid action, if at all possible. But as the fleet ran downwind in line abreast down the Channel, it would have been wide open to attack by a fleet following it with the advantage of the weather gage and it seems unlikely that Herbert could have avoided action, if he had been closely shadowed by the English fleet. He was in effect in the same position, but in reverse, as the Armada a century earlier. Only the fact that the English fleet was storm bound in the Thames estuary resolved the matter (Macaulay, 1883, 563). But why did Dartmouth station his fleet there? To propose an answer to that, let us consider a related question.

Did William intend to land at Torbay? Macaulay says he did and certainly the memories of the merciless suppression only three years before of the Monmouth rebellion ensured him a warm welcome in the south-west (Macaulay, 1883, 564-5). However, there appears to be some doubt about the matter (Speck, 1988, 85-6). Speck opines that it has now been established that it was indeed William's intention to land in the south-west and that the fleet's initial north-westerly heading was a feint. However, a feint would have been a dangerous tactic. The north-westerly heading was picked up by Dartmouth's scout ships and there is no reason to suppose that he would have remained ignorant of the subsequent change in heading. After all the new course would take the Dutch fleet even closer to the English fleet than the original north-westerly course (or a course direct from Hellevoetsluis to the Dover Strait) possibly even within sight of it (Lindgrén and Neumann, 1985, 642); the fleet certainly came within sight of the east coast of England (Whittle, 1689, 30). Under slightly more favourable circumstances, say with an ebb tide or some south in the easterly wind, Dartmouth could have weighed immediately to follow closely behind the Dutch fleet. If William really wished to avoid a naval battle, the risk was not worth taking. If this line of reasoning holds, then it follows that the original north-westerly heading represented a genuine intention to land on the north-east coast of England. De Rapin-Thoyras reports that 'Burnett says that the first scheme was to anchor in the mouth of the Humber' (1743, 776).

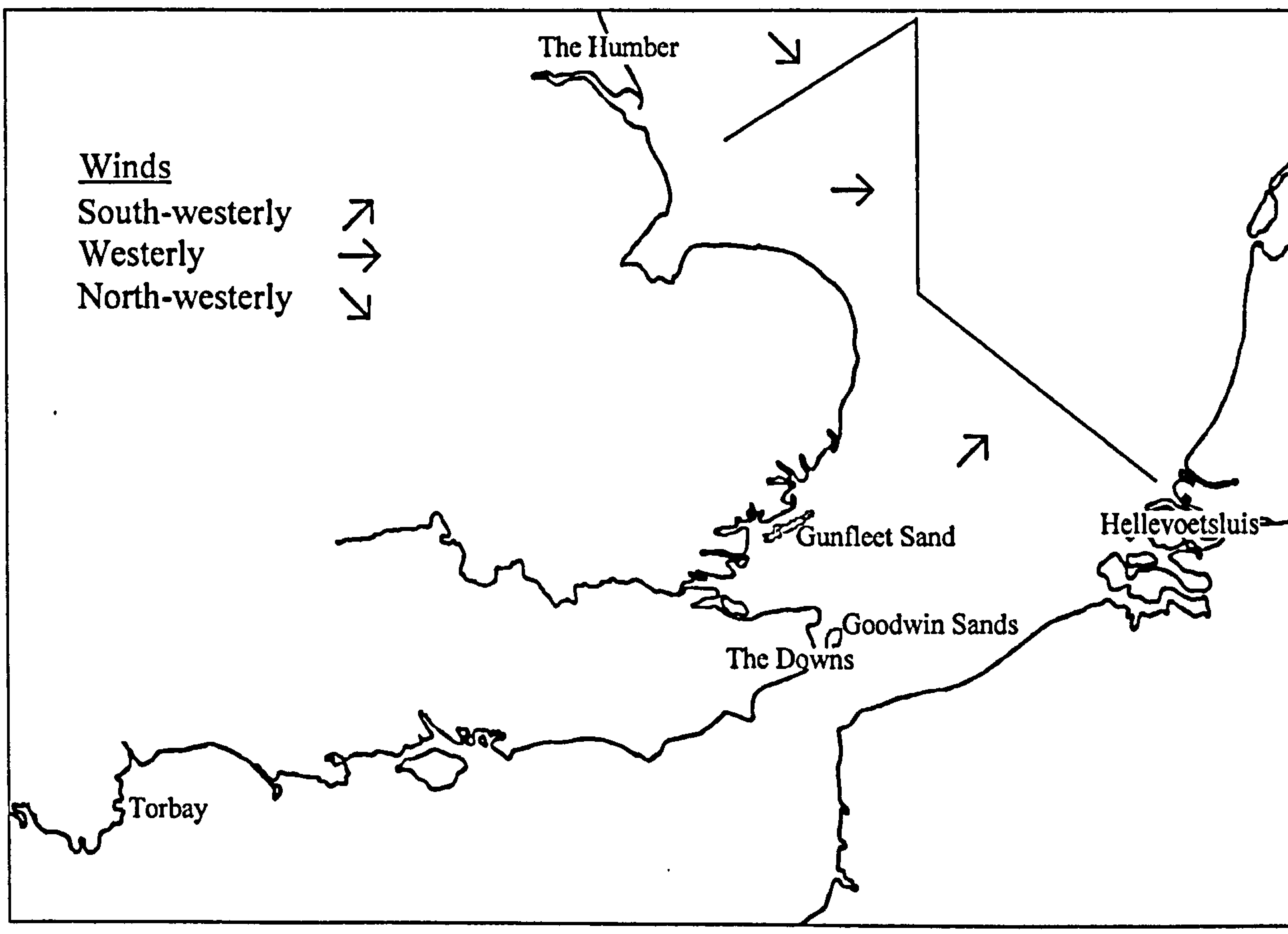


Fig. 30 The sketch map shows how William of Orange could have landed in the north of England with winds still blowing from the westerly quadrant. Sailing with a south-westerly he could lay the Humber on an easy beam reach. As the wind veered to the west he would harden up and eventually be sailing close-hauled, probably on a heading somewhat to the west of due north. When the wind veered into the north-west, he would tack and still be steering for England. The English fleet stationed off the Gunfleet Sand was well placed to sail with a following wind to intercept the Dutch fleet as it sailed north-west, and would have the weather gage. If the Dutch fleet left port with an easterly and sailed for the English Channel, Dartmouth would still have the opportunity of weighing on the port tack, close-hauled, to clear the sands of the Thames estuary (only the Gunfleet is shown for clarity) and could hope to follow the Dutch fleet closely down the Channel, again with the weather gage.

Dartmouth's decision to station his fleet to the north of the Thames estuary, rather than, say, in the Downs - a station from which it would have been much easier to intercept a fleet running down the Channel with an easterly wind - shows that he knew - what Herbert must also have known - that William did not need a wind in the easterly quadrant to reach England (Fig. 30). From Hellevoetsluis the Humber bears 317° True at a distance of some 135 nautical miles, near enough north-west and much closer than Torbay. With a south-westerly one can lay the Humber on a beam reach. As the wind veers (Fig. 25 in Chapter X, 114), the heading can be maintained by hardening up; when the wind gets to due west, one can still maintain a generally northerly heading and when it veers further into the north-west, as it will when the cold front comes over, the fleet can tack and, although not now making any northing, is at least making good its progress towards England. Tacking on wind shifts is what wins cups in yacht racing and there is no reason to suppose that senior naval commanders in the age of sail would not have been equally familiar with the tactic.

Such an analysis implies that it was the violence of the wind, rather than its direction, which kept William in port for October and the early part of November. The passage plan that Herbert formulated for William would have been to sail for whatever port in England the wind served, as soon as it abated. Given the lateness of the season, this would have been the only feasible way ahead. Favourable conditions for naval operations would not become more frequent until the following spring. In the meantime matters in England were coming to a head and, if he did not move soon, William might lose the initiative. He could not have afforded to turn down the opportunity of landing in northern England, simply to wait for an easterly to take him to the south-west. Moreover, if we accept Lindgrén and Neumann's evidence that the wind was in the east-north-east on the 9th and Gadbury's record that on the 11th, when William set out on his north-westerly heading, it was blowing from the east in London, it must follow that a landing in the north was William's preferred option and that he turned south for the English Channel only when, as Lindgrén and Neumann suggest, the wind backed to the north.

Seen in this light, Dartmouth's decision to station the English fleet off the Gunfleet makes good sense. It is true that he must have discounted the possibility that an easterly wind would bring William down the Channel, but with that exception he would have been well placed to weigh and intercept the Dutch fleet as soon as it set sail - and with the advantage of the weather gage.

The nature of the climate in the late seventeenth century adds weight to this analysis. The sixteenth and seventeenth centuries have been termed the 'Little Ice Age' and the late seventeenth century was particularly noted for the storminess of its weather (Lamb, 1995, 211-12). Lindgrén and Neumann detect in Dutch records for the first fifty years of the eighteenth century an 'excess of winds between southwest and west', an 'excess of southeasterlies' and a 'paucity of southerly winds', compared with the forty nine years 1888-1937 (1985, 639-40). The greater storminess of the period, which ties in well with contemporary descriptions of the naval operation, would have meant that weather windows, especially in the autumn and winter, were much less frequent, while the two 'excesses' noted by Lindgrén and Neumann would have made conditions for a passage to the north of England more likely, than they might have been today. Dartmouth's decision to discount the possibility of an easterly wind was perhaps less irresponsible than it might seem in modern meteorological conditions.

We have already noted, in terms of its purpose and result, the similarity between the invasions of Dutch William and Norman William. Lindgrén and Neumann (1985, 643) pointed to the parallelism in the extended period that both waited for favourable conditions to sail and in the fact that it was only after an abortive attempt in marginal conditions that they eventually successfully achieved their invasion passage. What struck Christine Grainge and me in our study of the Norman invasion was the evidence for the stress that the extended wait and the initial abortive sailing imposed on Duke William and for his steadfastness of purpose against all the odds (Grainge and Grainge, 1993, 271-2; 1996, 141-2). The same steadfastness of purpose was observed by contemporaries in William of Orange when his fleet had been driven back to Hellevoetsluis after its initial sailing (Whittle, 1689, 25-6; Dalrymple, 1771, 156; Macaulay, 1883, 561).

Note on Dates

Towards the end of the Middle Ages the calendar introduced by Julius Caesar (the Julian Calendar or Old Style) was getting seriously out of kilter with the solar year. Reforms to the Julian Calendar were introduced by Pope Gregory (the Gregorian Calendar or New Style) and adopted in France, Italy, Spain and Portugal in 1582. They were not adopted in England until 1752.

The dates in this chapter relating to the Spanish Armada and the invasion of William of Orange are quoted New Style. Those relating to the Norman invasion are Old Style.

Conclusion

What light do the four invasion passages we have examined throw on the thought processes of the Roman Naval Staff planning the naval operation of A.D. 43? At first sight these four attempts may seem to offer little enough in common: one west to east up the Channel, one east to west down the Channel, two northwards across the Channel, but with different departure and disembarkation points; one in high summer, one late in the season, one definitely outside the normal season and one at an unspecified time of year; two involving the actual or possible use of naval artillery, two before that technology was available.

Each of the four invasion passages shows that wind direction and strength is crucial. It is not simply that the wind direction should be favourable, or at least usable; it is that the wind strength should not be excessive. It was the violence of the wind that delayed William of Orange and forced his fleet to return to harbour after its first departure; it was the violence of the wind that scattered the Armadas of 1596 and 1597

- as well as that of 1588, which, having been delayed and scattered by gales in the Bay of Biscay, was eventually able to regroup off the Isles of Scilly; it was the violence of the westerly wind which drove the Norman fleet to St Valéry and in all probability it was the violence of the westerly winds, rather than their direction, while they were waiting at Dives, that prevented their sailing; lastly, through the allusive language of the panegyricist, we detect that it may have been stress of weather that led to the failure of Maximian's attempt *c.* 289 to land in Britain.

Allied with this is the importance of the weather gage. The action in the Channel in 1588 is a text-book case of a fleet gaining and exploiting the advantage of the weather gage. It would have been an important consideration too in 1688, had Dartmouth managed to sail more promptly from the Thames - or if the wind direction been different. The weather gage was probably an important factor in naval operations even before the introduction of the naval gun. If naval battles then came down to ship-to-ship boarding contests, nevertheless the fleet to windward would be able to control the opening of the battle, deciding whether to offer or decline battle. But this ultimately is only a special aspect of the general principle that the fleet to windward of its destination is most advantageously placed to arrive there (Grainge and Grainge, 1993, 263; 1996; 131).

Thus in all but one of the case studies we see that the planned passage put the invading fleet to windward of its intended landing, in terms of the prevailing wind. This is certainly true of the three Spanish Armadas, exploiting the prevailing westerlies to make their passage to the Channel; it was also true of the Norman Invasion fleet, in terms of what would seem to be its original plan, to sail from the Bay of the Seine with the prevailing south-westerlies, possibly to the Solent, more probably further east along the south coast, and similarly true of Asclepiodotus's passage to the Solent. Of course, as in the case of the Descent of Dutch William, it is the actual wind direction which counts on the day. But when it comes to planning, naval commanders can only work on the basis of the prevailing winds and, as we have seen, William of Orange had the alternative of using the prevailing winds to land in the north of England, possibly as his first preference, certainly as a reserve option. To construct a strategy on a passage in the teeth of the prevailing winds without a fall-back option is to invite failure.

We have seen also that the invasion passage is in each case influenced by its strategic context, economic, political and military, both by opening and perhaps more importantly by closing options. Thus while east Kent was an obvious place to land for Caesar - and I would, argue, for Plautius - as well as later for the migrating Anglo-Saxons, it was pretty well closed as an option for Constantius and would have been disastrous for Parma, because of its fortifications, first of Richborough and later of Deal, Walmer and Sandown castles, even if Parma seemed blissfully unaware of them. In like vein, William of Normandy could scarcely have launched his invasion from anywhere other than the Bay of the Seine; Boulogne was not available to him, since it was well within Ponthieu; moreover, the havens in the Bay had excellent communications with his hinterland. William of Orange too had no option but to sail from Dutch waters; the hostility of Louis XIV towards the Dutch would have closed French ports to him and certainly he would not have relished being constrained by stress of weather to take shelter on the French side of the Channel. Perhaps this was the reason for William's initial heading towards the north of England. Finally, the Spanish were locked into their flawed plan in 1588 by the fact that the Spanish army in the Netherlands was thought to be the appropriate army to undertake the invasion and Parma the right man to lead them (Rodríguez-Salgado, 1988A, 27). His lack of seaworthy fighting ships and his inability to assemble a fleet of barges and other small craft without the Dutch rebels - and through them the English - becoming aware of his plans was what committed the Armada to its disastrous voyage from Spain. But the clamant message of the tragedy of the Armada is the critical importance of good intelligence, good communications, unified control and clear strategic objectives.

It is difficult to identify the strategic significance of the Isle of Wight. Advocates of the Fishbourne hypothesis have argued that it played a rôle in later invasions and it does indeed figure in the accounts of the invasions of A.D. 43, A.D. 296, 1066 and 1588. It even occurs in Macaulay's account of William's Descent, but only to the effect that the fleet hove to in sight of its cliffs for Sunday morning worship (1883, 564). In 1588 it was set as a subsidiary objective, should the Armada fail in its main purpose, but it is unclear what value it could have had for the Spanish; in addition Medina Sidonia did consider using it as an anchorage to wait to hear from Parma. In A.D. 296 and in 1066, it was used as a base for a defending fleet, but to no effect, in A.D. 296, because the invaders are said to have eluded it in a fog, and in 1066, because they landed elsewhere. In A.D. 43, or soon thereafter, during his campaign in the south-west Vespasian took the Isle of Wight. Suetonius, who records this (*Vesp.*, 4), gives no details whatever and we have no idea what special significance, if any, the Romans gave to this victory, other than that it was among the exploits of a future Emperor.

But above all what we note from our case studies is that mounting an invasion crossing is an undertaking fraught with uncertainty. In this chapter we have considered a total of nine separate attempts to put an army ashore on the coast of Britain. Three only of these attempts were successful. If we discount the three Spanish Armadas of the late sixteenth century, the success rate is still only 50%. Such a consideration must have been a powerful reason why the Roman Naval Staff A.D. 43 would have done their utmost to reduce the uncertainty of the cross-Channel operation.

Chapter XII

The Roman Naval Staff Consider their Options

In this chapter and elsewhere I refer to the Roman Naval Staff. There is no specific evidence for the existence of such a body, although Vegetius sets out a hierarchy of naval ranks (Veg. *Mil.*, IV, 32). Webster identifies as *comites* (companions) a number of senior Romans who took part in the invasion (1999, 87-90). These men appear perhaps to have functioned as a war council to advise the commander-in-chief, but none seems specifically to have been involved in planning the naval side of the operation. To speak of the Naval Staff is, however, a useful shorthand to provide a context for the strategic decisions about the invasion crossing that must have been made by some one person or group of individuals within the command structure of the invasion force.

Politico-Strategic Context of the Claudian Invasion

In A.D 9 three legions under the command of Publius Quinctilius Varus had been wiped out in the Teutoburg Forest by German warriors led by Arminius. The significance of this disaster is signalled by a recent writer who opens the introduction to his history of the Roman army with a reference to it (Le Bohec, 2000, 7). It was to echo down to the nineteenth and twentieth centuries to become a major strand in the emergence of German national identity (Todd, 1992, 265-6), but it was equally and more immediately significant for the Romans, leading to a major change in strategic thinking, effectively ending Roman ambitions for a province of greater *Germania* east of the Rhine. The Emperor Augustus's policy would in future be that the empire should be consolidated within its existing boundaries. Tiberius, Augustus's successor, upheld Augustus's policy as 'a sacred trust'. Any cross-Channel adventure to occupy Britain would be ruled out until his death in A.D. 37 (*Agr.*, 13; Salway, 1998, 52; Webster, 1999, 65-6).

There was, it is true, one breach of this policy of consolidation within existing imperial boundaries. In A.D. 15 Germanicus mounted a naval expedition from the Rhine to the river Ems (*Ann.*, II, 5-26). Germanicus's thinking was that, by moving by sea and inland waterway, the legions would avoid the extended logistics and difficult terrain that an overland expedition would involve. The strategy was not entirely successful, the fleet was severely damaged in a storm on the return voyage and the adventure did not attract Tiberius's approval. Germanicus was recalled the following year.

For the fifteen years following Caesar's murder in 44 B.C. Octavian (later to be Augustus) had been preoccupied with consolidating his own position as *Princeps* ('First Citizen' - Salway, 1998, 49-50) and following up his uncle's expeditions to Britain cannot have figured high on his agenda. Expeditions had in fact been contemplated in 34, 27 and 26 B.C., but had not been launched because of trouble elsewhere within the empire (Dio, XLIX, 38: LIII, 22, 25). In any event it seems that Roman official circles may have come to the view that the occupation of Britain would not be a profitable undertaking. At some contemporary date, possibly soon after Augustus's death, Strabo records that British rulers had sent embassies to Rome and set up offerings on the Capitol, making the island virtually Roman. He added that the Britons had so readily submitted to heavy taxes on imports and exports that there was no point in occupying the island. These duties would have to be lowered in the event of an occupation, while the cost of an occupying army would equal any tribute that could be levied. Strabo repeats this opinion elsewhere, saying that the Romans had rejected the idea of invading Britain on two grounds: first, they had nothing to fear from the Britons who were not powerful enough to cross the Channel and attack the Romans; secondly, there would be no financial advantage in an occupation of the island (Strabo, II, 5, 8; IV, 5, 3; Frere, 1987, 32; Salway, 1998, 51-2).

If Britain remained beyond the reach of Rome's legions, she did not remain beyond that of her merchants (Richmond, 1955, 10-11). In the century following Caesar's conquest of Gaul, there had been a dramatic shift eastwards in the pattern of cross-Channel trade (Richmond, 1955, 12-13; Salway, 1998, 57-9; Webster, 1999, 49, 51-6). The trade between Brittany and the West Country, based on the mineral wealth of Cornwall, dwindled, whether because of Caesar's destruction of the Venetic fleet or because of the development of alternative resources in Spain. At the same time a considerable trade route developed between the Rhine and Essex, probably using ports focused on Colchester, thus creating another cross-Channel route in addition to McGrail's five further west (1983) and well within the capability of contemporary cross-Channel seamanship. Goods traded included both prestige goods and staple produce, such as corn, which may well have been of strategic importance for the Roman legions posted on the Rhine frontier. Strabo records exports from Britain as 'corn, cattle, gold, silver and iron; also hides, slaves and clever hunting-dogs' (Strabo, IV, 5, 2; Salway, 1998, 42). Studies of the landscape in Essex suggest that large-scale field patterns in the Chelmer valley and south of Braintree may antedate the Roman road system and, therefore, be the by-product of increased cereal production to meet the needs of this trade (Richmond, 1955, 12; Webster, 1999, 47). Imports into Britain certainly included wine and, in all probability, fine pottery and vessels of precious metals (Webster, 1999, 51-6). What is significant about this trade is that the hinterland in Britain is the territory of the Trinovantes, centred on Essex, and that of their neighbours, the Catuvellauni, based on Hertfordshire and encompassing much of the Home Counties north of the Thames, apart from Essex (Fig. 31). There also seems to have been some continuing trade closely following McGrail's cross-Channel route 7 (Seine to the Solent); this was through Hengistbury Head, ultimately linking Mediterranean trade networks through the Rhône and Seine with the hinterland of the Durotriges, if not the Atrebates; (McGrail, 1983, 325-6; Webster, 1999, 53). By contrast, however, Kent seems to have been isolated from this continental trade (Webster, 1999, 70-2).

The isolation of Kent in all probability was due in part to the dispositions left by Caesar in 54 B.C. (Detsicas, 1983, 3). Following representations made by the Trinovantes he had restored their young king, Mandubracius, and laid upon Cassivellaunus, usually thought to be the king of the Catuvellauni (for a contrary view see Webster, 1999, 45-6), the directive not to harm Mandubracius or the Trinovantes (*B. Gall.*, V, 20). It is from this special protection of the Trinovantes that there may have developed some sort of 'most favoured nation' status, allowing the flowering of the trade on the Essex/Rhine route. At the same time the fact that in 54 B.C. the four kings of Kent had responded to Cassivellaunus's call to attack Caesar's naval base after all the other tribes had yielded would have left them in bad odour as far as the Romans were concerned (*B. Gall.*, V, 22). Moreover, the fact that the inhabitants of Kent seem to have had no special tribal identity, perhaps even lacking names for the local groups led by their four 'kings', suggests that they may well have found it difficult to recover after their defeat at the hands of Caesar's legionaries and were particularly exposed to intervention from the all-powerful Catuvellauni (Detsicas, 1983, 1, 3-6).

In addition geography contributed to the economic isolation of Kent. In his study of cross-Channel seamanship in the first century B.C., McGrail notes:

> Of the cross-Channel routes, the short ones used by Caesar to cross the Strait probably had least commercial value because of limited river access inland on the French side, although there was good access in Britain via the Thames. The passages from the Rhine and the Seine (9 and 7) were evidently the most reliable commercial sea-routes, given that Continental goods could readily be brought to these rivers and that imports to Britain could be distributed, and exports assembled, in the Needles/Selsey Bill region for Route 7, and in the Thames/Stour region for Route 9 (1983, 333-4).

McGrail's point emphasises the importance of water-borne trade links on the Continental side and the particular significance of the Rhône/Saône link with the Rhine, Seine and Moselle, which allowed access for Mediterranean goods to northern Europe (Ellmers, 1996, 52), access which must have become more important with the extension of the Roman *imperium* to Gaul. His route 9 is from Bruges to Dover or Walmer in east Kent, with ultimate destinations on the British side up the Thames and the River Stour in Kent. Although he does not consider in detail the case for a route from the Rhine to Essex, he does mention the Blackwater/Colne estuary as a destination at the British end (1983, 332). In fact an open-water passage from Bruges to Harwich and thence to the Essex rivers, such as the Blackwater and the Colne, a popular passage of some 80 sea miles for present day East-Coast and Dutch yachtsmen, would present much the same sort of challenge as the crossing from the Seine to the Solent and might be preferable to a passage from the Rhine to the Essex rivers *via* east Kent, given the need in the latter case to thread one's way through the sandbanks of the Thames estuary.

The political history of Britain in the century between Caesar and Claudius is written in coin finds, supplemented by sparse notices in Roman documentary sources. Of necessity interpretation of the evidence tends to be speculative and some doubt must be entertained about the family and, occasionally, tribal affiliations of the various rulers named in the sources and identified on the coins. A common theme in interpretations is the identification of tribes and/or their rulers as having pro- or anti-Roman policies. One scholar writes of the 'polarization of the tribes on each side of the Thames Estuary' and goes on to say:

> The most important effect of Caesar's appearance on the British scene was to divide the south-eastern tribes into pro- and anti-Roman groups. Those who had suffered defeat, i.e. the tribes on the north bank of the Thames and in Kent were forced to pay an annual tribute which sustained a festering hatred of Rome. Those who benefited, the Trinovantes, the Catuvellauni if, as logic demands, (they) are the people of the Verulamion (sic) and Braughing areas and their allies, would have been rewarded by political alliances and access to trade with Rome, and for which there is archaeological support, as will be seen below. As far as Rome was concerned, south-eastern Britain had been conquered and treaty relationships had been established with a powerful group of tribes. The next stage would have been to allow the effects of trade and cultural contacts to prepare the way for full occupation with all the apparatus of government and law (Webster, 1999, 46).

We may well accept the reality of the trade and cultural contacts which Webster sees as flowing from Caesar's British expeditions. Indeed these would have followed in all probability from the extension of the Roman *imperium* to northern Gaul and the Rhineland and would have come into play, whether or no Caesar had undertaken his British adventures. But other aspects of this analysis do beg questions.

Firstly, there is no particular evidence for assuming that in terms of tribute levied the tribes that submitted were treated by the Romans any more favourably than those which were defeated. Caesar certainly demanded tribute when he left, but there is no indication in his dispatches that he levied it on those whom he had defeated rather than on those who had submitted. He states simply that he determined what tribute 'Britain' should pay each year. Moreover, the Trinovantes, who in surrendering asked for the restoration of their young king, Mandubracius, were, like other tribes, required to furnish hostages to be taken back to Gaul (*B. Gall.*, V, 20).

The second point concerns the tribute and how effectively it was levied. Scholars differ as to whether it was enforced (Richmond, 1955, 10; Frere, 1987, 27: Salway, 1998, 37). Frere implies that compliance with Caesar's requirements were in the interests of the tribute payers, among whom he counts the Trinovantes!

Thirdly, one may wonder how long resentment can 'fester', even if tribute continued to be paid. Now at the start of the third millennium, just over half a century since the end of the Second World War, it would be hard to speak of festering resentment of the Axis powers, except among special-interest groups, such as ex-P.O.W.s; certainly it is difficult to identify public policies as anti-German or anti-Japanese. Can hatred really be supposed to have festered on for nearly a century among some, and only some, of the British tribes? Indeed Tacitus speaks of the willingness of the Britons to submit to the payment of tribute (*Agr.*, 13). The reality is much more likely to have been that, as time went by, feelings of resentment and anti-Roman attitudes, no doubt initially very strong, would have faded away, as the élite of each tribe prospered increasingly from the growing trade with the empire.

Finally, one notes that, contrary to the more generally shared view among scholars, ascribing to the Catuvellauni anti-Roman attitudes, Webster sees them as pro-Roman.

None of this is to suggest that with the conquest and occupation of Gaul, Rome was not a significant factor in the external politics of the tribes of south-east Britain. As the dominant political, economic and military power in western Europe, she was bound to have a disproportionate influence on the affairs of the tribes just across the Channel. It would be entirely appropriate for British kings to send embassies to Rome and entirely in keeping with Roman thinking for Rome to see the kings sending such embassies as clients (Strabo, IV, 5, 3; Frere, 1987, 32; Salway, 1998, 51-2). It would also be natural for kings and princes banished from their kingdoms to turn up as supplicants in Rome in the forlorn hope that Rome might do something to restore them to their rightful place at home, or in the more realistic hope that in their exile Rome might afford them a place in the sun (Frere, 1987, 30; Salway, 1998, 47-8; Webster, 1999, 57). Whatever the British aristocracy may have thought of all this, it reflected the balance of power.

Perhaps, given the sparsity of the evidence, the best approach to an interpretation of the political scene is a minimalist one. This would restrict itself to concluding that during the century or so from Caesar's expeditions to the death of Tiberius the tribes of south-east Britain, with the notable exception of the inhabitants of Kent (Fig. 31), had by and large enjoyed increasing prosperity from the developing trade with the empire and had been brought to some extent under the influence of Roman culture. Their interest and that of Rome, as demonstrated by Strabo's comments, was in maintaining a stable status quo. Such stability does not seem to have been compromised, in spite of Caesar's injunction, by the subjection by the Catuvellauni of the Trinovantes sometime during this period, a step now more advantageous for the Catuvellauni because it gave them control of Colchester, the British hub of the developing Essex/Rhine trade network.

Thus at the death of Tiberius in A.D. 37 the most powerful tribe in the south-east would have been the Catuvellauni, who had shifted their capital to the Trinovantian centre of Colchester. South of the Thames the Atrebates and the Durotriges also prospered from trade with the empire, while the Kent of Caesar's 'four kings' was an impoverished backwater; its people still had not coalesced as a tribe; they were not yet the Cantiaci they were later to become (Detsicas, 1983, 1, 6-8).

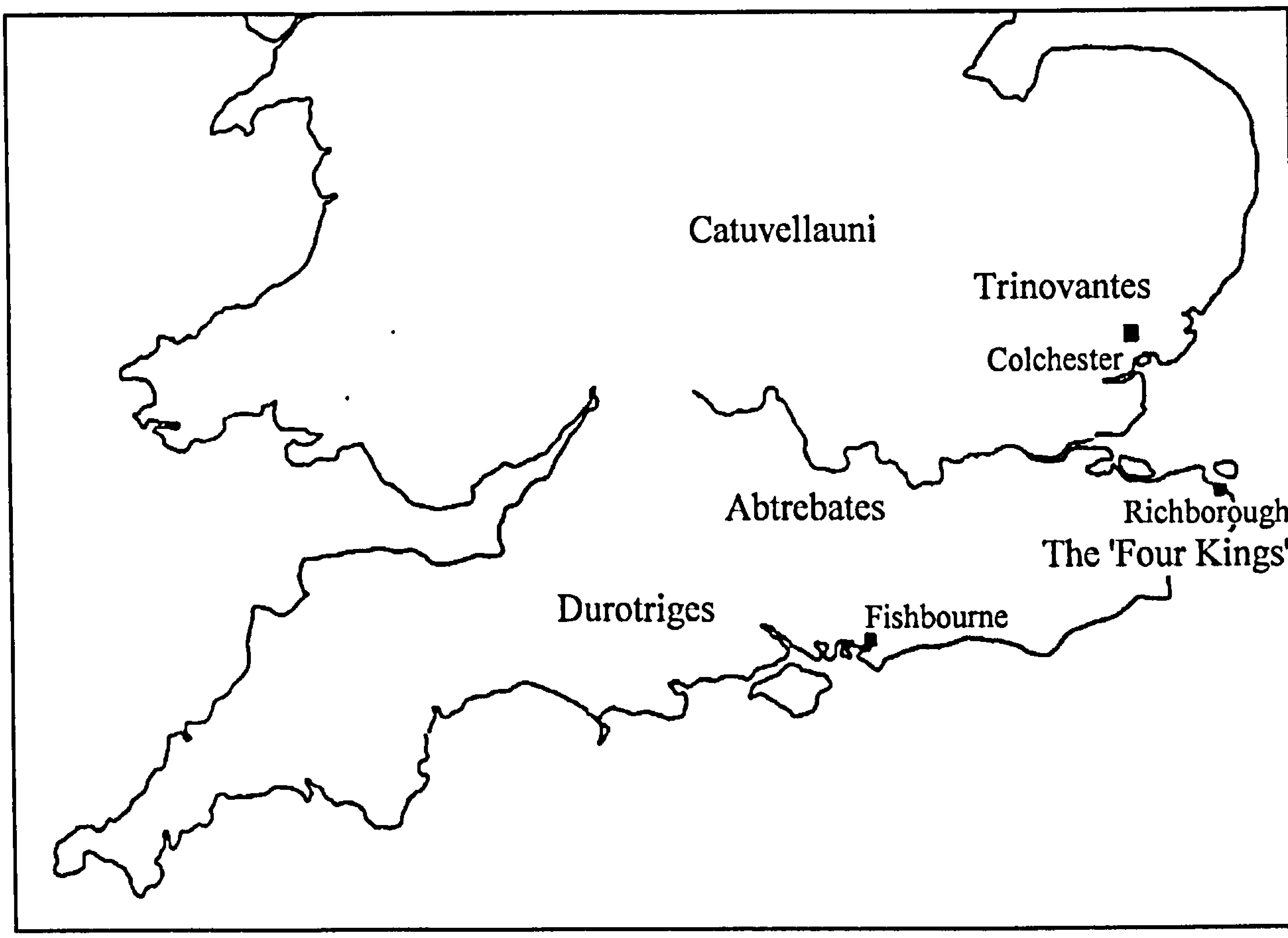


Fig. 31 Approximate disposition of significant British tribes at the death of Tiberius in A.D. 37 (Richmond, 1955, 19; Cottrell, 1961, 17; Frere, 1987, xvi; Salway, 1998, Map II; Webster, 1999, 32).

In A.D. 37 and the years immediately following, this stability came under threat on both the Roman and the British sides. The death of Tiberius brought his nephew to power in Rome. To describe the Emperor Gaius, better known as Caligula, as egregiously unstable would be a gross understatement. Within four years he was to be assassinated by his Guards' commanders (*Calig.*, 58). He was succeeded by his uncle Claudius, much to the latter's surprise. Claudius was considered to be in urgent need of some military triumph to consolidate his new position (*Claud.*, 17; Salway, 1998, 70-1). On the British side, sometime after the death of Tiberius, the king of the Catuvellauni, Cunobelinus, banished his son, Adminius, who fled to Gaul, where he surrendered to Gaius (*Calig.*, 44). Next came the death of Cunobelinus and the succession of two more of his sons, Togodumnus and Caratacus, who 'began a programme of aggression and enlargement' (Richmond, 1955, 18; Frere, 1987, 45; Salway, 1988, 67-8; Webster, 1999, 63-4). This was followed by the arrival in Rome of another wave of asylum-seekers, including ex-king Verica of the Atrebates. This triggered an outbreak of disturbances among the British, recorded by Suetonius: '*tumultuantes Britannos ob non redditos transfugas*' - 'Britons in uproar over our failure to return some refugees' (*Claud.*, 17).

Whatever Suetonius may have intended by his laconic phrase - one scholar has suggested that the uproar involved raids on the coast of Gaul; another riots threatening Roman merchants in Britain (Richmond, 1955, 18; Frere, 1987, 45) - it would appear that relationships between Rome and Britain had reached crisis point. This would be very significant for the Romans if it threatened the exports of corn which we have suggested may have been of strategic importance, particularly to the legions on the Rhine.

There has been a tendency among scholars to give greater weight to Dio's statement that Verica persuaded Claudius to undertake the British venture than to Suetonius's explanation that the venture was in response to the 'Britons in uproar'. This is perhaps because, with its considerable detail, Dio's text is the prime documentary source for the invasion. It is, however, worth recalling that Suetonius was writing perhaps a hundred years earlier than Dio.

Gaius had put in hand preparations for the invasion of Britain and, it seems, developed the naval facility at Boulogne, including the building of its lighthouse (*Calig.*, 46; Frere, 1987, 44, Salway, 1999, 60-1). But with his unstable character, with his violent mood swings between excessive bravado and cowering timidity (*Calig.*, 51), Gaius was not the man to carry them through. It fell to his uncle to meet the crisis when it was much further advanced.

Strategic Objectives Set for the Campaign of A.D. 43

If we are correct in our analysis and, in particular, in our assessment of the strategic importance to the Romans of the staple exports from Britain to Gaul, especially to the Rhineland, and if we are correct to say that the 'uproar' in Britain put those exports at risk, then the overall strategic objective of military operations in A.D. 43 must have been to secure the uninterrupted continuation of those exports. The Roman High Command, in the person of the Emperor himself, had determined that this would be achieved by the invasion and occupation of Britain. The successful prosecution of that overall objective could only be achieved by the defeat and/or submission of Togodumnus and Caratacus and their Catuvellauni and the seizure of the strategically important trading hub of Colchester and its hinterland.

We have noted the belief among the ancients that Claudius needed a military triumph to consolidate his authority and certainly once back in Rome he celebrated the conquest in style (Dio, LX, 22-3; *Claud.*, 17;

Webster, 1999, 168-71). In this he would not be the first, nor yet the last, head of government in ancient as well as modern times to draw political advantage from a military success; nor would Dio and Suetonius be the last, if they were the first, political commentators to draw attention to such a motive. This should not, however, be allowed to distract either from the strategic importance of the undertaking nor from the reality of Claudius's achievement in leading it.

Moreover, if we are right to see the protection of Roman trade interests as the prime aim of the expedition, then it follows that the restoration of ex-king Verica to power can never have ranked very high, if at all, among the Roman subsidiary objectives. Apart from the episode in 54 B.C. when Caesar intervened in the case of the Trinovantian Mandubracius, at a time when he was already on British soil, the Romans had never intervened in Britain to restore a deposed ruler and there is no particular reason to suppose that in A.D. 43 they would have gone back on Augustus's policy of consolidated frontiers simply for that reason.

In the event Verica was not restored. It is tempting and perhaps all too easy to see Tiberius Claudius Togidubnus, who emerged in the early Roman period as the puppet king of the Regni, as Verica's kinsman and heir and therefore restored by the Romans because Verica was no longer available (Cunliffe, 1998, 22; Hind, 1989, 13, 15), but there is not a shred of evidence to support it. One cannot go realistically beyond Cunliffe's alternative of the promising young man picked out by the Romans, that, to put it plainly, Togidubnus was a young magnate on the make who in A.D. 43 chose the right side.

Vespasian's campaign in the south-west with his *Legio II Augusta* is well documented, both in the archaeology and in near-contemporary Roman records (*Vesp.*, 4; Frere, 1987, 58-9; Salway, 1998, 92-4; Webster, 1999, 103-4, 107-10). Clearly it was a major operation; Suetonius credits Vespasian with the defeat of two tribes and the taking of more than twenty hill forts, together with the Isle of Wight. This is dramatically confirmed by excavations at Hod Hill where evidence was found of a *ballista* barrage directed against the chieftain's hut and at Maiden Castle where a cemetery yielded the skeletons of thirty-eight men and women who had met violent deaths, including one who had died from a *ballista* bolt in his spine (Richmond, 1962, 31-3; Wheeler, 1943, 61-8). However, we cannot know whether this campaign was part of the general eradication of resistance among the British, a pre-planned expedition to secure trade links with the mineral-rich Cornwall and Devon, or simply the escalation of an armed reconnaissance undertaken to keep the troops occupied while Plautius waited at the Thames for Claudius to arrive. The probability, however, is that the operation was subordinate to the overall war aim of the general conquest of Britain and seizure of Colchester. That this was not a separate undertaking, possibly landing somewhere further to the west than the main expeditionary force, is confirmed by Vespasian's presence recorded by Dio as with the main force soon after they landed (Dio, LX, 19; but see Salway, 1998, 92 for an alternative possibility).

We may therefore assume that the Naval Staff would have been briefed to consider options for the crossing with a view to choosing that which would put the invasion force in the most favourable position to defeat Caratacus and Togodumnus and to take Colchester, the centre of their power base.

The Rôle of Claudius

Claudius has had a bad press. Both Dio and Suetonius would have us believe that he was motivated solely by considerations of personal glory in prosecuting the occupation of Britain and there is more than a hint in their accounts that his presence during the final assault on Colchester was unnecessary (Dio, LX, 21; *Claud.*, 17). The impression of Claudius conveyed by Suetonius's *Life* is almost wholly without any redeeming feature, depicting him as both physically and mentally handicapped, a man who, until he succeeded to the purple, was considered by senior members of the imperial family, as well as his contemporaries, as unfit to hold down any public office. Even his succession is depicted as a ghastly aberration (*Claud.*, 10).

But reading between the lines there is a hint that there is more than a modicum of anti-Claudian spin in Suetonius's account. Much of its substance is no more than trivial court tittle-tattle and scarcely bears on the great issues which must have arisen in Claudius's fourteen-year reign. What does occasionally show through in Suetonius's account is the evidence of a keen intellect. Claudius certainly found refuge in literature and may well have been a competent scholar; in a letter to his grandmother, Livia, Augustus notes with surprise that Claudius, on an unnamed occasion, has spoken with clarity and concision (*Claud.*, 4). Suetonius briefly mentions what must be seen as the major achievements of Claudius's reign (*Claud.*, 20): the completion of water supply works, the draining of the Fucine Lake and the construction of a much needed and long projected harbour at Ostia; and, of course, the conquest of Britain. It is easy to miss the significance of these as achievements against the background of the derogatory trivia that make up the substance of Suetonius's biography.

Against this background, Claudius's instruction to Plautius, not to advance any further if he encountered 'any particularly stubborn resistance' (Dio, LX, 21), has an unreal quality. First, any half-competent general with the force at Plautius's disposal would have pressed on to Colchester, rather than wait for the arrival (from Rome!) of his commander-in chief; certainly the wording of the instruction, as Dio reports it, would have allowed him that leeway. Secondly, a general in Plautius's position would have been much more motivated to press on if he thought that his Emperor was some sort of military incompetent. Thirdly, there was much more to be gained by Claudius's presence than mere personal glory: by his presence he would have put the stamp of imperial authority on the submission of the British tribes and kings, an authority which would have been much enhanced in their eyes by exotic display, including Claudius's elephants (Bird, 2000, 102).

Moreover, in the unstable imperial politics of the day, there must have been some risk for Claudius in being absent from Rome for the six months of his British campaign. While away, Claudius left affairs, including 'the command of the troops' in the hands of Lucius Vitellius, father of a future Emperor, and was wholly dependent on his loyalty. The decision that the Emperor should personally take part in the British campaign must have been a calculated one.

All the signs then are that the decision that the Emperor would take part in the final push on Colchester was an integral part of the invasion plan. The Naval Staff would have been briefed to provide for his transport across the Channel with his elephants from a suitable embarkation port, which we know from Suetonius to have been Boulogne (*Claud.*, 17).

Supplies and Intelligence

In his fourth-/fifth-century *Epitome of Military Science* Vegetius was to stress two factors of critical importance in tactics and strategy. The first was the need for first-class intelligence (Veg. *Mil.*, III, 6). The second was the security of the army's logistics (Veg. *Mil.*, III, 3). We may be sure that the Naval Staff were seized of the importance of both.

Vegetius's teaching about intelligence covers both the lay-out of the land and the disposition of the enemy. Of the lay-out of the land he advises a general to have 'itineraries of all regions in which war is being waged written out in the fullest detail, so that he may learn the distances between places in terms of the number of miles and the quality of roads, and examine short-cuts, by-ways, mountains and rivers, accurately described' (Veg. *Mil.*, III, 6). He also stresses the responsibility of 'sailors and pilots' to have a good knowledge of the areas where they will sail and of the harbours where they will land (Veg. *Mil.*, IV, 43, 149). Information gleaned must be properly evaluated, for example, by using a number of sources and comparing one with another; Vegetius warns against unreliable informants who may claim to know more than they do or who may have ulterior motives for distorting the information they give (Veg. *Mil.*, III, 6). On the plans of the enemy, Vegetius counsels assiduous reconnaissance and the exploitation of traitors and deserters (Veg. *Mil.*, III, 6).

We have already noted that on his first expedition Caesar had virtually no intelligence of either harbours or the disposition of the enemy (Chapter II, 20: *B. Gall.*, IV, 20-1). In fact the purpose of this first undertaking was precisely to gather intelligence. When the campaign of A.D. 43 was being planned, there can be little doubt that the quality of available intelligence was much better than Caesar's had been. It is not simply that Verica was able to report the latest political situation in his kingdom and its relations with the Catuvellauni, or to give Roman naval commanders pilotage information about the entrance to Chichester Harbour; the latter would in any event have been specialist knowledge, not normally within the experience of an ex-king, while any information he had to offer about the political situation would certainly have been treated with caution and double-checked against other sources. It is that the years of growing trade had built up among Roman and Romanised Gallic merchants and seamen a considerable knowledge of the harbours, trade networks and peoples of southern Britain. In fact the picture of the trade networks which has emerged from the archaeology (e.g. Salway, 1998, 56-9; Webster, 1999, 51-6) may well indicate the limits and scope of the intelligence available to the military planners of A.D. 43. In that case, it is interesting to note the gaps: as we have already noted, directions for the coastal passage along the south coast from Boulogne to the Solent may well not have been available; in addition, it is possible that information about available cross-country routes from the Solent to the Thames may have been very sketchy.

The question of logistics is critical to the success of any military operation (Peddie, 1997, 23-46). Vegetius discusses in particular the ways of ensuring an adequate supply of grain and fodder and other provisions. He envisages that these might be requisitioned from the 'provincials' and in 'quantities always more than sufficient assembled at points well-placed for waging war and very well-fortified' (Veg. *Mil.*, III, 3). Cases of need might arise when an army might rely on foraging, as Caesar seems to have done on his first raid, although on his second he charged his legate, Labienus, left behind in Gaul, 'to ensure the corn supply'. But only a very confident general would ignore his supply lines and then only for very high stakes.

But no such risks were required of the staff officers planning the invasion of Britain in A.D. 43. It would, we may be assured, be a requirement of their planning to secure adequate supply lines for the legions and the auxiliaries as they moved forward into the hostile territory of Southern Britain. It has been suggested that the Romans might have relied on exploiting a good corn supply to be found in the Sussex area (Bird, 2000, 92). There might also have been supplies of locally grown corn in north-east Kent (Bird, 1999, 333), or even, as we have noted, in Essex specifically provisioning the legions on the Rhine. But there can have been no certainty that these supplies would have been adequate to meets the needs of the large Roman invasion force (Peddie, 1997, 32, 36); this would not have amounted to Vegetius's exhortation to exact provisions 'in good time and quantities always more than sufficient assembled at points well-placed for waging war and very well-fortified' (Veg. *Mil.*, III, 3). The only effective way of meeting Vegetius's recommendation would be to construct a fortified beachhead through which the necessary supplies would be imported.

Consideration of the Options for the Invasion Passage

We have identified two realistic options for the invasion passage: a landing on the coast of east Kent, following, as it were, in the footsteps of Julius Caesar; and a landing in the Solent region, maximising, as some scholars claim, the benefits of the defection of Verica.

1. Options for Claudius's Crossing

We know from Suetonius that Claudius crossed from Boulogne (*Claud.*, 17). Dio does not explicitly state that Claudius arrived in Britain at the same time and by the same route as the elephants, but this seems to be a general consensus and a reasonable assumption given their likely rôle in putting on a show to impress the British (Bird, 2000, 102). Whatever plans the Naval Staff adopted for the landing of the main force, they had to ensure that the beachhead where Claudius landed in Britain and his route thence to join Plautius was securely in Roman hands. Although he advocates Fishbourne for the landing of the main force, Hind accepts that Claudius may have landed at Richborough: 'If so, the journey would have been through an area cowed and submissive after Plautius' victories' (1989, 18). On the other hand Bird, who also argues for the Fishbourne hypothesis, considers that the route through Kent 'might still be rather dangerous' and sees diplomatic advantages for Claudius in landing at Fishbourne to restore Verica (or install Togidubnus) in person.

If one accepts the Fishbourne hypothesis as expounded by both Hind and Bird, it is difficult to identify from Dio's account any operation by the army which might have amounted to securing Richborough for Claudius's landing and the route he would have taken through Kent to join Plautius at the Thames. Bird does hypothesise that operations to secure this route might have been undertaken, 'from both directions', while Plautius was waiting for Claudius to arrive. If so, it would have been leaving things a little late and in the event Bird's proposal is that Claudius landed at Fishbourne. To put oneself in the position of the Roman Naval Staff planning the operation, to have Claudius land other than at the main invasion bridgehead must have seemed to be a major complication requiring the input of significant additional effort and resources. The only rational choice was for Claudius to land at the main invasion beachhead.

2. Richborough or Fishbourne

Having established the very high probability that Claudius would have landed at the same beachhead as the main invasion force, having embarked at Boulogne, let us compare Richborough and Fishbourne, both in terms of the challenges posed by each crossing and of the contribution that each would make to the major war aim, namely the capture of Colchester and the breaking of Catuvellaunian power.

Fishbourne

Landing here would only be required if the restoration of Verica or the installation of Togidubnus was a key initial objective of the campaign.

Distance for the open-sea passage from Boulogne is 95 NM. Passage is likely to take two and a half to three days, probably considerably more.

Favourable winds from the easterly sector are relatively infrequent for the outward passage from Boulogne; this could cause significant delay to each of the three waves of the invasion, as well as to Claudius's crossing. On the other hand for the return passage winds from the prevailing westerly sector are much more frequent.

On this passage it would not be possible to work the tides to any effect.

Passage along the Sussex coast would present hazards, such as the Owers which would require local knowledge. Since this passage does not seem to have figured among the regular passages of contemporary merchants and seamen, such local knowledge might not have been available.

Good shelter would be available in Chichester Harbour.

Richborough

Landing here would serve main war aim of the destruction of Catuvellaunian power and the capture of Colchester. It would still serve the restoration of Verica or the installation of Togidubnus at a later stage in the campaign.

Distance from Boulogne is about 40 NM. The evidence of Caesar's passages is that passage time might be in the order of 16 to 18 hours.

Favourable winds for the outward passage from Boulogne are much more frequent and include winds from the prevailing quadrant, i.e. the south-west. For the return passage any wind with a northerly element in it will serve, which include those from the north-east whose frequency is enhanced by the funnelling effect of the Dover Strait.

The tides could be worked to considerable effect.

The only significant hazard would be the Goodwin Sands, which may not then have existed; in any event a course direct to the South Foreland and then following the coast along to the Wantsum would give the Sands a wide berth. Local knowledge likely to be readily available.

Good shelter would be available in the Wantsum, particularly in the vicinity of Richborough.

Fishbourne (cont.)

Security of the beachhead depends in large measure on the friendly cooperation of the local tribes, be they Atrebates or Regni. How far the Romans could safely rely on this would depend on their assessment of the reliability of advance intelligence.

Maintenance of the supply lines from Gaul to the beachhead would be more difficult for the reasons given above.

Distance by direct route from Fishbourne to likely Thames crossing would have been rather shorter than from Richborough (Hind, 1989, 15), but could involve terrain about which intelligence was sparse. Bird has drawn attention to the need for the legions to avoid the Wealden clay which would lie on their direct line of advance (2000, 95).

Richborough (cont.)

Richborough on its island or peninsula provides an excellent site for a fortified beachhead and possesses much the same advantages as Caesar noted in the strongholds of the Veneti (*B. Gall.*, III, 12). It does not depend for its security on the friendliness of the local tribes.

A beachhead at Richborough supplied from Boulogne would unquestionably be the easiest means of securing an efficient supply route.

Although longer, the route from Richborough to the likely Thames crossing, following the firm ground of the North Downs, was already well known from Caesar's expeditions.

Individually these considerations may be debatable, but, if we put ourselves in the position of the Roman Naval Staff planning the operation in advance, they must have seemed, when taken together, powerful arguments for preferring the Boulogne/Richborough route for the invasion. Some of the difficulties associated with the Boulogne/Fishbourne route might be alleviated by planning a crossing from the Seine to the Solent; for example, a more advantageous incidence of favourable winds might be anticipated. But other difficulties would still remain and Boulogne/Richborough remains from the naval point of view the easier and preferable route; McGrail gives the Seine/Solent route a relative reliability factor of 71% compared with 98% for the Boulogne/Walmer route (1983, 333). Moreover, to shift the port of embarkation westwards still leaves Claudius waiting in uncertainty at Boulogne for a favourable easterly to bring him and his elephants to Fishbourne. Above all the need to provide a safe and reliable crossing for the Emperor must have been a major consideration and Boulogne to Fishbourne scarcely answers it.

Chronology

While we know that the invasion was launched and completed its objective of eliminating Caratacus and Togodumnus and seizing Colchester within calendar A.D. 43, details of the chronology within the year are uncertain. Nevertheless the sparse evidence available hints that the campaign objectives were achieved in short order.

The relevant information is as follows:

1. The ancients were wary of putting to sea in the winter months. Caesar displays in his diary a clear reluctance to put off the return voyage to Gaul beyond the autumnal equinox (*B. Gall.*, IV, 36; V, 23). Vegetius confirms this ancient wisdom: he divides the year into months which are very suitable for navigation, those which are doubtful and the rest which 'are impossible for fleets by a law of nature' (Veg. *Mil.*, IV, 39). The suitable period runs from the 27th May to the 14th September; the impossible season from the 11th November to the 10th March. The two periods between these dates are doubtful when the activities of merchants may not cease, 'but greater caution should be shown when an army takes to the sea in warships than when the enterprising are in a hurry for their private profits'. Vegetius no doubt had conditions in the Mediterranean in mind, but similar considerations are known to have applied in northern waters (McGrail, 1983, 259-60). The practicalities are that, once the spring equinox has passed, the frequency of opportunities for setting sail, especially for the short crossing from Boulogne to Richborough, is increasing daily, while from mid-August onwards, with nights setting in, the opportunities are daily less frequent.

2. A literal reading of Dio's text implies that, when Plautius's legionaries mutinied at the thought of the invasion of Britain, Claudius had to send out his freedman Narcissus to enforce obedience (Dio, LX, 19; Salway, 1998, 82). This, says Dio, caused the departure to be delayed. The assumption is that Narcissus was at Rome, some 800 miles away, as the crow flies. This would mean waiting at least a month for Narcissus, allowing the news to travel to Rome and Narcissus to travel back at an average of 50 miles a day; this makes no allowance for difficulties such as that of traversing the Alps. Webster (1999, 104) cites the claim by Suetonius (*Iul.*, 57) that Caesar could achieve 100 (Roman) miles a day (92 statute miles) 'in a hired carriage', but adds that 'the normal speed of the post averaged five miles an hour'. It is clear that the speed attributed to Caesar was outside normal experience, both because Suetonius saw fit to mention it and because he says that Caesar often arrived before the messengers sent to announce his approach! Butler and Cary state that 'there is no other record of such a distance being covered in a day by Caesar or any other

Roman before the institution of the Imperial post' (1927, 123). Moreover, it is unlikely that Narcissus would have been able to match on his return the speed achieved by the courier. Salway puts the delay at the more likely figure of two months.

3. A further literal reading of Dio's text records that when he reached the Thames, Plautius sent for Claudius (Dio, LX, 21; Salway, 1998, 85-6). Again the assumption is that Claudius was summoned from Rome, confirmed by Dio's statement that 'when the message reached him' Claudius entrusted affairs at Rome to Lucius Vitellius. Suetonius gives an unsympathetic account of Claudius's difficult journey which included a passage from Ostia to Marseilles, during which he was 'nearly cast away twice in the furious north-westers, off Liguria and near the Stoechades islands' (*Claud.*, 17). Dio adds that the journey through Gaul was partly by land and partly along the rivers. This delay would have been at least the two months that Salway ascribes to it and possibly nearer three.

4. Claudius spent sixteen days in Britain and was away from Rome for a total of six months (Dio, LX, 23; *Claud.*, 17). This time scale would allow him a hurried two months' journey to Britain and a more leisurely three and a half months' return.

5. A *terminus ante quem* for the submission of the British kings to Claudius is given by an Alexandrian diobol (Barrett, 1998, 574-7). This coin has the inscription on its obverse '*ΒΡΕΤΑΝΝΙΚΟΣ ΚΑΙΣΑΡ*' and is dated to Claudius's third regnal year. Since the Alexandrian mint began its year on the 29th August, the latest date of its minting is considered to be 28th August 43. The title 'Britannicus' was conferred on Claudius by the Senate after they had learnt of his success at Colchester, the news of which Claudius had sent ahead of his own return to Rome. Barrett considers that this indicates that Claudius achieved the submission of the British kings shortly before mid-August at the very latest with his arrival in Britain no later than 'the closing days of July'. He bases this on the notice by Suetonius of Caesar's 'record land speed' of 100 miles a day and another by Pliny the Elder citing 'nine days for a fast journey by sea from Puteoli to Alexandria'. However, we have suggested that 50 miles a day might be a more reasonable land speed even for a courier. As for the voyage to Alexandria, the distance involved by a great circle route is some 1,100 miles. To make the voyage in nine days would involve an average speed of just over 5 knots. Casson includes the passage from Puteoli to Alexandria cited by Pliny in a list of single-ship passages in antiquity made with a fair wind which achieved speeds of this order (1971, 283-9; McGrail, 1987, 263).

Taken together we have the following:

Stage	Number of Days
Colchester to Boulogne	3
Boulogne to Rome @ 50 miles a day	16
Senate convenes and confers title	2
Rome to Alexandria	9
Design and minting of coin	2
Total	**32**

If we assume that the initial attempt to embark had been in mid-March and follow through the delays from then, the following schedule arises:

Event	Approximate Date
Legions mutiny	mid-March
Narcissus addresses legions	beginning of May
Plautius reaches Thames	beginning of June
Claudius joins legions	beginning of August
British kings submit to Claudius	mid-August

This schedule allows six weeks for Narcissus to respond to Plautius's summons, but assumes that weather conditions would have allowed an immediate sailing for Britain. It also fits Barrett's assumption that a submission shortly before mid-August could have been recorded on a coin minted in Alexandria before the end of August. However, the schedule is impossibly tight and clearly something does not fit. There seems to be no reason to doubt the evidence of the coin. Barrett says, on the basis of advice from the curator, that it appears genuine and adds that his suggested *terminus ante quem* of mid-August for the surrender of the British kings is 'an absolute metaphysical *terminus*' and that a reasonable *terminus* would set 'at the very least a month between the surrender and the coin's appearance', perhaps two (Anthony Barrett, pers. comm.). We must look elsewhere.

There are two aspects of Dio's account which frankly verge on the unbelievable: that the mutiny should have been allowed to continue for the weeks which would have been necessary for Narcissus to arrive from Rome; and that Plautius should have waited at the Thames for the two months or so which it must have taken Claudius to respond to Plautius's summons, if he received it at Rome. The difficulties of the chronology disappear if one assumes that Narcissus was already at Boulogne when the mutiny occurred (Peddie, 1997, 35). If so, it would be entirely natural that, as the Emperor's personal representative, he should address the troops.

In like vein, it is not unreasonable to assume that when Plautius sent for Claudius, not to strengthen his resolve against difficult opposition, but to receive the submission of a new province that was virtually ready to surrender - we should remember that by then Togodumnus had been killed, Caratacus driven back into west Britain and only the taking of Colchester remained of the original campaign aims - Claudius was waiting in the wings at Boulogne. If Claudius intended all along to lead the legions into Colchester, this would be the natural thing for him to do.

It might be claimed that to propose this is to do undue violence to the sources. In fact there is nothing in this which contradicts Suetonius's account and Dio does not say that Narcissus was sent out specifically to deal with the mutiny, much less sent out from Rome. As to Claudius's arrival in Britain, scholars have already expressed disbelief at Dio's account on the grounds of the reason given for his summons (Salway, 1998, 85). It is frankly incredible that the Roman campaign should have remained stalled for the supposed months of Claudius's leisurely, even if hurried for an Emperor, progress from Rome to Britain. Suggestions have been made that Plautius spent the time consolidating the Roman gains: Webster considers that it was now that Vespasian was sent off on his campaign with his *Legio II Augusta* in the south-west, on the grounds that this was the one area of advance still open to Plautius without exceeding his remit from the Emperor (1999, 103-4); Bird proposes that Plautius now took the opportunity to pacify Kent and to make diplomatic overtures with British magnates in advance of Claudius's arrival. The problem with these ideas is that they would have afforded the tribes north of the Thames time to regroup. Instead of making 'their anguished farewells to their kinsfolk' (Webster, 1999, 103), Caratacus and his followers would have been able to spend the time exhorting them to renewed resistance.

The Naval Staff's Preferred Option

Setting aside Germanicus's abortive adventure of A.D. 15, the invasion of Britain would be the first major operation outside the consolidated boundaries of the Empire since the loss of the three legions under Varus in the Teutoburg Forest thirty-four years earlier. Varus had been overconfident and had allowed himself to be ambushed. Salway (1999, 89) suggests that Claudius must have been keenly aware of the lessons of this disaster and we may be sure that his staff officers were too. Unnecessary risks could not be afforded.

There is only one option that on naval grounds the Naval Staff could have recommended to the Roman High Command, namely the Boulogne/Richborough option. What would have been planned for the naval operation could well have been on the following lines:

1. A first wave, of perhaps a single legion and supporting units, would cross as soon as the sailing season opened to secure a beachhead at Richborough and fortify it as a supply base.

2. As soon as this had been achieved, a second and a third wave would cross and move through the now fortified beachhead of Richborough to secure a forward base, possibly, but not certainly, at

the crossing of the Kentish Stour at Canterbury. Once these forces had met and the troops not required for the garrison at Richborough had joined them, they would be ready to move forward through Kent to secure the route to the Thames crossing and to deal with Caratacus and Togodumnus.

3. The fleet would be available to ensure secure swift communications and logistics between Boulogne and Richborough throughout the campaign and beyond.

4. The Emperor would travel to Boulogne to be there in time to cross as soon as he heard from Plautius that he was ready to march on Colchester. All those items required to make the required imperial display, including his elephants, would be waiting.

What if the Fishbourne option weighed so heavily in the minds of the High Command that a plan on these line was overruled? If that were so, the Naval Staff must have pointed to the difficulty of the Boulogne/Solent passage and argued on the grounds of the prevailing winds for an embarkation port on the coast of Gaul as far west as possible (Grainge and Grainge, 1993, 263; 1996, 131), possibly on the Seine, better still in lower Normandy, best of all on the Cherbourg peninsula, where the open-water passage would be less than 70 nautical miles. But we know that Claudius embarked at Boulogne. This would still leave him either waiting for the infrequent anticyclonic conditions required for the voyage to the Solent or crossing to Richborough to progress to the Thames along a route that no one in advance could be certain would be secure.

Ultimately the argument turns on the hypothesis that the Romans considered that Verica was a loyal ally and that his kingdom would provide a friendly base for the Roman beachhead. One of the lessons of the disaster of A.D. 9 was that allies were not to be trusted. Until the ambush in the Teutoburg Forest, Arminius had been considered a friend of Rome.

Chapter XIII
Conclusion

Claudius in Britain

In the ancient sources Claudius cuts a somewhat ludicrous figure and nowhere more than in the part ascribed to him in the British campaign. Whether one follows Dio, who would have us believe that Claudius was persuaded into the adventure by a refugee ex-king, or Suetonius, who regarded the invasion of Britain as a minor episode undertaken merely for the sake of Claudius's military glory, the overall impression is of an expedition undertaken on a whim and organised in such a way as to allow Claudius maximum credit for minimum personal risk and contribution.

Such an interpretation of the events of A.D. 43 does not do justice to the professionalism of the Roman army (Le Bohec, 2000, 119). The British expedition involved enormous resources of personnel and *matériel*; it achieved its overall strategic objective of the subjection of the Catuvellauni and their allies in short order and inaugurated four centuries of Roman rule in Britain. A military operation on such a scale would not have been mounted to satisfy a whim, even of someone as powerful as the emperor, without the dedicated support of the senior ranks in the army. This would have been the more so, given that the invasion represented a complete break with the imperial policy, dating back to the disaster in the Teutoburg Forest, of consolidating the empire within its existing boundaries. The potential risks - and costs - involved in taking and holding Britain were considerable; not least in establishing a new northern *limes*, which in the event would prove a major source of trouble for years to come. Strabo had offered the opinion, which may well have been that of the military, that the tribute to be gained would not equal the cost of holding Britain. I would argue that, to be committed to the invasion, the senior ranks of the army would have needed a better cause than the restoration of some petty British king or the promotion of Claudius's military reputation.

I suggest that that better cause is to be found in the increasingly unstable relationships between Britain and the empire. These date from the death of Tiberius and the accession of the mad emperor Gaius, reaching crisis point with the death of Cunobelinus and the programme of aggrandisement initiated by his sons Caratacus and Togodumnus. Ultimately this instability threatened the supply of strategically important commodities, notably to the legions stationed on the Rhine. The judgement that these could be secured only by the control of the sources of supply would have been one made by senior members of the imperial staff and endorsed by Claudius himself. This would have required the occupation of Britain, the defeat of the Catuvellauni and the seizure of Colchester. This is the context that explains the presence of Claudius in Britain. It matters little whether he personally took over the detailed direction of the campaign or not; what mattered was that his presence conveyed to the British tribes, in a way that nothing else could, the message that Rome had taken over. It was the emperor who personified Roman power. And that is why Claudius brought his elephants; they reinforced the display of his imperial status, as he received the submission of the British kings at Colchester.

It would, however, be perverse to suggest that pride in the military achievements of Rome played was no part in the mindset of the leaders of the invasion (Salway, 1998, 66). Educated Romans of the first century A.D. would have been well versed in their Vergil and would know, in particular, the three lines from the sixth book of the *Aeneid*:

> *Tu regere imperio populos, Romane, memento;*
> *Hae tibi erunt artes, pacisque imponere morem,*
> *Parcere subiectis, et debellare superbos* (*Aen.*,VI, 851-3).

> Forget not, Roman, that it is your destiny to rule the peoples; these shall be your skills: to impose the ways of peace, to spare the defeated and to crush the proud in war (translation adapted from Salway, 1998, 66).

These lines of Vergil express a deeply ingrained belief among Romans of his generation about their place in the world. The whole of the last section of Book VI of the *Aeneid* (lines 671-892) is devoted to a glorification of Rome's greatness at the centre of her growing empire and of the part played by the descendants of Aeneas, in particular by Caesar Augustus himself. Individual heroes do figure in Vergil's account, but the main theme is the destiny of the Roman people personified in the Emperor.

Verica in Rome

Verica is central to the Fishbourne hypothesis. This hypothesis depends on three assumptions: that the British tribes were polarised by pro- or anti-Roman attitudes; that Verica and his Atrebates were among the pro-Roman tribes; and that the Romans would have intervened to restore a deposed pro-Roman king.

Let us take the third assumption first and allow that Verica was pro-Roman, perhaps even an ally of Rome. The readiness of the Romans to intervene cannot be assumed to have been automatic. They certainly did not intervene when the Catuvellauni took over from the Trinovantes, in spite of Caesar's injunction that the independence of the latter was to be respected. But, if they were to intervene, at the massive cost in resources that we know was involved, there must have been some other reason touching Rome's interests at the highest level. This, I suggest, is to be found in the threat to strategic exports from Britain to the empire.

As for the first two assumptions, the evidence for them is vestigial and uncertain, depending almost entirely on coin finds, which can be interpreted either to support the assumptions or to negate them. For example, a king who styles himself *rex* on his coins may be demonstrating his pro-Roman allegiance; he may alternatively be demonstrating no more than the increasing influence in Britain of Roman culture (Salway, 1996, 56). There is no pressing reason why the very real conflicts that did exist between individual tribes should be seen in terms of differing attitudes to Rome. Those conflicts can equally well be explained by competing aspirations to control material and economic resources, as exemplified by the take-over by the Catuvellauni of the Trinovantian trade hub at Colchester.

This is not to cast doubt on the reality of Verica's arrival in Rome, or wherever it may have been that he made contact with the Roman authorities. No doubt the reason for his expulsion is to be found in Catuvellaunian aggression. But his flight to Rome is not evidence of his pro-Roman sympathies; where else was an ejected king to find asylum? For their part, the Romans are likely to have treated him as a useful source of intelligence to be evaluated in the light of information from other sources. While they would have considered exploiting any magnate willing to serve them as a client king, one may question whether they would have regarded an elderly superannuated ex-king as a suitable candidate for the task. They would scarcely have regarded his restoration as a prime objective of the campaign and, as we have noted, he was not restored.

If this is accepted, the question of whether the Romans landed in Chichester Harbour or at Richborough turns solely on their assessment of how well a beachhead at the one or the other would have served the overall campaign objective of defeating the Catuvellauni and of taking Colchester. The answer to that question depends partly on the way the land campaign could be managed after the landing. Advocates of the Fishbourne hypothesis have argued that a landing in the Solent area makes better sense of the account of the land campaign provided by Dio and other ancient sources; it has not been my purpose in this thesis to challenge that view. But the answer also depends, in my view critically, on the constraints on the Roman naval strategy.

Constraints on the Roman Naval Strategy

The task that faced the Roman Naval Staff was to provide for the safe passage across the Channel of four legions, together with auxiliary units including cavalry, numbering perhaps some 35,000 to 40,000 men, and to follow this up with the safe passage of Claudius himself and his elephants. The limited capability of the available ships, particularly of the transports built in the Romano-Celtic tradition, must have meant that the passage could be contemplated only in good weather with a light and favourable wind. The fact that this was a fleet operation, not a passage by a single ship, would have limited even further the speed that could be achieved and extended the passage time. When these limitations are weighed in the context of the maritime conditions in the English Channel, particularly of the prevailing winds, the option of landing in Chichester Harbour or anywhere in the Solent from an embarkation port in the Boulonnais is ruled out.

These questions are at the heart of this thesis. I considered it important to explore them in depth, even though much of the material investigated is well known to seamen and to maritime archaeologists. However, it is only too easy for the student of the invasion little acquainted with the reality of passage-making under sail in the English Channel to draw lines on sketch maps proposing hypothetical, but impossible, invasion routes. My purpose has been to share this material with those who are not specialists in maritime studies and thus to widen the basis of the debate about A.D. 43.

The sailing rig of Romano-Celtic sea-going ships with their single forward-located mast remains a conundrum, at the centre of which lie the two factors of directional stability and leeway resistance. It is their poor leeway resistance that would have limited these ships to off-wind sailing. With a fore-and-aft sail satisfactory directional stability would have been possible only when sailing close to the wind. The opposite would have applied with the square sail; as it came closer to the wind, a square-rigged Romano-Celtic ship would have come to the point where lee helm would have set in. What my analysis suggests, however, is the crucial point that directional stability cannot be assessed in purely static terms. It is essentially a question of understanding the dynamic balance between the force of the wind, not only on the sail(s), but also on the hull and superstructure, and the force of the water on the underbody of the hull, including all its appendages. It is a balance that shifts with the point of sailing and the weight of the wind.

Our study of these matters is significantly hampered by the fact that no experimental work has been carried out on a reconstructed Romano-Celtic sea-going ship. However, any such experimental work must allow for the fact that we know virtually nothing about the superstructure, if any, that such ships might have carried. The model of St Peter Port 1 in the Maritime Museum in Castle Cornet, Guernsey (Plate V), and the depiction of Blackfriars 1 on the cover of Marsden's book (1994) both show a conjectured deckhouse on the aft deck, inferred from evidence found at St Peter Port (Rule and Monaghan, 1993, 128). Such a structure would have had a significant impact on the directional stability of the vessel.

The fact of the matter, though, is that no ship with a single fore-and-aft sail can have perfect directional stability on all points of sailing. Nor can it with a single square sail, unless the mast is mounted close amidships, as in the case of the clinker-built ships of the Nordic tradition (Andersen, 1986, 208-219). Given the forward-located mast of the Romano-Celtic tradition, we must conclude that their builders and sailors must have accepted some form of compromise as to directional stability. I believe that the balance of the evidence points strongly to a compromise in the form of a battened square sail and an acceptance of limitations on windward sailing. It is in my view particularly telling that other similar configurations of mast and sail are known in modern, as well as in ancient, times. The case of the Humber keels and that of the gundalo *Philadelphia*, both mounting square sails on forward-located masts, seem to me to be strong circumstantial evidence that Romano-Celtic ships may well have been operated with square sails, even if that prejudiced their directional stability. Moreover I would argue that that prejudice would be limited to sailing close to the wind.

However, in concluding that Romano-Celtic ships sailed with a battened square sail, I do recognise that others will argue for some form of lugsail. But what must be discounted is the hypothesis that they were rigged with spritsails.

The other constraint on the options open to the Claudian naval strategists would have been the sheer unpredictability of passage-making by fleets in the age of sail. In this thesis I have reviewed a total of sixteen cross-Channel fleet operations. Of these a total of eight (50%) failed to reach their destination. This overall figure includes seven cross-Channel passages by Caesar's fleet or parts of it, of which two (29%) failed to reach their destination. The two failed attempts were the result of bad weather and adverse winds; arguably their commanders were under pressure from Caesar to make the crossing as soon as possible. If one disregards these two cases, the high success rate on the short Channel-crossing from Boulogne to the Wantsum becomes impressive when compared with the low success rate of the other attempts taken together (33%). Even if one excludes the ill-fated voyages of the three Spanish Armadas, the success rate of fleet passages on the other routes across the Channel is still as low as 50%.

If the Claudian naval commanders really were charged to ensure the safe passage of their legions and of their emperor across the Channel, then there really was only one route available to them. It was the route from Boulogne to the east coast of Kent, pioneered a century earlier by Julius Caesar.

Moreover, once we accept that the primary objective of the campaign was not to reinstate Verica, there is nothing in the politico-strategic context which would have required a landing anywhere else. From our review of other invasion passages we noted the importance of the politico-strategic context in defining the options open to those planning cross-Channel operations. William of Orange, for example, had to take account of the hostility of the France of Louis XIV towards the Dutch, while William of Normandy could not have embarked from the Boulonnais for a crossing to east Kent, because his jurisdiction as Duke of Normandy did not extend that far. For Constantius Chlorus in A.D. 296 a landing on the east coast of Kent would have been out of the question, because of the newly constructed Forts of the Saxon Shore, especially at Richborough and Reculver.

Envoi

Even when the maritime factors have been weighed in the balance along with the other arguments, the debate is still, as I said in Chapter I (13), an inferential one. At the conference of the Sussex Archaeological Society in October 1999, when the question where the Claudian invasion task force landed was debated, the Conference Chairman, Professor Barry Cunliffe, closed the discussions with an invitation to those present to keep an open mind (Sussex Archaeological Society web site: www.sussexpast.co.uk/ad43conf.htm). Of course, this must be right. It is always possible that further evidence in one form or another may turn up to influence the course of the continuing debate. However, I have to say that, in my view, the weight of the maritime argument is so strong, that the landing in A.D. 43 must have been at Richborough. From the archaeology of the site, it seems very likely that the landing would have been, as Dio seems to suggest, in three waves. For my part, only the discovery of Tacitus's lost *Annals* confirming a landing elsewhere than at Richborough could provide the basis for a different view.

Plate I Aerial view of Richborough Castle and the Stour (former Wantsum) beyond. The defensive ditches protecting the Roman invasion beachhead, which have been traced over a length of 2,100 feet, can be seen at the near left hand corner of the fortified enclosure. (© Skyscan Balloon Photography, source: English Heritage Photo Library.)

Plate II The parallel defensive ditches protecting the Roman invasion beachhead at Richborough. They date to the earliest period of the Roman occupation and were quickly replaced by the first-century supply base. (© Gerald Grainge.)

Plate III The Wantsum today: the Stour beneath Richborough Castle. After periods of heavy rain standing water on large areas of the marsh creates a simulacrum of the ancient Wantsum. (© Gerald Grainge.)

Plate IV The Wantsum today: view from Richborough across the marsh towards Thanet. In the background against the white cliffs of Thanet the ridge of the Stonar bank is clearly visible. In Roman times the whole of the marsh in the foreground was under water creating a sheltered waterway between the Stonar Bank and Richborough. (© Gerald Grainge.)

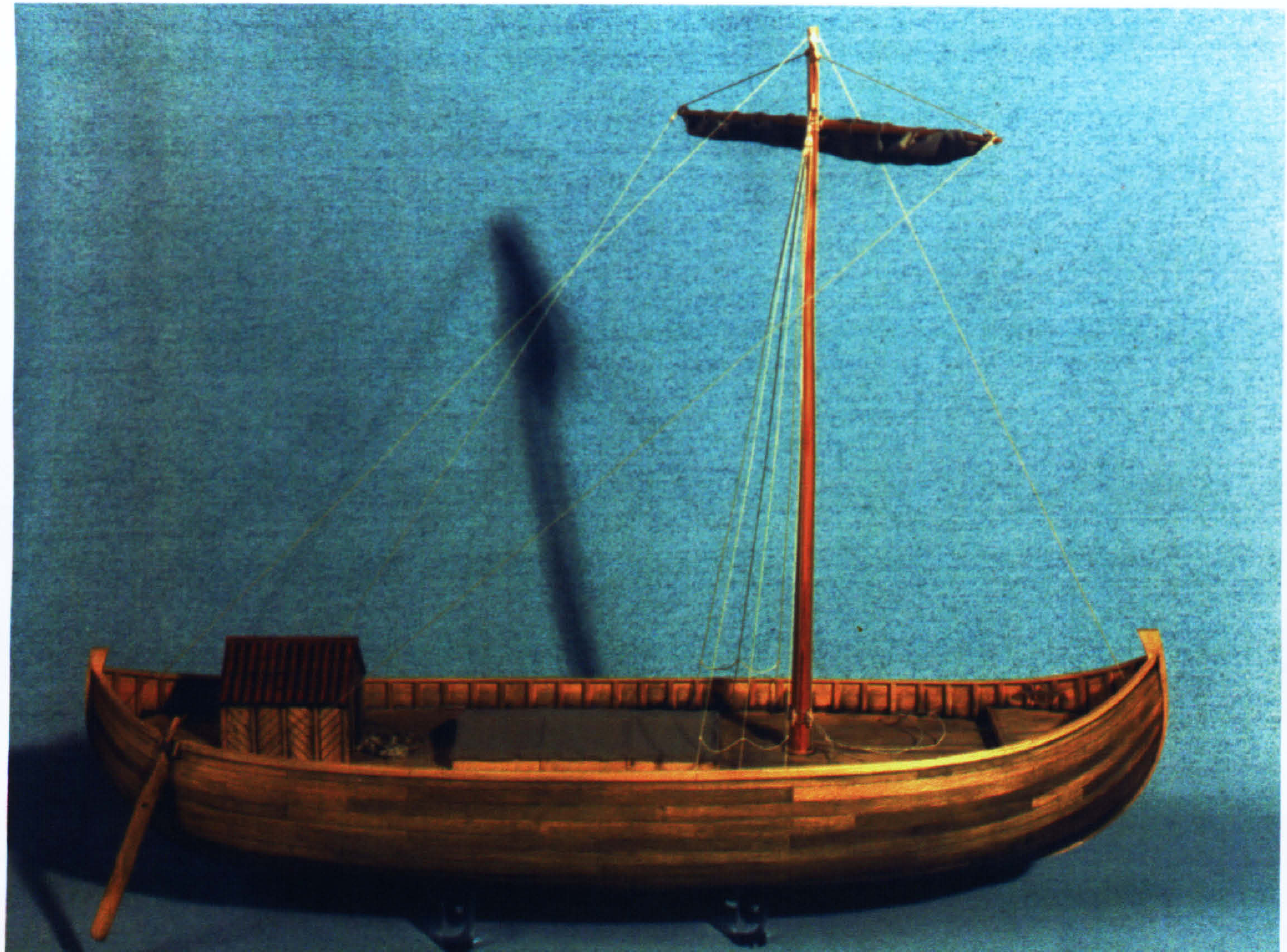


Plate V *Asterix*: this model reconstruction of St Peter Port 1, on display at Castle Cornet, Guernsey, was named *Asterix* after a competition among the schoolchildren of Guernsey. The detail of the superstructure, including the deckhouse, is, although conjectural, based on evidence found on site. Reproduced by permission of Guernsey Museums and Galleries.

Plate VI Model reconstruction of the floor timbers and planking recovered from St Peter Port 1, on display at Castle Cornet, Guernsey. The darker pieces represent components actually found. They clearly demonstrate the characteristic massive framing of the Romano-Celtic tradition. The bows are to the right and the mast step may be discerned in the middle of the group of three darker timbers about one third back from the bows. Reproduced by permission of Guernsey Museums and Galleries.

Plate VII Late Roman-period *intaglio* found on the foreshore at Southwark depicting a warship (Henig and Ross, 1998, 325-7). Reproduced by permission of the Museum of London.

Plate VIII. Man overboard! A failed rescue attempt (Casson, 1996, 50-1). The ship in the middle is a sprit-rigged *codicaria* and is luffing up to avoid a collision with the vessel bearing down on her from the right. Relief on a third-century A.D. sarcophagus thought to be from Ostia and now in the Ny-Carlsberg Glyptotek, Copenhagen. Reproduced with permission of the Museum.

Plate IX A *balam* from Bangladesh under sail and 'apparently making some way to windward' (Greenhill with Morrison, 1995, 124). Photograph by Dr. Basil Greenhill and reproduced with his permission.

Plate X The present-day Humber keel *Comrade*. The continuity of the type name, which can be traced back to the Anglo-Saxon migration period, may represent a continuity of ship-building tradition back to the ships of that time. Although certainly not linked in evolution to the sea-going ships of the Romano-Celtic tradition, modern Humber keels share with them many features of design and function, including the forward-located mast. Photograph reproduced by permission of the Humber Keel and Sloop Preservation Society.

Appendix I

Impact of Tidal Streams on Ground Speed: Worked Example

In this Appendix I set out a worked-up example of the impact of adverse tidal streams on ground speed, using the case of Caesar's return to Gaul from his last expedition to Britain. In this passage of nine hours, his fleet achieved a ground speed of some three and a third knots. A passage of this duration from Deal to Boulogne must have involved a period of adverse tidal streams, because the tidal streams change direction every six and a quarter hours. Assuming that the fleet took the tidal streams at the greatest disadvantage, the speed through the water could not have exceeded some five knots. This can be demonstrated by working up a navigational plot taking account of tidal stream data from a modern navigational chart (Imray Chart C8, July 1998). In working up this plot, the following have been assumed:

1. That the fleet took an hour to reach a departure point off Deal approximating to the position of the modern South Brake light buoy.

2. That a constant heading through the water was maintained of 170° True, i.e. just east of south. This would be a heading which, ignoring tidal streams, would bring the fleet clear of Cap Gris Nez to the offing of Boulogne. As such it might well have been adopted at night time by pilots who did not have modern navigational lights to rely on, or indeed the later Roman lighthouse at Boulogne. However, in not allowing in any way for the offset of adverse tidal streams it significantly increases the distance actually followed over the ground.

3. That the fleet maintained a constant speed of five knots through the water, whether by rowing or otherwise.

4. That High Water Dover was at approximately 2200 hours UT. High Water at this time would mean that as soon as the fleet reached the departure point off Deal the tide would turn foul, i.e. we are assuming that the full six and a quarter hours of foul tide would impact on the fleet. It would also mean that the tide would be midway between neaps and springs.

A plot worked up on this basis would bring the fleet to a point off the coast of Gaul some six nautical miles north-east of Cap Gris Nez at 0300 hours UT (Fig. 32), when the tide would turn. We may assume that the fleet then turned to follow the coast with a now favourable tidal stream towards Boulogne. This would bring it to a point within two to three nautical miles of Boulogne at 0515 hours UT.

The tidal data are as follows:

Time UT	Tide at Dover	Rate (knots)	Set (°True)	Tidal Diamond
2200-2300	HW	1.6	038	G
2300-2400	HW + 1 hour	1.8	039	G
2400-0100	HW + 2 Hours	2.5	044	I
0100-0200	HW + 3 hours	1.5	040	L
0200-0300	HW + 4 hours	0.4	065	M
0300-0400	HW + 5 hours	0.4	255	M
0415-0515	HW + 6 hours	1.8	223	H

(Source: Imray Chart C8, July 1998; it is to be noted that for five of the seven hours the tidal stream is running in a north-easterly direction - 45° True, or close to it.)

This exercise does not claim to be an authentic reconstruction of the passage; that would require more information, including the exact date of the passage. It does, however, illustrate that, taking a worst case scenario, involving not only an adverse tide, but also a heading which makes no allowance for the effects of the tide, it would have been possible to make the crossing within the time reported by Caesar with a constant speed through the water of no more than five knots. Had Caesar been working his tides (Appendix III), so as to take advantage of a south-west going tidal stream, then the speed through the water would have been quite leisurely.

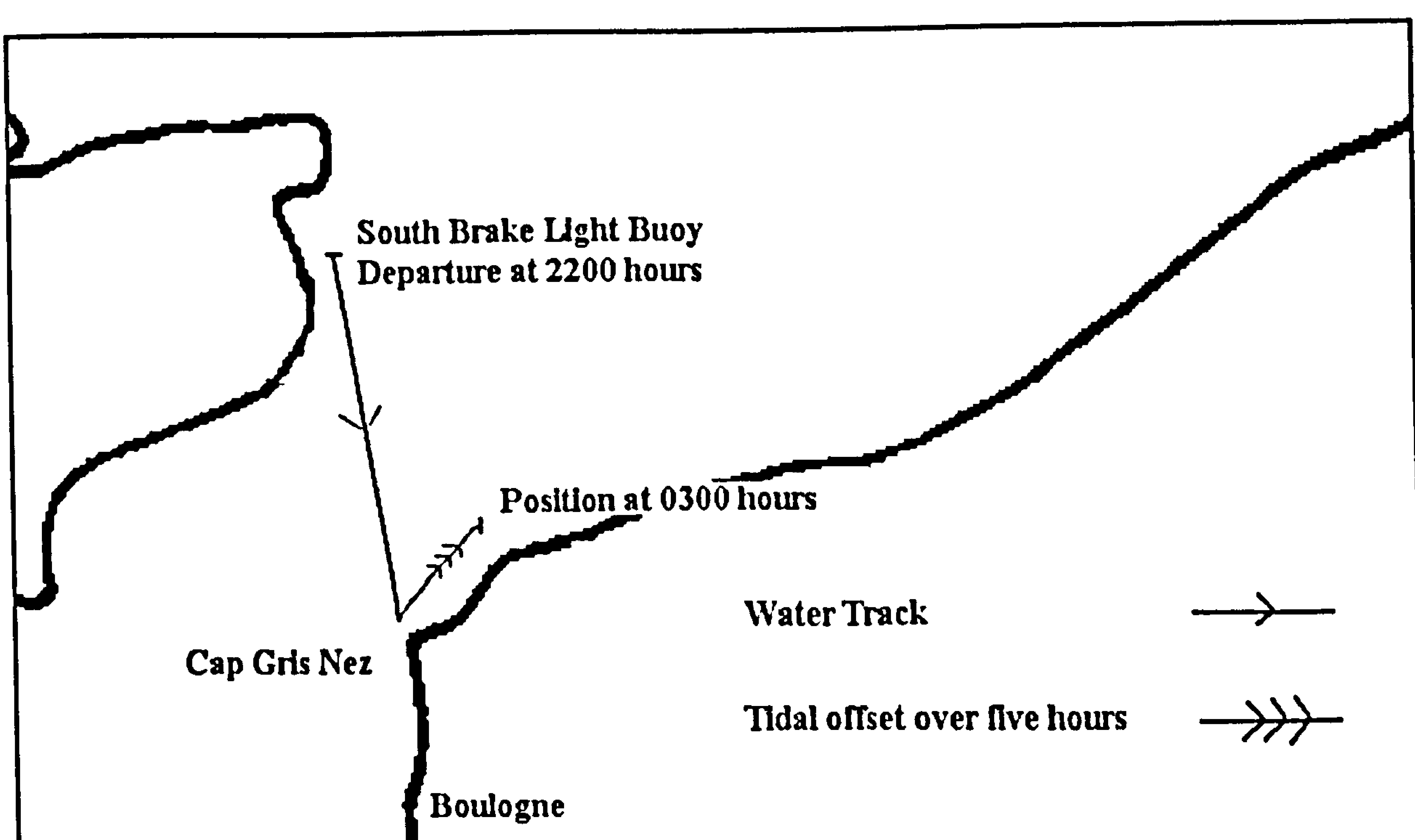


Fig. 32 Hypothetical plot of Caesar's return from Britain in 54 B.C., demonstrating the affect of adverse tidal streams. After five hours of north-east going tidal streams, the fleet arrives some six nautical miles north-east of Cap Gris Nez. The tide will now turn and with its aid the fleet should arrive off Boulogne some two hours later.

Appendix II

Storm Surge: the Cavalry Fleet is Driven Back

In 55 B.C. Caesar's cavalry sailed four days later than the main expeditionary force. Although it set out with a favourable breeze, it was driven back by a violent storm before it reached Britain. Caesar described the incident in the following terms:

> None of them could hold on its course; some were carried back to the selfsame port whence they had started, others were driven away, with great peril to themselves, to the lower, that is, to the more westerly, part of the island. None the less, they cast anchor; but when they began to fill with the waves they were obliged to stand out to sea in a night of foul weather, and made for the Continent (*B. Gall.*, IV, 28).

The fact that the fleet was driven back to the Continent, either directly or after attempting to anchor, suggests a wind from the north or north-west. Such a wind would be consistent with an earlier, gentler south-westerly as the warm front and then the cold front of a deepening depression passed over to the north (Chapter X, 114-5). This would have prevented them from landing, but would have allowed some of the fleet to make the shelter of the South Foreland, 'the lower, that is, the more westerly, part of the island'; but an anchorage there would have been uncomfortable, particularly when the tide changed.

A storm force wind from the north-west or north, together with an associated deep depression passing to the north would also be consistent with the surge tide conditions which, I suggested in Chapter II (21-2), caused the damage the same night to the main fleet at anchor or hauled ashore in the neighbourhood of Deal (NP 28, 1977, 23).

The height of the storm seems to have been at night, but it had already set in while it was still light, when the fleet was 'in view of the camp' (*B. Gall.*, IV, 28-9). When the moon is full, as it was reported to be that night, high water at Dover is at approximately eleven o'clock morning and evening (UT) and the tidal stream changes from south-west to north-east an hour or so earlier (NP 233, 1963). A possible reconstruction is that the fleet left 'the upper port', i.e. the port where it had been 'detained by the wind' four days earlier, thought by Edwards to be Ambleteuse (1917, 211), at around nine or ten o'clock in the morning to catch the tidal stream as it turned north-east. The wind was a gentle breeze from the south-west or west associated with the approaching warm front or with the warm sector of a depression which would shortly intensify violently. Six hours later the fleet would have been off the coast of east Kent; the tide turned to run to the south-west and they would have been fighting the tide to make their anchorage. About the same time or a little later the cold front passed over and the wind veered to the north-west, increasing in force. Even without the increase in the strength of the wind, the fleet would have been losing ground against both tide and wind and the appropriate tactic would have been to anchor until the tide and hopefully also the wind changed direction. The strength of the wind made that impossible, although some attempted to anchor in the lee of the South Foreland, while the rest followed tidal stream and wind back to the continent. The ships sheltering off the South Foreland would have found their berth untenable once the tide turned, say at around nine or ten o'clock in that evening, because of the sharp sea kicked up by the wind-over-tide conditions. After an unpleasant night at sea, possibly riding ahull, they too reached a haven in Gaul the following morning.

Appendix III

Did Caesar Work the Tides?

In the following analysis Roman times, reported in 'hours' and 'watches' (Chapter V, 39) are interpreted on the basis of a crossing in early August with sunrise at about 0430 hours UT.

Caesar reports the timing of his first expedition to Britain as follows:

Event	Time (Roman)	Time (UT)
Weighed at Boulogne	'about the third watch'	0000 to 0215 hours
Reached Britain	'about the fourth hour'	0815 to 0930 hours
At anchor off South Foreland	'till the ninth hour'	1430 to 1545 hours

He then weighed anchor and proceeded about seven Roman miles further along the coast (about five and a half sea miles) with a favourable tide, which would have taken him perhaps between one and two hours.

If we accept that he weighed at Boulogne soon after the tide turned, this would allow us to assume that HW Dover that day was around 0230 hours in the morning and around 1500 hours in the afternoon. Examination of the tidal atlas (NP 233, 1963) shows that the tidal streams off Boulogne would have begun to run favourably at about 0130 hours.

The tide would be turning against the fleet off the South Foreland at around 0630 hours and the last part of the passage until 0815 to 0930 hours would have been against the tide. Caesar's account makes it clear that there were stragglers among the fleet for whom he waited at South Foreland (*B. Gall.*, IV, 23). An adverse tide at the end of the passage would increase the probability that the fleet would string out, as any racing sailor knows.

However, this interpretation does not fit Caesar's statement that there was a full moon four days after the crossing, since HW Dover is around eleven o'clock at full moon. HW four days before would be about three and a half hours earlier. Pencilling in the times of HW at 0700/1930 hours with the appropriate times for the other states of the tide in the tidal atlas (NP 233, 1963) shows immediately, not only that the crossing of the Strait would be against an adverse tide, but also that Caesar would have an adverse tide for his coasting along the east Kent shore at the very time that he records that he had the tide in his favour.

Both of Caesar's statements are explicit, but there is a possibility that he may have been mistaken as to the exact phase of the moon on the night when his fleet was hit by a storm surge. If we assume that on the afternoon of the crossing, HW Dover was at 1700 hours with the morning HW at 0430, this shows (NP 233,

1963) that when the fleet left Boulogne the tidal stream was still flowing south-eastwards. It would become favourable at around three in the morning, perhaps less than an hour after the fleet left, and would remain so until around half past eight in the morning when the fleet was close to the South Foreland. However, the tide would not turn favourable for the run along the coast until three o'clock at the earliest.

High Water around five o'clock would mean that on the day of the crossing the moon was near its first quarter. Four days later it would not yet be full, but it would be approaching it. Tides would be making, but would not yet have reached the full spring range, which in any event is not on the day of the full moon, but a couple of days later. As to the swamping of the ships drawn up ashore, we have already suggested in Chapter II (21-2) and Appendix II that this was caused by a storm surge. Storm surges are not confined to spring tides and in extreme cases, when they can raise the sea level by as much as three metres, their effect can far exceed the differences between neaps and springs (NP 28, 1977, 23).

Caesar's account of the timing of the stages of the crossing is strong evidence that the Romans were working the tides. It is necessary to reconcile this with his statement about the phase of the moon at the time of the storm four days after the crossing. This can be done, provided that it is accepted that he reported the phase of the moon on the night of the storm with a degree of approximation.

Dimensions and Coefficients for Blackfriars 1 and Skuldelev 1 Compared

Appendix IV

	Skuldelev 1	BL A	BL B	BL C	BL D	BL E	BL F	BL G	BL H	BL I
Midships Underwater Area	4	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Maximum Beam	4.6	6	6	6	6	6	6	6	6	6
Beam at Waterline	4.5	5.62	5.62	5.62	5.62	5.62	5.62	5.62	5.62	5.62
Overall length	16.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
Waterline Length	15.6	17.34	17.34	17.34	17.34	17.34	17.34	17.34	17.34	17.34
Draught	1.27	**0.71**	**0.77**	**1.02**	**1.07**	**1.34**	**1.18**	**1.3**	**1.63**	**1.71**
Displacement Volume	34	**29.7**	**32.7**	**48**	**51**	**69.1**	**58.7**	**66.7**	**90.5**	**96.4**
Prismatic Coefficient	0.54	0.30	0.33	0.49	0.52	0.70	0.59	0.67	0.92	0.98
Slenderness Coefficient	3.47	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09
Midships Coefficient	0.70	1.43	1.32	0.99	0.95	0.76	0.86	0.78	0.62	0.59
Block Coefficient	0.38	0.43	0.44	0.48	0.49	0.53	0.51	0.53	0.57	0.58
Volumetric Coefficient	0.0090	0.0057	0.0063	0.0092	0.0098	0.0133	0.0113	0.0128	0.0174	0.0185

Note: BL A, BL B indicate the various roles and displacements of Blackfriars 1 tabulated in Marsden's Table 17 (1994, 194). Draft and Displacement Volume for Blackfriars 1 (emboldened) are the two dimensions for which Marsden gives varying values according to the weight of the cargo.

Appendix V

Estimated Performance of Blackfriars 1 Under Sail

Downwind

Marsden calculates (1994, 198-9) that, heeling at 12° in a beam wind with a total displacement of 66.5 tonnes, Blackfriars would have achieved 10.4 knots with a total force of 1.4 tonnes on the sail. He also offers the calculation that 10.1 knots might be achieved with a force of 1.1 tonnes on the sail, when the ship would heel to 8°. If one accepts Marsden's suggestion of a sail area of 64 square metres (1994, 74), these calculations imply pressures on the sail of 22 and 17 kilograms per square metre respectively (4½ and 3½ pounds per square foot). The first of these equates to a wind speed at the bottom end of Force 8 (34-40 knots), while the second approximates to the midpoint of Force 7 (28-33 knots) (Marchaj, 1964, 434). While Marsden does not go to the point of calculating the wind strength, one can agree with his conclusion that it would be difficult to heel the ship and that she would be very stable.

However, there seems to be a simplification in Marsden's methodology. The value of 1.4 tonnes as the weight in the sail for a speed of 10.4 knots (1.1 tonnes for 10.1 knots) is derived from the data for his Fig. 170 (1994, 198), showing in graph form the total hull resistance of Blackfriars 1 at various speeds up to 20 knots. On the principle of equal and opposite actions and reactions these values for hull resistance are equivalent to the value of the force required to drive the hull forward at the specified speed. But it does not follow that the sideways pressure on the sail in a beam wind will approximate to the force driving the hull forward (Marchaj, 1964, 77-9). Let us examine two cases, running downwind and reaching with an apparent beam wind.

The deciding factor in the first case is sail area and its profile is not significant; in particular the influence of sail camber, i.e. the depth of its curvature as a proportion of its chord or average width, is minimal (Marchaj, 1964, 139-40). On this point of sailing, considered as an aerofoil, the sail has stalled and the air on its lee side is turbulent and separated from the sail. The forward drive is now created by the weight of the wind on the windward side of the sail and if it does not match the total hull resistance, the ship will slow down until the two reach equilibrium. Therefore, the forward drive required to achieve a speed of 10.4 knots is 1.4 tonnes and, as we have seen, this would be created with a 64 square-metre sail in a wind at the lower end of Force 8, say 35-36 knots. However, what counts is the apparent wind, i.e. the strength of the wind blowing across the deck, which in this case will be 10.4 knots less than the true wind as noted by a stationary observer of 45-46 knots, near the top end of Force 9 (Chapter VII, 69-70). It is safe to assume that Blackfriars 1 never achieved her maximum displacement speed downwind or, if she did, her crew did not live to tell the tale (McGrail, 1987, 260). Even if we are talking about a larger sail, say 80 square metres, a true wind of at least 40 knots is required, the top end of Force 8.

As we have already noted, Caesar seems to have preferred light winds for his crossings and it has been suggested that an onshore wind of Force 4 (11-16 knots) is an upper limit for naval landing operations (Neumann, 1989, 233). At the top of Force 4 the approximate pressure would be 1 pound per square foot. However, one must again make allowance for the fact that this is the true wind and running downwind the apparent wind might be 4-5 knots less, say 7-12 knots with an approximate pressure of 0.2 to 0.4 pounds per square foot (Marchaj, 1964, 434). Running the calculation backwards this brings us to 0.16 tonnes on an 80 square metres sail at the higher wind speed to 0.06 tonnes on a 64 square metres sail at the lower wind speed. Marsden's graph is indicative, rather than precise (1994, 198), but scaling off these figures seems to indicate a range of speed from under three knots to some four and three quarter knots.

In a Beam Wind

Assessing the necessary wind strength to achieve specified speeds in a beam wind is rather more complex. In itself the theory is relatively simple, but experimental data specific to a low-aspect ratio square sail are not available and one can only make an educated guess as to the values of the variables involved.

When, as in Fig. 33, an airflow meets an aerofoil inclined to it at an angle of incidence (α) there will be a reduction in the pressure on its upper or lee side and an increase in the pressure on its lower or windward side (Marchaj, 1964, 43-51). The resultant total aerodynamic force (F_T) acting through a Centre of Effort (C.E.) can be resolved into a crosswind component (L) or lift and a downwind component (D) or drag. The value of these components will depend on the angle of incidence; once this exceeds a certain critical value the airflow over the upper or lee side of the aerofoil will become turbulent and the aerofoil will stall. Lift will collapse and drag increase dramatically. The extreme case of this, as we have seen, arises when running downwind, when the angle of incidence is 90°. In such a case it is the downwind component which provides the forward drive.

When reaching or sailing on the wind, however, the aim is to optimise the angle of incidence so as to achieve the maximum crosswind component, and hence forward drive, whilst minimising the downwind component or drag. The helmsman and sail-trimmer achieve this intuitively, without necessarily understanding the theory involved, by responding to the movement of the ship, the fluctuations of the wind and the trim of the sails. When the sail stalls, it will remain full, but boat speed will drop and there will be excessive leeway and, if there is any weight in the wind, excessive heeling too; when the angle of incidence is allowed to become too small, boat speed will drop and the luff, i.e. the leading edge of the sail, will begin to collapse. In an extreme case the whole sail will be taken aback and the vessel will stop.

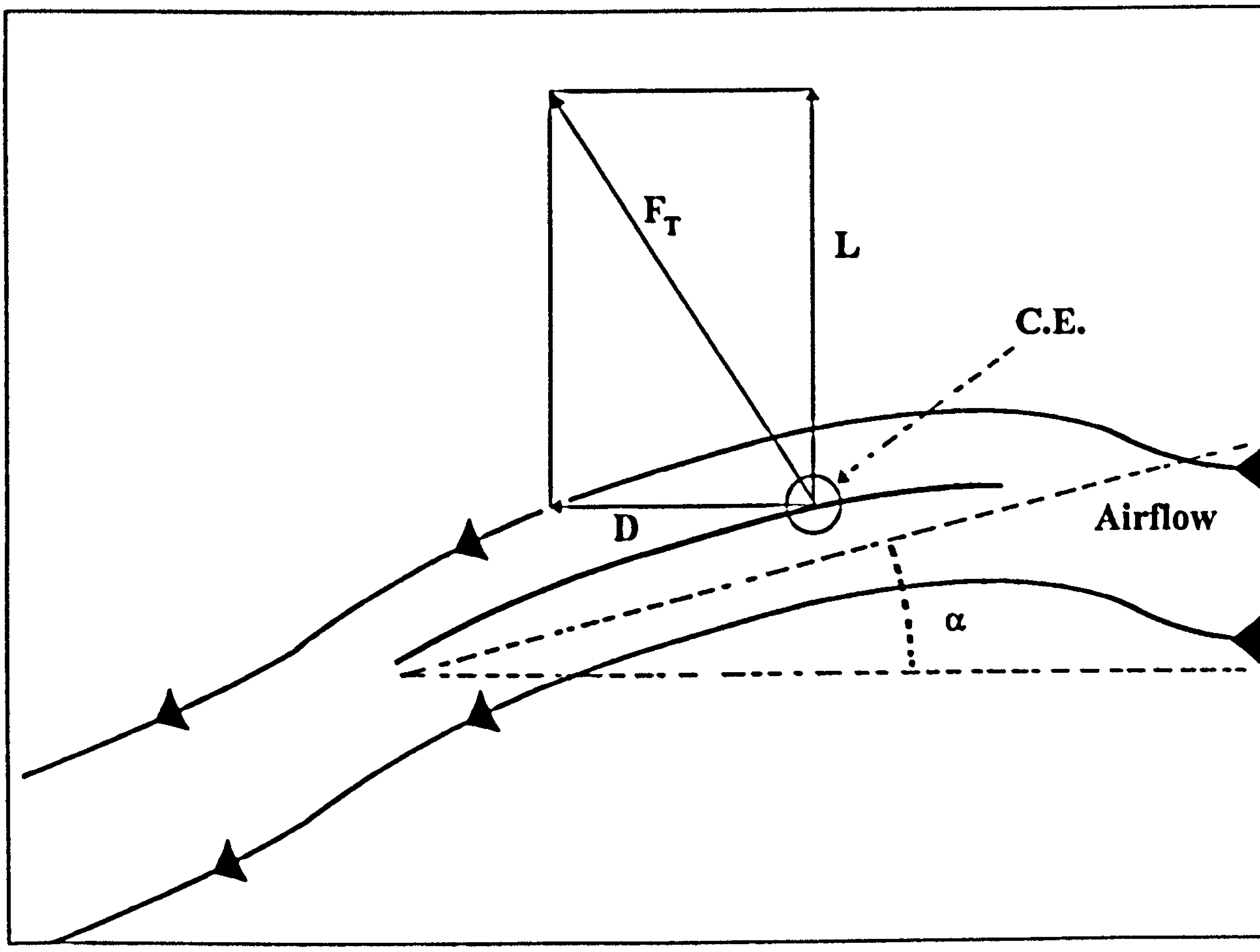


Fig. 33 Aerodynamic forces on an aerofoil (Marchaj, 1964, 50). α = angle of incidence; F_T = total aerodynamic force; L = lift; D = drag; C.E. = Centre of Effort.

Fig. 34 shows diagrammatically the aerodynamic and hydrodynamic forces acting on a square-rigged double-ended ship close hauled on the starboard tack, from a bird's, rather than a fish's, eye view (Smitt, 1984, 169). The angle of the ship's track through the water to the apparent wind is β, while the angle of incidence is α. The leeway, i.e. the angle between the ship's heading and her track through the water, is shown by angle γ.

The total aerodynamic force (A_T) is now resolved into the aerodynamic driving force (ADF) and the aerodynamic heeling force (AHF). It is in equilibrium with the total hydrodynamic force (H_T), arising from the water flow past the hull and resolved into the hydrodynamic drag force or hull resistance (HD) and the hydrodynamic lift force or leeway resistance (HL). In the single case only where we are sailing with an apparent beam wind, i.e. when $\beta = 90^\circ$, does the ADF equate to the crosswind component (L) and the AHF to the downwind component (D) of Fig. 33. This is the case that we are going to examine in relation to Blackfriars 1.

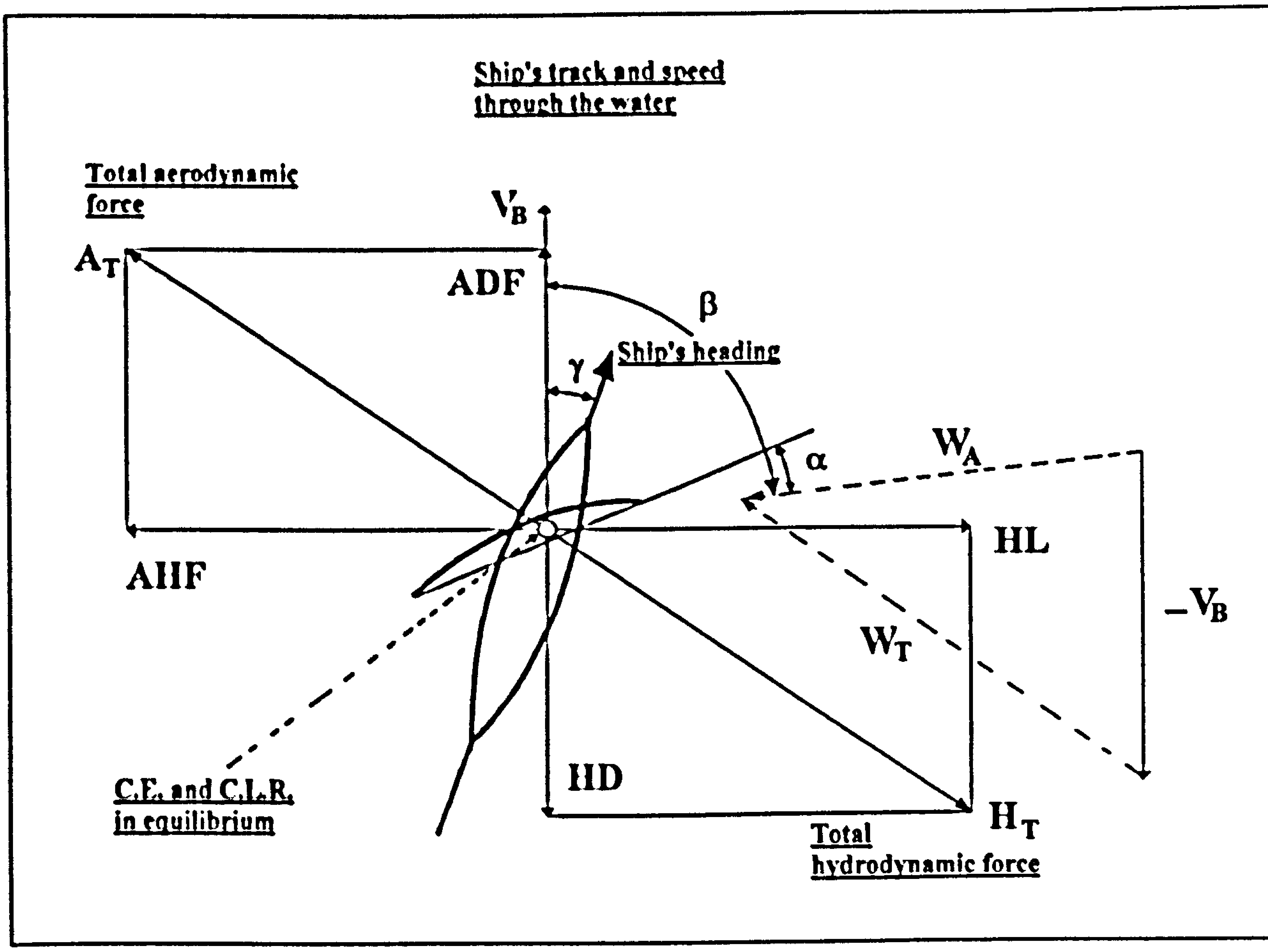


Fig. 34 A_T = total aerodynamic force; H_T = total hydrodynamic force; α = angle of incidence; β = apparent wind angle; γ = leeway (after Smitt, 1984, 169). The diagram brings together the detail of Figs 11 and 16 in Chapter VII (62, 70) and Fig. 33 in this Appendix.

Before doing that, we need to highlight from Fig. 34 that, except when sailing directly downwind, the direction of the apparent wind (W_A) is not the same as the direction of the true wind (W_T) (Keys, 1982, 22-4; 75-7). If we express the true wind, apparent wind and the ship's track and speed through the water (V_B) as vectors in terms of compass direction in degrees and of speed in knots, then the vector of the apparent wind is the difference of the vectors of the true wind and the ship's track and speed. Thus:

$$W_A = W_T - V_B.$$

However, care must be exercised with such calculations to ensure that the wind vectors are expressed in terms of the direction towards which the wind is blowing (Keys, 1982, 75; Smitt, 1984, 169). Otherwise addition, rather than subtraction, will be needed (see also Chapter VII, 69-70).

In his discussion of sailing theory and practice (1964), Marchaj includes much specific data in the form of graphs of the crosswind and drag coefficients (L and D of Fig. 33) for various configurations of sails. Most of these are inapplicable to our case, many, for example, involving an examination of the way in which the mast impinges on the efficiency of a fore-and-aft mainsail. However, one set of experimental results may tentatively be applied to the assessment of the performance of a square-rigged Blackfriars 1 in a beam wind (Marchaj, 1964, 130-3). These are results obtained for three aerofoils without masts, perhaps the nearest set of data to a square sail, where the impact of the mast on the performance of the sail would be minimal, because, being central to the windward side of the sail, it cannot affect the leeward side of the sail which is crucial in the sail's performance. However, the following qualifications should be made:

1. The aerofoils have a relatively high aspect ratio (A.R. = 5). The aspect ratio has a crucial effect on one of the three components of the aerodynamic drag on an aerofoil, induced drag. The lower the aspect ratio the greater the induced drag (Marchaj, 1964, 79-80). Given that one might expect aspect ratios much lower than 5 in Romano-Celtic ships, their drag coefficients must have been much higher.

2. The aerofoils were rigid and untwisted and so do not allow for factors arising from a flexible sail cloth. If, however, one assumes that Celtic square sail were indeed boomed and battened, as I suggest in Chapter VII (72-4), the aerofoils might well provide a reasonably good match.

3. The aerofoils differed only in their camber, having cambers of 1/7, 1/10 and 1/20 respectively. A wide range of differences were recorded for the three aerofoils. For example, the coefficient for the total aerodynamic force ranged from 1.1 to 1.7. Whilst this demonstrates the importance of selecting the best camber, it does not help us to find precision, given that there is no way we can establish the camber of Romano-Celtic sails.

Maximum Displacement Speed ($V = 1.4\sqrt{L}$)

At speed of 10.4 knots, close to her theoretical maximum displacement speed of 10.55 knots, Blackfriars 1 is estimated to require a forward driving force of 1.4 tonnes (Chapter VI, 47-8; Marsden, 1994, 198-9). Assuming the alternative sails of 64 and 80 square metres, this can be transformed into expressions of pressure as follows:

	64 square metres	80 square metres
kg/m²	21.87	17.50
lb/ft²	4.48	3.59

The three aerofoils for which Marchaj (1964, 130-3) gives experimental results have an area of 100 square feet. The forward drive force in pounds per square foot in an apparent beam wind are given as follows:

Apparent Wind Speed (W_A)	Aerofoil 1	Aerofoil 2	Aerofoil 3
10 knots	0.37	0.52	0.57
20 knots	1.48	2.08	2.28

Using the square rule, that the force of the wind increases with the square of its speed, the following table can be constructed showing forward drive pressure in pounds per square foot:

Apparent Wind Speed (W_A)	Aerofoil 1	Aerofoil 2	Aerofoil 3
10 knots	0.37	0.52	0.57
15 knots	0.83	1.17	1.28
20 knots	1.48	2.08	2.28
25 knots	2.31	3.25	3.56
30 knots	3.33	4.68	5.13
35 knots	4.53	6.37	6.98
40 knots	5.92	8.32	9.12
45 knots	7.49	10.53	11.54
50 knots	9.25	13.00	14.25

The emboldened figures are closest to the pressures required to create a forward drive of 10.4 tonnes with a square sail of 64 square metres and its alternative of 80 square metres. However it is possible to do better by using the square rule as follows:

Sail Area of 64 square metres

	Aerofoil 1	Aerofoil 2	Aerofoil 3
Apparent Wind Speed (knots) (W_A)	34.8	29.4	28.0
Forward Drive (lb/ft^2)	4.48	4.49	4.47

Sail Area of 80 square metres

	Aerofoil 1	Aerofoil 2	Aerofoil 3
Apparent Wind Speed (knots) (W_A)	31.1	26.3	25.1
Forward Drive (lb/ft^2)	3.58	3.60	3.59

Thus we have a range of apparent beam wind speeds capable, depending on the efficiency of the sail, of propelling Blackfriars 1 at 10.4 knots, close to her theoretical maximum displacement speed, from 25 knots for a larger most efficient sail to 35 knots for a smaller least efficient sail.

To establish the speed and direction of the true wind, we apply the vector formula (Keys, 1982, 75-7):

$$W_T = W_A + V_B$$

Let us assume that the track of Blackfriars 1 is nor' nor' east (22.5° True) and that she is reaching with an apparent beam wind blowing from the west nor' west (towards 112.5° True). We first establish the polar coordinates of the known vectors of her speed and track (V_B) and of the apparent wind (W_A), that is to say their speed in knots (*r*) and compass direction in degrees (θ). Using a scientific calculator these are converted into rectangular coordinates (*x*, *y*) and added together to produce the rectangular coordinates of the true wind (W_T) (Keys, 1982, 75-7). These are then converted back to polar coordinates to arrive at the direction and speed of the true wind.

(It should be noted that, unlike us, Keys expresses his wind vectors by reference to the direction from which the wind is blowing; he, therefore, subtracts W_A from V_B to arrive at W_T.)

Let us take first the apparent beam wind of 25 knots, i.e. aerofoil 3 with a sail area of 80 square metres.

	Polar Coordinates		Rectangular Coordinates	
	r	θ	*x*	*y*
	Speed	Angle		
W_A	25	112.5°	-9.57	23.1
V_B	10.4	22.5°	9.61	3.98
W_T	27.1	89.9°	0.04	27.08

This gives us a true wind from due west of about 27 knots or the top end of Force 6, two points (22½°) abaft the beam.

Now we take the apparent beam wind of 35 knots, i.e. aerofoil 1 with a sail area of 64 square metres.

	Polar Coordinates		Rectangular Coordinates	
	r	θ	*x*	*y*
	Speed	Angle		
W_A	35	112.5°	-13.39	32.3
V_B	10.4	22.5°	9.61	3.98
W_T	36.5	95.9°	-3.78	36.28

Now the true wind is from just north of due west at about 36-37 knots or the midpoint of Force 8, one and a half points abaft the beam.

It is perhaps unlikely, even she had a sail larger than that proposed by Marsden (1994, 73-4), that the sail on Blackfriars 1 could have achieved the forward drive of Marchaj's aerofoil 3. Although it can be no more than an educated guess, it seems reasonable to suppose that to achieve her maximum theoretical displacement speed in a beam wind, Blackfriars 1 would have required a Force 7 or 8.

Potential Speed in a Beam Wind Force 4

As we have noted, Force 4 (11 to 16 knots) is regarded as the highest desirable onshore wind speed for naval landings (Neumann, 1989, 233). As representative of this range, again let us take the figures we have already developed from Marchaj's graph (1964, 130-33) for 10 and 15 knots and apply them to the two different sail areas for Blackfriars 1 of 64 and 80 square metres.

Apparent Wind Speed (W_A) of 10 knots:

	Aerofoil 1	Aerofoil 2	Aerofoil 3
Forward Drive (lb/ft²)	0.37	0.52	0.57
Forward Drive (kg/m²)	1.81	2.54	2.78
Total Forward Drive (Tonnes) (Sail of 64 m²)	**0.12**	0.16	0.18
Total Forward Drive (Tonnes) (Sail of 80 m²)	0.14	0.20	**0.22**

Apparent Wind Speed (W_A) of 15 knots:

	Aerofoil 1	Aerofoil 2	Aerofoil 3
Forward Drive (lb/ft²)	0.83	1.17	1.28
Forward Drive (kg/m²)	4.05	5.71	6.25
Total Forward Drive (Tonnes) (Sail of 64 m²)	**0.26**	0.37	0.40
Total Forward Drive (Tonnes) (Sail of 80 m²)	0.33	0.46	**0.50**

The highest and lowest values for each wind speed have been emboldened. Referring to Marsden's graph (1994, 198), which, as we have noted, is indicative, rather than precise, we can interpret them as follows:

> At an apparent beam wind speed of 15 knots, the potential range for the ship's speed through the water appears to lie between five and eight knots, while at the lower wind speed of 10 knots it lies between three and five knots. Once again let us be cautious about the higher figures, which represent the most efficient of the three aerofoils in a laboratory environment.

Before finalising conclusions let us establish the true winds which produce these results. First take the apparent wind speed of 15 knots:

With a ship's speed of five knots:

	Polar Coordinates		Rectangular Coordinates	
	r	θ	x	y
	Speed	Angle		
W_A	15	112.5°	-5.74	13.86
V_B	5	22.5°	4.62	1.91
W_T	15.8	94.1°	-1.12	15.77

With a ship's speed of eight knots:

	Polar Coordinates		Rectangular Coordinates	
	r	θ	x	y
	Speed	Angle		
W_A	15	112.5°	-5.74	13.86
V_B	8	22.5°	7.39	3.06
W_T	17.0	84.4°	1.65	16.92

Now let us look at an apparent wind speed of 10 knots:

With a ship's speed of three knots:

	Polar Coordinates		Rectangular Coordinates	
	r	θ	x	y
	Speed	Angle		
W_A	10	112.5°	-3.83	9.24
V_B	3	22.5°	2.77	1.15
W_T	10.4	95.8°	-1.06	10.39

With a ship's speed of five knots:

	Polar Coordinates		Rectangular Coordinates	
	r	θ	x	y
	Speed	Angle		
W_A	10	112.5°	-3.83	9.24
V_B	5	22.5°	4.62	1.91
W_T	11.2	85.9°	0.79	11.15

The true wind speeds range from the maximum for Force 4 to a value on the cusp between Force 3 and Force 4. In all cases they are somewhat greater than the apparent wind speed, a feature which is here explained by the fact that in every case, while the apparent wind is on the beam, the true wind is abaft the beam, by as much as two and a half points (a point is 11¼°).

Heeling

It remains to consider the question of the aerodynamic heeling force. Marsden (1994, 199) concludes that Blackfriars 1 will heel to 12° when reaching at 10.4 knots in a beam wind. Is this supported by the foregoing? According to Marsden's results from the Boatcad programme, an aerodynamic heeling force of 1.4 tonnes is required to heel the ship to 12°.

Marchaj's graph of our three aerofoils (1964, 130-1) shows that with the apparent wind abeam much the greater proportion of the total aerodynamic force goes into the forward drive force and relatively little is available for heeling. Scaling off from Marchaj's graph shows that in an apparent beam wind of 10 knots the heeling force in pounds per square foot for the three aerofoils is:

Apparent Wind Speed (W_A)	Aerofoil 1	Aerofoil 2	Aerofoil 3
10 knots	0.058	0.082	0.12

Once again using the square rule the heeling forces in pounds per square foot for other apparent wind speeds can be calculated:

Apparent Wind Speed (W_A)	Aerofoil 1	Aerofoil 2	Aerofoil 3
10 knots	0.058	0.082	0.120
15 knots	0.131	0.184	0.270
20 knots	0.232	0.328	0.480
25 knots	0.362	0.512	0.750
30 knots	0.522	0.738	1.080
35 knots	0.711	1.004	1.470
40 knots	0.928	1.312	1.920
45 knots	1.175	1.661	2.430
50 knots	1.450	2.050	3.000

Taking the largest of these values. that for Aerofoil 3 at W_A of 50 knots, 3 pounds per square foot, we can calculate the heeling force for the larger of the two sail areas we have been considering:

Convert to kg/m²	3 x 4.88	=	14.64
Total heeling force in kg	14.64 x 80	=	1,171.2
Convert to metric tonnes	1,171.2 ÷ 1,000	=	1.17

This is just in excess of the force required to heel Blackfriars 1 to 8° (Marsden, 1994, 199), but the wind strength (Force 10) is such that, if she were at sea, she would be running under bare poles. These are survival conditions.

A more possible scenario is 35 knots, the highest of the wind speeds we considered to be required to enable her to achieve her maximum displacement speed in a beam wind, taking Aerofoil 3 as a worst case:

Convert to kg/m²	1.470 x 4.88	=	7.174
Total heeling force in kg	7.174 x 80	=	573.92
Convert to metric tonnes	573.92 + 1,000	=	0.574

This comes nowhere near heeling even to 8°, let alone the postulated 12°.

But what of the case of the ship sailing closer to the wind. Marchaj's graph also covers a track of 60° to the apparent wind. One can read off the following values for heeling force in terms of pressure in pounds per square foot:

Apparent Wind Speed (W_A)	**Aerofoil 1**	**Aerofoil 2**	**Aerofoil 3**
10 knots	0.233	0.328	0.384

Once again using the square rule the heeling forces in pounds per square foot for other apparent wind speeds can be calculated:

Apparent Wind Speed (W_A)	**Aerofoil 1**	**Aerofoil 2**	**Aerofoil 3**
10 knots	0.233	0.328	0.384
15 knots	0.524	0.738	0.864
20 knots	0.932	1.312	1.536
25 knots	1.456	2.050	2.400
30 knots	2.097	2.952	3.456
35 knots	2.854	4.018	4.704
40 knots	3.728	5.248	6.144
45 knots	4.718	6.642	7.776
50 knots	5.825	8.200	9.600

The inference may be immediately drawn that as she came hard onto the wind, heeling forces would come rapidly into play, forces which had not been significant in a beam reach.

Further calculation shows that a heeling force close to the specified 1.4 tonnes would arise at the following values of W_A (the total corresponding forward drive force is also shown):

Sail Area of 64 square metres

	Aerofoil 1	**Aerofoil 2**	**Aerofoil 3**
Apparent Wind Speed (knots) (W_A)	43.9	37.0	34.2
Heeling Force (tonnes)	1.402	1.402	1.403
Total Forward Drive (Tonnes)	1.794	1.787	1.786

Sail Area of 80 square metres

	Aerofoil 1	Aerofoil 2	Aerofoil 3
Apparent Wind Speed (knots) (W_A)	39.2	33.1	30.6
Heeling Force (tonnes)	1.398	1.403	1.404
Total Forward Drive (Tonnes)	1.788	1.788	1.788

With a forward drive force approaching 1.8 metric tonnes, there would be no question that Blackfriars 1 would be sailing at her maximum theoretical displacement speed of 10.55 knots. We can perform the vector calculations, taking the highest and lowest of the wind speeds under consideration to arrive at the true wind speed and direction. Once again let us assume that the ship's heading is nor' nor' east; the apparent wind will be close to nor' west by north, but again in the vector calculation we shall take the direction towards which it is blowing.

With an apparent wind speed of 30.6 knots:

	Polar Coordinates		Rectangular Coordinates	
	r Speed	θ Angle	x	y
W_A	30.6	142.5°	-24.28	18.63
V_B	10.4	22.5	9.61	3.98
W_T	27.0	123.0°	-14.67	22.61

This equates to a true wind at the top of Force 6, 79.5° off the bow.

With an apparent wind speed of 43.9 knots:

	Polar Coordinates		Rectangular Coordinates	
	r Speed	θ Angle	x	y
W_A	43.9	142.5°	-34.83	26.72
V_B	10.4	22.5	9.61	3.98
W_T	39.7	129.4°	-25.22	30.70

This equates to a true wind at the top of Force 8, 73.1° off the bow.

This would suggest that Blackfriars 1 would heel to 12° only in extreme conditions, when close-hauled in a wind at the top end of Force 6, probably much more. Marsden based his conclusion that she would heel as far as this in a beam wind, in part, on the identification of limber holes in her frames which would not operate until the hull reached 12° of heel. There is, however, another possible explanation for these limber holes. Any sailing ship running before the wind will tend to roll. It is recorded of *Ολυμπιάς*, the reconstruction of the Athenian trireme, which like Blackfriars 1, was stiff under sail, that with a gusty wind averaging 22 knots just abaft the beam, she was rolling and that the roll combined with the heel amounted to 10° or 12° (Coates, Platis and Shaw, 1990, 36). Perhaps the position of the limber holes in Blackfriars 1 allowed for extremes of rolling which might occur under such circumstances.

Conclusions

It is necessary to enter certain caveats. The first is that we have taken Marchaj's aerofoils as a proxy for the square sail on Blackfriars 1; as we have noted, their aspect ratio is much higher than we might expect on an ancient ship. It is highly unlikely that the sail on Blackfriars 1 would have performed as well as Aerofoil 3. The higher results can confidently be discarded.

Secondly, the data from which Marchaj's graph is derived do not allow for the windage of the mast and rigging, which would have increased the heeling moment in a beam wind, though probably not to the extent of invalidating our general findings about her resistance to heeling.

Thirdly, we have taken no account of the aerodynamic impact of the hull. That can only detract from the efficiency of the sail by adding to the aerodynamic drag (Marchaj, 1964, 103-4).

Fourthly, we have taken no account of leeway. Whilst this would not have any impact on our estimates of speed or of tendency to heel, it would have a significant effect on our estimates of track through the water by reference to the true wind. The heading of 79.5° into the true wind just mentioned would be wholly nullified by ten degrees of leeway.

Fifthly, we can have no certainty that Blackfriars 1 could have laid a track as close as at 60° to the apparent wind. The number crunching we have been undertaking merely shows the parameters of a track as close-winded as this, but cannot prove that it was possible. The question of the windward ability of Romano-Celtic ships is considered in Chapter VII.

Sixthly, our calculations have taken no account of the undoubted need to shorten sail with rising wind speeds.

Seventhly, it is not clear how far the Boatcad computer programme used by Marsden to generate the graph plotting the water resistance against speed for Blackfriars 1 (1994, 197-8) allowed for irregularities on the hull surface, for example nail heads or fouling, or for the resistance arising from the rudder(s). In trials of a reconstruction of the Hjortspring Boat it was observed that the results of measured resistance were about 30% greater than computed values up to a speed of 5 knots (Valbjørn et al., 2000, 8). Among the possible reasons advanced by Valbjørn and his colleagues for this discrepancy were the protruding stitching of the hull planks and the effect of the rudder. In addition it is well known that a fouled hull will create considerably more drag than a clean one; Hewitt and Lees-Spalding suggest that a year's growth in temperate waters may increase the frictional resistance of the hull by 100% (1990, 309-10). On balance one may expect that under normal operational conditions the drag arising from these factors would significantly depress the speed potential of Romano-Celtic ships.

With these caveats in mind the following conclusions might tentatively be advanced:

1. In all practical conditions of wind and weather, Blackfriars 1 would not have been able to achieve her maximum theoretical displacement speed or anything like it, whether close-hauled, reaching or running.

2. Downwind her absolute maximum speed through the water in conditions likely to be acceptable for an invasion fleet (Force 4) would be in the range from under three knots to perhaps four and three quarters, almost certainly towards the bottom end of that range.

3. With a beam wind in similar conditions her absolute maximum speed through the water in conditions likely to be acceptable for an invasion fleet (Force 4) is unlikely to have exceeded five knots and was in all probability considerably less. We may discount the calculation set out above for aerofoil 3 giving a ship's speed of eight knots as requiring a level of aerodynamic efficiency not possible with the technology available to the Romans.

4. At least in the configuration for which Marsden gives his data (1994, 198-9), i.e. with a draught of 1.3 metres, Blackfriars 1 presents as a very stiff vessel, unable to reach the heeling angle of 12° indicated by her limber holes (Marsden, 1994, 74).

5. Generally speaking Blackfriars 1 was a relatively sluggish vessel, with a comparatively low speed potential.

Appendix VI

Il Bragozzo: A Romano-Celtic survival on the Adriatic?

The *bragozzo*, a traditional fishing craft, surviving on the Adriatic into the twentieth century, is an extreme case of directional stability under sail; the major component of leeway resistance of this craft is provided by a deep stern rudder of considerable underwater area (Fig. 35). The hull is otherwise shallow and flat bottomed. This means that the combined C.L.R. of the hull and the rudder must be substantially aft of amidships.

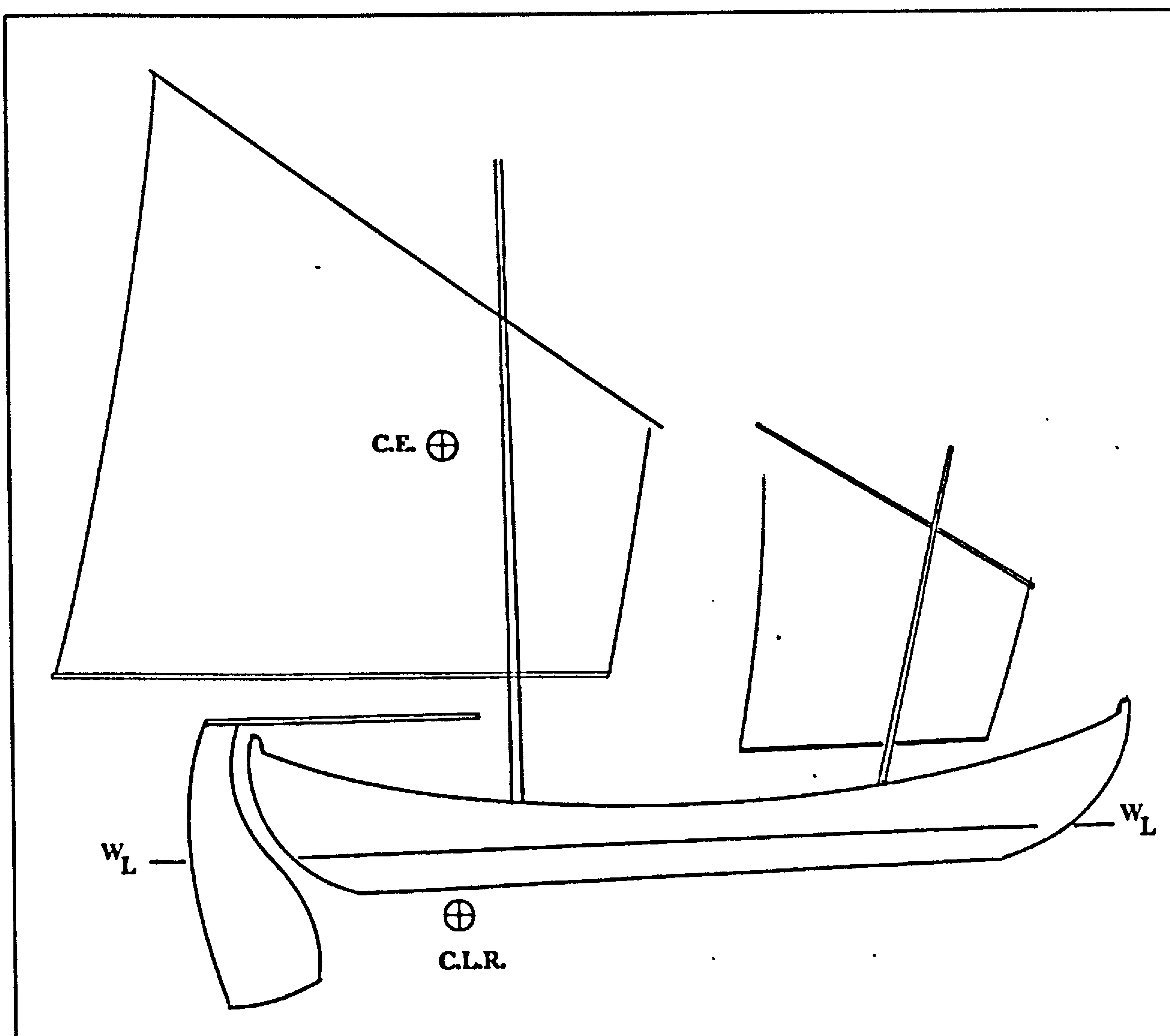


Fig. 35 Sketch of a *bragozzo* to approximate scale: the probable positions of the C.E. and the C.L.R. are shown very approximately (Marzari, 1982). Running and standing rigging is not shown.

Helm balance depends on a sail plan of such a form that the C.E. is also displaced aft. The usual sail plan of a *bragozzo* is two masts rigged with lugsails. The scale drawing of a 12.5-metre *bragozzo* shows that a short foremast is stepped 28% of the overall length aft of the bow (3.5 metres) and a much taller main mast 70% (8.75 metres) aft of the bow (Marzari, 1982, 88-9). From a sail plan (Marzari, 1982, 72-3) it is possible to estimate that the area of the mainsail is approximately five times that of the foresail, thus bringing the C.E. well aft of amidships. The scale drawing of a smaller version, the *bragozzetto chioggiotto* of 9.6 metres overall length, shows a single lugsail on a mast set 6.2 metres (65%) back from the bow (Marzari, 1982, 102).

The *bragozzo* goes effectively to windward, normally with some weather helm (Marzari, 1982, 173-5), although it is to be supposed that the helm balance would be very sensitive to the trim of the foresail, as well as to the weight and distribution of any cargo. Marzari gives no figures for leeway or for best heading to windward when close-hauled, but they are likely to be comparable with figures for other traditional craft surviving into the modern era. He does, however, indicate that windward performance is better on the starboard tack than it is on port: the rig is a standing lug, with the sails always to port of the masts; thus on the port tack the masts prevent the sails from taking up their full aerodynamic shape (Marzari, 1982, 174).

However it is clear that directional stability depends on the rudder acting as a keel and Marzari describes it as '*grave*' should the rudder break. In such a case he suggests that it might be necessary to get a tow from a neighbouring *bragozzo* or to attempt to reduce sail and replace the rudder with oars (1982, 175).

The structural details of the *bragozzo* are shared with other craft in the region, not only Venetian gondolas, but also everyday workboats, as can routinely be observed any day along the canals of Venice (Marzari, 1982, 63-92). The flat-bottomed double-ended hull is built of flush-laid planks fastened to close-spaced floor and side timbers. These are striking similarities with the Romano-Celtic tradition, in particular with the inland water craft of McGrail's type A (McGrail, 1995, 143). However, the separate floor and side timbers are lap-jointed or half-scarfed with galvanized nails and treenails to form genuine frames. Moreover, the building sequence is quite different from that of the Romano-Celtic tradition and genuinely frame-first (Marsden, 1994, 76-9). A heavy plank laid down on the workshop floor. This is not the keel plank, but a temporary base on which the complete framework of end-posts, floor timbers and side timbers is built up. The side planking is then fitted and the bottom planking last of all.

It could of course be argued that these differences result from an evolution of the Romano-Celtic tradition. But care should be taken in treating parallels in ship-building techniques separated by two millennia and by different geographic regions as evidence of continuity (Greenhill, 2000, 9). However, the Po valley was a Celtic area, known to the Romans as Cisalpine Gaul. An argument might just be advanced that the Romano-Celtic tradition extended to this part of the Celtic world two millennia ago and has survived to modern times in the *bragozzo* and allied craft.

Whatever view one takes of the origins of the *bragozzo*, its sail plan and rudder cannot realistically be taken as an indication that Romano-Celtic sea-going ships had any significant windward ability. Firstly there is no evidence for centrally-mounted stern rudders in northern waters in the Roman period and it must be doubted whether side rudders of sufficient area could have been efficiently rigged. Secondly relying on the rudder to provide leeway resistance would simply exacerbate the problems of directional stability created by the forward-located masts of Romano-Celtic sea-going ships, once they came onto the wind.

Appendix VII

Etymological Note:

Sagulum: the Celtic sail

Caesar reported that the sails of the Venetic ships were made of leather (*pelles pro velis alutaeque tenuiter confectae...* 'skins and pieces of leather finely finished were used instead of sails... '). He thought that this was either because the Veneti had no supply of flax, or, more probably, because leather provided a better material to withstand the weight of local weather conditions (*B. Gall.*, III, 13). Coincidentally, this comment may be taken as an indication that flax was used by the Romans for their sails, although they used hides for tents (*cf. sub pellibus* = in camp). Caesar's report has been interpreted by scholars as possible evidence that Celtic sails generally were made of leather (McGrail, 1987, 234; Ellmers, 1996, 62-3). In fact Ellmers entertains no doubt: he describes both the Bad Kreuznach mosaic and the Jünkerath gravestone as depicting sails made of leather and speaks of the 'Celtic leather sail'.

Ellmers introduces another factor into the discussion:

> The Celtic term for this (the Celtic leather sail) was the *sagulum*, and the Germanic word *Segel* is derived from the Celtic rather than the Latin *velum*; the first indication that the Germanic peoples also adopted what is now known as the sail from the Celts (1996, 62-3).

In his study of Indo-European synonyms, Buck (1949, 736-8) confirms in part the linguistic strand of this argument. He lists Old/Middle Irish *sēol* and Welsh *hwyl* as either cognate with or as loanwords from the Germanic word represented by Old English/Old Norse *segl* and present as one variant or another in all Germanic languages. However, for the Celtic and Germanic words to be cognate, i.e. for them both to be traced back to a common ancestor word before proto-Celtic was differentiated from proto-Germanic, would imply either that the technical innovation of sail can be traced back to that period or that the two language groups independently developed a term for the innovation, using the same cognate root. The improbability of either suggests that the words cannot be cognate, but that one must instead be a loanword. However, it is not linguistic evidence which will enable us to determine the direction of the borrowing and the archaeological evidence that the use of sail by the Celts predated that by the Germans and Scandinavians is strong evidence that, as Ellmers claims, the word was borrowed from Celtic by Germanic. Moreover, it might give some broad indication of the date of the borrowing.

Since none of the Celtic languages has been recorded in writing as early as this, we must rely on what we can glean from Latin writers. Latin dictionaries do record *sagulum* and the associated word *sagum*, but not as meaning 'sail'. Professor Ellmers was kind enough to indicate to me the source from which he drew his reference to *sagulum* (pers. comm.). It is from the account in Tacitus's *Histories* (V, 23) of the rebellion led by Civilis in A.D. 69 of the Batavians and Germans against the Romans:

> Civilis was now seized with a desire to make a naval demonstration; he therefore manned all the biremes and all the ships that had but a single bank of oars; to this fleet he added a vast number of boats, [putting in each] thirty or forty men, the ordinary complement of a Liburnian cruiser; and at the same time the boats that he had captured were fitted with particoloured plaids for sails, which made a fine show and helped their movement (*et simul captae lintres sagulis versicoloribus haud indecore pro velis iuvabantur*) (*Hist.*, V, 23).

The text of this passage shows clear signs of corruption and the translator offers the following comment:

> In the confused condition of the text at the beginning of this chapter, we cannot do more than give the probable sense of what Tacitus wrote (Moore, 1931, 214).

If the garbled text significantly affects the last sentence, then no meaningful conclusion can be drawn; however assuming that it does not, then certain points may be made with some confidence. The first is that *sagum/sagulum* means 'military cloak' and Tacitus's readers would have understood the last sentence very much in the sense offered by the translator and this too is what Tacitus would have meant to convey. That he wished his readers to understand that improvised sails were rigged is strengthened by the fact that these were small boats (*lintres*), which had been captured, and by the use of the verb *iuvabantur* which implies that some form of unusual assistance was being afforded to the propulsion of the boats.

Furthermore, this is not the only occasion when Tacitus reported the use of clothing for sails. When in A.D. 15 Germanicus's fleet was struck by a storm on its return voyage from the river Ems, Tacitus described the arrival of the surviving vessels 'some with a few oars left, others with clothing hoisted for canvas, and a few of the weaker in tow' (*Ann.*, II, 24).

Secondly, Ellmers suggests that the Celtic description *sagulum* designated a specific Gaulish form of sail and that it was this term that was confused by Tacitus himself and by all later historians and translators with the Latin *sagulum* meaning 'military cloak' (pers. comm.). This is not an untenable view, but it does imply that the ultimate source for Tacitus's account was not a Latin speaker, perhaps an eyewitness on the Roman side, but one of the rebels. The point, however, becomes uncertain when we consider that the rebels were not Celts, but Germans. If *sagulum* does mean 'sail' in this context, then the implication must be that the word was already an established loanword in Germanic in the first century A.D. In fact, Celtic would be replaced by Latin in much of Roman Gaul by the end of the Roman empire in the west and the loanword must have been borrowed by then; that it had been borrowed as early as this can only be conjecture.

Thirdly, it is not wholly implausible that sails should have been improvised, as Tacitus says, especially in view of Civilis's wish to make a display. The whole emphasis of the passage is on numbers, movement and colour.

Fourthly, if Tacitus and his readers are indeed confusing *sagulum* (meaning 'Celtic sail') with *sagum/sagulum* (meaning 'military cloak), they are confusing two Celtic words, one of which was already well known to Latin (and Greek - Liddell and Scott, 1997, 722) writers as a Celtic word. Isidore of Seville says in his *Etymologies* (Isid. *Etym.*, XIX, 24, 12-3):

> There is a military garment, the use of which began at the time of the Gallic expeditions from booty won from the enemy. From it comes the phrase used in the senate: 'Taking off their togas, the Roman citizens put on their uniforms [literally: went to their *saga*].' *Sagum* is a Gallic word: we speak of the *sagum quadrum* because in their country it was originally square or fourfold.

If then both *sagum/sagulum* (meaning 'military cloak') and *sagulum* (meaning 'sail') are Celtic, what we are seeing is not so much confusion in the minds of Latin writers as a natural evolution of meaning among Celtic speakers.

Most of the various words for 'sail' in the different Indo-European languages originally meant 'piece of cloth' (Buck, 1949, 736). Thus Latin *velum* means 'covering', 'awning' 'curtain' as well as 'sail' and survives into French as *le voile* ('veil') as well as *la voile* ('sail'). Buck traces the Celtic and Germanic words for 'sail' from the putative Germanic *segla-* and the putative Indo-European *sek-lóm*, meaning 'a piece of cloth'. This seems very like the word which turns up in Latin as *sagulum*. Although understood by the Romans as the diminutive of *sagum*, it may in Celtic have been a word in its own right and the form *sagum* may have been a back-formation created by Latin speakers from *sagulum*. However that may be, a semantic evolution of *sek-lóm* from 'piece of cloth' to 'cloak' and then onto 'sail' is not impossible.

However, *sagum/sagulum* means not simply a military cloak, but specifically one made of coarse woollen material (Walde and Hoffmann, 1954, 464; Latham, 1965, 416; Ernout and Meillet, 1967, 589; Lewis and

Short, 1969, 1617; Smith and Lockwood, 1976, 656; Niermeyer, J.F. 1976, 930; Glare, 1982, 1679). This connotation of wool is confirmed in medieval usage.

While the semantic trajectory: 'piece of cloth' - 'cloak' - 'sail', seems possible, what does seem unlikely is that the connotation of coarse woollen material should be lost as soon as the word is applied to a sail. Thus, while local conditions meant that the Veneti made their sails of leather, that would not have applied to the generality of Celtic sails and there seems to be some reason for supposing that the Celtic sail was a square sail with horizontal battens and a foot boom, normally made of wool. This use of wool would be in line with continuing medieval practice in north-west European waters from the Viking age onwards (Christensen, 1979, 190; Binns, 1980, 127-8; McGrail, 1987, 236).

Appendix VIII

Blackfriars I as a Horse Transport: Stability Calculations

The calculations set out below are based on those used by Marsden (1994, 194-7) for his assessment of the stability of Blackfriars 1. They differ by assuming a different height of the Centre of Gravity (CoG) for the cargo and cargo weights appropriate for ten, twenty and thirty horses.

	A: Assuming cargo weight of 10 tonnes	CoG of cargo @ 1.5 m.	CoG of cargo @ 2.0 m.
1	CoG of ship	2.48 metres	2.48 metres
	multiplied by weight of ship	32.70 tonnes	32.70 tonnes
		81.10	81.10
2	CoG of cargo	1.50 metres	2.00 metres
	multiplied by weight of cargo	10.00 tonnes	10.00 tonnes
		15.00	20.00
3	Add 1 & 2	96.10	101.10
4	Weight of ship	32.70 tonnes	32.70 tonnes
	Weight of cargo	10.00 tonnes	10.00 tonnes
	Total weight	42.70 tonnes	42.70 tonnes
	divide 3 by total weight		
	Height of combined CoG	2.25 metres	2.37 metres
5	Find height of metacentre from graph		
	for displacement of 42.70 tonnes	3.00 metres	3.00 metres
6	Subtract height of combined CoG	2.25 metres	2.37 metres
	Height of metacentre	0.75 metres	0.63 metres
	Metacentric Height as percentage of beam	12 %	10 %

B: Assuming cargo weight of 20 tonnes		CoG of cargo @ 1.5 m.	CoG of cargo @ 2.0 m.
1	CoG of ship	2.48 metres	2.48 metres
	multiplied by weight of ship	32.70 tonnes	32.70 tonnes
		81.10	81.10
2	CoG of cargo	1.50 metres	2.00 metres
	multiplied by weight of cargo	20.00 tonnes	20.00 tonnes
		30.00	40.00
3	Add 1 & 2	111.10	121.10
4	Weight of ship	32.70 tonnes	32.70 tonnes
	Weight of cargo	20.00 tonnes	20.00 tonnes
	Total weight	52.70 tonnes	52.70 tonnes
	divide 3 by total weight		
	Height of combined CoG	2.11 metres	2.30 metres
5	Find height of metacentre from graph		
	for displacement of 52.70 tonnes	2.90 metres	2.90 metres
6	Subtract height of combined CoG	2.11 metres	2.30 metres
	Height of metacentre	0.79 metres	0.60 metres
	Metacentric Height as percentage of beam	13 %	10 %

	C: Assuming cargo weight of 30 tones		CoG of cargo @ 1.5 m.	CoG of cargo @ 2.0 m.
1	CoG of ship		2.48 metres	2.48 metres
	multiplied by weight of ship		32.70 tonnes	32.70 tonnes
			81.10	81.10
2	CoG of cargo		1.50 metres	2.00 metres
	multiplied by weight of cargo		30.00 tonnes	30.00 tonnes
			45.00	60.00
3	Add 1 & 2		126.10	141.10
4	Weight of ship		32.70 tonnes	32.70 tonnes
	Weight of cargo		30.00 tonnes	30.00 tonnes
	Total weight		62.70 tonnes	62.70 tonnes
	divide 3 by total weight			
	Height of combined CoG		2.01 metres	2.25 metres
5	Find height of metacentre from graph			
	for displacement of	62.70 tonnes	2.75 metres	2.75 metres
6	Subtract height of combined CoG		2.01 metres	2.25 metres
	Height of metacentre		0.74 metres	0.50 metres
	Metacentric Height as percentage of beam		12 %	8 %

Appendix IX

Passage Planning: Boulogne to the Solent

The following worked example examines the passage from Boulogne to the Nab Tower at the entrance to the Solent on two bases: case 1, assuming a fleet maintaining an average speed of some five knots; case 2, an average speed of approximating to three knots.

The methodology used is that of Keys (1989, 84-9). Rather than plotting vectors of the water track and of the hourly tidal set and drift on a chart and measuring off the resultant ground track, as in Fig. 24 in Chapter X (110), trigonometrical formulae are used to convert the polar coordinates of course and distance (or tidal set and drift) into the rectangular coordinates of dLat, Departure and dLong. dLat is 'difference in latitude' and is measured in degrees and minutes, or nautical miles (a nautical mile is defined as a minute of latitude). dLong is 'difference in longitude' and is measured in degrees and minutes. A minute of longitude varies in length according to latitude and is equivalent to a nautical mile only at the equator. A special term, 'Departure', is used to denote distance east/west measured in nautical miles. Negative values for dLat and Departure indicate south or west as the case may be. Once dLong has been converted into Departure, using a formula based on the mean latitude (Mn Lat) of the ground track, dLat and Departure for the various vectors can be aggregated and the resultant totals converted back to polar coordinates giving the course and distance of the overall ground track.

The total distance over the ground is just over 96 nautical miles (Fig. 36). The analysis is in two legs, Boulogne to Beachy Head (50.65 nautical miles) and Beachy Head to the Nab (45.71 nautical miles). Both fleets are assumed to leave Boulogne at the most advantageous time, at two hours before High Water Dover, when the tidal streams in the offing are running between north and north east. Whilst not favourable, these streams have the advantage of carrying the fleets towards, rather than away from, the British coast. Six hours later, at four hours after High Water Dover, the tide begins to run favourably and after a total elapsed time of ten hours this brings the faster fleet averaging 4.93 knots to Beachy Head just as the tide turns foul. The slower fleet needs 17 hours at an average of 3.22 knots to arrive at the same point with the tide starting to run again in its favour. But because the tide turned against it before it could reach Beachy Head, the reduction of 35% in boat speed meant that the fleet needed 70% more time for this leg. In fact it had a favourable tide for only seven of the seventeen hours required for Leg 1.

The faster fleet starts Leg 2 stemming a foul tide, but the tide turns in its favour four hours later and begins to run very strongly off the Owers, bringing it off the Nab after nine hours at an average speed of 4.73 knots, having completed the total passage in nineteen hours at a combined average speed of 4.83 knots through the water. It is now still a hour or so from the entrance to Chichester Harbour and perhaps two or even three hours from anchoring and, taking account of the time required to leave Boulogne, the whole passage is unlikely to have lasted less than twenty four hours. In fact bearing in mind that this would have been a fleet passage, the factors discussed in Chapter IX affecting fleet operations, would have meant that the total passage time from embarkation to disembarkation is likely to have been considerably more.

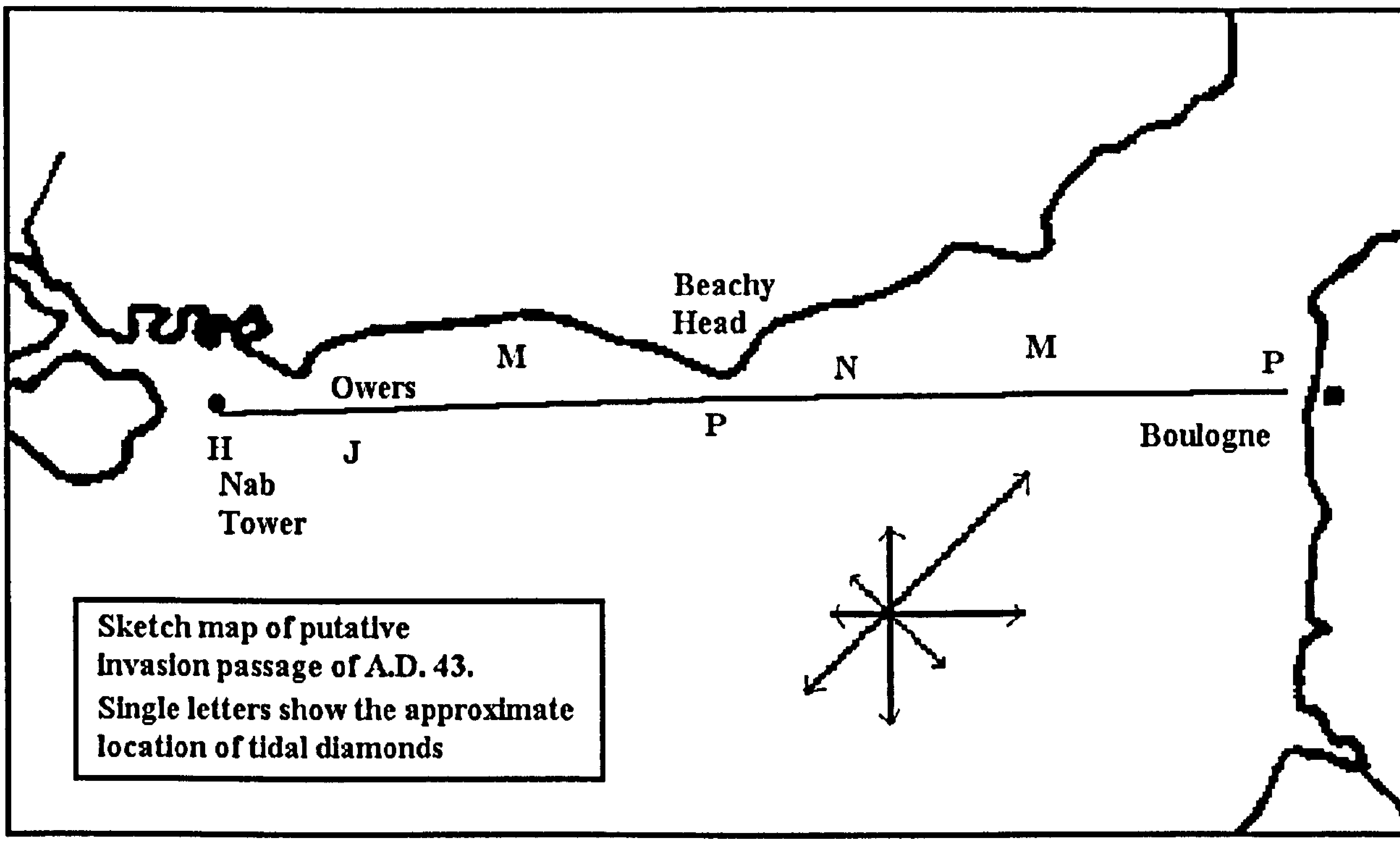


Fig. 36 Winds shown as in Fig. 1.

The slower fleet starts Leg 2 with four hours of favourable tide and finishes with the benefit of the same tidal streams running strongly off the Owers as the first fleet, but some thirteen hours later. All in all in the fifteen hours of this leg the tide is running in its favour for all but six hours and to complete it within the fifteen hours an average speed through the water of as little as 2.42 knots is required. Overall the passage of 95 nautical miles from Boulogne has taken thirty-two hours at an average speed through the water of 2.84 knots. Allowing time to leave Boulogne and to enter Chichester Harbour to anchor, the total passage duration for a single-ship movement cannot be much less than thirty-seven hours. But this was a fleet passage and the total time could not have been less than two to two and a half days from embarkation to disembarkation.

Comparing the two fleets it becomes clear that the slower the speed through the water, the more the time taken for the passage is adversely affected by the changing tidal streams. For a reduction in boat speed of some 40% (41.6%) the time required for the passage is nearly 70% (68.4%) greater. This corresponds to the intuitive understanding of racing yachtsmen that slower yachts are more at a disadvantage from adverse tides.

In fact it is only the very strong tides running in their favour off the Owers that enabled the second fleet to complete the passage in the thirty-two hours suggested. Had they been delayed for any reason in their arrival off the Owers, they could have found the tide against them running at speeds approaching three knots.

In our discussion of the speed performance of Blackfriars 1 as a potential representative of the Roman invasion transports (Chapters VI and VII and Appendix V) we concluded that generally speaking she was a relatively sluggish vessel, with a comparatively low speed potential; in conditions likely to be acceptable for an invasion, i.e. Force 4 or less, her likely maximum speed would have been five knots at the outside and then only in a beam wind. For the passage which we are considering, a beam wind from the south would have been downright dangerous, particularly if it were as strong as Force 4, for it would have turned the south coast, especially the stretch from Beachy Head westwards, into a lee shore. This would not have applied to a northerly wind, but that is not a common direction for the wind. Therefore, at least for planning purposes, it seems highly probable that, if the Roman naval staff considered this route, they would not have expected to complete the passage in less than two to three days. They would probably have allowed considerably more.

One final caveat should be entered: the steady average speed which has been assumed for this exercise is dependent a steady favourable wind. The infrequency of favourable winds for a west-bound passage in the eastern Channel may be gauged from the meteorological data set out in Appendix XI for selected stations in the eastern Channel (see also 'Wind and Weather' in Chapter X, 114-9).

The detailed workings are as follows (HWD = High Water Dover):

Boulogne to the Solent - Leg 1 - to Beachy Head — Admiralty Chart 2451

Case 1: Average speed assumed to be 5 knots approx.

	Tidal Streams	Set °	Drift Springs nm	Drift Neaps nm	Tidal Diamond	dLat nm	Dep nm
2	before HWD	95	0.3	0.2	P	-0.03	0.30
1	before HWD	20	1.1	0.6	P	1.03	0.38
	HWD	10	1.9	1.1	P	1.87	0.33
1	after HWD	47	1.1	0.6	M	0.75	0.80
2	after HWD	28	0.6	0.4	M	0.53	0.28
3	after HWD	0	0.0	0.0	M	0.00	0.00
4	after HWD	256	0.4	0.2	M	-0.10	-0.39
5	after HWD	248	1.6	0.9	N	-0.60	-1.48
6	after HWD	249	1.2	0.7	N	-0.43	-1.12
6	before HWD	250	0.6	0.3	*P	-0.21	-0.56
	Total Tidal Offset	333	3.18			2.83	-1.46

* Data from Tidal Diamond P on Chart 2450

		LatA	LatA °decimal	LongA	LongA °decimal
Boulogne		50°44'N	50.73	1°35'E	1.58
		LatB	LatB °decimal	LongA	LongA °decimal
Beachy Head		50°43' N	50.72	0°15'E	0.25
dLat	°decimal		-0.02		
dLat	nm		-1.00		
Mn Lat	°decimal		50.73		
dLong	°decimal				-1.33
Dep	nm				-50.64

	Course °	Distance nm	dLat nm	Dep nm
Ground Track	269	50.65	-1.00	-50.64
Subtract Tidal Offset			2.83	-1.46
Water Track	266	49.33	-3.83	-49.18

Average Speed required 4.93 Knots

Case 2: Average speed assumed to be 3 knots approx.

Tidal Streams	Set °	Drift Springs nm	Drift Neaps nm	Tidal Diamond	dLat nm	Dep nm
2 before HWD	95	0.3	0.2	P	-0.03	0.30
1 before HWD	20	1.1	0.6	P	1.03	0.38
HWD	10	1.9	1.1	P	1.87	0.33
1 after HWD	11	2.3	1.3	P	2.26	0.44
2 after HWD	28	0.6	0.4	M	0.53	0.28
3 after HWD	0	0.0	0.0	M	0.00	0.00
4 after HWD	256	0.4	0.2	M	-0.10	-0.39
5 after HWD	238	0.9	0.5	M	-0.48	-0.76
6 after HWD	225	1.5	0.8	M	-1.06	-1.06
6 before HWD	228	1.6	0.9	M	-1.07	-1.19
5 before HWD	228	1.4	0.8	M	-0.94	-1.04
4 before HWD	68	1.9	1.0	N	0.71	1.76
3 before HWD	68	2.6	1.5	N	0.97	2.41
2 before HWD	68	2.3	1.3	N	0.86	2.13
1 before HWD	68	1.2	0.6	N	0.45	1.11
HWD	210	0.1	0.0	*P	-0.09	-0.05
1 after HWD	264	0.9	0.5	*P	-0.09	-0.90
Total Tidal Offset	398	6.13			4.84	3.76

* Data from Tidal Diamond P on Chart 2450

	Ground Track Course °	Distance nm	dLat nm	Dep nm
	269	50.65	-1.00	-50.64
Subtract Tidal Offset			4.84	3.76
	Water Track Course	Distance		
	264	54.71	-5.84	-54.40

Average Speed required 3.22 Knots

Boulogne to the Solent - Leg 2 - Beachy Head to Nab Tower — Admiralty Chart 2450

Case 1: Average speed assumed to be 5 knots approx.

Tidal Streams	Set °	Drift Springs nm	Drift Neaps nm	Tidal Diamond	dLat nm	Dep nm
5 before HWD	95	1.0	0.5	P	-0.09	1.00
4 before HWD	84	2.0	1.0	P	0.21	1.99
3 before HWD	53	1.4	0.7	M	0.84	1.12
2 before HWD	56	0.6	0.3	M	0.34	0.50
1 before HWD	290	0.3	0.1	M	0.10	-0.28
HWD	252	1.4	0.7	J	-0.43	-1.33
1 after HWD	252	2.3	1.1	J	-0.71	-2.19
2 after HWD	252	2.4	1.2	J	-0.74	-2.28
3 after HWD	245	1.8	0.9	H	-0.76	-1.63
Total Tidal Offset	248	3.35			-1.24	-3.11

Beachy Head		LatA	LatA °decimal	LongA	LongA °decimal	
		50°43' N	50.72	0°15'E	0.25	
Nab Tower		LatB	LatB °decimal	LongA	LongA °decimal	
		50°40'N	50.67	0°57'W	-0.95	
dLat	°decimal		-0.05			
dLat	nm		-3.00			
Mn Lat	°decimal		50.69			
dLong	°decimal				-1.20	
Dep	nm				-45.61	
	Ground Track				dLat	Dep
	Course °	Distance nm			nm	nm
	266	45.71			-3.00	-45.61
Subtract Tidal Offset					-1.24	-3.11
	Water Track					
	Course	Distance				
	268	42.53			-1.76	-42.50
	Average Speed required			4.73 Knots		

Case 2: Average speed assumed to be 3 knots approx.

Tidal Streams	Set °	Drift Springs nm	Drift Neaps nm	Tidal Diamond	dLat nm	Dep nm
2 after HWD	263	1.5	0.7	P	-0.18	-1.49
3 after HWD	256	2.2	1.1	P	-0.53	-2.13
4 after HWD	263	2.0	1.0	P	-0.24	-1.99
5 after HWD	264	1.7	0.8	P	-0.18	-1.69
6 after HWD	121	0.6	0.3	M	-0.31	0.51
6 before HWD	80	0.8	0.4	M	0.14	0.79
5 before HWD	56	1.5	0.7	M	0.84	1.24
4 before HWD	51	1.6	0.8	M	1.01	1.24
3 before HWD	53	1.4	0.7	M	0.84	1.12
2 before HWD	56	0.6	0.3	M	0.34	0.50
1 before HWD	252	0.1	0.0	J	-0.03	-0.10
HWD	252	1.4	0.7	J	-0.43	-1.33
1 after HWD	252	2.3	1.1	J	-0.71	-2.19
2 after HWD	252	2.4	1.2	J	-0.74	-2.28
3 after HWD	245	1.8	0.9	H	-0.76	-1.63
Total Tidal Offset	444	9.47			-0.96	-9.42

	Course °	Distance nm	dLat nm	Dep nm
Ground Track	266	45.71	-3.00	-45.61
Subtract Tidal Offset			-0.96	-9.42
Water Track	267	36.25	-2.04	-36.19
Average Speed required		2.42 Knots		

Appendix X

Tides in the Wantsum Channel

The purpose of this Appendix is to attempt some estimate of the behaviour of the tides and tidal streams in the Wantsum Channel before it became silted up. The approach adopted is to compare the tidal heights as they can be calculated from modern data at Ramsgate and Herne Bay. These two ports, situated close to each end of the former Wantsum Channel, are taken as proxies for Richborough and Reculver. The comparison of tidal heights will establish the hydrostatic differential between these two points and hence the direction of the tidal stream. At the same time the tidal curves derived from the data will give an indication of the height of the tide at each end of the Wantsum.

A number of caveats need to be made. First, it is assumed that the hydrological tail of the Wantsum Channel will not wag the hydrological dog of the Thames Estuary, Dover Strait and southern North Sea. While the flow of water through the Wantsum Channel would have had an effect on the behaviour of the tides in the immediate area, and in particular tended to make the actual performance of the tides at Ramsgate and Herne Bay more like one another, it is argued that this would not have been significant enough to affect the general picture. The second caveat is a general one:

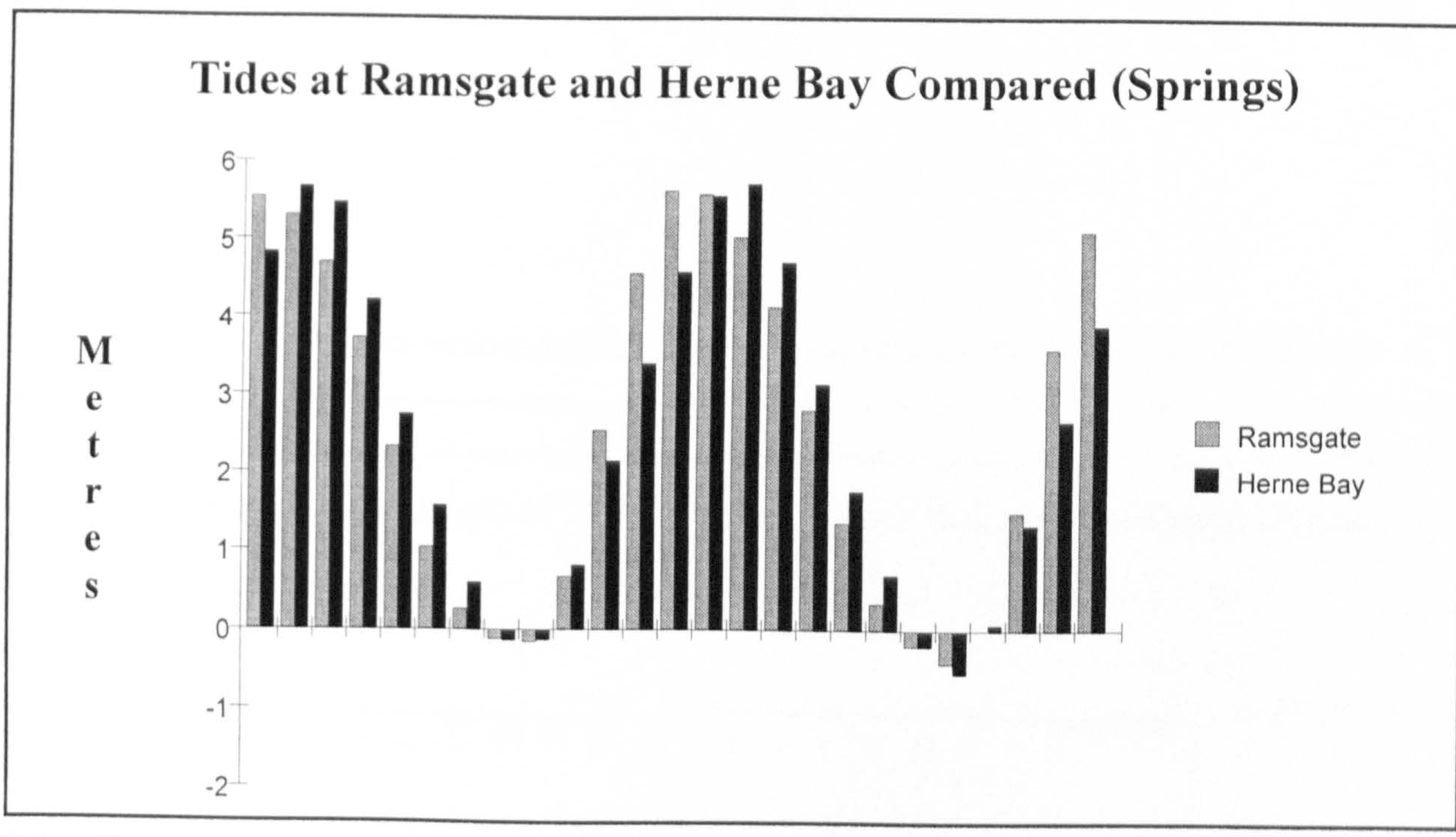
> Although it is a relatively simple matter to calculate the variations in the astronomical tide-generating forces, the response of the water to these forces is extremely difficult to predict since the configuration of land masses and the depths of the oceans and the seas all play a part. Modern prediction techniques are based on harmonic methods, relying on analyses of tidal observations which enable the relationship between the response of the water at any place and the variation in the astronomical forces to be identified (Keys, 1982, 146-7).

In other words prediction depends pragmatically on observational data and the changed configuration of the north and east Kent coasts must have had some effect on such data.

The third is that I have used the Admiralty simplified harmonic method of tidal prediction (NP 159A v. 2.0, 1990). This uses a dozen or so harmonic constants as opposed to the many more, 'sometimes in excess of 100', which are used in the daily Standard Port predictions listed in Part I of the Admiralty Tide Tables, 'which can thus be expected to be of greater accuracy' (NP 160, 1990, 1).

However, as will be seen, whilst these qualifications will mean that the data to be used will lack a degree of accuracy, this will not undermine the general thrust of the conclusions. In fact, they accord in general with the overall pattern of the tidal régime of the Thames Estuary and southern North Sea.

The calculation of the data was done by computer programme (NP 159A v. 2.0, 1990) which was loaded with the harmonic constants for Ramsgate and Herne Bay (NP 160, 1990, 4). Two dates were selected, 18th September 1993 (springs) and 25th September 1993 (neaps). The programme was run for each of these dates for the two ports and the height of the tide extracted at hourly intervals. An adjustment was made to the data for Herne Bay to allow for the difference between Mean Tide Level at the two places. The results were then plotted on a graph (Fig. 37).



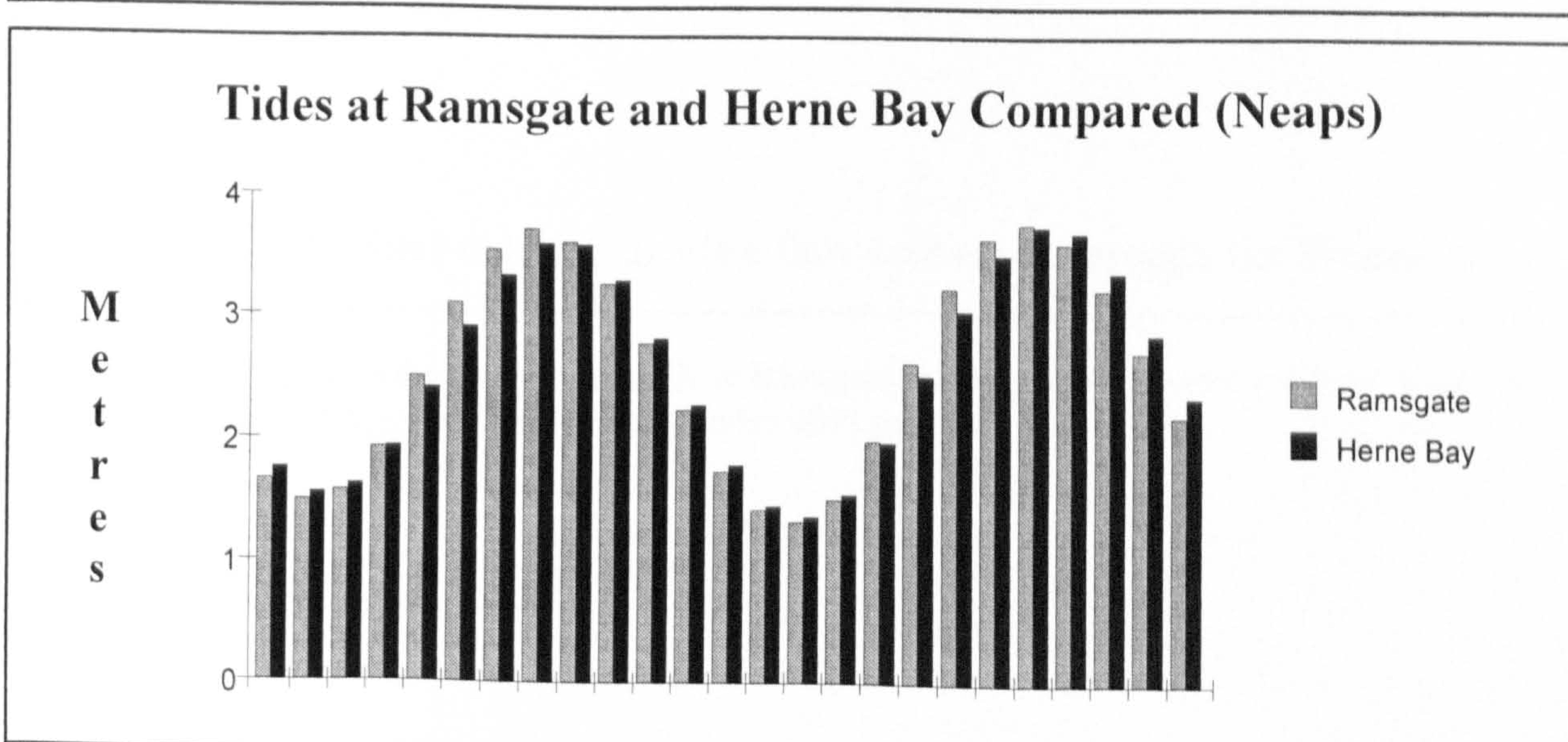


Fig. 37 Tides at Ramsgate and Herne Bay plotted at hourly intervals for the 18th September 1993 (springs) and 25th September 1993 (neaps).

Figure 37 reveals the general trend that during the flood the tide is higher at Ramsgate than at Herne Bay, while the reverse applies during the ebb. This suggests that during the flood the tide would be flowing westwards through the Wantsum Channel and eastwards during the ebb. This is shown graphically in Fig. 38.

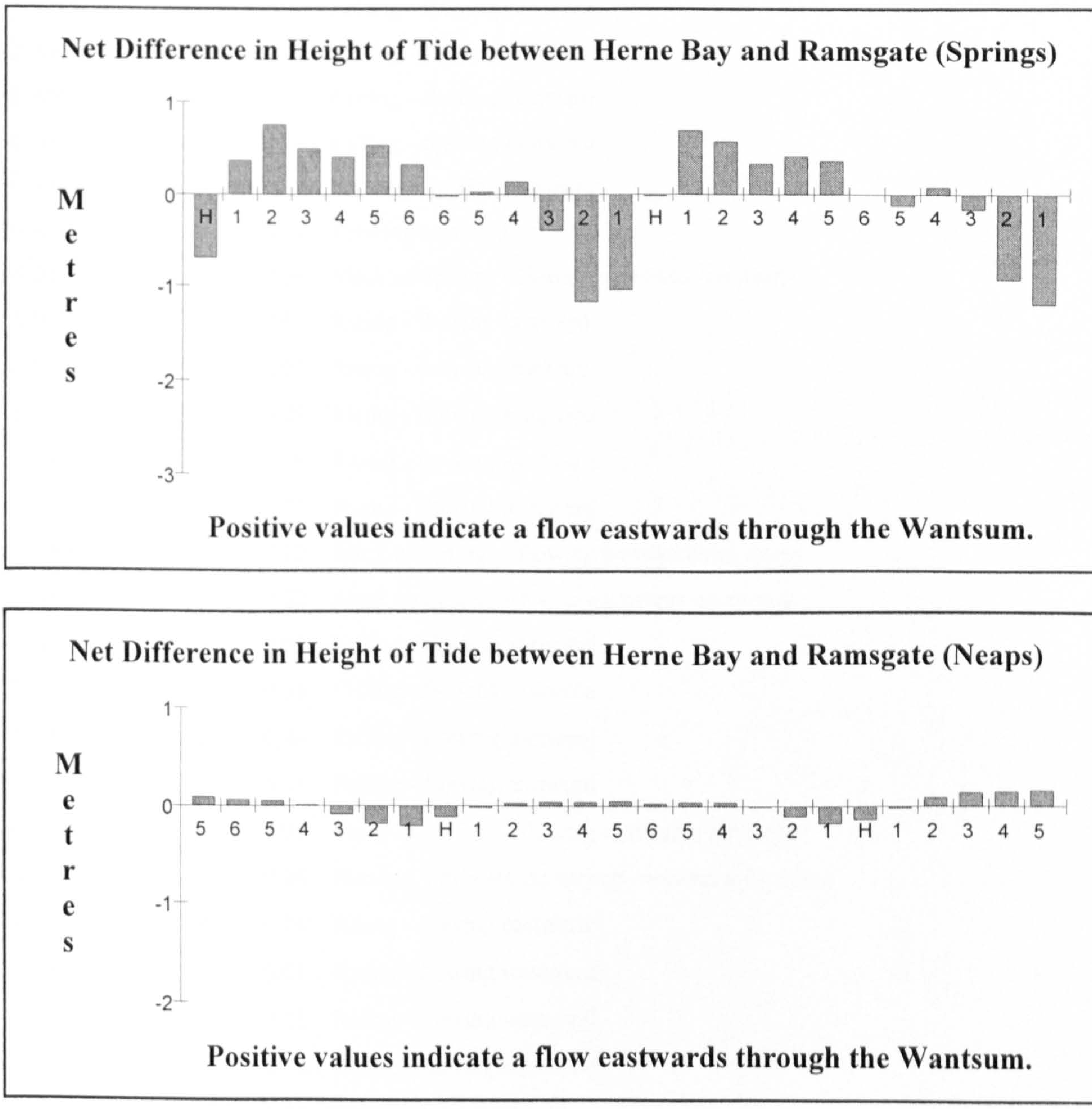


Fig. 38 Net difference in the height of the tide at Ramsgate and Herne Bay plotted at hourly intervals for the 18th September 1993 (springs) and 25th September 1993 (neaps).

The values for the net differences in the height of the tide at Ramsgate and Herne Bay plotted in Fig. 38 may be interpreted as follows:

A	B	C	Comment
HWD	-0.70		Flowing westward
1 AHWD	0.37		Falling - flowing eastward
2 AHWD	0.76		Falling - flowing eastward
3 AHWD	0.50		Falling - flowing eastward
4 AHWD	0.41		Falling - flowing eastward
5 AHWD	0.54		Falling - flowing eastward
6 AHWD	0.33	0.09	Flowing eastward
6 BHWD	-0.02	0.06	Slack on springs - flowing eastwards on neaps
5 BHWD	0.03	0.05	Rising - flowing eastward
4 BHWD	0.14	0.01	Rising - flowing eastward
3 BHWD	-0.39	-0.09	Rising - flowing westward
2 BHWD	-1.17	-0.19	Rising - flowing westward
1 BHWD	-1.04	-0.21	Rising - flowing westward
HWD	-0.02	-0.12	Slack on springs - flowing westwards on neaps
1 AHWD	0.69	-0.02	Slack on neaps - flowing eastwards on springs
2 AHWD	0.57	0.03	Falling - flowing eastward
3 AHWD	0.33	0.04	Falling - flowing eastward
4 AHWD	0.41	0.04	Falling - flowing eastward
5 AHWD	0.36	0.05	Falling - flowing eastward
6 AHWD	0.00	0.03	Slack on springs - flowing eastwards on neaps
5 BHWD	-0.12	0.04	Flowing westward on springs - eastward on neaps
4 BHWD	0.08	0.04	Rising - flowing eastward
3 BHWD	-0.16	-0.01	Rising - flowing westward
2 BHWD	-0.93	-0.11	Rising - flowing westward
1 BHWD	-1.20	-0.18	Rising - flowing westward
HWD		-0.14	Flowing westward
1 AHWD		-0.02	Flowing westward
2 AHWD		0.09	Falling - flowing eastward
3 AHWD		0.14	Falling - flowing eastward
4 AHWD		0.15	Falling - flowing eastward
5 AHWD		0.16	Falling - flowing eastward

A = State of tide by reference to Dover

B = Height difference in metres at springs

C = Height difference in metres at neaps

Negative figures show that the height of the tide is greater at Ramsgate and that therefore the flow is westwards through the Wantsum.

There appear to be one or two anomalies in the data, but in broad terms a pattern does emerge which is reasonably consistent with the tidal pattern of the Thames Estuary and southern North Sea. As the tide ebbs, the flow is eastwards through the Wantsum Channel and continues so on the first of the flood. This is a pattern which would make it possible for a ship to leave the Medway at high water and to carry the tide through the Wantsum and join the flood to Dover and possibly across the Strait to Boulogne and Quentovic.

Initially on the flood the flow in the channel is eastward, but it turns westward somewhere between 3 and 4 hours before High Water Dover and there is some hint of a continued westward flow over the hour or so of High Water. This might give some hindrance to a ship bound from Boulogne to the Medway. If she works the Dover Strait tides correctly she would arrive off Richborough around 5 hours after High Water Dover. At this point the flow would be easterly in the Wantsum Channel and will continue so for another three hours or so. If she wished to carry straight on along the north Kent coast, she would have to stem the tide through the Wantsum. However, this would not be much different to the position today that requires ships wishing to take the flood into the Medway and the London river first to stem the foul tide to the North Foreland.

Perhaps not surprisingly, the tidal height differences show a significant divergence between the data for springs and those for neaps, which would indicate that the rates of the tidal streams in the Wantsum Channel were significantly greater at springs than at neaps. I have not attempted to give the rates a numerical value. However, comparison with the data from other inshore channels can give an indication. Using the same methodology, Fig. 39 shows the net difference in tidal heights between two points on the Menai Strait, Caernarfon and Beaumaris. The Menai Strait is well-known for the rates of its tidal streams, 'generally 3 knots, but 5 knots off Abermenai, 6 knots at the Bridges and 8 knots at the Swellies' (Stableford, 1993, 483). The Swellies are the part of the Strait between the road and rail bridges where the constriction of the channel and numerous rocky islets not only increase the speed of the tidal stream but also contribute to its treacherous reputation.

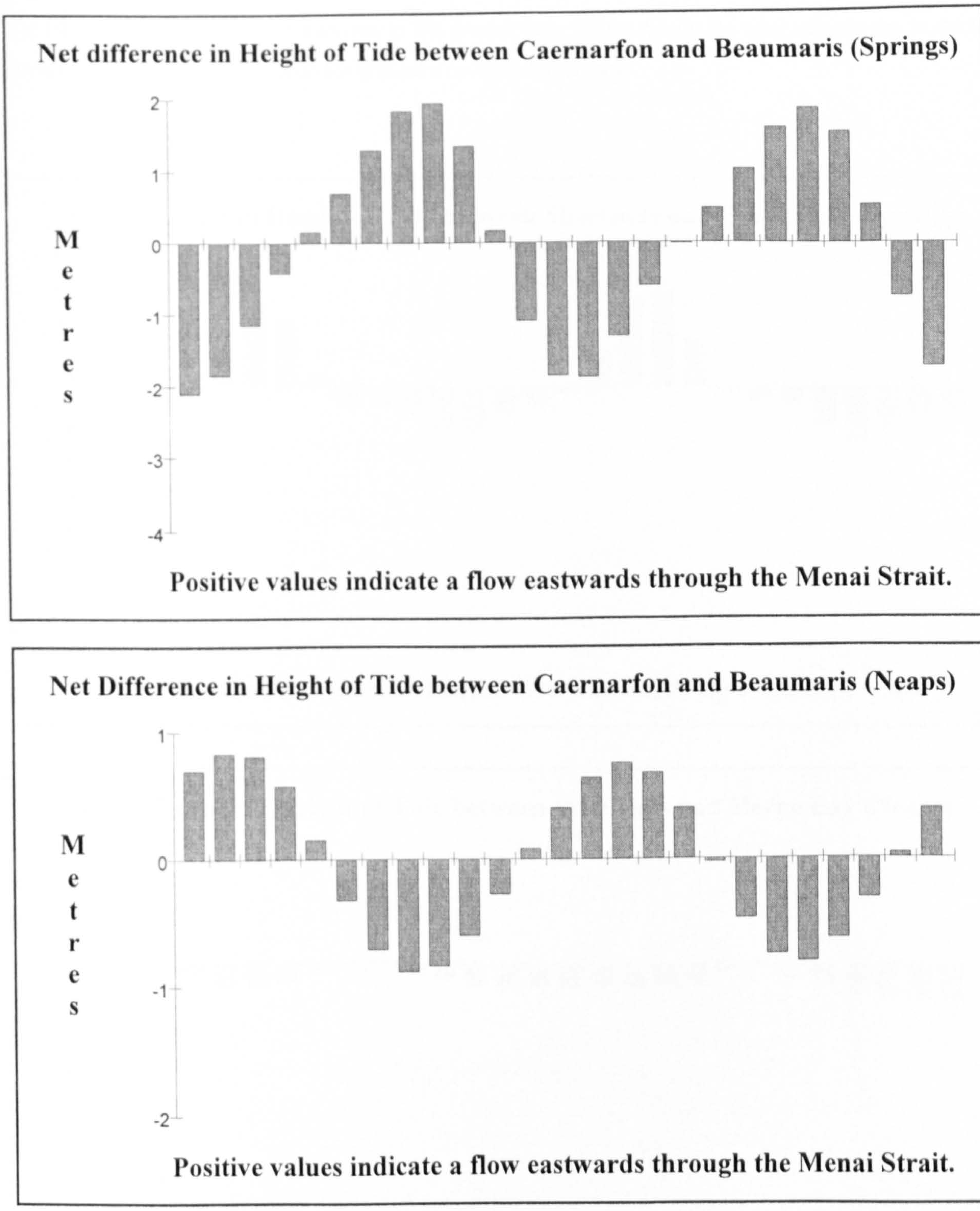
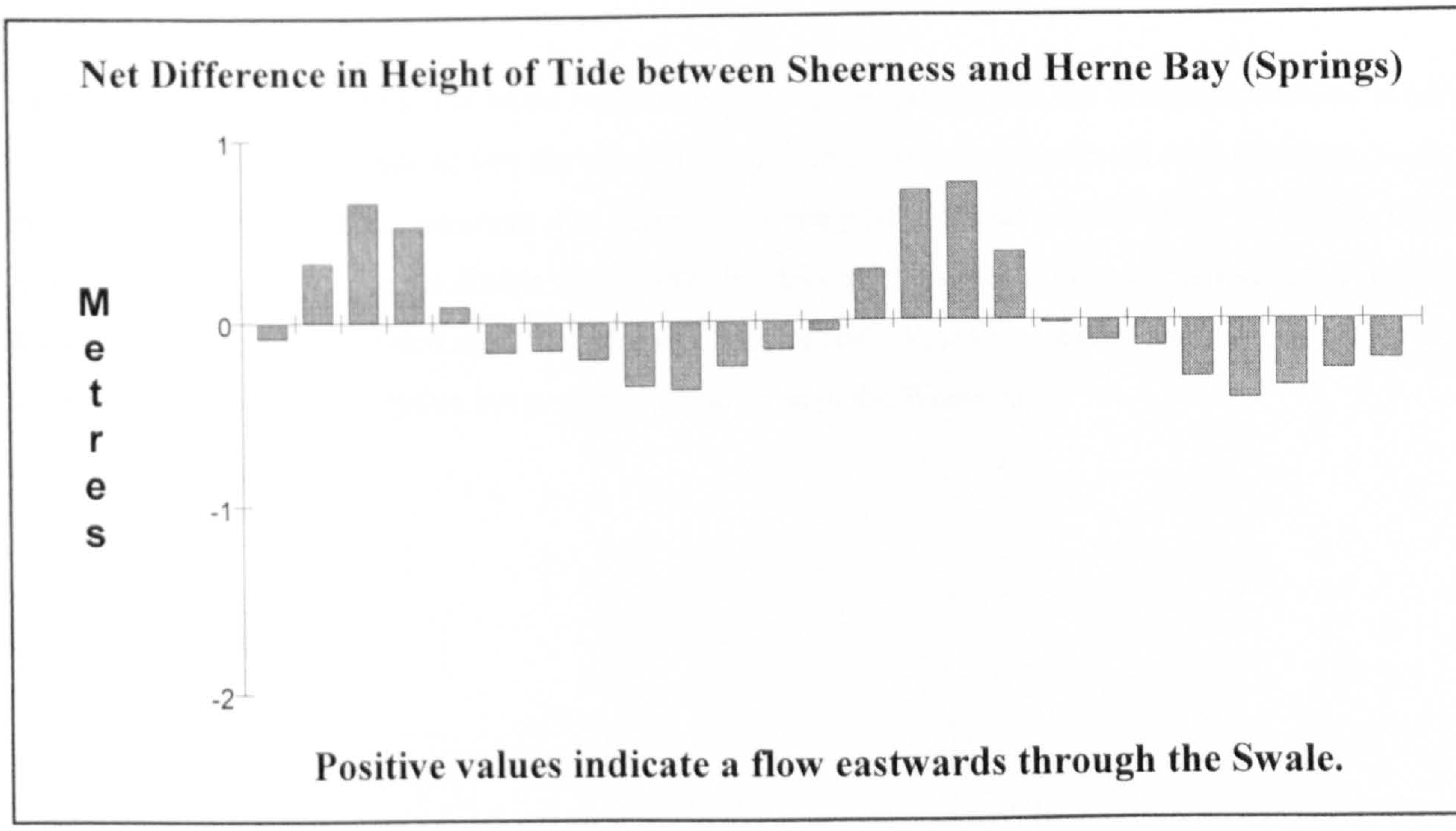


Fig. 39 Net difference in the height of the tide at Caernarfon and Beaumaris plotted at hourly intervals for the 18th September 1993 (springs) and 25th September 1993 (neaps).

By contrast, the net difference in tidal heights between Sheerness and Herne Bay is shown in Fig. 40. These two points are at either end of the Swale, a shallow inshore water way, which divides the north Kent from the Isle of Sheppey and which survives to the present day. In the Swale the tidal streams are moderate, probably less than 2 knots, and do not present a navigational hazard.



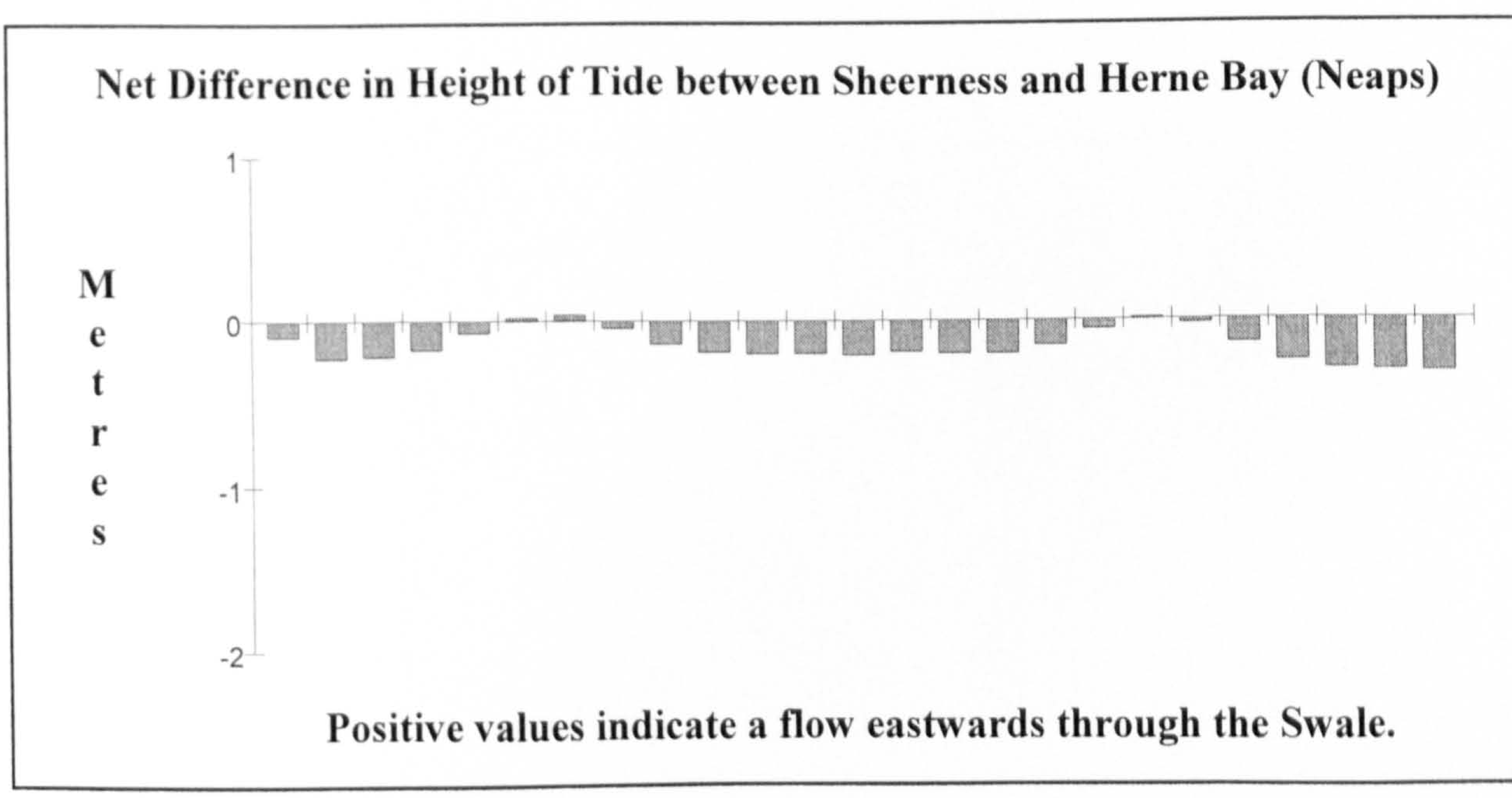


Fig. 40 Net difference in the height of the tide at Sheerness and Herne Bay plotted at hourly intervals for the 18th September 1993 (springs) and 25th September 1993 (neaps).

Comparing the data for the Wantsum with the Menai Strait and the Swale suggests strongly that the Wantsum would have been much more akin to the latter than to the former and that, in particular, it would have shared its moderate tidal streams. Furthermore, it would not have presented the islets and rocky outcrops which create significant hazards in the Menai Strait. There is no justification in the data for the suggestion that the Wantsum 'might well have been treacherous, if open to tides at both ends' (Hind, 1989, 14).

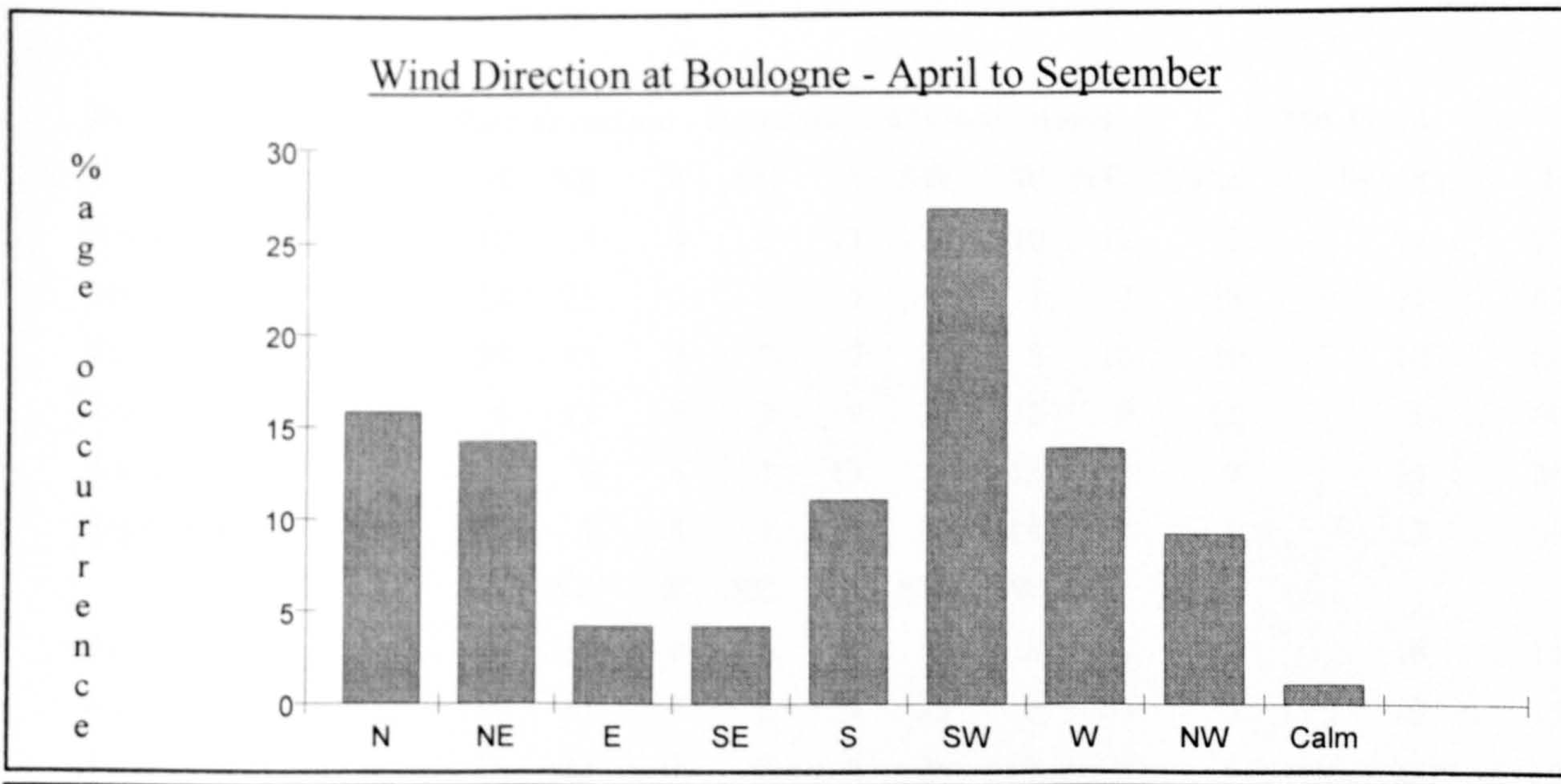
Furthermore, there would appear to be no basis in the data for supposing that the Wantsum Channel would experienced a double high tide or that the stand at High Water was more significant then elsewhere in the immediate region. Hawkes's comment that Sarre was 'strategically placed where vessels using this inner route had to put in to wait on the double tide' (1982, 76) does not make sense even in the meaning that they waited at Sarre to take the flood up to the Medway and beyond. Vessels wishing to take the flood up the Thames would have had no option but to stem the tide through the Wantsum.

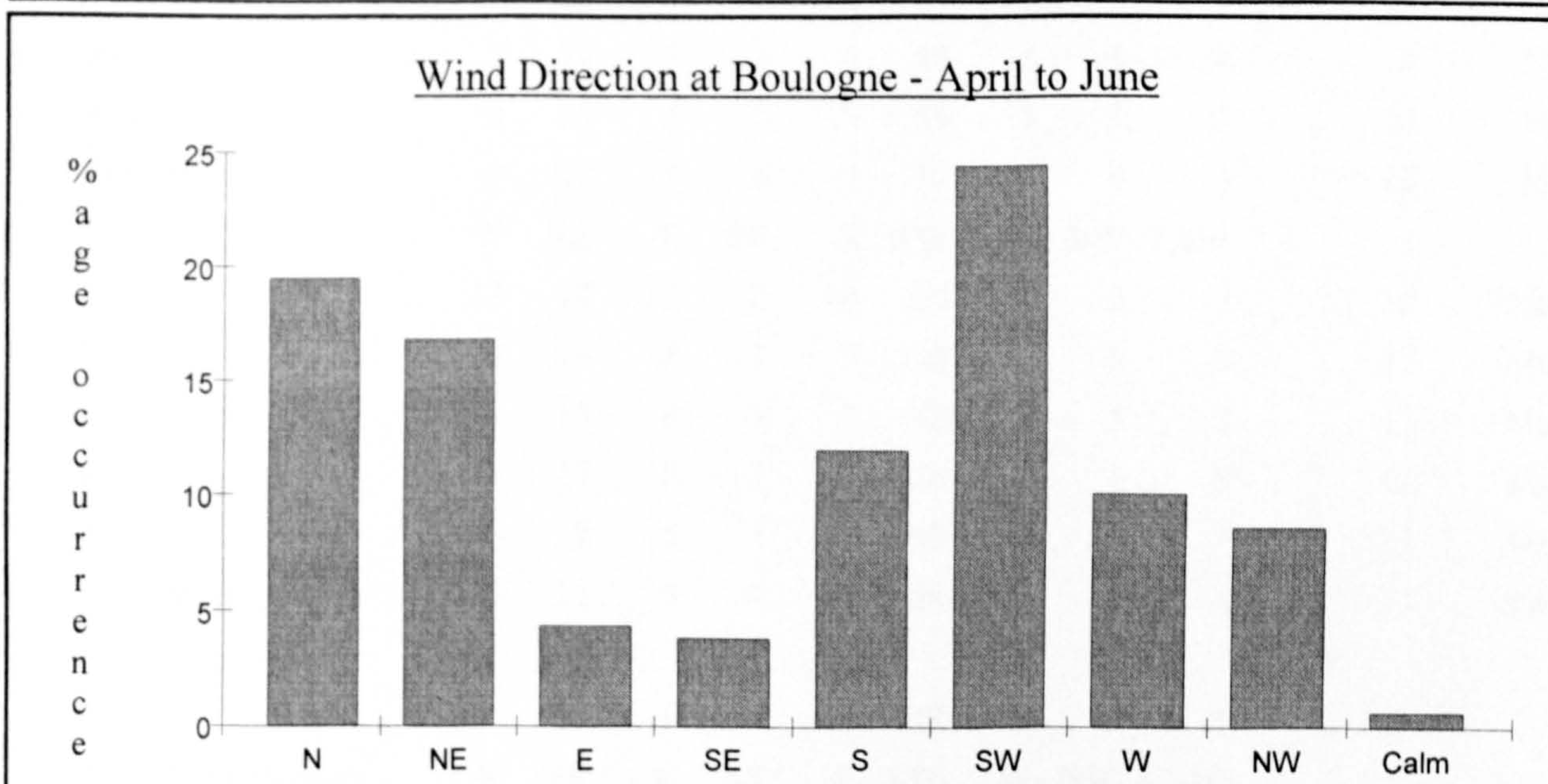
Appendix XI

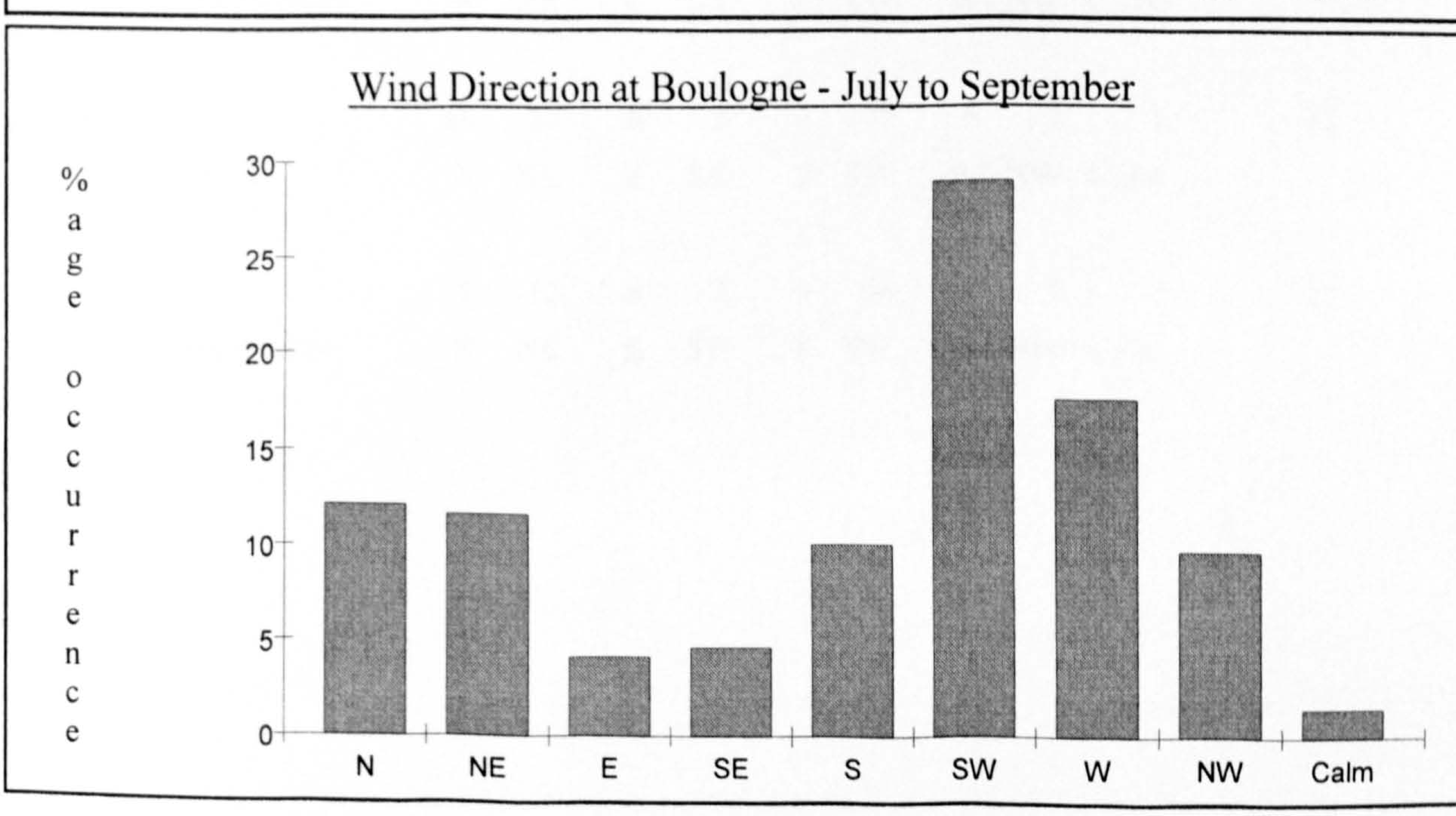
Meteorological Data from Selected Stations

The following sets of modern meteorological data displayed alternately in numeric and graph form are drawn from the *Channel Pilot* and *Dover Strait Pilot* (NP 28, 1977, 39, 41-2, 46; NP 27, 1977, 50, 57):

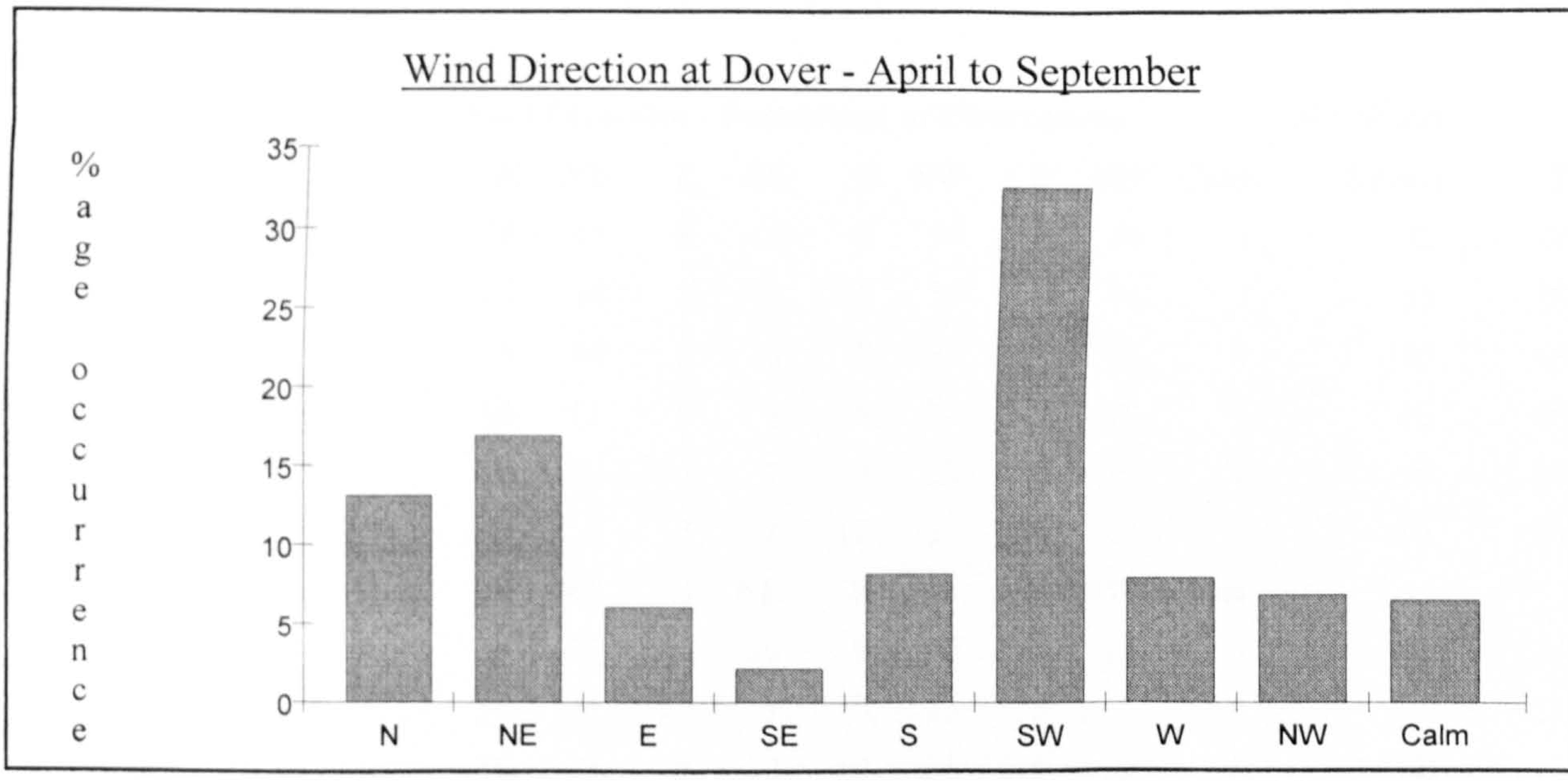
Boulogne	Wind Direction - Percentage of Obsevations									Mn Wind	
	N	NE	E	SE	S	SW	W	NW	Calm	Speed	Time
April	13	19	6	10	17	16	9	8	1	11	09:00
May	21	19	6	5	13	18	8	9	1	10	09:00
June	15	16	7	1	14	25	11	10	1	10	09:00
July	10	12	7	5	16	23	15	10	3	9	09:00
August	10	9	6	6	12	29	16	9	2	10	09:00
September	9	13	5	10	14	18	15	14	3	11	09:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	17	19	2	4	8	31	13	7	0	12	15:00
May	26	17	3	2	11	20	11	11	1	11	15:00
June	25	11	2	1	9	37	9	7	0	11	15:00
July	16	12	3	2	6	36	15	10	0	12	15:00
August	15	10	1	1	4	41	21	8	0	12	15:00
September	13	14	3	4	8	27	23	7	1	12	15:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	15	19	4	7	13	24	11	8	1	12	Means
May	24	18	5	4	12	19	10	10	1	11	Means
June	20	14	5	1	12	31	10	9	1	11	Means
July	13	12	5	4	11	30	15	10	2	11	Means
August	13	10	4	4	8	35	19	9	1	11	Means
September	11	14	4	7	11	23	19	11	2	12	Means
Means	16	14	4	4	11	27	14	9	1	11	
April to September	N	NE	E	SE	S	SW	W	NW	Calm		
Means	20	17	4	4	12	25	10	9	1	11	
April to June	N	NE	E	SE	S	SW	W	NW	Calm		
Means	12	12	4	5	10	29	18	10	2	11	
July to September	N	NE	E	SE	S	SW	W	NW	Calm		

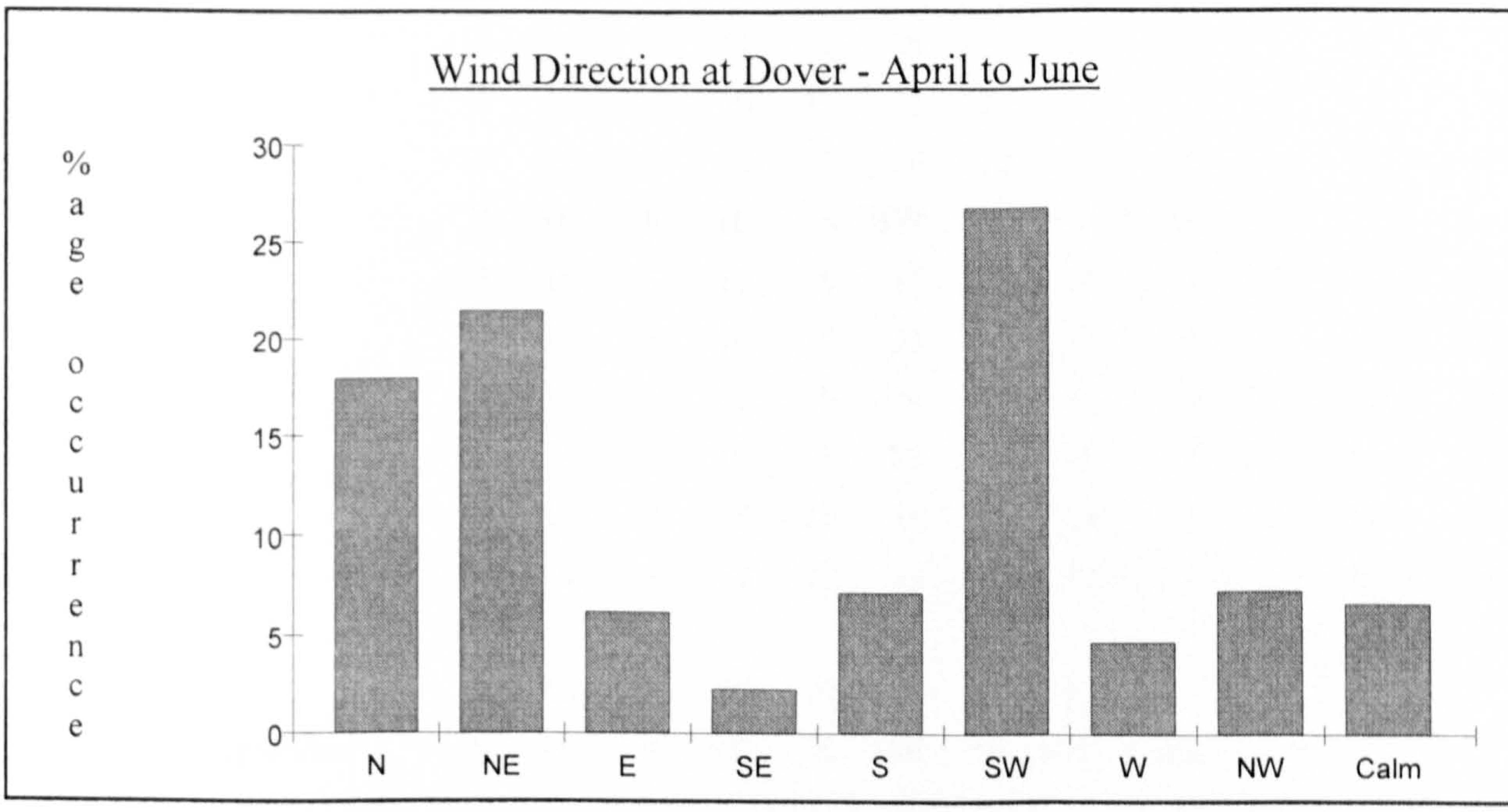

Wind Direction at Boulogne - April to September
%age occurrence
0
5
10
15
20
25
30
N
NE
E
SE
S
SW
W
NW
Calm

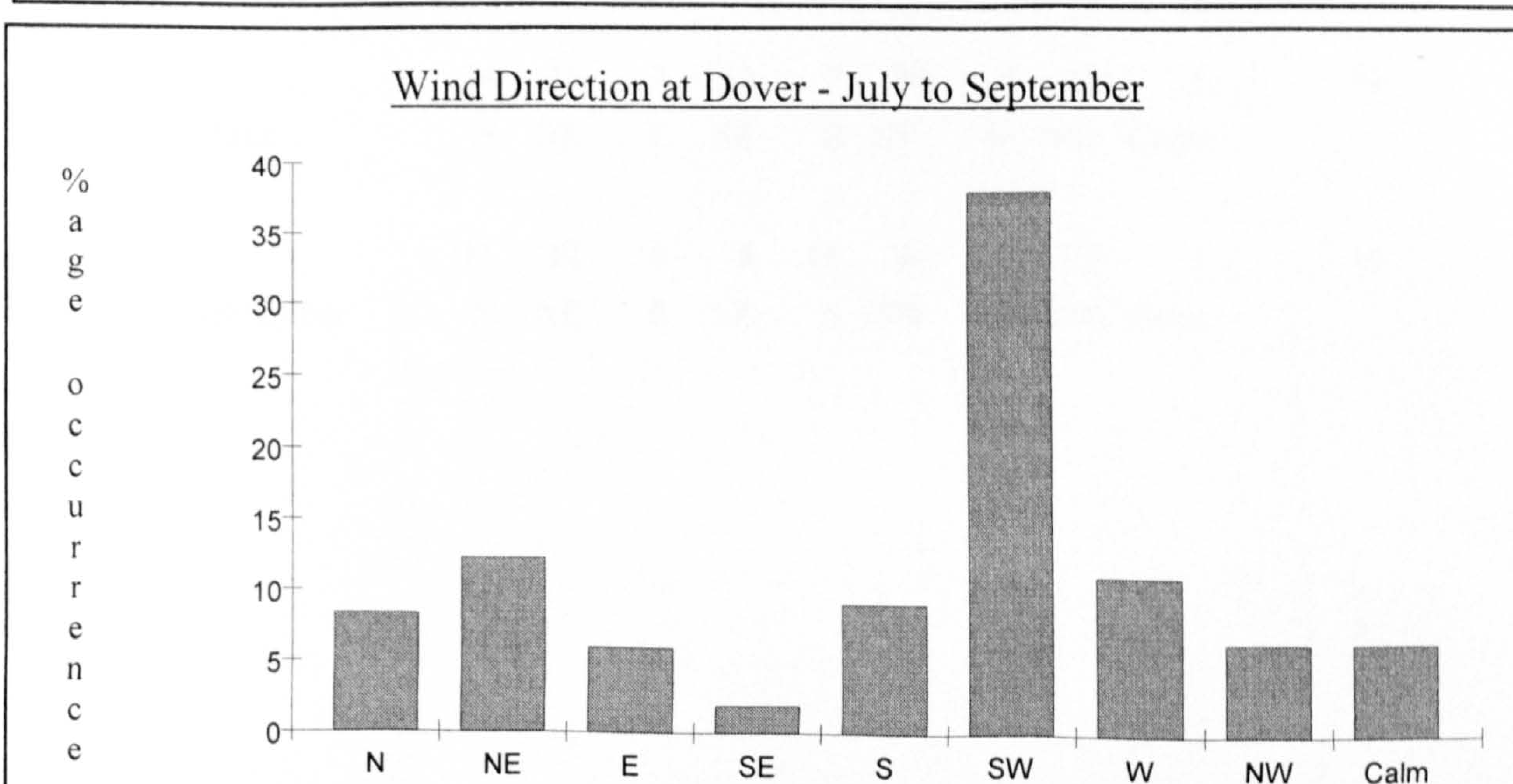

Wind Direction at Boulogne - April to June
%age occurrence
0
5
10
15
20
25
N
NE
E
SE
S
SW
W
NW
Calm


Wind Direction at Boulogne - July to September
%age occurrence
0
5
10
15
20
25
30
N
NE
E
SE
S
SW
W
NW
Calm

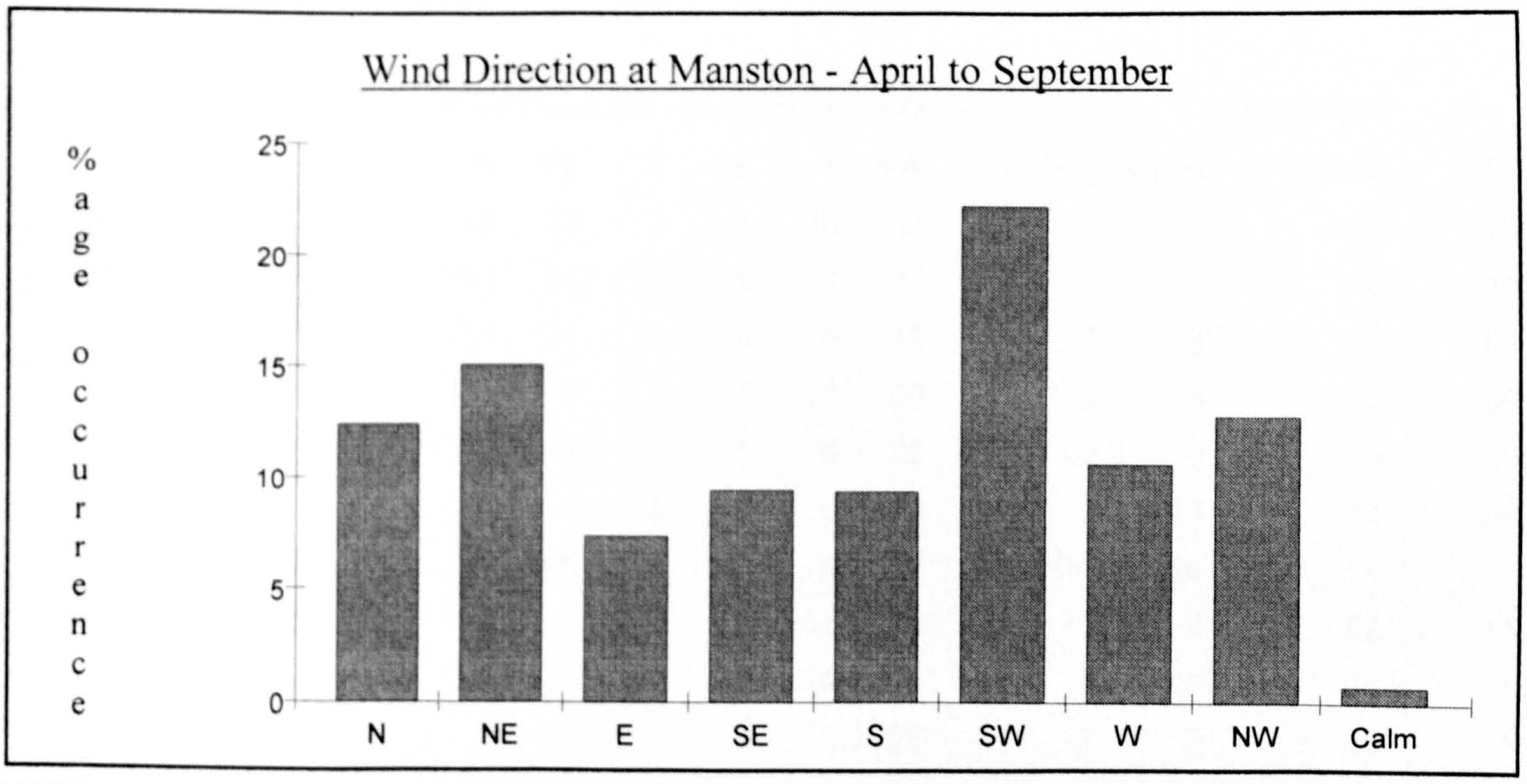
Dover	Wind Direction - Percentage of Obsevations									Mn Wind	
	N	NE	E	SE	S	SW	W	NW	Calm	Speed	Time
April	18	15	4	3	11	24	10	12	3	14	09:00
May	24	23	7	2	7	17	1	7	13	11	09:00
June	20	13	5	2	7	29	5	10	10	10	09:00
July	6	12	8	2	9	29	12	9	12	11	09:00
August	7	6	4	1	13	37	15	9	8	11	09:00
September	20	7	5	3	13	20	18	9	5	13	09:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	15	20	6	2	9	34	4	6	3	16	15:00
May	16	35	8	2	3	23	5	4	5	13	15:00
June	15	23	7	3	6	34	3	4	5	13	15:00
July	3	21	9	1	4	49	5	3	6	13	15:00
August	5	11	5	0	9	58	5	3	5	13	15:00
September	9	17	5	5	7	35	12	6	3	13	15:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	17	18	5	3	10	29	7	9	3	15	:7Ma ns
May	20	29	8	2	5	20	3	6	9	12	Ma ns
June	18	18	6	3	7	32	4	7	8	12	Ma ns
July	5	17	9	2	7	39	9	6	9	12	Ma ns
August	6	9	5	1	11	48	10	6	7	12	Ma ns
September	15	12	5	4	10	28	15	8	4	13	Ma ns
Means	13	17	6	2	8	32	8	7	7	13	
April to September	N	NE	E	SE	S	SW	W	NW	Calm		
Means	18	22	6	2	7	27	5	7	7	13	
April to June	N	NE	E	SE	S	SW	W	NW	Calm		
Means	8	12	6	2	9	38	11	7	7	12	
July to September	N	NE	E	SE	S	SW	W	NW	Calm		

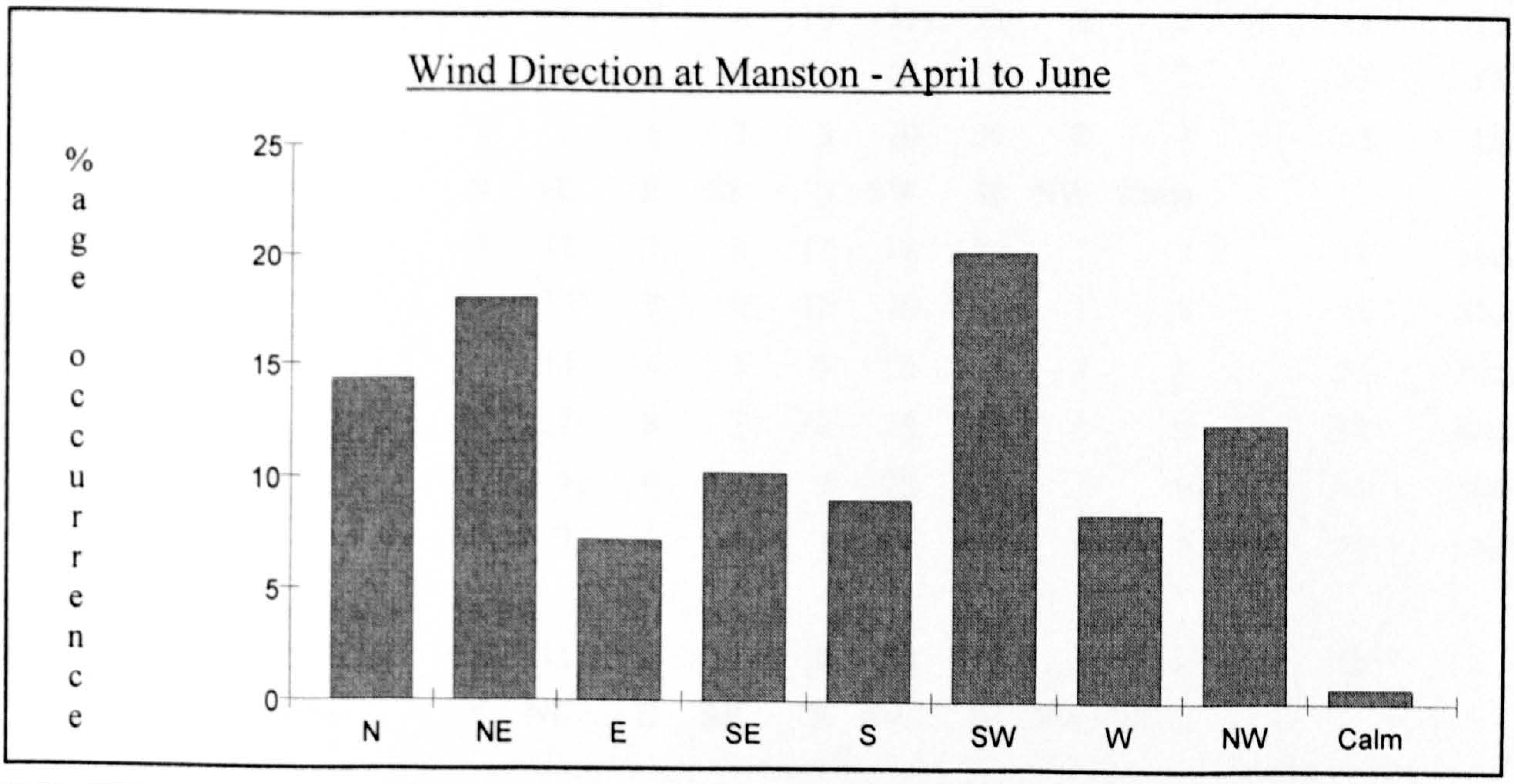

Wind Direction at Dover - April to September
%age occurrence
35
30
25
20
15
10
5
0
N
NE
E
SE
S
SW
W
NW
Calm

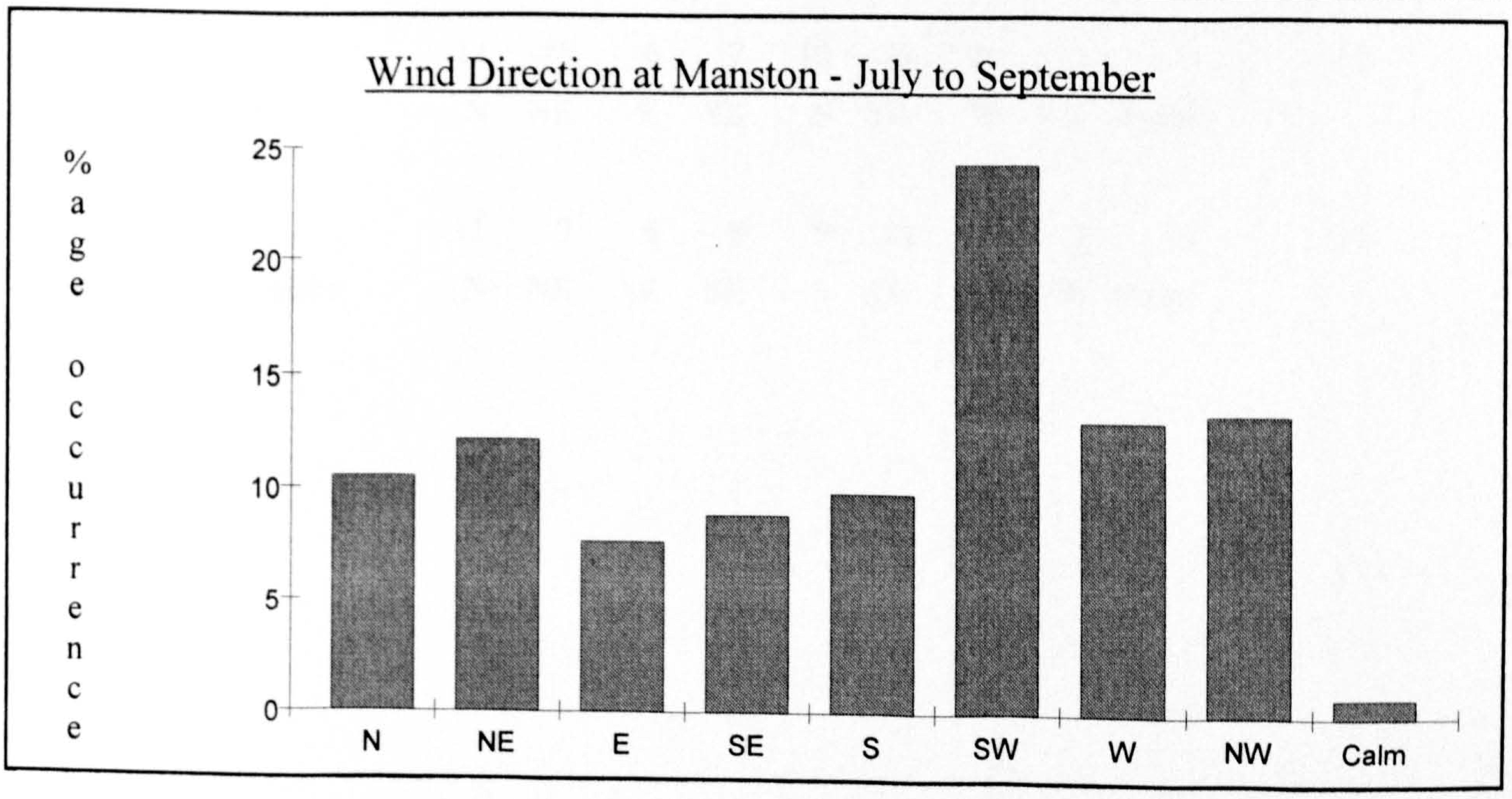

Wind Direction at Dover - April to June
%age occurrence
30
25
20
15
10
5
0
N
NE
E
SE
S
SW
W
NW
Calm


Wind Direction at Dover - July to September
%age occurrence
40
35
30
25
20
15
10
5
0
N
NE
E
SE
S
SW
W
NW
Calm

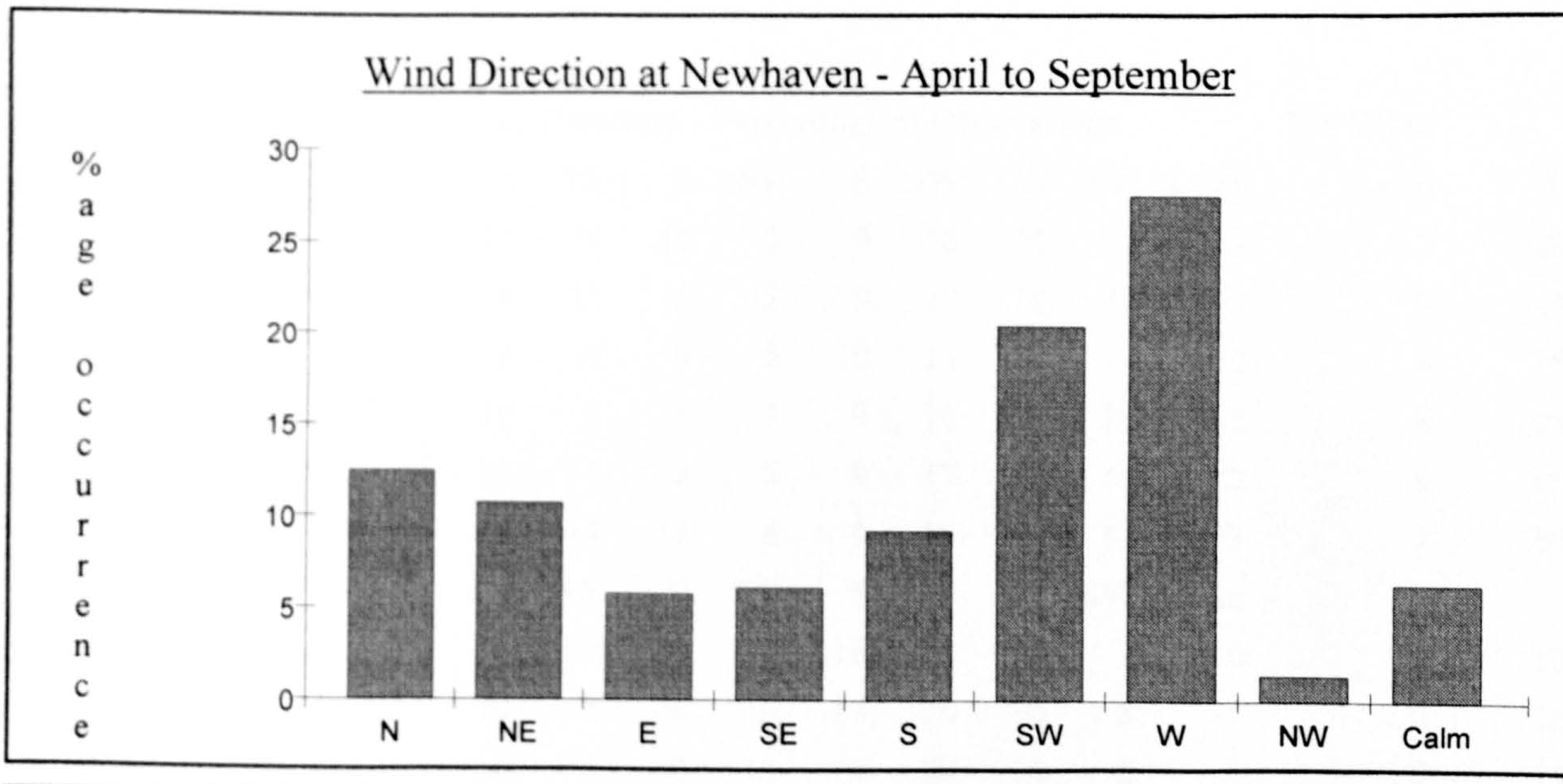
Manston	Wind Direction - Percentage of Obsevations									Mn Wind	
	N	NE	E	SE	S	SW	W	NW	Calm	Speed	Time
April	16	15	6	9	9	16	11	16	1	12	09:00
May	16	14	7	11	10	18	9	14	1	11	09:00
June	15	14	5	10	8	23	11	14	1	10	09:00
July	14	11	5	8	8	24	12	18	1	10	09:00
August	12	10	6	7	9	22	16	17	1	10	09:00
September	9	8	7	8	12	23	19	13	1	10	09:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	15	23	7	10	8	17	8	12	0	13	15:00
May	14	21	10	9	9	23	5	9	1	13	15:00
June	10	21	8	12	10	24	6	9	0	12	15:00
July	10	16	9	11	8	26	9	11	1	11	15:00
August	8	16	10	10	10	25	10	10	1	12	15:00
September	10	12	9	9	12	26	12	11	0	11	15:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	16	19	7	10	9	17	10	14	1	13	Means
May	15	18	9	10	10	21	7	12	1	12	Means
June	13	18	7	11	9	24	9	12	1	11	Means
July	12	14	7	10	8	25	11	15	1	11	Means
August	10	13	8	9	10	24	13	14	1	11	Means
September	10	10	8	9	12	25	16	12	1	11	Means
Means	12	15	7	10	9	22	11	13	1	11	
April to September	N	NE	E	SE	S	SW	W	NW	Calm		
Means	14	18	7	10	9	20	8	12	1	12	
April to June	N	NE	E	SE	S	SW	W	NW	Calm		
Means	11	12	8	9	10	24	13	13	1	11	
July to September	N	NE	E	SE	S	SW	W	NW	Calm		

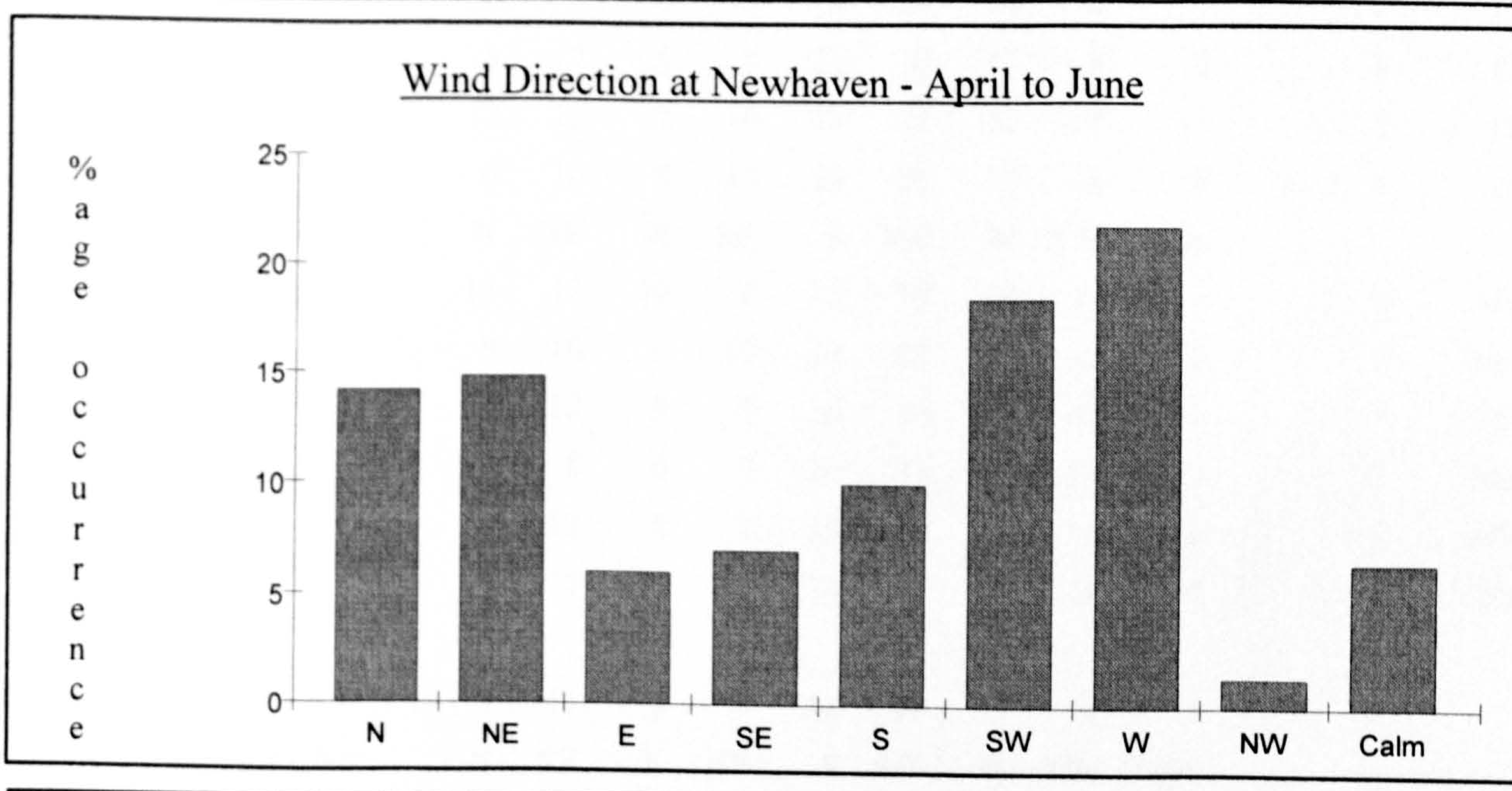

Wind Direction at Manston - April to September
%age occurrence
0
5
10
15
20
25
N
NE
E
SE
S
SW
W
NW
Calm

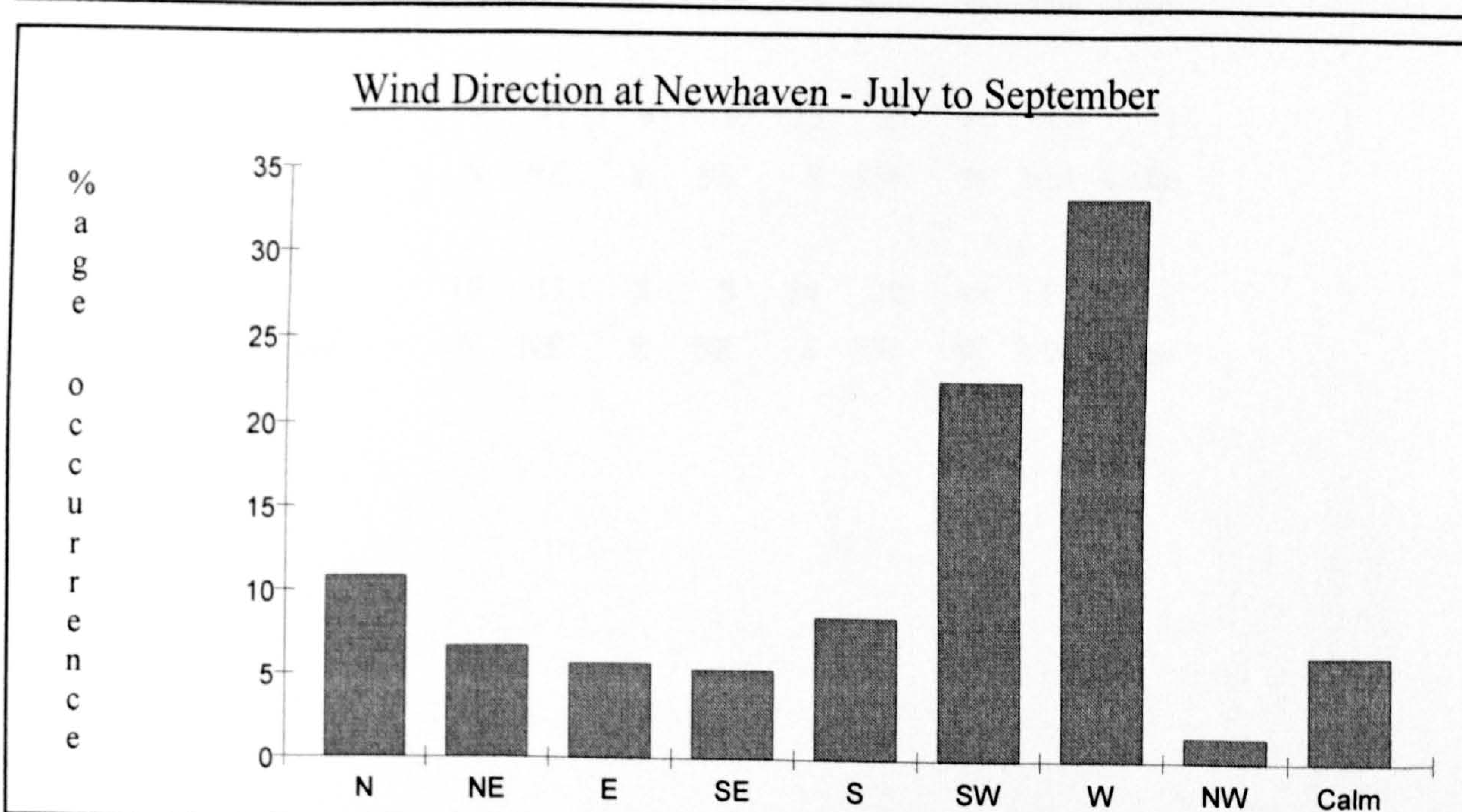

Wind Direction at Manston - April to June
%age occurrence
0
5
10
15
20
25
N
NE
E
SE
S
SW
W
NW
Calm


Wind Direction at Manston - July to September
%age occurrence
0
5
10
15
20
25
N
NE
E
SE
S
SW
W
NW
Calm

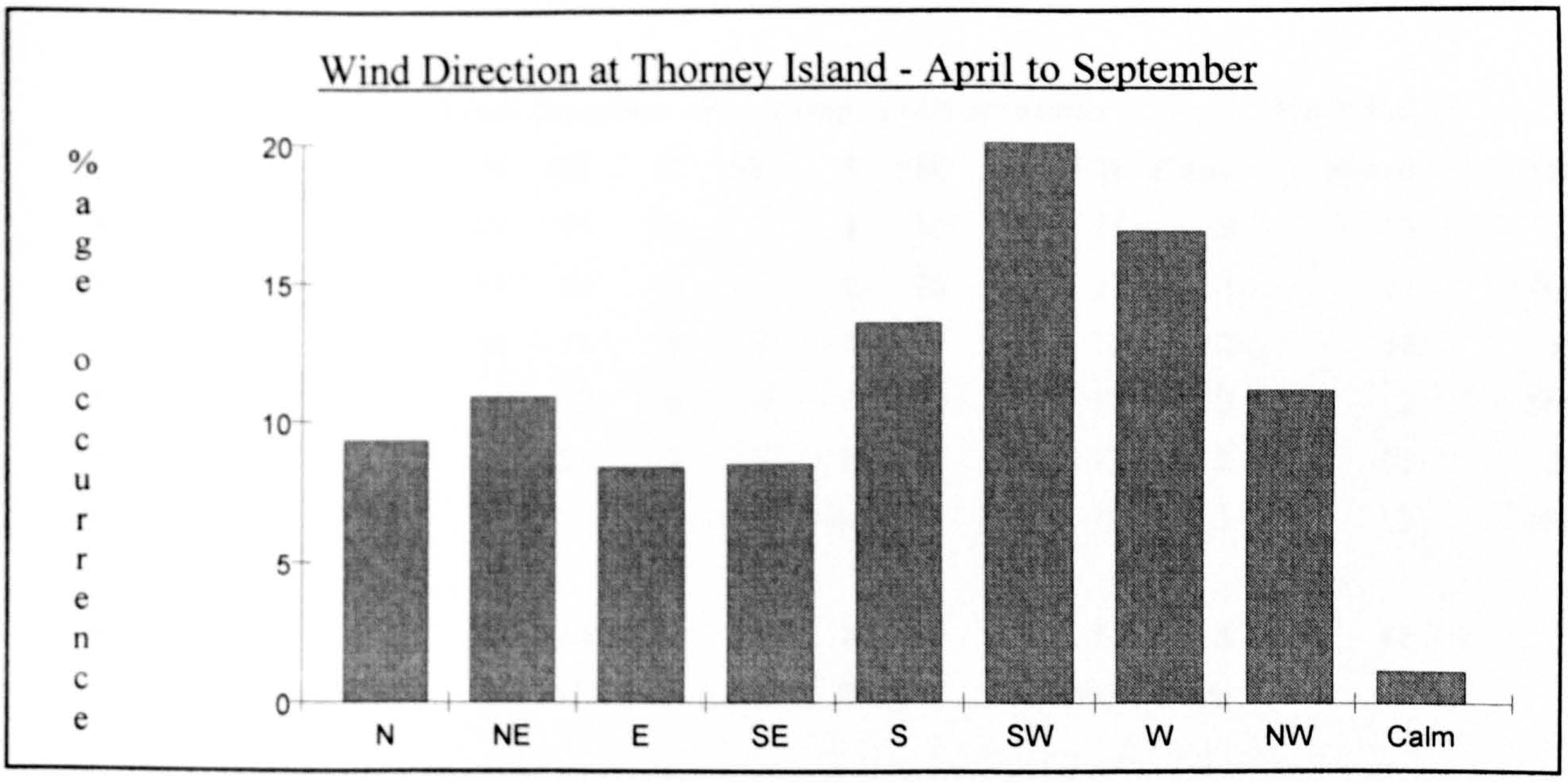
Newhaven	Wind Direction - Percentage of Obsevations									Mn Wind	
	N	NE	E	SE	S	SW	W	NW	Calm	Speed	Time
April	18	18	5	6	10	12	19	2	9	12	09:00
May	21	16	7	8	7	16	13	1	12	10	09:00
June	21	14	3	4	6	18	24	2	8	10	09:00
July	13	8	8	5	10	20	25	2	9	10	09:00
August	18	7	5	5	6	22	28	2	9	10	09:00
September	20	8	5	2	6	13	31	2	13	11	09:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	8	15	9	9	11	16	25	2	4	13	15:00
May	10	14	7	10	16	21	19	0	3	12	15:00
June	7	12	5	5	10	28	31	1	3	12	15:00
July	3	6	7	8	10	31	33	0	3	12	15:00
August	2	5	3	5	11	28	43	1	2	13	15:00
September	9	6	6	7	8	20	39	2	2	13	15:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	13	17	7	8	11	14	22	2	7	13	Means
May	16	15	7	9	12	19	16	1	8	11	Means
June	14	13	4	5	8	23	28	2	6	11	Means
July	8	7	8	7	10	26	29	1	6	11	Means
August	10	6	4	5	9	25	36	2	6	12	Means
September	15	7	6	5	7	17	35	2	8	12	Means
Means	13	11	6	6	9	20	28	1	6	12	
April to September	N	NE	E	SE	S	SW	W	NW	Calm		
Means	14	15	6	7	10	19	22	1	7	12	
April to June	N	NE	E	SE	S	SW	W	NW	Calm		
Means	11	7	6	5	9	22	33	2	6	12	
July to September	N	NE	E	SE	S	SW	W	NW	Calm		

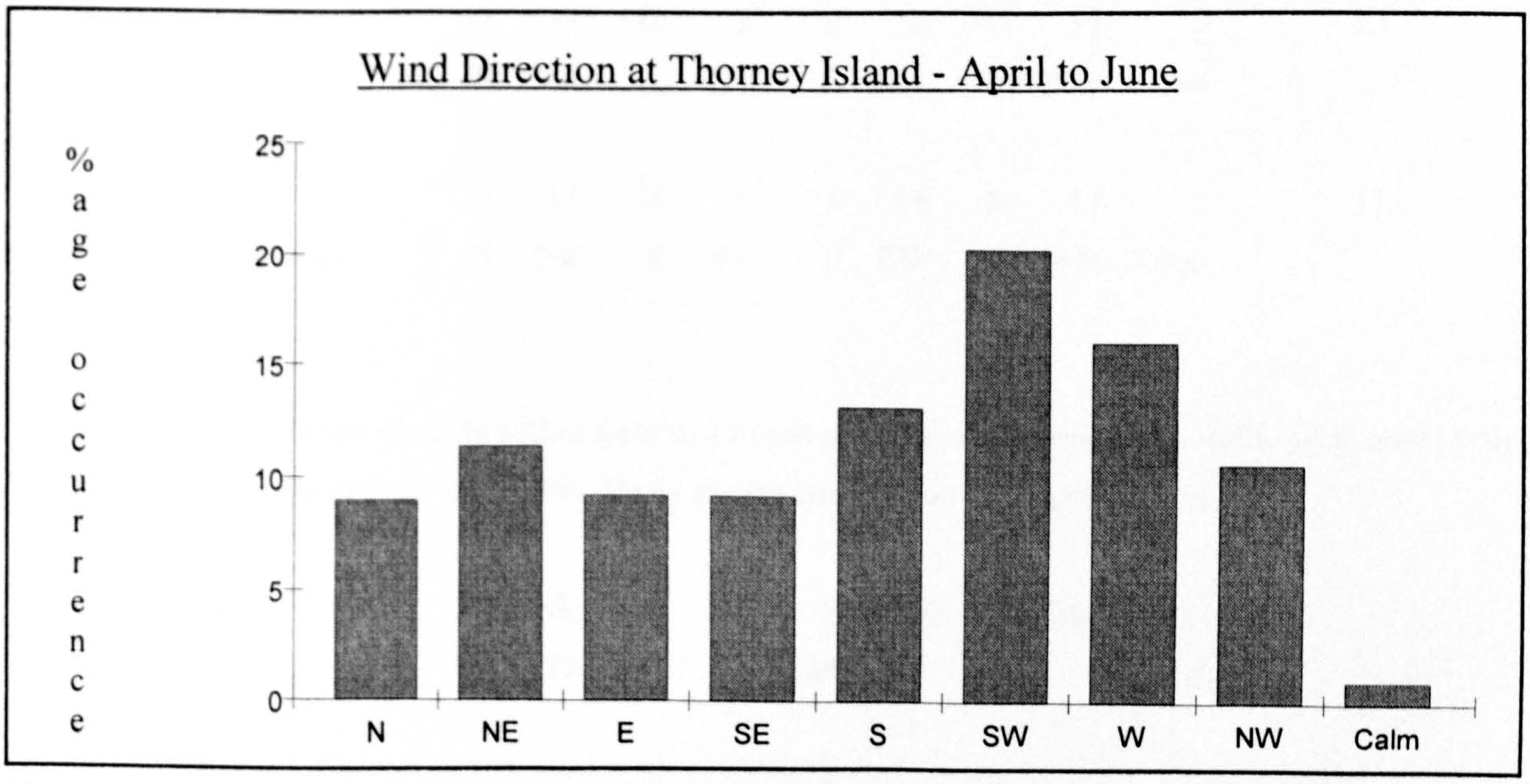

Wind Direction at Newhaven - April to September
%age occurrence
0
5
10
15
20
25
30
N
NE
E
SE
S
SW
W
NW
Calm

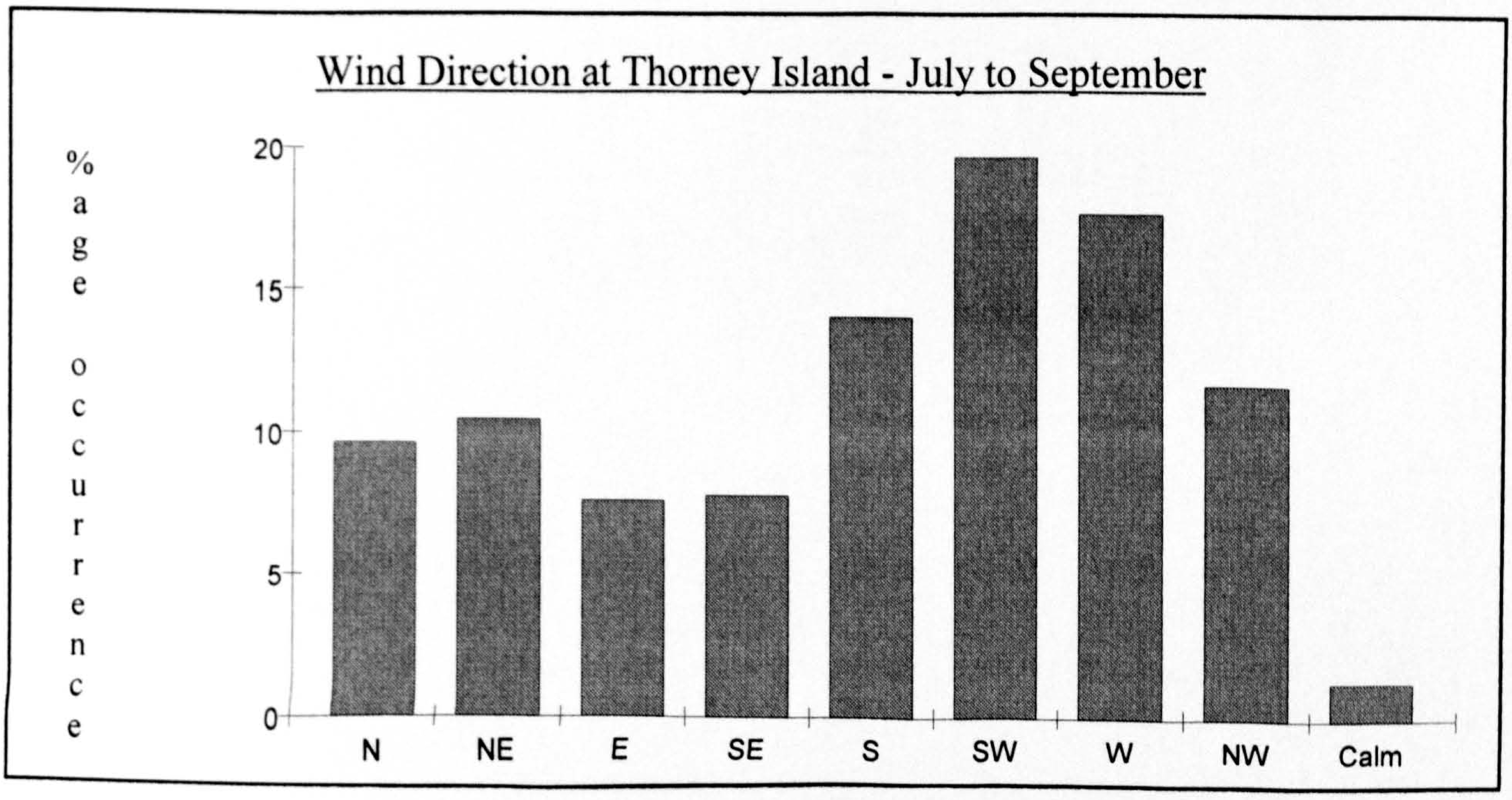

Wind Direction at Newhaven - April to June
%age occurrence
0
5
10
15
20
25
N
NE
E
SE
S
SW
W
NW
Calm


Wind Direction at Newhaven - July to September
%age occurrence
0
5
10
15
20
25
30
35
N
NE
E
SE
S
SW
W
NW
Calm

Thorney Island	Wind Direction - Percentage of Obsevations									Mn Wind	
	N	NE	E	SE	S	SW	W	NW	Calm	Speed	Time
April	11	14	10	9	9	16	16	14	1	7	09:00
May	8	12	9	12	9	19	15	15	1	6	09:00
June	8	16	9	8	10	14	19	14	2	6	09:00
July	10	9	7	7	9	16	21	19	2	6	09:00
August	12	11	8	5	9	17	20	16	2	6	09:00
September	10	14	11	8	9	15	18	12	3	7	09:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	11	10	10	7	16	21	18	7	0	8	15:00
May	10	8	9	9	14	26	15	8	1	7	15:00
June	6	8	8	10	21	26	14	6	1	7	15:00
July	8	7	5	7	22	26	17	8	0	8	15:00
August	12	12	7	10	17	21	13	7	1	8	15:00
September	6	10	8	10	18	23	17	8	0	8	15:00
	N	NE	E	SE	S	SW	W	NW	Calm		
April	11	12	10	8	13	19	17	11	1	8	Means
May	9	10	9	11	12	23	15	12	1	7	Means
June	7	12	9	9	16	20	17	10	2	7	Means
July	9	8	6	7	16	21	19	14	1	7	Means
August	12	12	8	8	13	19	17	12	2	7	Means
September	8	12	10	9	14	19	18	10	2	8	Means
Means	9	11	8	9	14	20	17	11	1	7	
April to September	N	NE	E	SE	S	SW	W	NW	Calm		
Means	9	11	9	9	13	20	16	11	1	7	
April to June	N	NE	E	SE	S	SW	W	NW	Calm		
Means	10	11	8	8	14	20	18	12	1	7	
July to September	N	NE	E	SE	S	SW	W	NW	Calm		


Wind Direction at Thorney Island - April to September
%age occurrence
20
15
10
5
0
N
NE
E
SE
S
SW
W
NW
Calm

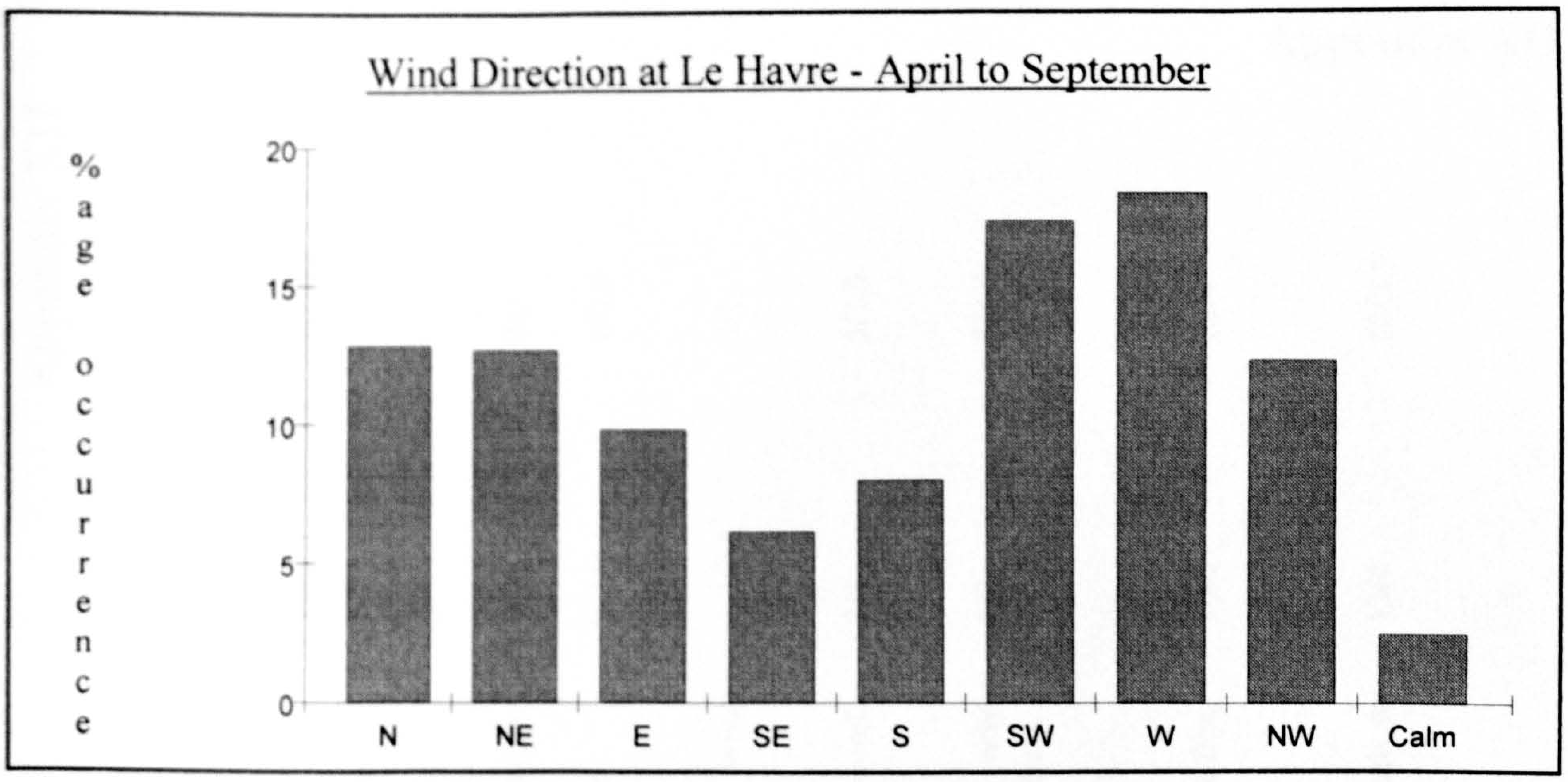

Wind Direction at Thorney Island - April to June
%age occurrence
25
20
15
10
5
0
N
NE
E
SE
S
SW
W
NW
Calm

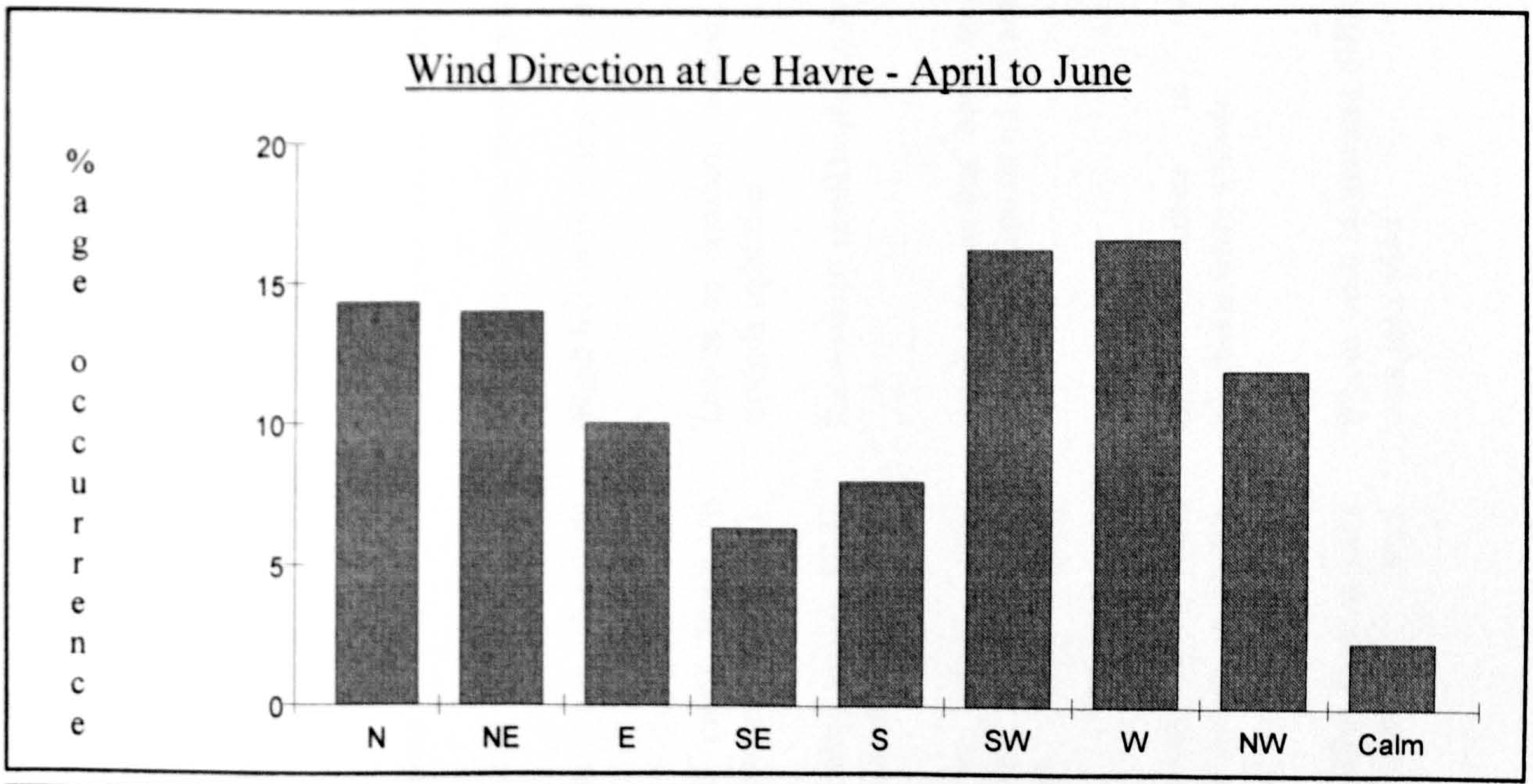

Wind Direction at Thorney Island - July to September
%age occurrence
20
15
10
5
0
N
NE
E
SE
S
SW
W
NW
Calm

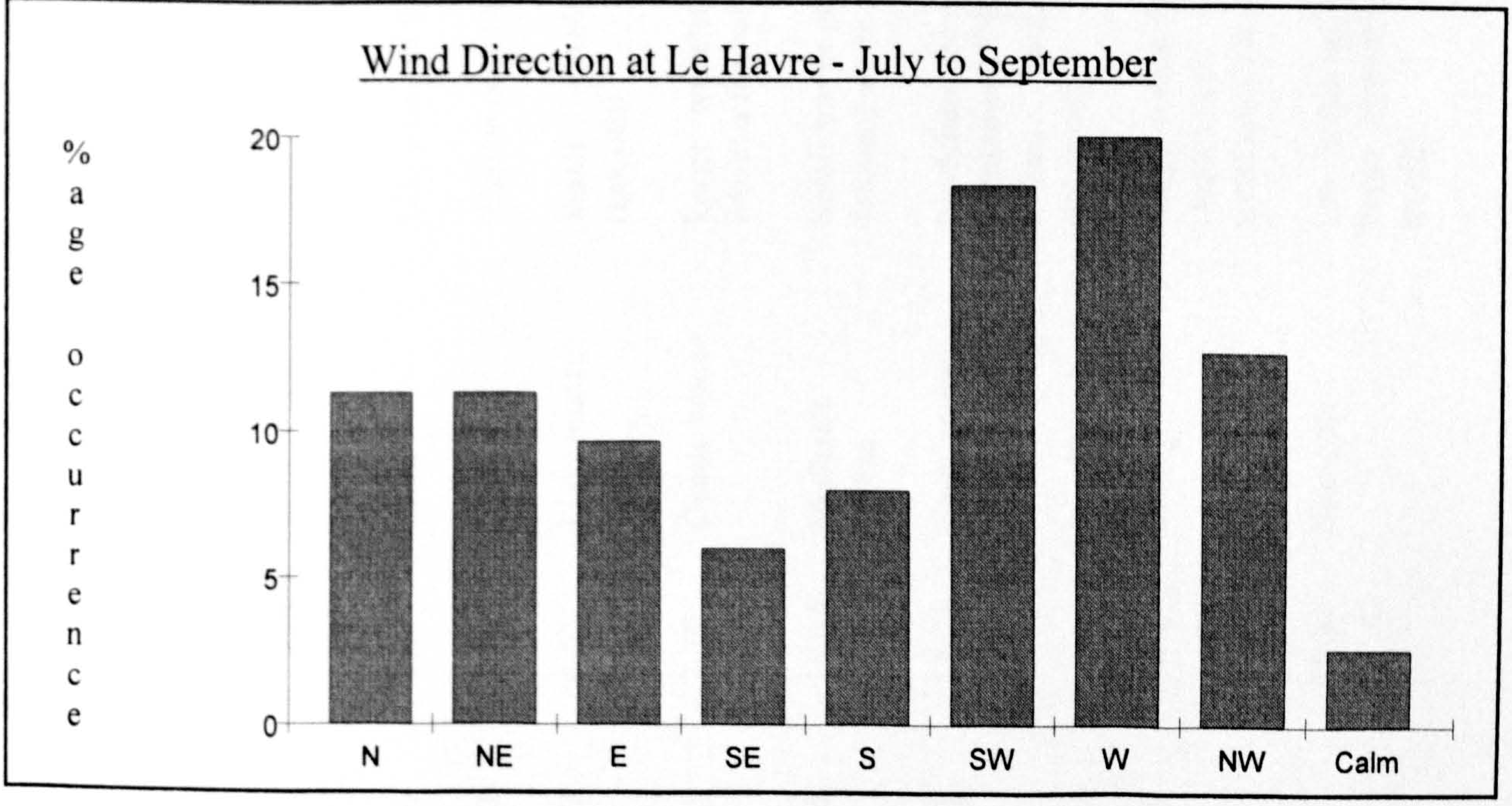
Le Havre	Wind Direction - Percentage of Obsevations									Mn Wind	
	N	NE	E	SE	S	SW	W	NW	Calm	Speed	Time
April	13	15	12	7	8	16	16	11	2	13	See
May	14	14	10	7	9	16	16	11	3	11	Note
June	16	13	8	5	7	17	18	14	2	12	See
July	14	12	8	4	6	17	21	15	3	12	Note
August	10	11	9	5	8	20	22	13	2	13	See
September	10	11	12	9	10	18	17	10	3	13	Note
Means	13	13	10	6	8	17	18	12	3	12	
April to September	N	NE	E	SE	S	SW	W	NW	Calm		
Means	14	14	10	6	8	16	17	12	2	12	
April to June	N	NE	E	SE	S	SW	W	NW	Calm		
Means	11	11	10	6	8	18	20	13	3	13	
July to September	N	NE	E	SE	S	SW	W	NW	Calm		

Note: At Le Havre wind direction data are based on observations made at 0600, 1200 and 1800; wind speed data at 0600 and 1200. Daily means have, therefore, been taken.

Aggregated	N	NE	E	SE	S	SW	W	NW	Calm
	13	13	7	6	10	23	16	9	3


Wind Direction at Le Havre - April to September
%age occurrence
0
5
10
15
20
N
NE
E
SE
S
SW
W
NW
Calm


Wind Direction at Le Havre - April to June
%age occurrence
0
5
10
15
20
N
NE
E
SE
S
SW
W
NW
Calm


Wind Direction at Le Havre - July to September
%age occurrence
0
5
10
15
20
N
NE
E
SE
S
SW
W
NW
Calm

Appendix XII

Beaufort Scale

Force	Mean Speed (knots)	Description	State of sea (description in brackets)	Ashore	Probable wave height ft/m	Probable max. wave height ft/m
0	0-1	Calm	Like a mirror (calm)	Calm; smoke rises vertically	0/0	0/0
1	1-3	Light air	Ripples only (calm)	Direction of wind shown by smoke	0/0	0/0
2	4-6	Light breeze	Small wavelets not breaking (smooth)	Wind felt on face; leaves rustle	0.7/0.1	1/0.3
3	7-10	Gentle breeze	Large wavelets, crests begin to break; a few white horses (smooth)	Leaves in constant motion; wind extends light flag	1.2/0.4	3/1
4	11-16	Moderate breeze	Small waves growing longer; fairly frequent white horses (slight)	Raises dust; small branches moved	3/1	5/1.5
5	17-21	Fresh breeze	Moderate waves, taking more pronounced form; many white horses, perhaps some spray (moderate)	Small trees in leaf begin to sway, crested wavelets on inland waters	6/2	8/2.5
6	22-27	Strong breeze	Large waves forming; white foam crests more extensive; probably some spray (rough)	Large branches in motion; telephone wires whistle	10/3	13/4
7	28-33	Near gale	Sea heaps up; white foam streaks begin blowing from crests (very rough)	Whole trees in motion; difficult to walk into wind	13/4	18/5.5

Appendix XII

Force	Mean Speed (knots)	Description	State of sea (description in brackets)	Ashore	Probable wave height ft/m	Probable max. wave height ft/m
8	34-40	Gale	Moderately high waves of greater length; crests break into spindrift, with foamy streaks (high)	Twigs break off trees; wind impedes progress	18/5.5	25/7.5
9	41-47	Severe gale	High waves with tumbling crests; dense streaks of foam; spray may affect visibility (very high)	Slight structural damage occurs (e.g. slates, chimney pots)	23/7	33/10
10	48-55	Storm	Very high waves with long overhanging crests and dense streaks of foam making surface of the sea white; heavy tumbling sea; visibility affected (very high)	Seldom experienced inland; trees uprooted, structural damage occurs	30/9	41/12.5
11	56-63	Violent storm	Exceptionally high waves; sea completely covered with long white patches of foam along direction of wind; visibility affected (phenomenal)	Very rarely experienced; wide spread damage caused	36/11	52/16
12	64 plus	Hurricane	Air filled with foam and spray; sea white with driving spray; visibility very seriously affected (phenomenal)	-	46/14	-

Notes: 1. Wind speed is taken as measured at 33 feet above sea-level.

2. The wave heights above are only a guide to what may be expected in the open sea, away from land.

Source: Best (1990, 237).

Glossary

Ahull: A sailing ship is said to be lying ahull, when she is drifting without sails set, a tactic adopted in storm conditions; she might alternatively be described as 'under bare poles'.

Angle of incidence: Angle at which an airflow (water flow) meets the longitudinal axis of an aerofoil (hydrofoil).

Apparent wind: Wind as observed and measured from a moving vessel, the movement of which alters the speed and direction of the wind as it affects the vessel.

Aplustre: In Graeco-Roman ships, the curved decorated stern.

Artemon: In Graeco-Roman ships, fore sail or the mast on which it is hoisted.

Aspect ratio: The ratio of the width of a sail to its height. The term is used of any aerofoil.

Augustus: Roman Imperial title; under Diocletian's reforms in the late third century it designated the two senior members of the Tetrarchy.

Azimuth: True horizontal bearing of a heavenly body; one of two elements defining the apparent position of the body relative to the observer, the other being its altitude above the horizon.

Back: Of the wind, to shift anti-clockwise, against the sun. The opposite of veer (*q.v.*).

Beam reach: Point of sailing when the wind comes from the beam or side of the vessel.

Beat: To sail close-hauled (*q.v.*): Old English *bœtan*; Old Norse *beita* - cognate with *beitiass* (*q.v.*).

Beaufort scale: Scale devised by Admiral Beaufort to denote the strength of the wind in numbered stages from 0 (calm) to 12 (hurricane). Originally defined in terms of observed criteria (sea state or the point at which frigates reefed their topsails), it is now defined in terms of ranges of wind speeds measured in knots (Appendix XII).

Beitiass: (Norse) spar used to hold the luff of a square sail taut to the wind when close hauled; seems to be akin to a spinnaker pole (Old Norse *beita*: to beat, to sail close to the wind).

Block coefficient: A speed assessment coefficient (∇/BLT; where ∇ = displacement volume, B = waterline beam, L = waterline length and T = draft). The block coefficient measures the proportion of the rectangular block defined the waterline length, the waterline beam and the draft which is taken up by the underwater body of the hull. Its theoretical maximum of 1.00 would represent a hull with a rectangular block-shaped underwater body. A low value is indicative of good speed potential. A value higher than *c.* 0.40 would appear to distinguish Romano-Celtic ships from those of the Nordic tradition.

Bowse: To pull hard (Webster, 1862, 142).

Burghal Hidage: Early tenth-century document listing the *burhs* or strongholds established for the defence of Wessex and the hidage (*q.v.*) assigned to the maintenance of each.

Caesar: Roman Imperial title; under Diocletian's reforms in the late third century it designated the two junior members of the Tetrarchy, deputies to the *Augusti*.

Camber: The degree of curvature in an aerofoil, expressed as a ratio of the depth of the curvature to the (average) chord (*q.v.*).

Carvel-built: Built with the hull planks flush (see Clinker-built); the term may also be used of hulls built 'frame-first', where the planking is laid flush on a pre-constructed skeleton of frames and timbers.

Centre of Effort (C.E.): Point on an aerofoil, for example a sail, through which the total aerodynamic force is considered to act.

Centre of Lateral Resistance (C.L.R.): Point on the fore-and-aft cross-section of the underwater body of a vessel, through which the total hydrodynamic force is considered to act.

Ceol: See Keel.

Chord: distance (average) between the luff and leach (*q.v.*) of a sail; distance between the leading and trailing edge of any aerofoil.

Clinker-built: Built with planks or strakes overlapping; method used, in particular, in north-west Europe in ships built in the Nordic tradition.

Close-hauled: A sailing ship is said to be close-hauled when she is sailing as close to the direction of the wind as she can without losing the forward drive of her sails.

Codicaria: A type of Tiber river craft of the Roman period used to transport cargoes from Ostia to Rome (Casson, 1965, 43-9).

Cog: Single-masted, flat-bottomed, straight-stemmed cargo vessel used in Frisia and Scandinavia from the beginning of the second millennium A.D.

Course: In a square-rigged ship, the lowest sail on a mast; thus fore course for the lowest sail on the foremast.

Curragh: Open craft built in the Celtic tradition of hides stretched over a wooden and wicker frame and used in the waters off western Ireland; in modern times covered with tarred canvas, propelled by oars, and in larger vessels by sail. Described in *The Voyage of St. Brendan*, 4.

Deadrise: Angle at which the garboard strake (*q.v.*) lies to the horizontal (McGrail, 1987, 114).

Deadweight: Weight of crew, equipment, victuals and cargo.

Declination: Angular distance of a heavenly body, such as the sun, measured north or south from the celestial equator.

Departure: Special term used to denote distance east/west measured in nautical miles; to be distinguished from dLong (*q.v.*), which is measured in degrees and minutes.

Displacement: Measure of the water displaced by a floating vessel; it can be expressed in terms of the volume or of the weight of the water displaced.

Displacement trap: Maximum speed that can be obtained by a vessel without planing; usually considered to be defined by the formula of 1.4 times the square root of the waterline length in feet ($V = 1.4\sqrt{L}$ where V = water speed in knots and L = waterline length in feet).

dLat: difference in latitude, measured either in degrees and minutes or nautical miles (a nautical mile is defined as a minute of latitude).

dLong: difference in longitude, measured in degrees and minutes. Unlike dLat (*q.v.*), it cannot be measured in nautical miles, because a minute of longitude varies in length according to latitude; it is equivalent to a nautical mile (*q.v.*) only at the equator.

Draft: Maximum depth of the underwater body of a ship's hull; 'when the draft of the vessel exceeds the depth of the water, the ship is most assuredly aground.'

Drift: See Set and Drift.

Eustatic: Of sea-level movements, world-wide, as opposed to local or regional.

Force: Of wind strength, see Beaufort scale.

Freeboard: Vertical distance from the waterline to the gunwale when the hull is upright.

Front: Boundary in the atmosphere between warm and cold air masses; a characteristic feature of Atlantic depressions, defined by Lamb (1988, 266) as 'essentially a line or narrow zone of discontinuity in the horizontal distribution of temperature, with an associated discontinuity in the barometric pressure and wind fields'. An advancing front in which cold air is displaced by warm is called a warm front; it will be followed by a cold front marking the advance of cold air displacing the warm air behind the warm front. The mass of warm air between the fronts is known as the warm sector.

Galleass: Galley, rigged with masts and sails, as well as oars.

Garboard (strake): Strake or plank lying adjacent to the keel.

Great circle: A circle on the surface of a sphere whose centre coincides with the centre of the sphere. A route taken along a great circle represents the shortest distance between two points on the earth's surface. See Rhumb line.

Grown timber: A wooden component fashioned from a part of a tree whose growth approximates to the shape of the final component; for example, a stem post might be carved from a suitably curved branch, or a framing timber from part of the trunk and an adjacent branch. McGrail has suggested that the supply of curved timbers might have been increased by artificially constraining branch growth (1987, 23-4).

Gunwale: Strake forming the upper edge of the side of a ship.

Gybe: Alter course when sailing before the wind so as to bring the wind from one quarter to the other; used particularly of fore-and-aft rigged ships, when the manoeuvre requires sails and booms to pass from one side of the ship to the other. As a noun, it defines a point of sailing with the wind on one quarter or the other; to be on the port gybe means to be sailing with the wind on the port quarter.

Hand: To take in (of sail).

Hidage: The value in hides of a land holding in Anglo-Saxon England; a hide was the basic unit of land division, deemed to be the holding that would support a peasant and his household.

Humber keel: Traditional inshore cargo carriers, plying the waters centred on the Humber estuary until the twentieth century and characterised by a single-masted rig with two square sails, a main and a top sail; they may have evolved from the ships used by the fifth/sixth-century Anglo-Saxon migrants (see Keel (*ceol*).

Humber sloop: Version of the Humber keel, with a single forward located mast rigged fore-and-aft with a gaff mainsail.

Induced drag: Drag caused by vortices formed at the head of a sail (or tip of a wing); the greater the aspect ratio (*q.v.*), the smaller their effect in proportion to the total area of the sail (or wing). Also caused in water by vortices forming at the bottom of the keel and rudder.

Intaglio: Gem with incised design.

Isobar: Line on a weather chart joining points with the same barometric pressure.

Keel (*ceol*): Name associated by the British priest Gildas with the ships of the Anglo-Saxons of the Migration Period, represented by the Sutton Hoo ship; the term appears in medieval documents, such as toll lists, as a ship type and is still used in modern times to designate traditional craft in England such as the Humber keel.

Ketch: A two-masted sailing ship, whose aftermost mast (termed mizzen) is shorter than her main mast; she differs from a yawl in having her mizzen stepped forward of the stern post.

Knarr: Ocean-going cargo ship in the Nordic tradition.

Knot: Speed of one nautical mile an hour; the term derives from counting the number of knots in the log line passing over the stern of the ship in a specified time; the log was a triangular piece of wood weighted so as to float vertically in the water and attached to the end of the log line which unwound from a reel held aloft; the time was measured by the turn of a sand glass; all in all a cumbersome three-man operation.

Lap joint: Joint created by overlapping the two pieces of timber to be joined; to be distinguished from a butt joint, in which they are secured end to end, and a scarf (*q.v.*).

Leach: The trailing edge of a sail; opposite edge to the luff (*q.v.*).

Lee: Downwind; the side of the ship opposite the direction from which the wind is blowing; protection from the wind.

Lee helm: The tendency of a sailing ship to turn downwind when the helm is released; the opposite of weather helm (*q.v.*).

Lee shore: Shore towards which the wind is blowing.

Leeway: Sideways movement of a vessel under the influence of the wind; measured as the difference in degrees between the ship's track through the water and her heading.

Liburnian: Roman warship propelled by two banks of oars and adapted from the pirate craft of the Liburnians, inhabitants of the Dalmatian coast.

Luff: The leading edge of a sail; the vertical edge which first enters the airstream. With square sails and spinnakers the luff can change according to the tack on which the ship is sailing. As a verb, to luff means to steer more closely to the wind.

Marine transgression: Flooding of low-lying coastal areas arising from a rise in sea-level.

Mast step: Socket or fitment intended to accept the heel or lower end of the mast.

Metacentric height: A key measure of stability; defined as the distance between centre of gravity and the metacentre (basically the point on the vertical centre line of the hull through which the centre of buoyancy acts - see Fig. 17 in Chapter VIII, 79). For a ship to be stable, it is not necessary for the centre of gravity to be below the centre of buoyancy, but it must be below the metacentre.

Midships coefficient: A speed assessment coefficient (A/BT; where A = area of midships underwater cross-section, B = waterline beam and T = draft), which measures the proportion of the rectangle defined the waterline beam and the draft which is taken up by the midships section. A low value is indicative of good speed potential (< 0.60 - McGrail, 1987, 197).

Mizzen: The aftermost mast of a ketch (*q.v.*) or of any three-masted sailing ship.

Mortice: Slot cut in the edge of a plank to allow the insertion of a tenon (*q.v.*) to hold it flush to an adjoining plank; mortice-and-tenon joints were used in Greek and Roman shipbuilding in antiquity to create the flush-laid shell of the hull.

***Nao*:** Large armed merchantman in the Spanish Armada; deriving from the Latin word for ship (*navis*), the term applied mainly to vessels built on the Basque coast of Spain (Barkham, 1988, 158-63).

Nautical mile: Distance equivalent to the length of one degree of latitude on the surface of the earth; the average length approximates to 6080 feet, but varies slightly with latitude; divides into 10 cables of about 200 yards.

Neap tides: Tides with the least range between high and low water in each fortnightly period; occur twice a month a day or two after half moon. At neaps tidal streams are at their weakest.

Overfalls: Turbulence caused in the water flow when it is disturbed by irregularities in the sea bed. They often occur close to land, off a promontory, for example, and can be dangerous (Hewitt and Lees-Spalding, 1990, 297).

Polar diagram: Circular graph plotting ship speed for a particular wind speed against wind direction relative to the ship's bow.

Polar Coordinates: Coordinates used to define the position of a given point on a graph in terms of its linear distance from the origin of the graph and the angle between the 'x' axis and the line joining the point to the origin of the graph. In navigation the 'x' axis is north/south, the angle is defined in terms of compass direction (bearing) and the distance is measured in nautical miles and/or cables. See also Rectangular Coordinates.

Prismatic coefficient: A speed assessment coefficient (∇/AL; where ∇ = displacement volume, A = area of midships underwater cross-section and L = waterline length) which is useful for assessing the wave-making resistance of hulls at speeds equivalent to values of $V/\sqrt{L}$ (where V = water speed in knots and L = waterline length in feet) in the range of 0.6 to 1.1.

Quartering wind: Wind from a direction defined in relation to the ship concerned as between dead astern and from the beam.

Rate: Speed of a tidal stream or current, usually measured in knots.

Reach: A sailing ship is said to be on a reach when she is sailing with the wind coming from one side or other of the vessel; if the wind is blowing directly from the side of the vessel, she is said to be on a beam reach; if from forward of the beam, but not so far as to be close-hauled (*q.v.*), she is on a close reach; if she to sailing with a quartering wind (*q.v.*), she is on a broad reach.

Rectangular Coordinates: Coordinates used to define the position of a given point on a graph in terms of its linear distance from the origin of the graph along 'x' and 'y' axes set at right angles to each other. In navigation the 'x' axis is north/south (dLat - *q.v.*) and the 'y' axis is east/west and the distances are measured in nautical miles (Departure - *q.v.*) or linear degrees (dLong - *q.v.*); the system of defining position by latitude and longitude (where the origin is the intersection of the Greenwich meridian (0°)

with the equator) is the principle case of applying rectangular coordinates to navigation (Appendix IX, 206). See also Polar Coordinates.

Relative reliability factor: Term coined by McGrail (1983, 332-4) to denote the statistical assessment of the difficulty experienced on different Channel routes in the late first millennium B.C. The easiest route is given a rating of 100%; lower percentages are calculated for other passages taking into account the statistical effect of factors such as the probability of unfavourable winds and the length of the passage. The measure is relative, not absolute and assigning a rating of 100% to the easiest route does not mean that all attempted passages on that route will be successful.

Rhumb line: Course between two points along which a constant compass heading is maintained or which cuts each meridian at the same angle; to be distinguished from a Great Circle (*q.v.*), which is the shortest distance between two points on the surface of the earth.

Running: A sailing ship is said to run when she is sailing downwind.

Scarf: A joint in a strake, frame or other timber, in which the two parts overlap diagonally.

Scull: To propel a small boat using a single oar over the stern. The person sculling stands up, facing aft, and, moving the oar blade from side to side, creates a forward thrust by alternating the angle of the blade in each stroke. The method has been used to move a replica of an Athenian trireme sideways (Coates, Platis and Shaw, 1990, 31).

Set and drift: Set indicates the direction of a tidal stream; drift the distance it has moved in a given period of time.

Slenderness coefficient: A speed assessment coefficient (L/B; where L = waterline length and B = waterline beam); high values have been suggested by McGrail as an indicator of good speed potential (> 5 - 1987, 197). He has also suggested that a slenderness coefficient ≤ 5 is one of the criteria to be used to identify a specialised cargo vessel (1987, 201).

Spring tides: Tides with the greatest range between high and low water in each fortnightly period, occurring a day or two after new and full moon. At springs tidal streams are at their strongest.

Studding sail: A light-weather sail set outboard of a square sail, using an extension of its yard.

Tack: The forward lower corner of a sail; the bottom end of the luff (*q.v.*). As a verb to tack means to alter course when sailing so that the bow passes through the eye of the wind. A sailing ship is said to be on the port (or starboard) tack if the wind is blowing from her port (or starboard) side.

Tenon: Tongue to be inserted into a mortice (*q.v.*) to create a mortice-and-tenon joint; it is secured in its slot by a peg or treenail.

Tidal diamond: Position, marked on a chart, for which hourly tidal data are given; conventionally marked with a diamond.

True wind: Wind as observed and measured at a fixed point on the surface of the earth.

Under bare poles: See ahull.

Universal Time (UT): Broadly speaking, mean solar time as measured at the Greenwich Meridian (formerly GMT); however, it is derived from observations of the stars, rather than the sun, and is formally defined by a mathematical formula as a function of sidereal time (Duffett-Smith, 1988, 17-9, 174)

Vector: Mathematical concept of a line having a fixed length and a fixed direction in space, but no fixed position.

Veer: Of the wind, to shift clockwise, in the same direction as the sun. The opposite of back (*q.v.*).

Volumetric coefficient: A speed assessment coefficient (∇/L^3; where ∇ = displacement volume and L = waterline length), significant chiefly in assessing speed potential at values of $V/\sqrt{L}$ in excess of *c*. 1.1 when the effect of the 'displacement trap' (*q.v.*) comes into effect.

Weather gage: The advantage of being to windward; a warship is said to have the weather gage when she is to windward of an enemy.

Weather helm: The tendency of a sailing ship to turn into the wind when the helm is released; the opposite of lee helm (*q.v.*).

Weather shore: Shore from which the wind is blowing.

Wishbone rig: Fore-and-aft rig in which a triangular sail is spread aft from the mast by a horizontally rigged, divided spar, the so-called 'wishbone'; the sail is rigged inside the spar, the two parts of which are curved outwards to allow the sail to take up its natural camber (*q.v.*).

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In references to ancient sources the following abbreviations have been used:

Agr.	Tacitus, *Agricola.*
Ann.	Tacitus, *Annals.*
ASC	*Anglo-Saxon Chronicle.*
B. Gall.	Caesar, *De Bello Gallico.*
Calig.	Suetonius, *Gaius Caligula.*
Carmen	*Carmen de Hastingae Proelio.*
Claud.	Suetonius, *Divus Claudius.*
Dio	Dio Cassius, *Historia Romana.*
Egil.	*Egils Saga Skallagrímssonar.*
Gest. Guil.	*Gesta Guillelmi ducis Normannorum et regis Anglorum.*
Gest. N. Duc.	*Gesta Normannorum Ducum.*
Gildas	Gildas, *De Excidio Britonum.*
Hist.	Tacitus, *Histories.*
Isid. *Etym.*	*Isidori Hispalensis Episcopi Etymologiarum sive Originum Libri XX*
Iul.	Suetonius, *Divus Iulius.*
O. E. Or.	*The Old English Orosius.*
Pan. Lat.	*XII Panegyrici Latini.*
RIB.	Collingwood, R.G., and Wright, R.P., 1965, *The Roman Inscriptions of Britain*, Oxford: Clarendon Press.
Strabo	Strabo, *Geography.*
Veg. *Mil.*	Vegetius, *Epitoma Rei Militaris.*
Vesp.	Suetonius, *Divus Vespasianus.*

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