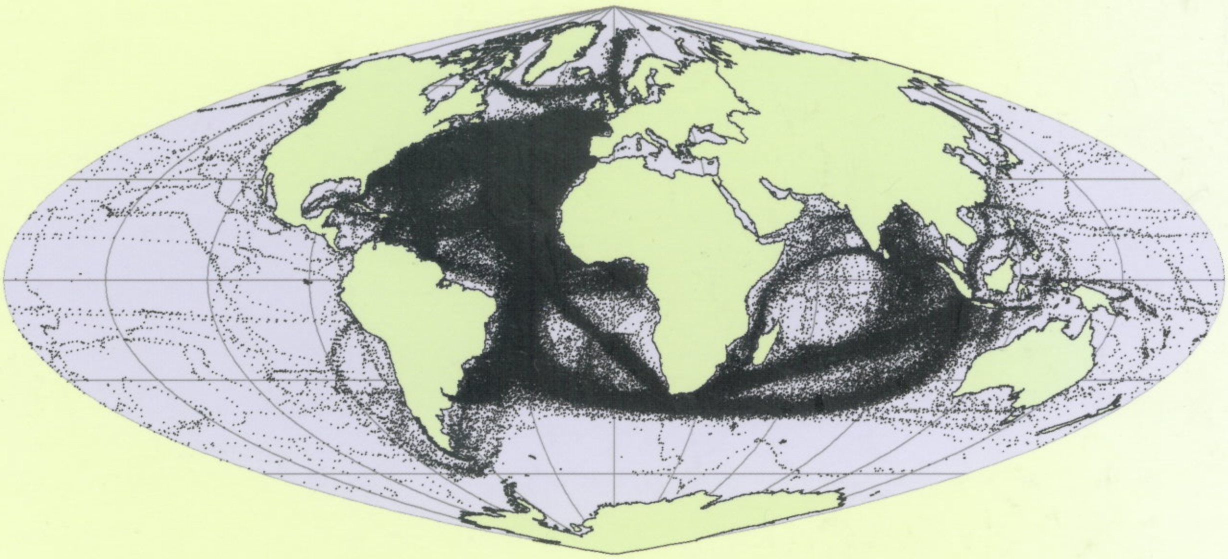
CLIWOC



Climatological database for the world's oceans: 1750 to 1850

EUR 21236

CLIWOC

Climatological database for the world's oceans: 1750 to 1850

Results of a research project
EVK1-CT-2000-00090

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2006 EUR 21236

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 2006

ISBN 92-894-8279-6

Printed in Italy

PRINTED ON WHITE CHLORINE-FREE PAPER

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FORWARD

The CLIWOC research project (Climatological Database for the World's Oceans: 1750 to 1850)[1] was funded by the European Commission as part of its 5th Framework research programme. Work began in 2000 and was completed in 2003, during which time it drew together scientists from the UK, Spain and The Netherlands with participants also from Argentina and the USA. Calling upon the documents in the archives of European nations, it demonstrated how historical papers, in this case the logbooks of ships from the long-gone 'age of sail', could be used to support and sustain important climatic research. Such logbooks contain a veritable wealth of detailed daily weather observations from all the world's oceans. From them a picture can be recreated of the climate of those times, which, coming as they did before any significant anthropogenic influence could be exerted on the climate, provide a unique opportunity to explore how the climate of the oceans behaved in 'natural' conditions. As such, logbooks offered a rare research possibility as no other source of information or supply of data for oceanic areas matches them for detail and reliability over this time period.

The project was concerned not only to contribute to the science of climatic change but to establish logbooks in their proper place as a new and important source of climatic information for that part of the world for which historical data are in such short supply - the oceans - and as a source that is far from exhausted. The information had, however, to be scrutinised with particular care. Much of it is non-instrumental and based on judgements of wind and weather made by experienced senior officers. Scientists have, in the past, been reluctant to acknowledge the importance of such data, and the project team had to offer convincing evidence of the integrity of their source. Moreover, this is a truly vast fund of information. Across Western Europe there exist over 120,000 logbooks for the study period, and many more from earlier and later years. The project team recognised the

(1) Contract number EVK2-CT-2000-00090

inevitable limitations that time imposed upon them, and confined its attention to a sample of just 10,000 of those available. As a result, the important database created by the project's efforts was designed to accommodate future work in this field by conducted by the CLIWOC team or by those who follow. The team laid the ground in this field by developing the means and methods with which the raw data, so seemingly non-scientific at first glance, can be rendered in a form of inestimable value for scientific research, the more so because all of the findings and data are freely available on the project website[2]. The project was able to conclude with preliminary conclusions of its own, and demonstrated how, for the first time, wind field patterns from this essentially pre-instrumental age can be reconstructed for the world's oceans and compared with those from more recent times to gauge the degree and character of climate change. Perhaps most encouraging of all, however, was the high level of public interest aroused by the project, with the demands of the media consuming more time than had been anticipated – but time that was willingly given for this important aspect of modern-day scientific research.

The following pages describe in more detail the background, execution and outcome of this unique research project that brought together not only the scientists but also the archived resources from several countries.

(2) www.ucm.es/info/cliwoc

ACKNOWLEDGEMENTS

Neither this book nor the CLIWOC project would have been possible without the support of a large number of people and organisations. Thanks must go to those who so ably assisted in the completion of the project through the partners of the participating national groups.

For the Spanish partners: Natalia Calvo, Guadalupe Fernández, David Gallego, Esther González, Eneko Mazo, Daniel Paredes, M. José Portela, Francisco Rubio. Pilar del Campo and Dolores Higueras at the Archivo del Museo Naval and Antonio López at the Archivo General de Indias.

For the UK partners: Dr. Clive Wilkinson (office manager) and Ellie Gatrill-Smith, Catharine Ward and Simon Bailey who worked diligently towards the successful conclusion of the abstraction of data from the logbooks at the National Maritime Museum, Greenwich, Excellent coordination with the Museum was maintained through Dr. Nigel Rigby (NMM Director of Research). Mike Salmon (University of East Anglia) performed all the calculations for the reconstruction of the circulation indices and the pressure data.

For the Dutch partners: the abstraction process was carried out by Esther Balkestein, Florie Barnhoorn, Pauline Beckers, Denise Berck, Frank Boekhorst, Chantal Dekker, Inge Hickmann, Niels Hupkes, Roel Huttenga, Maarten Koek, Renate Meijer, Bruni Oehlers, Simone Pathuis, Rob de Rooij, Jolanthe Schretlen, Ronald Schurink, Marja Segers, René Snoey Kiewit, Toni Spek, Tineke Tegelaers, Theo Tieken, Pim Vente, Eric Verlinde, Rolf de Weijert; Netherlands Institute for Scientific Information Services (NIWI): Richard Bos, Sirius Bosch, Dr. Peter Doorn, Drs. Berry Feith, Iolando da Mata Brito; Nationaal Archief: Suzanne Barbier, Liesbeth Keijser, Joop Korswagen, Ton van Velzen; Others: I. van den Bout, Prof. Dr. Femme Gaastra, H.A. Hachmer, Irene Jacobs, Drs. W. Kerkmeijer, Juliette Uitdenbogaard, W. Visser and Frits Koek (technical project leader)

For the Argentinean partners: Carlos Baez, who worked diligently on the abstraction of data from the French and Spanish logbooks, and Fabian Diaz, who contributed to the abstraction of data from French logbooks. Particular mention must also be made of the Executive Secretary of the Centro Regional de Investigaciones Científicas y Técnicas of Mendoza – Argentina (Ing. Carlos Wuilloud), who lent the microfilm readers and made special provision for the completion of the work.

The project could not have been conducted without the help of a large number of additional individuals and organisations. We are pleased to acknowledge the assistance of the following: our two official advisers, Dr. David Parker (Hadley Centre, UK Met Office) and Dr. Henry Diaz (NOAA), the staff at the National Maritime Museum (Greenwich), the British Library, the Public Record Office (Kew), the School of Earth Sciences (University of Leeds), Archivo del Museo Naval (Madrid), Archivo General de Indias (Seville), the Nationaal Archief of the Netherlands (The Hague), and the staff of the Netherlands Institute for Scientific Information Services (Amsterdam).

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INTRODUCTION

CLIWOC: A CLIMATOLOGICAL DATABASE FOR THE WORLD'S OCEANS

(1750 to 1850)

This edition has been prepared at the request of the European Union. It describes how one of their RTD Framework V funded projects was prepared and carried to its successful conclusion. It provides an example of international and interdisciplinary research that has provided a new and important source of climatic information and simultaneously has captured the imagination and interest of people far beyond the academic community for whom it was originally intended. In so small way it has brought modern science closer to the general public.

The members of the CLIWOC team gratefully acknowledge the support of the EU and their staff through this project, and for the opportunity to convey their thoughts, views and findings to a wide readership through this volume.

Introduction and background

Twenty years ago the study of the climate of the past centuries was a matter of largely academic interest. Since then, growing concerns about the causes and the consequences of climatic change and, in particular, of man-induced global warming have aroused interest in the question of climatic change at the decadal and century time-scales. Whilst climatic modellers have endeavoured to provide ever-clearer predictions of how the planet's climate will evolve over the next century, scientists have also developed new techniques and discovered new sources of data with which we can understand the nature of past climatic change in the industrial and pre-industrial periods. These methods and sources have allowed us to glimpse the nature of climatic change at the time scale of thousands, if not tens of thousands, of years. Information from such diverse sources as ice cores, tree rings, corals, sea floor sediments as well as the short-term instrumental record, whilst distinct in their many ways, compliment each other in providing a collective picture of how the Earth's atmosphere responds to equally diverse influences both internal (volcanic dust, greenhouse gases etc.) and external (variable levels of solar activity, orbital variations and cosmogenic) influences. Wide-ranging though these sources for information on past climates might be, they cannot provide the comprehensive and detailed view of the atmosphere that scientists demand. For example, data may be limited in the degree of temporal detail that they can provide; ice core and sea bed sediment data, though matchless in the length of time scale that they embrace, are limited in temporal resolution to time scales of years, decades or centuries. No less incomplete is the geographic coverage. In short, scientists have an unquenchable thirst for climatic data that cannot yet be fully satisfied. The CLIWOC project, responding to this demand, has identified and explored a new source of climatic data that, whilst limited to little more than the past three centuries, offers unique advantages of a temporal scale of resolution that is daily, combined with a geographic range that is nearly global.

This new source of information is formed by the logbooks and journals kept by ships' officers in what might best be termed 'the age of sail'. Their detailed character and manner of preparation and survival will be discussed later, but one of the most remarkable features of this source is the very large number - over 120,000 - that have survived from what might be termed the 'pre-instrumental' period before 1850, some dating back to the mid-seventeenth century. Each contains a daily record of the ships' activities and includes information on the prevailing weather. Collectively they represent an estimated twelve million days of potentially valuable climatic data. These documents are to be found in the archives of many European nations but, most abundantly, in those of the countries that once held imperial sway over much of the globe; Great Britain, France, Spain and The Netherlands. In contrast to contemporary and many later sources, they contain information for the weather and climate of the oceanic regions. In this sense, and quite without design, the many ships engaged in the interests of their respective nations behaved as in informal network of weather observatories. The information that they gathered, whilst non-instrumental, is known was shown by the project to be reliable, and sufficient of it resides in the archives to provide a meteorological picture of extraordinary detail. In notable contrast to many studies, the major problem was posed not by any shortage of data but by an abundance so great as to present a significant logistical challenge of abstraction and digitisation. The following pages describe the nature of the CLIWOC project, its planning, strategy and results.

Origins of the CLIWOC project

A number of researchers, most notably the late Professor Hubert Lamb, had suggested the importance of logbooks as a source of climatic information, but they had been used only in a limited fashion, commonly to supplement reconstructions using land-based observations. No comprehensive review of their content, quality and availability had been made. The original inspiration to undertake such an enterprise came from the INM/NOAA funded international workshop organised in Toledo, Spain, in September 1997 on the theme of "digitisation and preparation of historical surface marine data and metadata" (Diaz and Woodruff, 1999). From this meeting came the idea of bringing together researchers from across Europe to examine the availability of logbook data for the 'pre-instrumental' period. It was evident that a vast accumulation of instrumental data was being collated through the agency of COADS (now ICOADS) but that no significant attention was being given to pushing the record, albeit with non-instrumental information, back into the eighteenth and early nineteenth centuries – periods for which it was made evident there were a notable number of logbooks. Exactly how many was not known at the outset. Neither was it evident where they were to be found.

Informal contacts and meetings soon made clear the vast resource that had hitherto lain untouched by climatologists. Notable collections of logbooks were identified in

The Netherlands, Spain, France and the United Kingdom. A number of preliminary small scale studies undertaken independently by team members suggested the data to be valuable for the purposes of climatic reconstructions, while the geographic range, which included the North and South Atlantic and the Indian Oceans offered scope for a geographically wide-ranging study if attention were confined to the period 1750 to 1850; the former marking the establishment of near-global empires by a number of nations (and a corresponding coverage of logbooks), and the mid-nineteenth century seeing the beginnings of steam powered sailing and the gathering of extensive, but instrumentally-based, observations.

A team of British, Dutch, Spanish and Argentinean partners presented a proposal to the European Union under their RTD Framework V research programme for funds to pursue logbook-based studies. As the project title indicates, the primary concern was to produce a database using this source that would be freely available for the scientific community to use and, equally importantly, to develop. The latter point is significant because it was apparent from the outset that it would be impossible to recover data from all available logbooks, and only a relatively small, carefully selected, proportion could be used at this stage. Nevertheless, the stated objectives of CLIWOC, as they appeared in the bid document, are worth restating:

To produce and make freely available for the scientific community the world's first daily oceanic climatological database for the period 1750 to 1850.

To realise the potential of the database to provide a better knowledge of oceanic climate variability over the study period.

To prepare summary and derivative measures from the database to complement and integrate with other contemporary series.

To use the database to determine the character and scale of oceanic climatic change and variability at various time scales during the final stages of the pre-industrial period.

To use the information to extend and enhance existing oceanic-climate databases.

To disseminate the proposal's findings and to stimulate interest and awareness in this source with a view to fostering its further development and realising its scientific potential.

The CLIWOC team were awarded 1.1 million euros and the project ran between 2000 and 2003. The principal partners are listed in Table 1, although acknowledgement is also given to the US-based ICOADS team who became closely involved with the project as it unfolded and its potential became evident.

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Table 1. Principal participants and partners of the CLIWOC project.

CHAPTER ONE

THE NATURE AND CHARACTER OF LOGBOOKS

For climatic research this is a vast treasure trove waiting to be used.

H.H. Lamb (1982, p. 79)

An overview of logbooks

Lamb's comment on old logbooks conveniently summarises the situation before the CLIWOC project began, drawing attention to the great number of logbooks and to their unfulfilled potential. In order to grasp the significance of logbooks in climatic research it is important to recall that there are many similarities between those maintained by present-day marine officers and those of the past, of which the close attention to the prevailing sea and weather conditions is, within the current context, the most important. Nevertheless some differences will be found and attention is here focused on those logbooks that were written before the mid-nineteenth century, a time when, arguably, instrumental observation came to dominate over those based on visual observation and judgement. The ICOADS (International Comprehensive Ocean-Atmosphere Data Set) team have done much to draw these instrumental observations into a valuable database (Woodruff, *et al.*, 1998 and Elms *et al.,* 1993), while the work of Manabe (1999), using similar data from the Japanese fleets, should also be acknowledged. Such valuable contributions notwithstanding, one of the principal objectives of the CLIWOC project was to explore how far these exercises in database preparation and design could be repeated using the earlier logbooks with their different methods of making weather observations.

Although the logbooks used in the CLIWOC project were drawn from four national and language sources (Great Britain, France, Spain and The Netherlands), the broad similarity in content and, though to a lesser degree, style is noteworthy and is evident in documents from the seventeenth to the mid-nineteenth century – a period that might be described as 'the age of sail'. This is not to suggest that logbooks contain only climatic information. They do not, and a later chapter will discuss the full range of logbook material and its potential for research in different fields. For the moment attention is concentrated on the climatic elements, of which three are recorded with notable, indeed daily, regularity. These are wind force, wind direction and the general state of the weather.

Wind force must, in this context, be recognised as distinct from wind speed; the latter could not be measured until the invention of the cup anemometer by Robinson and the pressure tube anemometer by Dines, both in the late nineteenth century. It was even later before the anemometer had been adapted for ship-board use and even today the issue of suitable exposure has yet to be resolved. Before that revolution, wind force was estimated by officers making reference to the state of the sea and to the response of the ship to the stresses imposed on it by the wind, and to the sails that were carried. It must not be supposed, however, that such subjective assessments lack accuracy or consistency. They were made by officers who for the most part had had many years at sea, perhaps entering their respective national services at tender ages of 10 or 11. Neither should it be forgotten that such subjective observations continue to play an important role in marine observations in the twenty-first century and are used by the various meteorological services for forecasting and archiving. The UK Met Office still publishes its *State of Sea Booklet* (Meteorological Office, 1983) with which officers can estimate wind force by comparing the sea state with a set of calibrated photographs representing each of the thirteen points on the Beaufort Scale. Further recognition of the significance of this approach to weather observations comes in the form of the *Marine Observer's Handbook* (Meteorological Office, 1977), the sentiments of which would be recognized by eighteenth century naval officers:

> *Non-instrumental observations are very important and, being estimates, they are dependent upon personal judgement of the observer. This judgement is the product of training and experience at sea, together with practice in making observations.* (p.37)

Wind directions were the only observations that could be claimed to have been made with the assistance of instruments and were estimated by reference to the ship's compass and by paying attention also to the movement of flags, the waves and of the ship itself. By convention, these observations were made using the 32-point compass (Figure 1.1). In this first instance it was common for no correction to be made for the variation between magnetic and true north, although officers were always careful to note the degree of magnetic variation.

Wind force and wind direction were recorded at least daily whilst the ship was at sea. Because of the importance of wind direction in this age of sail, it tended to be the more frequently recorded, often being noted several times each day as it changed. Both force and direction were written in generally terse but informative terms. Wind directions were entered with notation in the form of, for example, SW (for south-west), NbE (for north by east) etc., the abbreviations (in their various linguistic forms) being commonly preferred and only the four cardinal points (north, south, east and west) tending to be written in full. Compass degrees were not used for this exercise, although they were employed for purposes of chart-based navigation and plotting. As will be demonstrated later, the wind force terms were not greatly different to those later formalised by Beaufort (Wheeler and Wilkinson, 2004). However, these wind force terms were of a specialised nature, their meanings being made yet more obscure by the fact that they changed as the vocabulary

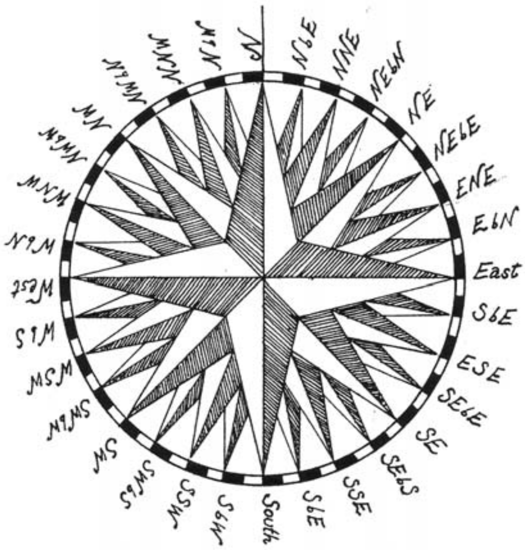


Figure 1.1 The mariner's 32-point compass

evolved over the decades.

The general descriptions of the weather were, however, different in not employing a specialist vocabulary. The weather was briefly described, but used the everyday language of the officer, making reference to, for example, rain, snow, drizzle and its intensity (light, heavy, showery etc.). Fog would be noted and thunder and lightning observed, often with some indication of the direction from which it came. Icebergs, sea ice cover and similar hazards were also noted. In the absence of what would today be regarded as 'significant weather', mariners would describe the weather as perhaps, cloudy, fair, fine or hazy depending upon the circumstances.

Instrumental observations of the type with which meteorologists are familiar today were the exception rather than the rule before the mid-nineteenth century. On board vessels in the service of the EEIC (English East India Company) daily barometric and thermometric observations were mandatory from the late eighteenth century onwards when the Company's Chief Hydrographer, Alexander Dalrymple, introduced this requirement, and dedicated spaces were included in the pre-printed sheets of which the logbooks were composed (May, 1974 and Cook, 1989). From the early 1830s they also became commonplace in the Royal Navy ships attached to the Hydrographic Survey. Given, however, that the Royal Navy's Hydrographer at the time was none other than Francis Beaufort, this is perhaps not surprising. Another source of early marine instrumental data is found in the logbooks of ships on voyages of exploration. Those by Cook (Beaglehole, 1968), Pérouse (Dunmore, 1995) and Malaspina (David *et al.*, 2004) are amongst the most well-known, but there several hundred others to be found in archives and collections around Europe. Before that date thermometric and, to a greater extent, barometric observations in logbooks were exceptional. This is not to suggest that marine barometers were not in use. They were (McConnell, 2005), but they were used for such weather predictions as could be made by reference to rising and falling air pressure and the readings were not considered important enough to be entered into the logbooks. Their presence, on the rare occasions when it does occur, reflects the interest of particular officers rather than any requirement on the part of the respective naval administrators. With the exception of the logbooks of the EEIC, the difficulty presented by such instrumental records is their temporal and spatial inconsistency that leaves wide areas and long periods of time without data for the 'pre-instrumental' period (before the mid-nineteenth century). Fortunately this problem is not repeated with the statutory observations of wind force, wind direction and weather made by all vessels in national or quasi-national services, the voluminous legacy of which ensures a much more consistent coverage from the early 1700s onwards.

The purpose of logbooks

An important question arises from the enthusiasm and dedication with which mariners collected these observations: why were they made? Sorrenson (1996) offers cogent arguments for the sailing ship as a scientific instrument. This is doubtless true of the voyages of discovery, but less so for the day-to-day mariner plying his trade across the world's oceans.

This contrast is important because the huge majority of logbooks are from this source. The average sea officer would not normally have been a scientist. Indeed, he may not have been schooled much beyond the needs of his profession, and although his notes and observations were used by hydrographers such as Dalrymple and Horsbrough (both of the EEIC), and Beaufort (Royal Navy) to help understand the sea's tides, currents and weather, this application was directed more to efficient and safe navigation and the preparation of the important guides known as 'sailing directions' rather than to pure science. So the question of why logbooks were kept is pertinent. The answer is two-fold: on the one hand, and as will be described shortly in more detail, mariners needed information on wind force and direction for safe navigation and to determine how far they had sailed and in which direction (by no means an easy task). This necessity dates from the earliest days of transatlantic navigation; as evidence we have the Royal Order issued in 1575 by the Spanish king Philip II which required masters and pilots of his ships in the *Carrera de Indias* (the route from the mainland to the American colonies) to keep a record of each trans-Atlantic journey, including a detailed

Figure 1.2 A typical logship, logline and reel used to measure a ship's speed.
By courtesy of Archivo del Museo Naval, Madrid

description of the voyage and of any geographical discoveries, winds, currents and hurricanes. These records were used to produce the *derroteros* or sailing instructions for the new captains and masters. Secondly, logbooks formed a wider, official record of the voyage. The loss or damage to cargo, delays or, in the case of warfare, failure to engage the enemy and many other questions could be answered by reference to the logbook, and they were the principal documents used in courts marshal, official enquiries and investigations. Once again, it is interesting to note that logbooks continue today to perform these same functions.

Nevertheless it was to navigation that logbooks made their greatest contribution. For centuries mariners had been able to determine their latitude by reference to the sun or to the Pole Star. The difficulty was posed by the need to determine longitude. Even when, in the late eighteenth century, the two solutions were invented, those of the marine chronometer invented by John Harrison and the determination of longitude by lunar distances developed by the English Astronomer Royal, Nevil Maskelyne, it would be decades before they were widely used (Hewson, 1983). The cost of a chronometer and the arithmetic challenge of lunar distances (a method rendered yet more problematic by the requirement of clear skies) both militated against their ready acceptance. Until well into the nineteenth century many mariners persisted with the more traditional method of estimating position by dead reckoning; a term probably derived from 'deduced' reckoning (Cotter, 1978). The deductions were made by methods that required knowledge of the prevailing wind strength and direction.

Recalling that vessels were powered principally by the force that the wind exerted on the sails, they would be propelled in a forward direction at a speed that depended upon the area of sail being used, the strength of the wind and a host of other factors. The relationship between the former two elements is non-linear and complex (Prager, 1905). The course that the ship was intended to follow would be set by the navigational officer and directed by the helmsman making reference to the ship's compass. Knowledge of the ship's movement required also measurement of its speed. This was accomplished using a logline, which consisted of a flat, roughly quadrilateral-shaped piece of wood some 15 centimetres across (Figure 1.2). This so-called logship was fixed to a long length of logline but balanced by a small lead weight in such a way that it floated vertically in the water (Norie, 1889). At intervals of an hour the logship was 'heaved' over board and the logline being run out. The intention was to manage the paying out of the logline is such a way that the logship remained stationary in the water as the ship proceeded on its course. The line would be run out in this manner for 30 seconds, the time being measured using a small hourglass. The length of line run out would indicate the speed of the ship: the longer the length of line, the greater the speed. To assist in this purpose the line divided into a number of equidistant lengths each marked by a knot, hence the term 'knot' for nautical speed. The system was in principle identical across all navies and ships, and the distance between the knots on the logline was of the same proportion to the nautical mile as the timing period was to the hour. Given that the nautical mile was set to 6080 feet, and that the log was usually run for 30 seconds, the length of logline between knots was 6080/120 = 50.6 feet (15.4 m). In reality, and to ensure that distances were under-estimated rather than over-estimated – the problem of making an unexpectedly early contact with the land toward which the ship was sailing can be imagined – the knotted distance was often set at 50 feet. To ensure further that the line did not suffer stretching the knotted intervals could be checked again the distance between two nails driven into the deck of the ship at 50 feet separation. By this simple means, the number of knotted intervals passed by the line in 30 seconds gave the ship's speed (in knots, or nautical miles per hour). Subdivisions into nautical furlongs, sometime wrongly termed fathoms, were made giving eight to the mile.

A ship's officer would, by the above procedures, know his direction and his speed and, were no other factors involved, simple geometry would allow him to determine how far and in what direction his ship had travelled in the previous 24 hours. Changes of course would merely add to the arithmetic by dividing the day into different time intervals, but not detract from its superficial simplicity. Unfortunately other forces were at work for which correction had to be made, and which introduced a disagreeable scope for error and uncertainty. Whilst a ship might follow a compass course it would be deflected from this by the effect of any ocean currents – this being known as 'drift' – and by the effect of the wind on the mass of the ship – known as 'leeway' (Figure 1.3). To comprehend this better, it is easiest to imagine a ship sailing in a due westerly direction, perhaps from Europe towards America. The helmsman is guided by his compass and steers his directed westerly course. However, a strong northerly wind is blowing and whilst the compass course and principal (bow-to-stern) axis of the ship remains pointing to the west, it is in fact following a course slightly south of west. The processes of dead reckoning were needed to take such factors into account, and allowance could be made for the strength of the wind and its direction in relation to the course of the vessel. Such procedures were by no means simple. They required a surprising degree of arithmetic skill and training on the part of navigational officers. They are described in popular contemporary

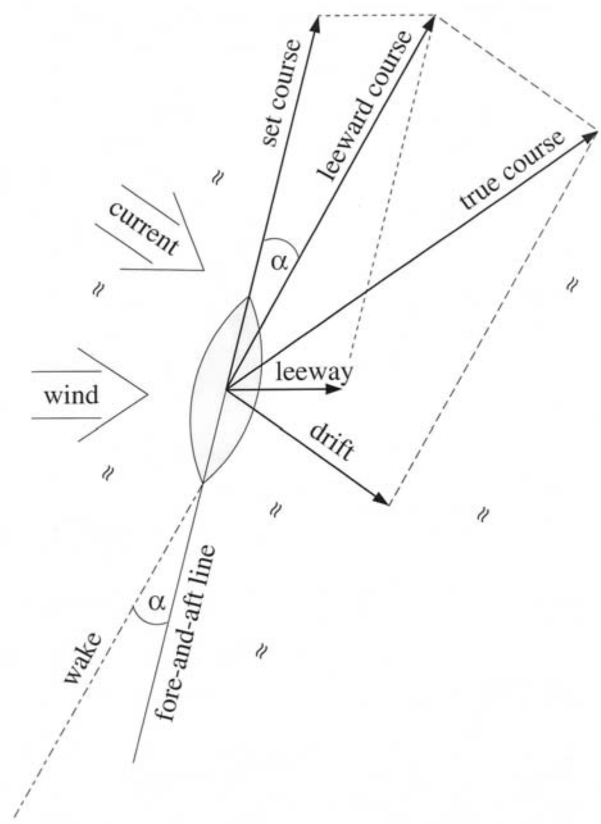


Figure 1.3 Diagrammatic representation of the effect of wind and currents on the course of a sail-powered ship. By courtesy of John Hopkins University Press.

texts in different languages such as Robertson's *The Elements of Navigation* or Norie's *Epitome of Practical Navigation*, Jorge Juan's *Compendio de Navegación para Caballeros Guardiamarinas*, Cornelis Pietersz' *Handleiding tot practicale of werkdadige gedeelte van de stuurmanskunst,* or Klaas de Vries' *Schatkamer, ofte Konst der Stuurlieden.* When using the system of dead reckoning, the only reliable measure that could be made was that of latitude, and this characteristic led to the curiosity of nautical beginning at noon and twelve hours ahead of the civil day (Harries, 1928). This resulted from the fact that latitude, most commonly being determined by the altitude of the sun, could be most reliably estimated at noon, which became the time at which all calculations and navigational computations were executed. Once again this was common to all national groups and was only slowly replaced by the use of the civil day as the nineteenth century proceeded.

Understanding of the principles of navigation developed over the centuries (May, 1973) but was given particular impetus by the growth of the overseas maritime empires of Spain, followed by those of The Netherlands, England (later Great Britain) and France. It is not surprising that the common challenge of navigation should lead to logbooks of broadly similar content, and from the mid-seventeenth century they began to assume a form in which they include material that renders them useful for scientific interpretation. Prior to that time, diaries and journals had been kept that, whilst being of general or geographical interest, tended not to include the useful observational information that characterises their successors. It was the growing need in the areas of trade and political expansion that administrative accountability led to the requirement of ships' officers in the various national services or of large organisation such as the EEIC, the Hudson's Bay Company or VOC (*Verenigde Oostindische Compagnie*: the Dutch East Indies Company) to maintain records of their voyages. A good example of this trend is given by the Naval Instructions from the British Admiralty to serving officers issued in 1731:

> *He* [the ship's captain] *is, from the Time of his going on board, to keep a journal* [logbook], *according to the Form set down* [see text below] *and to be careful to note therein all Occurrences, viz. Place where the Ship is at Noon; Changes of Wind and Weather; Salutes, with the Reasons thereof; remarks on Unknown Places; and in general, every Circumstance that concerns the Ship, her Stores, and Provisions. At the End of every Six months he is to send a Copy of his Journal for the said Time, to the Secretary of the Admiralty, and at the Expiration of the Voyage, to deliver a general Copy of his Journal, signed by himself, into the Admiralty and Navy Offices.*

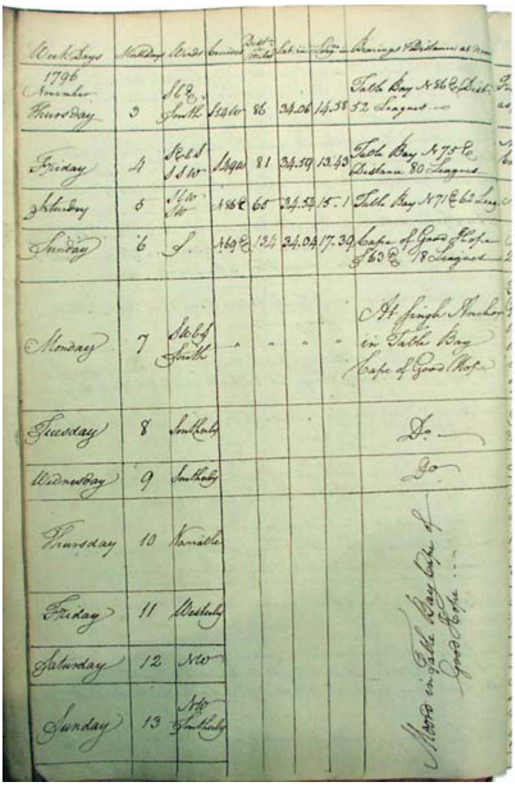
Similar requirements were in the orders to officers working on the Spanish Mail route connecting La Coruña with Havana and Buenos Aires in the second half of the eighteenth century, with the additional obligation of delivering the completed logbook of the voyage to the senior officer in La Coruña upon the ship's return (Garay Unibaso, 1987). It is against this backdrop of administrative necessity and of the secure navigation of the vessel that logbooks should be understood.

British logbooks

Although the Naval Instruction cited above was directed toward the senior officer of the Royal Navy vessels, it became common practice for more junior officers also to maintain their own logbooks. Ships' lieutenants, of whome there might be one to six depending on the size of the ship, would each keep a logbook. This document served as proof of time at sea and was used to secure payment and was vital in the quest for promotion to captain. The ship's master, who in English Royal Navy ships was the principal navigational officer, would also keep his personal logbook. After 1810 the lieutenants' and captain's logbooks were slowly phased out, to be replaced by a general ship's logbook, prepared collectively by successive officers of the watch: a system that continues to the present day. Only in the case of the logbooks of the EEIC, of the Hudson's Bay Company and of the very few logbooks of merchant and whaling ships that have survived, was the responsibility for their preparation confined to the principal officer.

From as early as the 1670s the layout of the logbooks settled into one of two forms. The more common, which developed into its conventional form by 1690 (Harries, 1928), is illustrated in Figures 1.4 and 1.5. and summarised as follows:

Columns 1 and 2: these give the dates by day name and number. It is important to remember that before early nineteenth the nautical day begins at noon ahead of the civil day and, as a result that events between noon on 21st January to noon on 22nd January, for



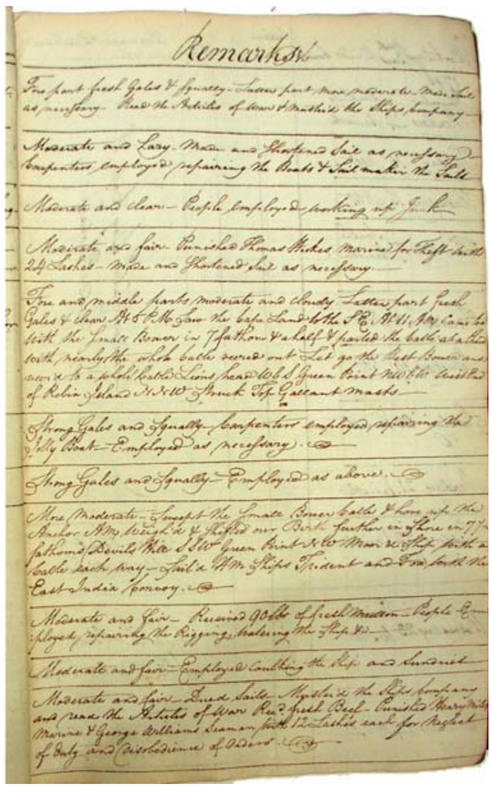


Figure 1.4 Left hand page of a typical Royal Navy logbook from the late eighteenth century. This example is from the logbook of HMS Rattlesnake, November 1797 when cruising in the South Atlantic. By courtesy of the National Maritime Museum, Greenwich

Figure 1.5 Matching right hand logbook page for Figure 1.4. By courtesy of the National Maritime Museum, Greenwich example, would be reckoned to have taken place on 22nd. When dealing with logbooks from different nations it must also be remembered that the English calendar was of the Julian form until September 1752 when the Gregorian form was adopted. Before that time English dates were 11 days behind those of other European, especially Catholic, states where the Gregorian calendar had been in use for many years. In the oldest logbooks the days were given by astronomical symbols rather than by names.

Column 3: the course of the ship was described for the 24 hours of the nautical day. The Master's dead reckoning estimates would allow him to chart successive midday positions, the course being the line connecting the two irrespective of the changes in course made during the day, by tacking for example.

Column 4: the wind directions, as noted above, were estimated using a 32-point compass

Column 5: the distance sailed in nautical miles was calculated by the same means and on the same basis as the course.

Column 6: latitude was determined using an octant or sextant or, for earlier periods, a backstaff. It is given in degrees north or south of the Equator.

Column 7: longitude was recorded on the basis of degrees east or west of some arbitrary point. Greenwich did not become the prime meridian until the late nineteenth century, even later for some vessels. Most commonly, the adopted zero meridian was the port of departure, but it could change during long voyages as major landmarks or ports whose position was known were passed.

Column 8: bearings and distances at noon were reckoned at the conclusion of each 24 nautical day. These bearings need not have been to any observable point and could be based on charted estimates from important landmarks such as Land's End. Bearings were usually in degree from true north and the distances in leagues (3 nautical miles).

The facing, right-hand, page was headed 'Remarks on board his Majesty's Ship'. Here were to be found the written accounts of the day. They always began with a note of the wind force and weather. These may be supplemented by further observations later in the day, which was usually divided into first, middle and latter parts, each of eight hours. This section contained much general information on the operation of the ship including punishments, food supplies, changes of sail and much more (see Chapter 7), of which the weather element formed only a small, but important, part.

Many Royal Navy logbooks were of this form, but some masters' logbook and the majority of those of the EEIC adopted a different layout, illustrated in Figure 1.6 in which it can be seen that each day is described in a half page with scope for hour-by-hour entries of the ship's course and speed in knots (K) and furlongs (F). This system also allows for changes in wind direction to be noted at the appropriate times they occur. This is followed by an estimate of leeway (see above) with a larger area in which the general accounts, including wind force and weather descriptions, could be written. Navigational detail follows at the foot of each half page. Here can be found estimates of latitude and longitude, sometimes duplicated where they are based on observation and on dead reckoning. In this logbook, which is of an EEIC vessel, it can be seen that there are items for barometric and thermometric observations. The variation (departure

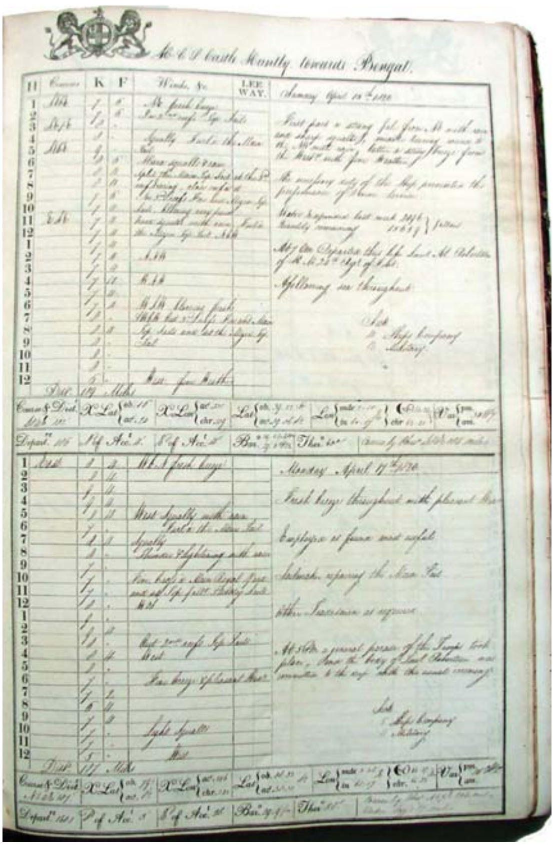


Figure 1.6 Logbook page for a ship in the service of the EEIC. This example is from the logbook of the Castle Huntley en route for India from London in 1820. By courtesy of the National Maritime Museum, Greenwich.

of true from magnetic north) was also commonly included here. English logbooks, both those of the Royal Navy and of the merchant service, remained in these two forms well into the 'instrumental' period.

Spanish and French logbooks

The Spanish and French logbooks usually correspond to an individual round voyage and were stored as separate volumes. In common with the logbooks of other nations, those written by French and Spanish officers included some hourly observations including hydrographical measurements and meteorological observations. Latitude and longitude were sometimes estimated and observed several times a day. Spanish officers commonly, however, had a better eye for geographical detail and included maps of the coasts or islands, sketches of other ships, or even drawings in colour of exotic birds or flowers.

The observations were taken on board every two hours, with noon marking, as it did for mariners of all nations, the start of the nautical day. The original observations were recorded on a blackboard divided into several columns. These columns contained the hour of a day, the nautical miles and fathoms per hour that the ship covered and the leeway made by the effect of the wind on the ship. Where appropriate, additional notes were included on such matters as the distance to the coast and the magnetic variation. At the conclusion of each 24 hours period, all these observations were copied into the formal logbook.

The majority of the Spanish and French logbooks conformed to present day A4 size or even larger. The layout of any logbook tended to vary in a rather more marked fashion than was the case for British and Dutch documents, but nevertheless conformed to one of a small number of styles.

a) Tables: some logbooks, an example of which is given in Figure 1.7, presented an almost purely tabular form of presentation.

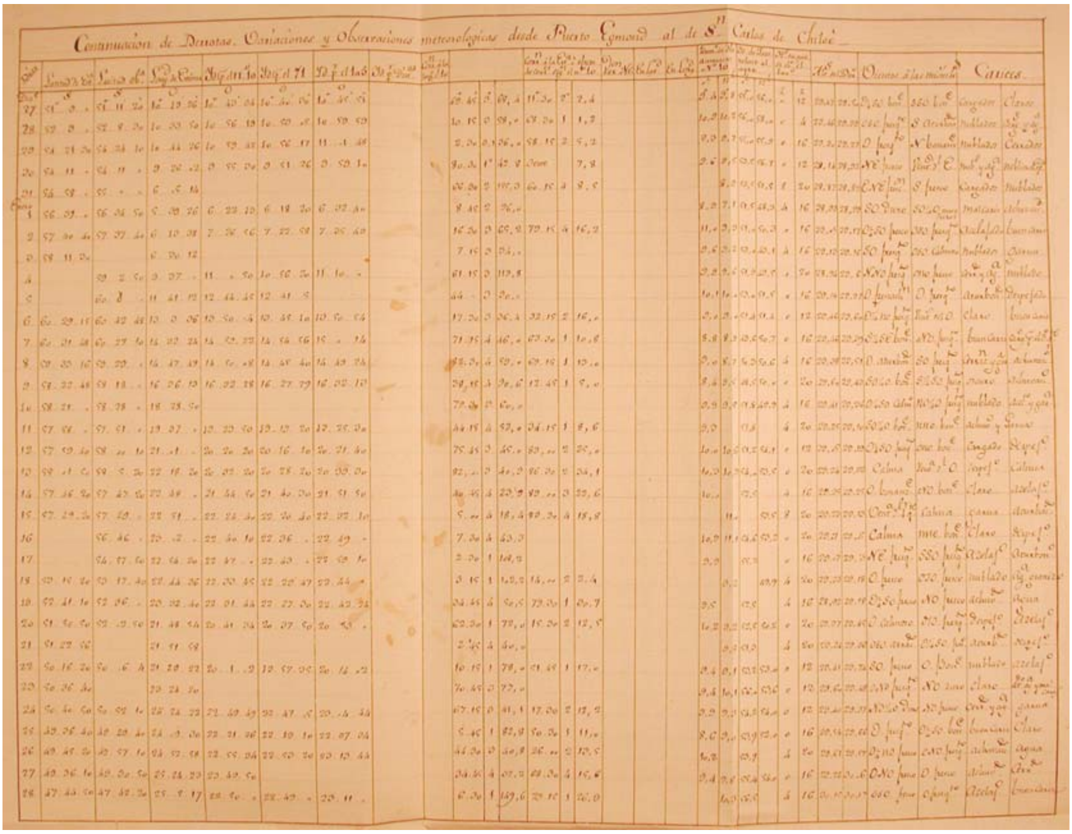


Figure 1.7 A page of a typical Spanish table-style logbook.
By courtesy of Archivo del Museo Naval, Madrid

These logbooks present a single table per page that contained the date, hour, latitude, longitude, course, distance, wind direction and speed and state of the sky. In later years, when instruments were more common on board vessels, air temperature and pressure might also be recorded. This format was not common, and only about 5 per cent of logbooks were of this type.

b) Tables and remarks: This type of logbook is much closer is style to those of the EEIC and some Dutch logbooks (Figure 1.8). A table is included which contains much the same information as above set out in hourly form. However, each page also includes a

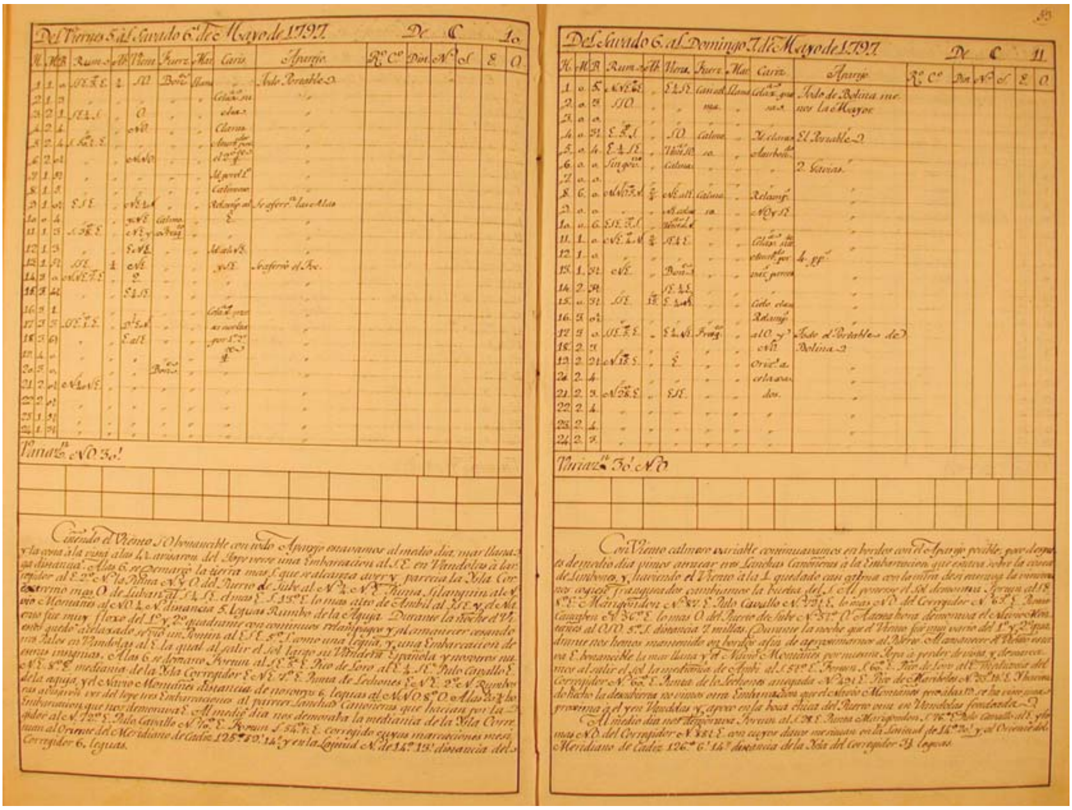


Figure 1.8 A typical Spanish table and remarks style of logbook.
By courtesy of Archivo del Museo Naval, Madrid

section of comments, remarks and general observations or *acaecimientos*. This section recorded the most important events of the day such as storms, punishments of the crew, diseases, deaths, meetings with other ships, etc. Sometimes meteorological observations were also included such as sea state and cloud cover, even the colour of the sea water is known to have been commented upon (if near a coast). It is estimated that just over 40 per cent of Spanish logbooks conformed to this style.

c) Text: in this case, all the information of the journey (observations, calculations and remarks) were written down as continuous text. Some logbooks also included notes or accounts in the margins. Figure

1.9 shows an example of diary-type approach. About 30 per cent of the logbooks were of this type.

The remaining 25 per cent of logbooks were of various mixed forms of the above. From around 1730, printed sheets became more common leaving the officer only to complete his entries in the allocated spaces. Despite this variability in style and layout, the content was standard and included the navigational and meteorological data that were required by CLIWOC.

Dutch logbooks

Following an initial assessment of logbook availability in the Dutch archives attention was focussed primarily of those held by KNMI (Royal Dutch Meteorological Institute). Here were found the so-called extract logbooks which were summaries based on the original documents and containing mainly meteorological information. These extract logbooks were prepared in the 1860s as KNMI became aware of the growing need for sea-based climatological information. For this purpose, former captains and officers were recruited and set to work on logbooks dating back to 1826 preparing material in a standard tabular layout originally

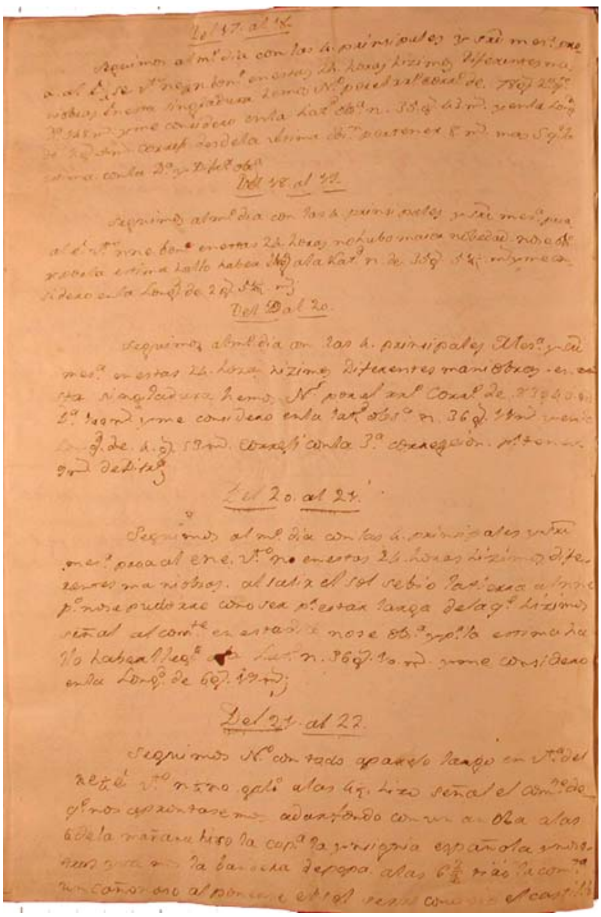


Figure 1.9 A typical Spanish logbook written in the text style.
By courtesy of Archivo del Museo Naval, Madrid.

designed by Maury and Jansen and adopted by the Brussels Conference in 1853 (Quetelet, 1854) as the international standard. Being paid per record, the extractors developed a shorthand method of noting the weather information with many of the symbols being developed by the extraction team (see Chapter 5 and Appendix III). The meaning of almost all of them was established as part of CLIWOC project (Koek and Können, 2005). Several ship logbooks were transcribed into each single extract logbook. Most of the latter contain six observations per day. However for CLIWOC only the noon observation was digitised, being the ones that corresponded to the latitude and longitude estimates.

In a situation not unlike that which prevailed for the Spanish logbooks, the regular ship logbooks were presented in several styles. One type is the 'open form' with no particular

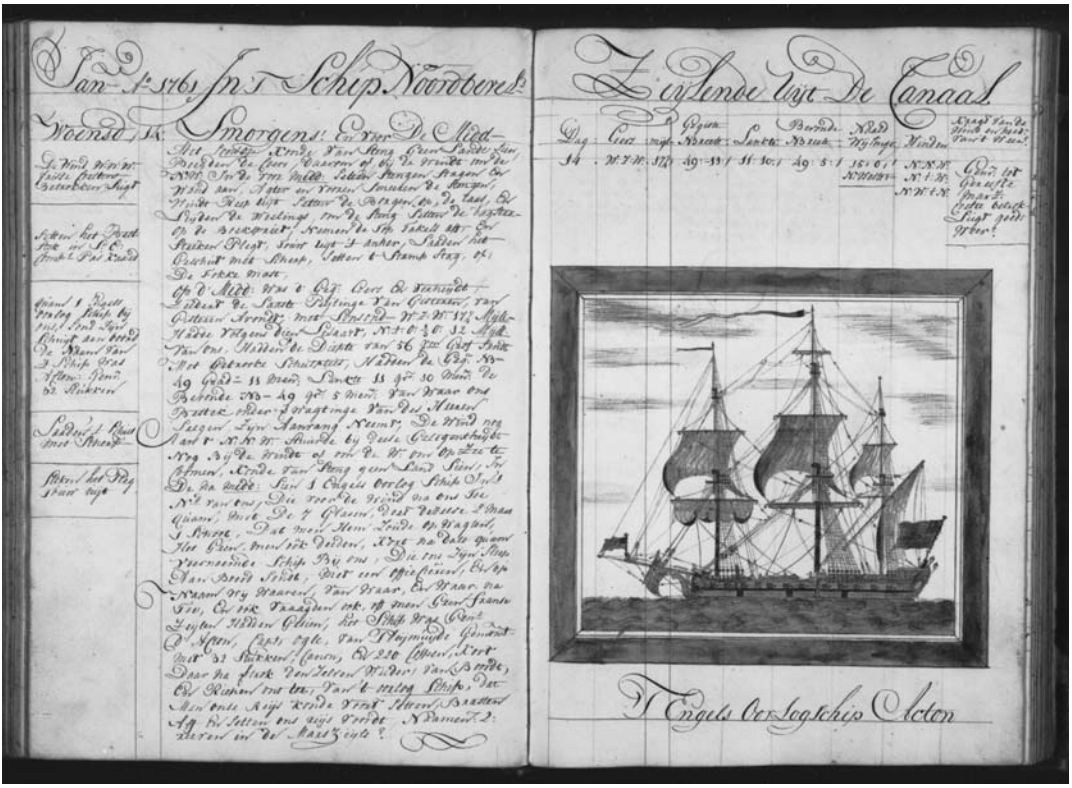


Table 1.10 Pages from the logbook of the Dutch VOC ship Noordbeveland on 14 January 1761.The layout is open form, but differs in including a sketch of the English ship Acton that was encountered that day in the English Channel. By courtesy of the Nationaal Archief, The Hague.

format in which the logbook keeper simply noted sequentially, and on a daily basis, what happened during the voyage. This may include anything, from weather to punishments to exotic animals that were seen, ships' positions, etc. Generally however, a daily report started with a description of wind and weather. Positional information, often hidden in the text, referred to noon observations, sometimes accompanied by dead reckoning calculations and estimates of the course and distance sailed during the previous day (so-called 'course and distance made good'). In cases where the ship was sailing in coastal waters, the positional information was given in the form of bearings and distances to visible landmarks.

The second type of logbook is of pre-printed tabular format. On VOC ships, this type of logbook was already in use at the end of the seventeenth century. In the CLIWOC period, the VOC ships used both the tabular and open formats, while the other Dutch companies and the Navy used the open format throughout the eighteenth century. The format in the tabular VOC ship logbooks remained more or less the same. The headings of the columns are as follows: on the left page it had the columns *Month, Day, Remarks / Encounters / Events*, while on the facing page the columns were for: *Day, Course, Miles, Dead Reckoning (DR) latitude, DR longitude, Established latitude, Established longitude, Needle (compass), Winds and weather*.

Around 1800, the Dutch Navy and merchant fleet switched from the open format to a tabular format with a standard design. The headings of the columns printed on the left page are: *Watch, Glasses (time), 'Course made good', Distance in miles, Wind direction (compass points), Wind force / weather / sky, Thermometer reading, Barometer reading, Compass orientation, Azimuth, Water at the pump*, while on the facing page the following column headings are printed: *Notes, Remarks / manoeuvres / discoveries / events / etc*. This practice persisted until 1854, the year that the international standardization of logbooks (Quetelet, 1854) was introduced on the Dutch ships.

Conclusion

Logbooks of all nations offer obvious possibilities for those wishing to study the weather and climate of past decades and centuries. Setting aside the question of data accuracy, which is considered in Chapter 3, the observational and recording conventions possess some important advantages. Each observation is fixed with relative accuracy in space and time. They are not 'proxy' data, but are based on direct observations of conditions at the time. They also form a continuous series during the voyages and replicate in many respects the system of marine observations made by ocean-going vessels of the twenty-first century. The principal difference is that the latter are transmitted to regional data gathering centres and used for real time forecasting before being archived. Observations from old logbooks, so similar in many ways, have had, in contrast, to wait two centuries or more before being collated and assembled into a database.

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CHAPTER TWO

LOGBOOK AVAILABILITY AND USE

There are at present 1000 King's vessels employed. From each of them there are from 2 to 8 Log books deposited every year in the Navy Office; those log books give the wind and weather every hour....what better data could a patient meteorological philopher desire?

Francis Beaufort (1774 – 1857)

Beaufort's prescient observations were as true of English logbooks as they were of those from France, Spain and The Netherlands. Yet more remarkable is the fact that so many of those logbooks have survived to the present day. This chapter describes where the logbooks that were used as part of the CLIWOC project are to be found. In doing so, the major European collections of Spain, the UK, The Netherlands and France are discussed but this is not to imply that others do not exist elsewhere. They do. Some, the Danish collections for example, are well-known but had to be excluded for practical reasons. Others possibly await discovery or recognition and may add significantly to this already rich source of climate data. No attempt is made here to explore logbooks or similar documents from outside of Europe, although the logbooks collected by the nineteenth century US naval officer Matthew Fontaine Maury deserves recognition and have recently been incorporated into the ICOADS data set (see Chapter 9).

The Spanish Archives: an introduction

The majority of Spanish logbooks are held in two main collections. The logbooks

Section	Dates covered	Number of *legajos*
1. Patronato	1480 to 1790	306
2. Contaduría	1513 to 1778	2126
3. Contratacíon	1492 to 1794	6335
4. Justicia	1515 to 1600	1214
5. Gobierno	1492 to 1858	18760
6. Escribaní	1525 to 1760	2864
7. Secretaría	1674 to 1822	648
8. Correos	1752 to 1846	895
9. Estado	1642 to 1830	110
10. Ultramar	1605 to 1870	1013
11. Cuba	1712 to 1872	2967
12. Consulados	1520 to 1870	1903
13. Titulados de Castilla	18th and 19th centuries	14
14. Tribunal de Cuentas	1851 to 1899	2751
15. Diversos	1492 to 1898	48
16. Mapas y planos	16th to 19th centuries	6457

Table 2.1 Organization and Holdings of the General Archive of the Indies (AGI)

Figure 2.1 A view of the Archives of the Indies, Seville.

of the official mail ships can be found in the *Archivo General de Indias* (AGI, General Indies Archive) in Seville. Other official logbooks are kept at the *Archivo del Museo Naval* (AMN, Archive of the Naval Museum) in Madrid. In addition to these two archives, the *Archivo General de la Marina* (AGM, General Archive of the Navy) in Viso del Marqués (in the province of Ciudad Real) holds an important collection although they fall outside out of the timeframe of CLIWOC project and are not described here. The organization of the archives varies depending on their origin and the historical factors that brought them into being.

The General Archive of the Indies

The General Archives of the Indies (AGI) keeps the documents relating to the Spanish Administration of the American colonies and the Philippines from the time of their discovery until they became independent over 300 years later. It was created at the end of the eighteenth century during the reign of Charles III in order to gather scattered accumulations of documents from the National Archive of Simancas in Valladolid where there were problems with lack of space. Documents relating to the American colonies and their administration had been variously deposited in the House of Trade (in Seville and Madrid), in the Consulates of Seville and Cádiz and in the Indies Council and the Secretary of State offices in Simancas and Madrid. After 1785 these scattered collections of papers and reports were gathered together in the *Lonja de Mercaderes* (the Merchant's Meeting House) in Seville. This building had been used during the seventeenth and eighteenth centuries as headquarters for most of the activities linking Spain and to her colonies (Figure 2.1). Today the Archive is organised in a manner that reflects the administrative structure and management of those colonies. The interested reader can find a more detailed description on the AGI in García Herrera *et al*. (2001). Table 2.1 shows the different sections of the AGI and the number and date ranges of manuscript *legajos* (bundles) contained in each of them. The archive is extensive and includes over 43.000 bundles with around 80,000,000 pages that occupy approximately eight kilometres of shelves.

Many naval documents and accounts can be found in the AGI, some of which will be mentioned in Chapter 6, but the CLIWOC project focussed on the logbooks of the *Correos* (Mail) section of the archive. These had the advantage of being directly comparable in content and general style to the logbooks of the other partner nations. The mail service between Spain and the American territories was organized by the Indies Council through the system of *Navíos de Aviso*, which attempted to maintain regular communications between mainland Spain and some of the most important ports in the Caribbean and South America. Charles III established in 1774 what was then a modern mail service (Garay Unibaso, 1987). The organization, routes, personnel and ship types and size to be used was defined in the *Real Ordenanza del Correo Marítimo* (Royal Order of the Naval Mail Service) in 1777. The Service operated successfully until 1793 when the French Napoleonic wars brought about its demise. It was not re-established, and following the end of the wars the Spanish American territories became independent. The service has left, however, a legacy of consistently prepared and detailed logbooks for an important part of the CLIWOC period.

There were two the main routes for this Mail Service; the *Carrera de la Habana*, which connected La Coruña in north-western Spain with Havana, and *Carrera de Buenos Aires*, which operated between La Coruña and Buenos Aires. The ships were scheduled to sail for Havana at the beginning of every month, with intermediate ports of call in Santo Domingo and Puerto Rico. The ships typically stayed in port for two weeks before returning directly to Spain. The outbound route tended to follow the trade winds on the south side of the Azores anticyclone, while the return trip took advantage of the westerly winds that were frequent on the northern side of that system. From Havana, the mail was distributed onwards to what is today Mexico, Central America, Colombia and Venezuela. The ships for the longer voyage to Montevideo were timetabled to leave Spain on the 15th February, April, June, August, October and December. They sailed directly to Montevideo from where, because of the hazardous navigation in the Rio de la Plata estuary, the mail was transported to Buenos Aires in smaller ships.

Most importantly from the present point of view, it was mandatory for all the captains from the Mail Service to keep a logbook during the journey and to deliver a copy to the Head of the Mail Office at La Coruña upon their return. Before 1864, all these logbooks, together with the other documents of the Mail Service, were stored in the archive sections of *Gobernación* (State) and of *Ultramar* (Overseas). In 1864 they were moved and stored together in the AGI. Currently, the series of documents in the *Correos* section is categorised into sub-series depending on the dates and routes of the voyages. The various series are described in López Gutierrez (1996). They are also readily accessible electronically at the AGI; one of the few archives where this helpful facility can be called upon.

The Naval Museum Archive

The Naval Museum Archive (AMN) was established in Madrid in the 1930s as a military historical archive. Most of the documents were provided by the Hydrographic Depository created at the end of the eighteenth century in order to keep all the ships' logbooks and hydrographical reports submitted by the officials of the Spanish Navy during their scientific expeditions and commissions. The scientific expeditions were often carried out for political purposes, while the commissions were related more specifically directed to hydrographic surveying and were conducted by highly trained mariners. Nonetheless, these scientists did not focus exclusively on hydrographical and astronomical studies, and some of these expeditions had a multidisciplinary character. A good example of this is Alejandro Malaspina's circumnavigation of the globe. The Madrid Archive today comprises four main divisions: *Depósito Hidrográfico* (Hydrographic Depository), *Real Compañía de Guardamarinas* (Royal Company of Navy Cadets), *Fondos de Adquisiciones y Donaciones* (acquisitions and donations), and *Museo Naval* (Naval Museum). Table 2.2 summarises the categories and collections kept in the ANM.

Series or collections by categories	Dates	Volumes
Hydrographic Depository		
Expediciones científicas, diarios de navegación y derroteros	16th to 19th C	1000
Compendios, tratados, memorias, proyectos, reglamentos, ordenanzas, compilaciones, publicaciones	1701 to 1900	70
Colección NAVARRETE (copias de documentos de diversos archivos recopilados entre 1789 y 1793)	10th to 18th C	49
Colección SANZ DE BARUTELL		54
Barcelona (copia de documentos del archivo de la Corona de Aragón)	1110 to 1717	25
Simancas (copia de documentos del Archivo General de Simancas)	1388 to 1701	29
Colección VARGAS PONCE	1244 to 1821	69
Colección VÁZQUEZ FIGUEROA	1810 to 1835	34
Colección ZALVIDE	15th to 18th C	9
Colecciones de asuntos diversos de la Marina	18th and 19th C	23
Real Compañía de Guardamarinas		
Expediente de limpiezas de sangre (probanza de nobleza)	1717 to 1866	294
Relaciones del personal de la Real Compañía de Guardias Marinas	1717 to 1838	90
Cartas de la Orden de Guardias Marinas	1790 to 1821	1
Contaduría de Marina		
Expedientes de ingreso de meritorios al Cuerpo del Ministerio	1783 to 1864	12
Escuadra de Galeras de España		
Expediente de ingresos Guardias Estandartes	1728 to 1744	1

Table 2.2 Distribution and origin of the series and collections kept in the Naval Museum Archive (AMN).

The collection of logbooks in the AMN is one of the biggest in Spain and is derived from scientific expeditions as well as from the *Marina Mercante y Militar* (merchant and naval branches of the Navy). The main routes followed by the naval vessels were from Cádiz to Callao in Chile and from Cádiz to Montevideo, with short trips from Montevideo to Santa Catalina and Rio Grande. Other important routes were those from Cádiz to Puerto Rico, Veracruz and Havana and finally, although not so frequently, Cádiz to Manila in the Philippines via the Strait of Magellan. Sometimes the ships departed from other Spanish ports such as La Coruña or Ferrol in the north of Spain, or from Málaga and Cartagena in the south, but most called in at Cádiz before starting the trip across the oceanic legs of their voyages.

Under the CLIWOC project a total number of 877 logbooks were analysed and abstracted, 467 from the AGI and 410 from the AMN. This represented the majority of known and available logbooks in Spanish archives. In addition, all the AMN logbooks that belonged to the period of study were photographed by the Spanish team and a complete set of digital images was produced that allowed studies to be undertaken without the need for constant attendance in the archives.

The British Archives: an introduction

The British archives contain one of the largest collections of ships' logbooks and journals in the world. For the period between 1750 and 1850 there are over 100,000 such items. The various collections represent the wide range of maritime activities undertaken by the British from the seventeenth century onwards. The greatest numbers of logbooks are those written by the officers of the Royal Navy. A small number prepared by very junior officers such as midshipmen have survived, but these were not used in the project. Although by far the largest collection, the Royal Navy logbooks are by no means the only items that could be called upon. An notable collection of journals kept by officers of the English East India Company (EEIC) also exist, while logbooks of the Hudson's Bay Company vessels are also kept in British archives. Both companies had extensive interests abroad; the EEIC vessels sailed regularly between Britain, India and China, while those of the Hudson's Bay Company sailed not only to northern Canada but could also be found in the Pacific Ocean trading through the ports of the America west coast. In addition, there are a number of whaling logbooks and a few kept by officers from privately owned merchant ships (Figure 2.2). For the most part these did not need to be called upon, the team's requirements being met by the major collections.

Logbooks from the seventeenth century and until the mid-nineteenth century are more properly described as officers' logbooks rather than as ships' logbooks of the type that are today prepared and to which all officers contribute collectively. Before about 1820 all officers on board a Royal Navy vessel kept their own individual logbook, sometimes known as a journal. These were submitted to the Admiralty in order for them to draw their

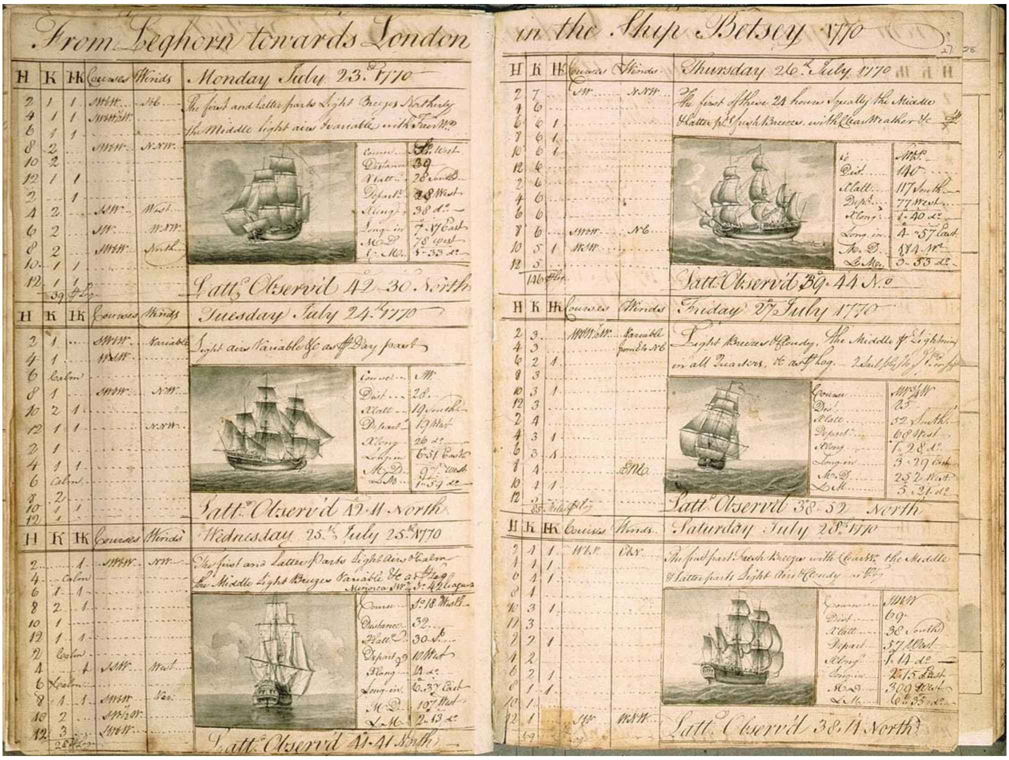

Figure 2.2 A page from the logbook of the Betsy. A rare example of a logbook of an eighteenth century merchant vessel. By courtesy of the National Maritime Museum, Greenwich

pay. The captain or commander of a vessel always kept his own journal, which is usually more detailed than those of the other officers. This additional detail was commonly concerned with the general management of the ship, as he was personally accountable to his superiors for the conduct of the vessel and its crew. Oddly, not all captains wrote up their own logbooks. Depending on their rank and wealth, some employed a clerk or secretary and merely signed the book to give it the required mark of authenticity. Other important logbooks were kept by the ship's master (responsible for navigation) and by lieutenants.

Larger vessels might carry as many as five or six lieutenant's each of whom would be required to keep a logbook. As a result of this, it is possible to choose from a variety of journals for any particular voyage and select those that were the best kept or contain the most detail. In many cases both the captain's and the master's logbooks have survived. The master's logbook tended to have more detailed information on the progress of the vessel and might sometimes be preferred to the captain's logbook for purposes of gathering weather information. Comparisons of officers' journals from the same ship indicate that logbooks were not simply copied from one officer by another. Although a great deal of information was shared, it is also clear from the slight differences in both observed and calculated longitude, that officers made and recorded many of their own observations.

For the East India Company logbooks, there is less choice. Journals were usually kept only by the captain, who was also the chief navigating officer. The first or chief mate and sometimes the second mate might also keep a logbook. Although such 'duplicate' logbooks can be found for East India Company voyages, generally only one (either captain or chief mate) has survived.

At the time of writing, British logbooks can be found in three repositories according to their origin. The National Maritime Museum, where the bulk of its collection consists of lieutenants' logbooks; the British Library, that holds East India Company journals; and the National Archive (formerly known as the Public Record Office), which holds mainly captains' and masters' journals. The UK team examined nearly 6,000 logbooks from the various collections but digital images could not be prepared and all the work was undertaken in the archives.

The National Maritime Museum

The National Maritime Museum (NMM: Figure 2.3) is located at Greenwich in South East London. The 5205 volumes of lieutenants' logbooks were transferred to the Museum from the Admiralty in 1938. Each volume contains anything from six to twenty individual logbooks. Until 1807, Royal Navy lieutenants were required to keep a logbook for each voyage or 'tour of duty' and submit it to the Admiralty before receiving their pay. The volumes, catalogued under (ADM/L), are arranged according to the name of the ship rather than the author of the logbook. Where more than one ship is contained in a volume

Figure 2.3 A view of the National Maritime Museum from the north-west.
By courtesy of the National Maritime Museum, Greenwich

	Pre 1700	1700-1749	1750-1809	1800-1849	Total
Lieutenants' logbooks					
No. of volumes	316	1921	2968		5205
Approx. no. of logbooks*	3500	24000	35000		62500
Other collections					
Volumes	5	56	243	507	811
Approx. no. of logbooks	10	70	350	700	1130

Table 2.3 Distribution of logbooks held in the National Maritime Museum. Greenwich
**Assuming an average of 12 logbooks per volume*

they are usually vessels whose names begin with the same letter, though there are some exceptions. The individual logbooks in each volume are for the most part, arranged chronologically though there is sometimes a wide range of dates represented. A number of captains' logbooks have found their way into the NMM collection. Very often they are duplicates of those found in the National Archives at Kew and are more numerous within Museum's collection for the period 1793 to 1807. The approximate range and extent of the logbooks held at the Museum is outlined in Table 2.3.

The Museum also keeps over 100 journals written by officers of the East India Company. Seventy of these can be found in the merchant shipping section under catalogue heading LOG/C. Others are held in collections of family documents. The most significant of these are the collections of Archibald Hamilton (1778-1848), consisting of fourteen volumes, and Joseph Dudman (1790-1865), comprising fifteen volumes. The lieutenants' logbooks and those noted above constitute the majority of items held by the Museum although there are additional merchant shipping logs, some logbooks from whaling ships and a few logbooks of French and Spanish warships.

The British Library

The British Library is located in Central London. Here can be found most of the logbooks and journals written by officers of the English East India Company (EEIC). This particularly useful collection of over 3,800 items is held in the Oriental and India Office section. Most of them are catalogued under heading L/MAR/B. They are bound chronologically under the name of the ship. Typically, each volume contains three to five logbooks, and each logbook consists of both the outward and return leg of the voyage. The period covered by the logbooks is mostly the eighteenth and early nineteenth century up until 1834 (when the Company ceased most of its activities). There are just under 200 journals covering the period before 1700, some going back to the early seventeenth century. These logbooks are of particular value as they cover three oceans on their regular sailings to and from the Far East and India - the North and South Atlantic and the Indian. From the 1780s they include also daily thermometer and barometer readings. Fortunately they have been carefully catalogued and an essential guide to this collection is the

	Admirals' Journals	Captains' logbooks	Masters' logbooks	Logbooks of scientific voyages	Hudson's Bay Company logbooks
Catalogue class	ADM 50	ADM 51	ADM 52	ADM 55	BH 1
Years covered	1702 to 1916	1669 to 1852	1672 to 1840	1700 to 1850	1667 to 1830
No. of volumes	n/a	4563	2103	n/a	n/a
Approx. no. of logbooks*	413	22800	10500	215	129

Table 2.4 Distribution of logbooks held in the National Archives, Kew.
**Assuming an average of 5 logbooks per volume*

Catalogue of East India Company Ships' Journals and Logs 1600-1834, by Anthony Farrington, published by the British Library in 1999. There are about 50 logbooks scattered among the Additional Manuscripts collection, but these were not called upon by the CLIWOC team.

The National Archive

The National Archive, formerly know as the Public Record Office, is located at Kew in South West London. It is the largest and most important archive in Britain containing official records of government from the earliest times. It holds an extensive collection of logbooks written by admirals, captains and masters. Table 2.4 summarises the availability of these items.

The Admirals' journals are held in section ADM/50 but are generally less useful than the logbooks of more junior officers as they tend to deal with fleet and strategic matters rather than the everyday operation of the ships, which was left to the captain and master. Many are purely narrative and do not have the ordered structure of formal logbooks, but some do follow the layout found in the more traditional form of logbook. The captains' and masters' logbooks (ADM/51 and ADM/52 respectively) are more helpful and follow much the same format as the lieutenants' logs held at the National Maritime Museum. They, too, are arranged and catalogued by the name of the ship rather than the name of the officer and several different ships (usually beginning with the same letter) may be contained in one catalogued volume.

The National Archives also holds microfilm copies of the logbooks of ships of the Hudson's Bay Company. These vessels made regular high latitude sailings between London and Hudson's Bay and are catalogued under BH. Mention must also be made of section ADM/55 in which can be found logbooks of so-called 'voyages of discovery'. The cover much the same period as the standard Royal Navy logbooks but have added historical importance – James Cook's logbooks are held here for example - and may contain useful instrumental data.

The Dutch Archives: an introduction

There are two different types of Dutch logbooks used in this project: extract logbooks (Koek and Können, 2005) which have mainly been preserved at the Royal Netherlands Meteorological Institute (KNMI), and regular (unabridged) ship logbooks that are kept in a number of national archives and museums.

The main source of the regular Dutch ship logbooks is the National Archive of The Netherlands, with the Zeelands Archive constituting an important second source. In addition to these principal collections, the CLIWOC project's Dutch team called upon the smaller logbook resources of the following organisations: The Netherlands Maritime Museum Amsterdam, The Netherlands Institute for Scientific Information Services (Amsterdam), the Maritime Museum Rotterdam, the Northern Maritime Museum (Groningen), the Municipal Archives of Amsterdam, Schiedam and Dordrecht, the Archive of Utrecht National Museum of Natural History (Leiden) and Gotherbung University Library.

The Royal Netherlands Meteorological Institute

The Royal Netherlands Meteorological Institute, known more commonly as the KNMI, was created in 1854 and is the official meteorological institute for The Netherlands.

Most of the historical documents and observations are, however, retained under governmental regulations in *Het Utrechts Archief* (the Archive of Utrecht). Although *Het Utrechts Archief* holds many valuable documents, KNMI continues to keep much historical material in its own care. Among the latter documents several of the so-called extract logbooks can be found. The Dutch team found 20 extract logbooks that belonged to the CLIWOC period. These preserved the condensed meteorological data for 273 voyages. The 60,103 records provided by this source constitute just over two-thirds of the Dutch nineteenth century observations (including 57 per cent of the wind observations) used in the project. The original logbooks on which the extracts are based are presumed lost.

The Dutch National Archive

The *Nationaal Archief* is located in The Hague and is the largest public archive in the country. Almost 1000 years of Dutch history are stored in 93 kilometres of shelves of documents, maps, drawings and photographs. It also embraces one of the largest collections of material from the Dutch East India Company (VOC), although it also holds ship logbooks from other companies and from the Dutch Navy. The *Nationaal Archief* provided notable assistance by copying many logbooks onto film, which were then processed into digital images by The Netherlands Institute for Scientific Information Services (NIWI). The Dutch team digitised 11,673 records directly from the original documents and 35,523 records from 11,628 digital image copies. In total 266 *Nationaal Archief* logbooks were used in the CLIWOC project.

The Zeelands Archive

The *Zeeuws Archief* is the main archive for Zeeland, the most south-westerly province of The Netherlands. It is known, for good reason, as the 'treasure house' of its history. The *Zeeuws Archief* was created in 2000 as the result of a merger of the former State Archives in the province of Zeeland with the Municipal Archives of Middelburg and Veere. The *Zeeuws Archief* is located in a new and well-equipped building in the centre of the provincial capital of Middelburg. The Dutch team used only film material from this archive (60 logbooks, producing 1,830 images which yielded 10,250 records). The film copies were directly available from the archive and consisted of ships logbooks of the *Middleburgsche Commercie Companjie* (the Middelburg Commercial Company), whose ships sailed regularly from Zeeland via the West African coast to Surinam and the Caribbean, and then back to Zeeland.

French Archives and logbooks.

Around 85 per cent of the French logbooks are kept at the National Archives (*Archives Nationales*). They are organised in two main collections within the Marine Funds section (*Fonds de la Marine*). Those logbooks written before 1870 can be found in the *Centre d'Accueil et de Recherche des Archives Nationales* (CARAN) at Paris. Those dated later are kept in the *Archives Centrales de la Marine* of the Navy Historical service at the Chateau de Vicennes. The rest of the available French logbooks can be found at the *Centre des Archives d'Outre Mer* (CAOM), at Aix-en-Provence, at the National Maritime Museums, located at Paris, Brest and Rochefort and at different local archives at ports such as Cherbourg, Brest, Lorient, Rochefort and Toulon. The scattered nature of these collections made the task of logbook selection more difficult than had they been held and catalogued centrally.

In CARAN there are around 3000 references to logbooks corresponding to the period from 1594 to1870. They are derived from French Navy, private and West Indies Company ships and cover the routes from mainland France to the colonies in North America, the West Indies and Africa and across the Mediterranean. A more detailed description can be found at Bourgin (1963). The CLIWOC team used French logbooks from the *Archives Nationales, Section Marine, Service Hydrographique, "Marine Subserie 4 JJ 7-26: Journaux de bord"*. A sample of 149 items has been digitised and 17 microfilm rolls were selected to provide a comprehensive data sample. The microfilm rolls contained between 2 and 22 logbook copies from ships the destinations of which included Canada and the Antilles Islands. They cover a period embracing the second half of the eighteenth century and the early decades of the nineteenth century. One of the rolls contained four logbooks describing, unusually, voyages from France to South American ports such as Rio de Janeiro.

These logbooks were microfilmed in 1974 for use by several bodies including the US Library of Congress, the University of South Western Louisiana, Loyola University of New Orleans, Memphis State University and the Mississippi Department of Archives and History. The microfilm of the section of French archival series devoted to the Louisiana region (here defined in its widest, historical, sense) was made by the Louisiana Colonial Records Project under the terms of the Library of Congress Wilbur Fund.

Logbook sampling strategies

It is clear from the foregoing sections that many logbooks are available, covering large areas of the world's oceans. Equally clearly, some form of structured approach had to be adopted in order to optimise the project's resources and to secure data of the highest quality. With this in mind, some overall strategic decisions were made at an early stage in the project's life. Most importantly, it was decided to extract data only for vessels in the open sea and not from those in harbour. Given that most of the logbook data related to wind force and direction, the turbulence and boundary layer distortions on the wind field that inevitably occurs near land rendered observations from such places as unreliable. Furthermore, areas of confined seas such as the Mediterranean, the Caribbean and the Baltic were also excluded and attention was focussed on the major oceanic regions of the North and South Atlantic and the Indian Oceans. Ideally, the team would have included the Pacific Ocean on the same basis, but the coverage for that area was severely limited and offered no possibility of the same form of potentially intensive coverage provided by high frequency of sailings in the other oceans. The temporal framework was, of course, 1750 to

1850 (although Dutch records were used to 1854), within which the objective was to acquire information for each month of that hundred-year long period.

In the event, the sampling systems of the national teams was largely dictated by the number of logbooks available. In the case of the Spanish group, the relatively small number of logbooks allowed all 500 or so to be extracted and many of them to be photographed. The Dutch, similarly, were able to extract data from about 50 per cent of the logbooks available to them. The situation in the French archives was more tentative because of the dispersed nature of the collections and the absence of a central catalogue with which to gain an overview of what was available. In this case greater than usual reliance was placed on those documents that were readily available in microfilmed or similar form.

The strategy adopted by the UK team had, of necessity, to be different to that used by the other partners. This difference was a consequence of the very large number of logbooks that could be called upon. Figure 2.4 summarises the distribution of the major UK logbook types by decade over the CLIWOC period. The vast number of logbooks available from the UK archives (over 100,000) made it impossible for the team to examine all, or even a significant proportion of them. Limitations of time and money required that only

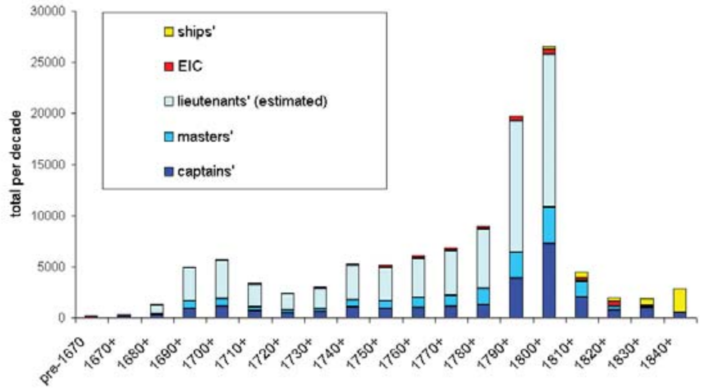

Figure 2.4 The decadal availability of British logbooks (by categories) from the 1680s to the close of the CLIWOC period.

some 6000 could be extracted for examination. The UK team used all three archives and their work was directed by a structured sample. This structuring of the sample was only possible because of the additional Royal Navy documents in the National Archives that allowed the team to determine which vessels had been stationed in certain areas at certain times. By this means it was possible to take the three oceanic areas of the North and South Atlantic and the Indian Oceans in turn and to determine which ships were present in those areas at any given time. As a result an optimal geographic and temporal coverage could be attempted. However, the execution of this task was not without its difficulties. The seasonal sailings of ships of the EEIC, which made use of the monsoon circulations to assist their inward and outward passages, left gaps in some months. Moreover, whilst Royal Navy logbooks were abundant during periods of warfare and conflict, ships were laid up in times of peace and the potential coverage offered by logbooks decreased accordingly. This feature partly explains the fluctuating pattern of logbook numbers seen in Figure 2.4. The Pacific Ocean was always poorly represented, and whilst some EEIC ships sailed to through the South China Sea there were insufficient to support a complete temporal coverage of even this sub-region of that huge ocean.

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CHAPTER THREE

BRINGING ORDER TO THE LOGBOOK VOCABULARY: THE CLIWOC DICTIONARY

I'll deliver all; And promise you calm seas, auspicious gales,

And sail so expeditious that shall catch your Royal fleet afar off…

W. Shakespeare, *The Tempest* Act V.

An introduction to weather terminology and logbook keeping

Even a cursory inspection of a typical logbook from the age of sail provides a clear impression of the wealth of climatic data that they contain. But this impressive volume of information can only serve a wider, scientific purpose when it is fully understood, and it was soon apparent to the CLIWOC team that some form of working dictionary was needed with which to translate the archaic language of a long gone age and technology into modern terms. By means of this dictionary a degree of terminological uniformity is introduced that not only expresses old in new terms but also allows the different national sources to be brought together and a coherent database to be created from them. The vocabulary of those distant times is superficially, even deceptively, familiar. It is, however, the nature of language that words change their meanings over time, some pass into, others out of, fashion. Did the term 'gale' always possess the unambiguous definition that it currently enjoys[1]? In Shakespeare's time, as the opening quotation makes clear, the term 'gale' did not connote the hazardous conditions that are prompted by today's forecast warnings. When did some terms such as' breeze', 'hurricane' or 'typhoon' first enter the European vocabulary? What was meant by the term 'soft gale', and why is the term no longer used? These are just a few of the questions that the CLIWOC team had to answer as a

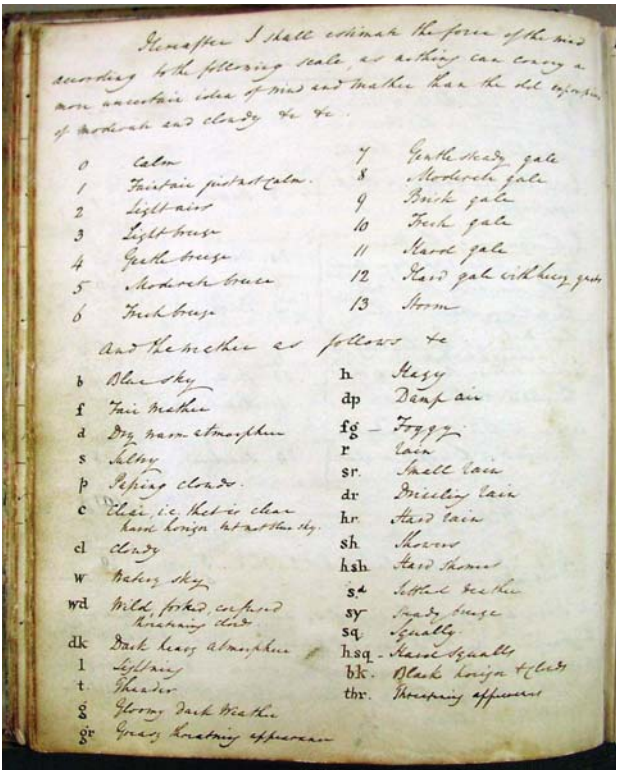
(1) The UK Met Office defines a gale as a wind speed of 34 knots or more sustained for a period of 10 minutes.

Figure 3.1 An East Indiaman in a gale by Charles Brooking. By 1800 the term 'gale' had assumed its current meaning, but some years before the understanding was quite different.
By courtesy of the National Maritime Museum, Greenwich

preliminary step towards bringing order to the data and the creation of the database.

Of the three categories of archaic logbook data, that for wind direction required no linguistic redefinition other than translation into English. All mariners, irrespective of their nationality, used the 32-point compass that had had something of a universal character from the earliest times of sea travel. The next category, that of general descriptions of the weather, used non-technical terms and in a style that would have been readily understood by any literate contemporary person. Again, the principal requirement was for a direct translation into English with no other re-expression being required although, as will be noted in Chapter 5, the information can be 'coded' for efficient database management.

The observations of wind force were quite different and required particular attention. These were expressed using brief technical terms that, whilst being understood by the mariners, would have meant little to those who spent their lives on land. More so than the conventions by which wind direction and the weather were described, those for wind force changed over time and many of the terms in use in the eighteenth and early nineteenth century would be unrecognisable to today's trained observers. Furthermore, instead of the 13 forces that today embrace the full range of the Beaufort scale, each national group counted close to 100 different wind force terms in the logbooks. Yet, as will be shown, this remarkable rich vocabulary does not reflect linguistic chaos. There was order, albeit unofficial, in the various national systems and the CLIWOC team's principal task was to provide a translation key by which such archaic terms could be re-expressed in Beaufort scale equivalent numbers and descriptions (the scale as it is currently defined is included in Appendix I to this volume). By this means the observations became directly comparable across different time frames and linguistic preferences, and could be included in the database in a readily comprehensible form that can be put



Hereafter I shall estimate the force of the wind according to the following scale, as nothing can convey a more uncertain idea of wind and weather than the old expressions of moderate and cloudy &c &c.

0	Calm	7	Gentle steady gale
1	Faint air just not calm	8	Moderate gale
2	Light air	9	Brisk gale
3	Light breeze	10	Fresh gale
4	Gentle breeze	11	Hard gale
5	Moderate breeze	12	Hard gale with heavy gusts
6	Fresh breeze	13	Storm

And the weather as follows &c

b	Blue sky	h	Hazy
f	Fair weather	dp	Damp air
d	Dry warm atmosphere	fg	Foggy
s	Sultry	r	Rain
p	Passing clouds	sr	Small rain
c	Clear, i.e. that is clear hard horizon but not the sky	dr	Drizzling rain
cl	Cloudy	hr	Hard rain
w	Watery sky	sh	Showers
wd	Wild, forked, confused threatening clouds	hsh	Hard showers
dk	Dark heavy atmosphere	st	Settled weather
l	Lightning	sy	Steady breeze
t	Thunder	sq	Squally
g	Gloomy dark weather	hsq	Hard squalls
gr	Greasy threatening appearance	bk	Black horizon & clouds
		thr	Threatening appearance

Figure 3.2 Page from the logbook of HMS Woolwich, 13th January 1806 in which Francis Beaufort describes for the first time the wind force and weather code system that now bears his name. By courtesy of the UK Met Office

to immediate scientific use. Although Beaufort first proposed the wind force and weather scales that bear his name as long ago as 1806 (Figure 3.2), it was not formally adopted by the Royal Navy until 1838 and has undergone a number of changes since that time. International recognition had to wait yet longer - until the first International Maritime Conference held in Brussels in 1853. This important event was organised by the American US Navy hydrographer Lt. Matthew Maury with the intention of "Establishing a uniform system of meteorological observations at sea, and of concurring in a general plan of observations on the winds" (Maury, 1854). Such agreements, which even then were limited to the ten participating nations, come too late to have any immediate bearing on the CLIWOC project. The International Meteorological Organisation adopted the Beaufort wind and weather scales in only 1939; over 100 years after its first proposal. In other words the only logbooks in the CLIWOC project that conformed to any systematic observational procedures were those of the Royal Navy, but only from 1838.

Importantly, the system of logbook keeping proposed by Maury differed little from those in common use before that time. He suggested that observations be made every two hours, to include many measures that had been familiar to officers for centuries: latitude, longitude, wind direction, wind force, currents and the state of the weather. Only the request for regular observations of air pressure and of sea and air temperatures and the highly structured layout of the logbook page would have been new. This faltering approach to the adoption of standardised procedures for marine observations is not to deny the existence of some order or informal conventions for observations in earlier times. Indeed, it is only in logbooks that wind force terms were used in a regular and broadly consistent fashion before the mid-nineteenth century. Contemporary land-based activities lacked anything comparable. Only the five-point wind strength scheme proposed by the *Societas Meteorologica Palatina* (Kington, 1988) in the late eighteenth century bears comparison with the wind force scales used by mariners, and that early attempt at an organized network of observatories failed, sadly, to survive the upheavals of the Napoleonic Wars.

The preparation of the CLIWOC dictionary was a largely empirical exercise that required the careful scrutiny of the logbook terms using the methods of content analysis. This endeavour was nevertheless supported by the remarkable number of contemporary documents and dictionaries that cast additional light on the meaning of different terms. Furthermore, other logbook entries could also be used to help define the archaic terms. Of particular importance in this respect were the records the distances covered each day by the vessels. Because a ship's speed and wind strength are positively related up to force 7 (Prager, 1905), the relative strengths of winds of up to that force could be determined by reference to the distance sailed on that day (this point is discussed in more detail in a following section). References to the amount of sail that could safely be carried also clarified the issue of wind force definition, and Beaufort himself used this criterion to order and define many of his wind force terms (Kinsman, 1969). This feature was to be of particular assistance when dealing with the Dutch logbooks. The procedures were also assisted by the wide geographic range of the logbooks that were called upon. As noted in Chapter 2, all four nations had political interests that encompassed the North and South Atlantic Oceans. The VOC and EEIC were also active in the Indian Ocean and the South China Seas while some Dutch ships and those of the English Hudson's Bay Company (HBC) had interests in the very high latitudes of the North Atlantic. This range embraced the earth's principal climatic regions and constituent weather from the high- and mid-latitudes, through the more settled conditions of the sub-tropical anticyclones, to the trade winds belts and the occasional severity of the tropics. As a sampling frame it gave opportunity to include the full range of conditions that could be encountered and terms that mariners would have used to describe them.

Although over 400 wind forces terms were found across the four languages many descriptors were used only once or twice, usually in an idiosyncratic fashion and by single officers, and at the heart of the vocabulary was a much more limited subset of descriptions that provided the majority of logbook entries.. To understand how this 'system' could have come into being it must be remembered that in those distant times few officers attended any formal naval college and such education that they had was acquired at sea. Many officers joined their national services as young as 11 or 12. They were trained 'on deck', were skilled and experienced in their duties (Lavery, 1989) and coached in a strong oral tradition that saw terms passed down the generations, slowly evolving as they did so. By time they had become logbook-keeping officers they were well-versed in the ways of observation and judgement, although some were occasionally given to linguistic eccentricities, this was rare. Not only were a large number of terms used, the range tended to expand over time as mariners became familiar with more exotic climates and adopted the local words to describe specific conditions. The terms 'hurricane' (Sp. *huracan*, Fr. *ouragan*, Du. *orcaan*), so commonly used today, was derived from the Carib term *furacan.* The word 'monsoon' (Sp. *monzón*, Fr. *monssons*, Du. *moessen*) came from the Arabic *mausin*, and 'typhoon' (Fr. and Sp. *tifon*) from the Chinese term *tai fung* for 'great wind'. These words formed no part of the European vocabulary until mariners introduced them from the fifteenth century onwards.

These terms raise the wider issue of other similarities between the languages and vocabularies. The term 'breeze', which was to be important in applying to half of the elements of the Beaufort Scale, was derived from the Spanish 'brisa' and had been used by the earliest navigators to describe the trade winds that blow onto the tropical South American coastline. Sir Walter Raleigh provides one of the very first printed uses of this term in English when he describes in 1597 the difficulties of navigating the coast of Guyana '…against the brize [sic] and east winds'. Other terms crossed the linguistic divide such as calm (Sp. *calma*, Du, kalm, Fr. *calme*). Adjectival qualifiers also revealed an international character, of which 'fresh' (Sp. *fresco*, Du. *fris* , Fr. *frais*) was the most widely used. This internationalisation is interesting because it took place long before Maury's persuasive endeavours at the Brussels Conference of 1853. How did it arise? It probably reflects the international maritime community that grew up despite the competition between the imperial powers. Officers would meet in ports, even on the open seas, and these meetings would have been an arena for the exchange of ideas, experiences and language. On the other hand some Spanish terms remained constant in use and definition for centuries. Terms such as: *calma* (calm), *bonancible* (moderate breeze), *bonanza* (fair weather), or *calmoso* (light breeze) had, according to the dictionaries from the sixteenth century (Covarrubias, 1994), enjoyed the same meaning from as early as the first Spanish expeditions of the sixteenth century.

Terms and definitions in British Logbooks

The century-long study period of the CLIWOC project witnessed a steady development of marine nautical terminology. Beaufort first proposed his wind and weather scales in 1806, about half way through the study period, but it did not represent a radical break with the traditional vocabulary of the time. Quite the opposite: Beaufort's achievement was to take the most popularly used terms of his day, exclude the others, and eventually to put himself in a position of authority from where he could require all Royal Navy observers to adopt the system (Huler, 2004). In a wider sense, this study of the English nautical vocabulary is also a study of the origin of the now universally-adopted Beaufort scale.

The first task was to gain an impression of the vocabulary with which the CLIWOC had to work. Over 22,000 wind force entries were sampled, comprising 14,800 from Royal Navy logbooks, 5400 from those of the EEIC and 1900 from the HBC. This distribution is in approximate proportion to the availability of logbooks. This sample produced 98 different wind force terms. The extraordinary number of terms (the Beaufort scale is limited to just

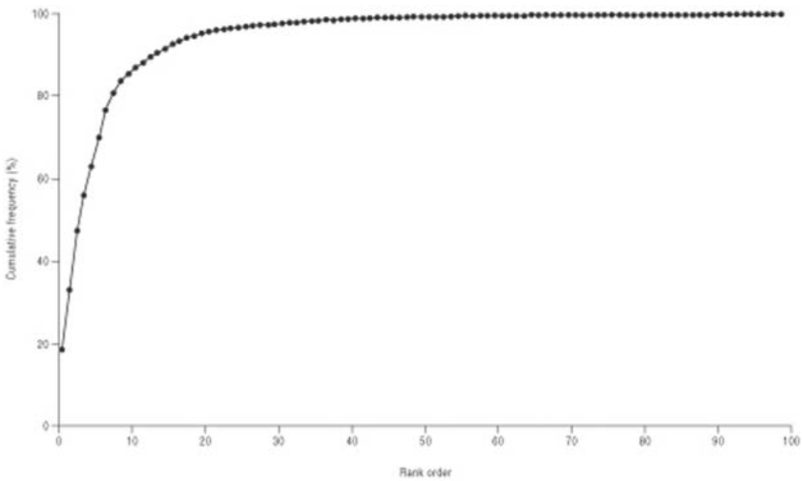


Figure 3.3 Cumulative distribution (in percentages) of English logbook wind force terms.

13!) must not, however, be thought of as indicating descriptive anarchy. Figure 3.3 shows the cumulative percentage of usage when terms are ordered by their frequency of occurrence in the sample, and it should be noted that if one takes the 13 most used terms they account for 90 per cent of all sampled logbook entries. Table 3.1 lists these terms and indicates those that were adopted in the Beaufort system and its various versions of the later nineteenth and twentieth centuries (Wallbrink and Koek, 2001). Beaufort's remaining terms were those that occupy the upper end of the scale - 'whole gale', 'storm' and 'hurricane'. They were in use in 1800 but, by definition, not frequently encountered. He is, on the other hand, very specific in his rejection of the most popular term of his age, 'moderate', and he wrote in his logbook "…nothing can convey a more uncertain idea of wind and weather than the old expression of moderate and cloudy." Many other terms were also rejected, some of them popular, for example, 'pleasant breezes' and 'variable'. The CLIWOC sample also found forty-five of the terms were used on fewer than six occasions and can be attributed to the idiosyncrasies of the officers in question. This statistical evidence alone supports the hypothesis that there existed a widely used, if informal, pre-Beaufort scale.

Wind force term	Rank by usage	Frequency of usage	Cumulative frequency by percentage.
moderate	1	4109	18.8
fresh gales	2	3232	33.6
fresh breezes	3	3182	48.1
light airs & calm	4	1880	56.7
light breezes	5	1561	63.9
moderate breezes	6	1549	70.9
little wind	7	1492	77.8
strong gales	8	865	81.7
calm	9	641	84.7
variable	10	367	86.3
strong breezes	11	327	87.8
pleasant breezes	12	319	89.3
moderate gales	13	238	90.4

Table 3.1 The thirteen most widely used English wind force terms in the CLIWOC sample. Items in bold were later to be included in the Beaufort Scale.

Differences were discovered to exist between the vocabularies of officers in the three English services - the Royal Navy, EEIC and HBC. Royal Navy officers used only 53 terms, while those of the HBC used 37. The EEIC officers' used 73 terms but in a form that recognised not only the force of the wind but, uniquely, included acknowledgement of the nature and origin of the wind. Thus, in addition to breezes and gales, they also took care to indicate trade winds or monsoons, qualifying those forms by the popular adjectives of 'fresh', 'moderate' or 'strong'. The EEIC system could be described as a 'matrix' of terms, one axis of which was force *per se* from light to strong, and the other a generic classification of breeze, trade, monsoon or gale. This close attention to detail is probably the result of the prompting of the EEIC's first hydrographer, Alexander Dalrymple. He required also that officers record daily air temperature and pressure and was concerned to use the ships as a means of gathering valuable scientific information. He was almost certainly the proposer of the wind scale that bears the Beaufort's name (Fry, 1967; Konvitz, 1983; Wheeler and Wilkinson, 2004).

Having established the overall character of the vocabulary, the next step was to provide the translation of terms into their Beaufort scale equivalents. It must be recalled that Francis Beaufort was himself an experienced Royal Navy officer and former midshipman for the EEIC (Courtney, 2002) and his understanding of terms would not differ from that current at the time. Thus Beaufort's definitions (Appendix I) can be fairly taken as the representing their meaning to the wider nautical community. It will be recalled that the list of the thirteen most widely-used terms in Table 3.1 includes nine that he adopted, and in these cases no redefinition was considered necessary.

Guidance on the matter of the other terms came from legacy of seventeenth, eighteenth and nineteenth century dictionaries and nautical texts. Most important of these is William Falconer's *Universal Dictionary of the Marine,* which ran to several editions in the late

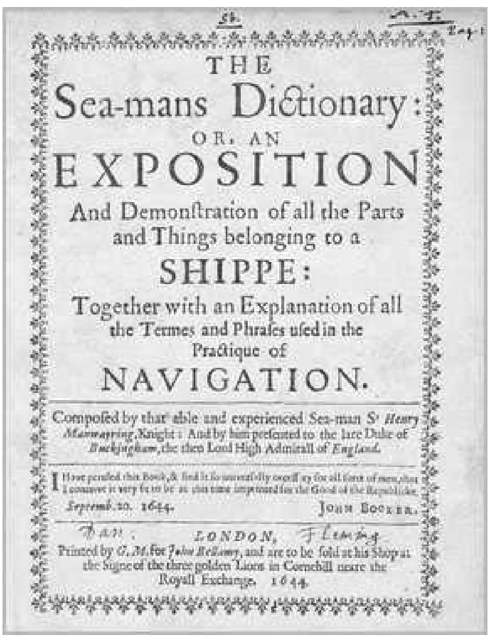

THE
Sea-mans Dictionary:
OR, AN
EXPOSITION
And Demonstration of all the Parts and Things belonging to a
SHIPPE:
Together with an Explanation of all the Termes and Phrases used in the Practique of
NAVIGATION.
Composed by that able and experienced Sea-man Sr Henry Manwayring, Knight: And by him presented to the late Duke of Buckingham, the then Lord High Admirall of England.
Septemb. 20. 1644. John Booker.
LONDON,
Printed by G. M. for John Bellamy, and are to be sold at his Shop at the Signe of the three golden Lions in Cornehill neare the Royall Exchange. 1644.

Figure 3.4 Cover page of Henry Mainwaring's nautical dictionary for the seventeenth century.
By courtesy of the National Maritime Museum, Greenwich.

eighteenth and early nineteenth century (Falconer, 1780). The *Oxford English Dictionary* (1933) provided historical information on many of the terms used to describe wind force. Also helpful was *Horsborough's Sailing Directions* (Horsborough, 1817) in which can be found brief descriptions of how some of the observations were made. To these can be added Sir Henry Mainwaring's *Nomenclator Navalis* (*The Seaman's Dictionary*) published in 1644 and reprinted by Manwaring and Perrin (1922), John Smith's *A Sea Grammer* (from 1627 but republished in Goell (1970)), Nathaniel Butler's *Boteler's Dialogues* (from the 1640s and republished in Perrin (1929)), Romme's (1804) *Dictionnaire de la marine Anglaise* and the later dictionaries of Smyth (1867), Paasch (1890) and Pirrie (1895). All these publications assisted in defining some of the wind force terms that Beaufort was to abandon to history. Some of the above also helped in translating between the languages, and Falconer's (1780) and Romme's (1804) dictionaries include French-English sections.

The logbooks themselves could be consulted to help in defining terms not included in the above texts. Most importantly, wind forces could be calibrated against the distances sailed (ship's speed) in a day. As noted above and in Chapter 1 there is a well-understood association between the two. Over the range from Beaufort force 0 to 7 the relationship is such that greater speeds equate to stronger winds. Beyond that point the relationship becomes a negative one because sails have to be taken in, and the ship's speed will decrease. This non-linear relationship was tested and found to be reproduced using terms for which definitions already existed (Figure 3.5). Only 'moderate gales', a term that appears to have become all but redundant by 1800 and provides only a small sample on which to base the estimated mean distance, fails to conform to the overall pattern. Hence, those wind descriptors that had no definition could be placed at a point on the graph by reference to the mean distance sailed when those particular winds prevailed. The Beaufort Scale equivalent was then determined by the category to which the distance matches. Ambiguities between for example, hard gales and light breezes are evident from the

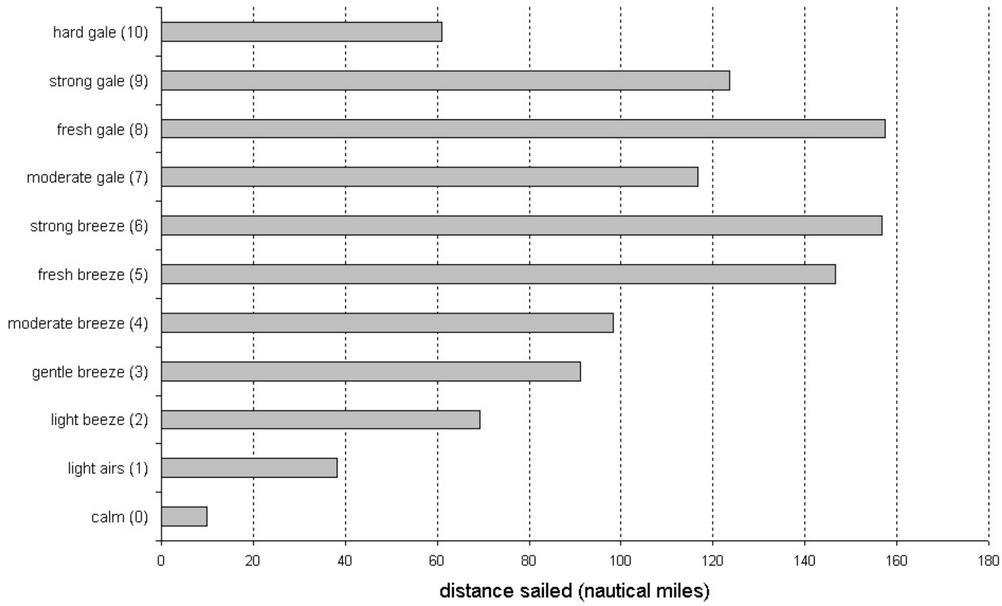


Figure 3.5 Graph of mean distances sailed under each of the Beaufort wind forces as determined by reference to the British logbooks.

complete logbook entry.

By these various means nearly all of the 98 terms could not be re-expressed as a Beaufort force. The very few that could not be re-expressed represented less than 1 per cent of all logbook entries.

Terms and definitions in Dutch Logbooks

The Dutch, with the Danes, were among the first to suggest a regulated system of wind force observations using this method (Frydendahl *et al*., 1992). The Dutch wind force vocabulary is remarkable also for degree to which the terms were based on the maximum amount of sail that a vessel could carry under the prevailing conditions. Nearly 50 per cent of the descriptors make reference to the composition of the sails. In contrast to the Dutch terminology, the non-Dutch sources of the CLIWOC database contain only five expressions that rely on a description of the sails: in English (topgallant gale), in French (*a basses voiles*) and in Spanish (*de alta vela*, *de vela larga* and *de toda vela*). Although Beaufort did not describe winds in terms of the sails that could be set under different conditions and, for example, avoided use of the term 'topsail gale', he did use this criterion to define points on his wind force scale. A storm (force 10), for example, is defined as a wind of such violence that "…which she [the ship] could scarcely bear with close-reefed main topsail and reefed foresail."

In describing the winds by reference to the sails that could be carried, the Dutch mariners went further than Beaufort. How this system, so different from those of the other nations, arose is far from clear and the contemporary sailing instruction (De Vries, 1736, 1752, 1777, De Boer, 1769, 1775, Pietersz, 1791) cast no helpful light on the question. The answer might lie in the frequently commercial sources of Dutch logbooks. In contrast to the military characteristic of the British (mostly Royal Navy) collection, a large proportion of Dutch logbooks are from corporate shipping companies of the *Verenigde Oostindische Compagnie* (VOC), the *Westindische Compagnie* (WIC) and the *Middelburgse Commercie Compagnie* (MMC). The task of their crews was to sail as fast as possible to transport exotic goods into the home markets without delay. More sail meant higher speeds, but this principal was constrained by other factors to do with the length of the ship and the degree to which it would pitch or roll if 'over-sailed' (Van Manen and Van Oossanen, 1988). It is therefore not surprising that Dutch officers paid closer attention to the trim of their vessels than did those of the military fleets who, chases excepted, would 'cruise' with sail areas less than the maximum that could be born.

The management of the sails was no simple matter (Harland and Myers, 1984) but, in general, if the sails were to be removed from a vessel under full sail (usually at the optimum of Beaufort force 6 or 7), the process generally started with the uppermost and smallest, then progressing to lower and larger sails. By the mid eighteenth century sail technology had already improved so far that sails did not need to be taken in completely, but could, by the process of 'reefing'[2], be progressively reduced in area. Sails were described as single, double, triple or close reefed depending upon how many of the rows

(2) a reef is a line of long canvas tags stitched to the sail that allowed part of it to be hauled in, but leaving all that below the reef exposed to receive the wind.

of reefs were taken up. Close reefing would make the greatest reduction in sail area.

Until the end of the eighteenth century most of the ocean-going vessels were square-rigged sailing ships, the sails being suspended from wooden 'yards' that ran across the width of the ship. The sail plan of a typical ship of the period (the outward designs differed relatively little between the nations) is given in Figure 3.6. Each sail had a name, the inclusion of which, together with a reference to its degree of reefing, described the wind force. The terms evolved over the years as sail design became more complex, with larger sails being split into smaller, more manageable, units as technology improved. For instance, the term *dichtgereefde marszeilskoelte* (close reefed topsail breeze) was not used before 1816 and *bovenbramzeilskoelte* (royal sail breeze) – a refinement of *bramzeilskoelte* (topgallant breeze) – was introduced around 1830.

Because the Dutch wind force terminology is closely linked to the sailing practice, it provided a simple means of determining the order of the many Dutch wind force terms. While attention to the degree of reefing and sail composition allowed for refinements in the Dutch translations that were not possible in the other languages.

The Dutch element of the dictionary differed in another respect. In many cases there was little need for translation of terms to the Beaufort scale: the work had already been done and a large number of so-called extract logbooks had been produced in the 1860s (KNMI, 1954) using original ship logbooks from 1826 onward. As the Beaufort scale had been officially adopted in the Netherlands in 1853 following the International Conference in Brussels (Quetelet, 1854), the archaic wind force terms in the originals were directly transcribed into those of the Beaufort system. By this fortunate means over half of the Dutch observations had already been transformed by, importantly, teams of experienced mariners. Unfortunately, however, although one table of conversions was found (Groeneijk, 1848), details of the conversion procedures have not survived. At the conclusion of these processes of transcription, only just over 1 per cent of Dutch logbook

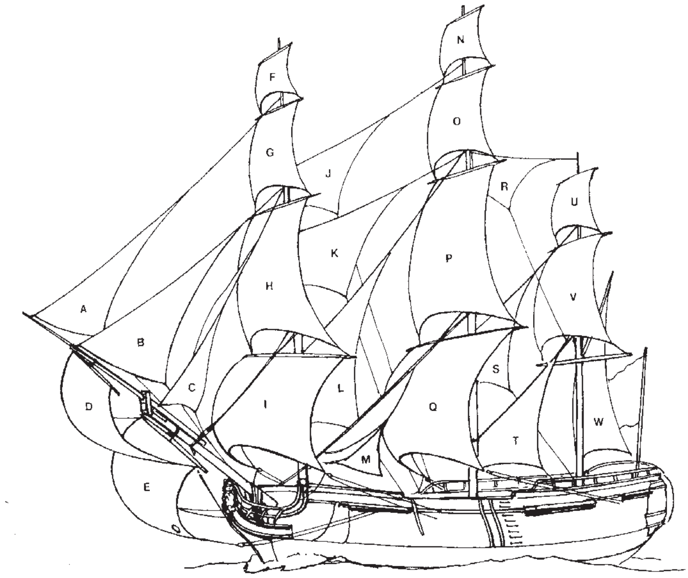


Figure 3.6 Sail plan of a typical eighteenth century sailing ship. The key is given in Table 3.2.

entries could not, with confidence, be re-expressed as a Beaufort force number – a situation similar to that for English and Spanish terms.

Terms and definitions in French and Spanish Logbooks

In many respects the problems presented by translating French and Spanish wind

key letter	description	key letter	description	key letter	description
A	Flying jib	I	Fore course or fore sail	Q	Main course or mainsail
B	Jib	J	Main topgallant staysail	R	Mizzen topgallant staysail
C	Fore topmast staysail	K	Middle staysail	S	Mizzen topmast staysail
D	Spritsail topsail	L	Main topmast staysail	T	Mizzen staysail
E	Spritsail	M	Main staysail	U	Mizzen topgallant sail
F	Fore royal sail	N	Main royal	V	Mizzen topsail
G	Fore topgallant sail	O	Main topgallant sail	W	Mizzen sail
H	Fore topsail	P	Main topsail		

Table 3.2 Key to the sail plan in Figure 3.6

force terms into Beaufort scale equivalents were similar to those for English terms. The sense of the vocabulary was broadly similar and the Dutch preference for sail-based descriptors was largely avoided. In Spain the adoption of the Beaufort scale had been a more protracted process than in other European nations. Although France had been a signatory to the agreements reached at the Brussels International conference of 1853, Spain had not and the Beaufort system was not introduced until well into the second half of the nineteenth century. In common with other nations, the situation before that time was characterised by a lack of any formal conventions. A search of the main archives for Spanish naval documents - the *Archivo del Museo Naval* (Archive of the Naval Museum, AMN) and the *Archivo General de la Marina* (General Navy Archive, AGM) – and many nautical texts of the age, including the seminal works of Juan y Santacilla (1757) and Ulloa (1795), confirm this lack of any systematic procedures. The important maritime dictionary produced by O'Scanlan (1831) represents the first attempt to impose some tighter order on the Spanish conventions for observation made at sea.

In some respects this slow progress is surprising as it had been the Spanish and Portuguese navigators who had first embarked on the deep sea navigation that required logbook keeping. As early as 1575 a Royal Order had been issued that required masters and pilots who navigated in the *Carrera de Indias* (the route from the mainland Spain to the colonies in America) to keep a record of each trans-Atlantic journey. This was to include a detailed account of any geographical discoveries, winds, currents and hurricanes but made no specification of terms to be used. The completed logbooks had to be delivered to the Professor of Cosmology in the *Casa de Contratación* in Seville (AGI, *Indiferente General*, 1956, L.1, f266r–266v) [3]. Nevertheless, wind descriptors were included as early as the sixteenth century and were used by Prieto and Herrera (1999) to reconstruct conditions encountered by ships that passed through the Strait of Magellan during the sixteenth and seventeenth centuries.

(3) References to manuscript sources in the Archivo General de Indias (Seville) are denoted by the initials AGI, followed by the name of the section of the Archive where the manuscript is located, and a number identifying the bundle, to which the manuscript belongs.

Spanish attempts to standardize wind observation procedures otherwise enjoyed little success, but matters changed in the eighteenth century when some new terms, similar to those used in English, started to be used. Before 1750, most of the Spanish authors of nautical treatises ignored the terms used in other countries to describe wind force and character. After 1750 matters improved, giving scope for a better understanding of logbook terms. For example, the *Tratado de la Cosmographia y Nautica* (Treatise on Cosmology and Navigation) - Cedillo (1745) - states that winds

> '….are divided in steady and unsteady…, others are tempestuous as hurricanes, others still or calm. Others are called *terral* [from land] which blow from land…Others are marine which blow from the sea and are steadier and healthier.

In addition, Juan y Santacilla (1771) helpfully quantified some wind forces:

> 'The wind running at 24 feet per second is *bastante violento* [quite violent] in such a way that it is difficult walking … The wind running at 66 English feet is a *tempestad fuerte* (strong storm) and if it is more, a *huracan* [hurricane]'.

Ulloa (1795) defines the different wind intensities with yet greater rigour, 'According to its strength, and starting to count, from *calma muerta o chicha* [dead calm], when no wind is felt, it is said to be only *calma* [calm], when, from time to time a very light wind is felt; *vagajillo*, which others write *vahajillo*, when some very weak wind, not reaching water surface, is noted; *ventolina* [light airs], when this *vagajillo* points from different parts, without any of them fixed or preferred; *viento entablado* [settled wind], when it points from a specific direction; *viento fresco* [fresh wind], which is also called wind of all sails and, in other style, topgallant wind, when all the sails are set and they do not flap; *frescachón* [near gale], when it is rough and does not allow to use topgallant sails; *cascarrón* [rough], when it is needed to take in the topsails; *ventarrón* [gale], when it obliges to furl the sails except the mainsails; *temporal* (storm), when it is needed to stay only with the staysails and foresail. Besides, there are squally and gusty winds and hurricanes'.

Such unambiguous reflections on the meaning of archaic terms were an indispensable aid in the preparation of the CLIWOC dictionary.

The total number of wind force descriptors in the 500 or so Spanish logbooks, and after taking account of differences in spelling, was 104. In common with the experience from the English vocabulary, a large number of these terms was used only once or twice, and the thirteen most popular account for almost 90 per cent of all logbook entries. Of these, the most frequently encountered was *bonancible* (moderate breeze) accounting for 23 per cent, followed by *fresquito* (fresh breeze) 20 per cent, *fresco* (fresh-strong breeze) 19 per cent, *calmoso* (light breeze) 9 per cent and *flojo* (gentle breeze) 7 per cent. It is interesting, and bears witness to the international character of the nautical vocabulary of the age, that all of these descriptors, in their English form, were adopted by Beaufort. Applying the methods of contents analysis and by consultation of contemporary texts, it was possible to give Beaufort scale definitions to all save a very few of the Spanish terms.

As explained in Chapter 2, only 99 French logbooks could be examined. The meaning of the terms that they contained was assessed through contemporary texts and contents analysis. The *Diccionario Marítimo Español* (O'Scanlan, 1831), although a Spanish item, contains an appendix with French – Spanish translations. Equally useful was the *Nuevo Diccionario Francés-Español y Español-Francés.* Alexander Dalrymple's late eighteenth unpublished treatise entitled *Practical Navigation* also contains a summary table showing the correspondence between English and French terms, and is one of the earliest attempts at direct translation. Falconer's *Universal Dictionary of the Marine* (1780) also contains a valuable appendix of French terms.

Eliminating differences of spelling etc. some 100 different descriptors were identified but, again, many of them (35) were used only once, and only 30 of them more than 12 times. The term *bon frais* revealed the highest frequency (22 per cent), followed by *petit frais* (20 per cent), *joli frais* (8 per cent), *variable* (5 per cent) and *bon petit frais* (4.5 per cent). However, among the most widely used terms, and in contrast to the Spanish experience, only one term in its English form, *joli frais* (moderate breeze), became part of the Beaufort scale. The terms *grand frais* and *calme* also were included in the Beaufort scale, but their relative frequencies of usage were low at about 3 per cent. Other terms included in the Beaufort scale such as *legére brise* (light breeze), *petite brise* (gentle breeze) and *bonne brise* (fresh breeze) were only occasionally used, with frequencies of less than 1 per cent. Once again only a small number of the least frequently used terms could not be confidently defined.

A footnote on the question of wind speed

Today's climatologists are used to estimating the strength of the wind by its speed. But mariners have always been more comfortable with the concept of wind force and the action of the winds on the ship and its sails. It has, however, proved to be a more than difficult task to equate Beaufort force with wind speed. Beaufort had never intended to measure the speed of the wind and the wind speed ranges now commonly attached to his scale are a recent addition, having only appeared in the twentieth century. Even today there is some disagreement over the precise nature of the relationship, some indeed going so far as to suggest that such correspondences are impossible to justify. The CLIWOC project did not concern itself with this issue, but the debate provides an intriguing footnote to this part of the project's activities.

The first serious attempt at correlating wind force with speed did not take place until the late nineteenth century, when Richard Curtis (Curtis, 1897) presented his paper to the Royal Meteorological Society. This was followed by studies completed by Simpson (1906 and 1926) for the UK Meteorological Office. Only in 1949 were wind speeds adopted to replace Beaufort force numbers. But the matter was not laid to rest and the World

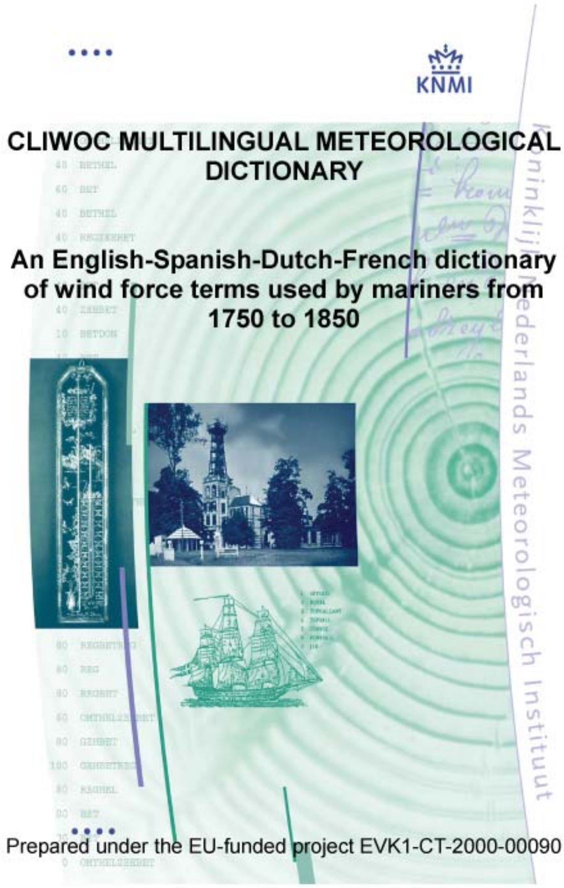


Figure 3.7 Cover page of the CLIWOC Multilingual Dictionary

Meteorological Organisation felt compelled to produce another report (WMO, 1970). Today, the debate continues, and it in the light if this unresolved issue that the wind speed column of Appendix I should be read and understood.

The CLIWOC multilingual dictionary

The dictionary was completed in 2003 (Figure 3.7). It provides a discussion of the nature of the four vocabularies of the project and a general background to its preparation. Beaufort equivalent force numbers and notes where necessary are included for nearly 500 terms from the period 1750 to 1850. Summary appendices of cross references and summary 'look up' tables are included. Printed copies are available from Professor Ricardo Garcia Herrera (Universidad Complutense de Madrid), Dr. Dennis Wheeler (University of Sunderland) or Mr. Frits Koek (KNMI), all of whose contact details are given in Table 1. Alternatively downloadable pdf versions are available from the project website at www.ucm.es/info/cliwoc.

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CHAPTER FOUR

LOGBOOK DATA VERIFICATION AND CORRECTION

I am confident that more ships perish by our ignorance of the winds and currents than by other disaster…if the masters of ships were oblig'd to give in journals of their voyages to all parts of the worlds: and those for many years compar'd with each other, we should not only be able to collect a history of the trade winds and monsoons…but should find, that there are many Anniversary tempests which might be foretold.

Bohun (1671), p.298.

Introduction

Although the CLIWOC project was the first to abstract large volumes of logbook information to support a scientific database, the team were by no means the first to recognise the scientific potential of these data gathered from around the world. The application of logbook information to climatological studies has a long history. Perhaps the first of a long and notable line of scientists to appreciate the use to which the information could be put was Ralph Bohun who, in 1671, made the remarkable statement with which this chapter opens. Bohun seems, however, never to have had the opportunity to put his theory into practice. Isaac Greenwood's (1727) paper presented at the Royal Society of London some half a century later is similarly enthusiastic, but more instructive about logbook information and its use. Meanwhile, and more famously, Edmund Halley (1686) had drawn heavily on logbooks when theorising on the trade winds and similar circulations, while Hadley's (1735) ground-breaking paper also drew on the accumulated information derived from the logbooks of ships navigating in the tropical latitudes. By the late eighteenth century the hydrographer of the EEIC, Alexander Dalrymple (1778 – see also Figure 4.1) and, later, John Horsbrough (1817), used the growing number of logbooks of the Company's ships to prepare 'sailing directions'. These publications were intended to make for safer and faster journeys between the Far East and England. They were as much written for economic advantage and ship safety as for other purposes, but contained the distillation of the practical knowledge of winds that was itself a matter of scientific importance at a time when our knowledge of the planet was still imperfect. The views of the Royal Navy's hydrographer, Francis Beaufort (Figure 4.2) echo those of his EEIC counterparts and he was instrumental in formalising the content of Royal Navy logbooks by use of his wind force and weather scales and codes (Courtney, 2002). But it was the seminal publications of Piddington (1848) and Reid (1849) that were to see logbook information being brought to the highest level of scientific understanding. In both cases logbook data, which by then was becoming increasingly instrumental in character, was used to help in understanding the nature of storms and hurricanes and lay the foundation for much modern science in this field. Indeed, it was Piddington who first used the term 'cyclone' drawing on logbook records to recreate the circulation of air around tropical storms in the Indian Ocean.

Interestingly, none of the above authors expressed concern regarding the accuracy and reliability of the data from

Figure 4.1 Portrait of the first hydrographer to the English East India Company, Alexander Dalrymple. By courtesy of the British Library.

Figure 4.2 Portrait of Admiral Sir Francis Beaufort. By courtesy of the National Maritime Museum, Greenwich

which their often monumental conclusions on climate were drawn. This is not surprising. Chapter 1 has already demonstrated that the weather element of logbook entries were required not only to justify actions taken by the commander, actions for which he may later be held accountable but, more importantly, for everyday activities of which navigation was the most important. In other words it was beholden on the observing officer to make the best estimate possible of the winds and weather. To do otherwise, and allow unreliable data to be included in the processes of dead reckoning, would be to put his and his crewmens' lives at risk. There is therefore a strong *prima facie* case to suggest that the observations are reliable.

Assessing logbook data reliability and consistency

However persuasive such deductions might be, it was important that the CLIWOC project made its own endeavours to estimate as objectively as possible the accuracy of the data. There were very few precedents on which any similarly objective judgement could be based. Oliver and Kington (1970) stated that when logbooks were prepared by the officers of ships in company "…an encouraging agreement between them becomes apparent." (p.520). This suggestion was supported by the agreement found to exist between logbook data and the daily synoptic patterns established using land-based, often instrumental, data. As a result, both Kington (1988) and Lamb (1991) had sufficient confidence in logbook data to use them in their reconstructions of past synoptic conditions. Wheeler (1988) took the

Figure 4.3 The wreck of HMS Magnificent, March 1804. By J.C. Schetky. By courtesy of the National Maritime Museum, Greenwich

more practical approach of using present-day sailing vessels taking part in one of the Tall Ships Races and conducting an experiment to record wind force and wind direction on a long voyage using the methods that had been employed two centuries ago. These observations were compared with the contemporary synoptic maps, and the results confirmed Oliver and Kington's observation that they provided a faithful representation of conditions at the time. Wheeler (2001) used the logbooks of English ships engaged in the Trafalgar campaign of September and October 1805. In this situation, the logbooks of twenty or more ships, all in the same area at the same time, could be compared. The assembled data indicated that there was perfect agreement with respect to daily wind direction and wind force for two-thirds of the observations. The degree to which the remaining one third disagreed was minor. For example, the wind forces might differ by one unit of the Beaufort Scale (a precursor of which was then in widespread use). Wind directions differences were of the only of two or three points of the 32-point compass. Such findings are encouraging but based on small and very specific samples.

The CLIWOC project required a more wide-ranging review. Clearly it would not be possible to compare the written record with the events that they described. Nevertheless situations did arise that allowed the consistency of the record to be assessed and for Oliver and Kington's (1970) suggestion regarding ships in company to be subjected to closer scrutiny. Such opportunities were limited however, and confined to those occasions when the logbooks had survived of two or more ships sailing 'in company'. The logbooks of such vessels would have been prepared independently, and although the ships would have been in sight of one another, exchanging signals even perhaps crew, there is no evidence to suggest collaboration in their preparation, and it can be concluded that where the two records coincide the consistency suggests also that they are reliable. Where, on the other hand, there are wide disagreements between the records, the observational system and skill of those using it have to be questioned.

One set of duplicate logbooks that could not be used in this exercise were the multiple documents found on larger ships where the captain, the master and the lieutenant's each produced their own logbook. These logbooks, whilst prepared individually, were based on the rough deck logs written up by the officer of the watch and to which they all had access (very few of these 'rough' logs are known to have survived). Each officer might have added some of his own notes, the captain, for example, being careful to include lists and reasons for punishments, but the essential weather information may well have been common to all and therefore not independently derived.

Paired voyages: analysis and review

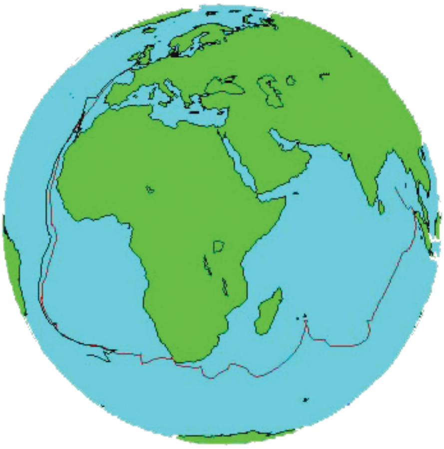
The list of paired voyages that were used in the analysis is provided in Table 4.1. Because so many more British than Spanish, French or Dutch logbooks had survived, there is a preponderance from that source. But, given the similarities of observational procedures that are known to have characterised the study period, this is less of a problem

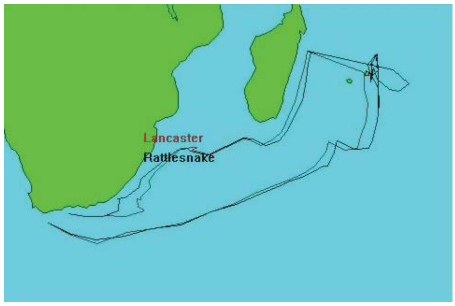
Start date	End date	Route (and sub-sample number)	Nationality and source
4th April 1795	9th June 1795	Greenwich to Cape of Good Hope (sub sample 1)	English (EEIC)
31st January 1800	9th June 1800	Cape of Good Hope to Mauritius and return (sub sample 2)	English (RN)
8th September 1799	8th November 1799	England to Barbados (sub sample 3)	English (RN)
17th July 1800	18th November 1800	Cape of Good Hope to Reunion and return (sub sample 4)	English (RN)
7th February 1816	8th May 1816	Java Head to the Downs (sub sample 5)	English (EEIC)
10th April 1815	20th August 1815	Downs to Penang (sub sample 6)	English (EEIC)
23rd June 1806	7th August 1806	Plymouth to Barbados (sub sample 7)	English (RN)
8th April 1807	26th May 1807	Cape of Good Hope to the River Plate estuary (sub sample 8)	English (RN)

Table 4.1 Details of voyages of ships in company, the logbooks of which were used to examine recording methods. EEIC = English East India Company, RN = Royal Navy

than would otherwise have been the case. Figures 4.4a and 4.4b show the routes of two such voyages in company. As far as was possible, only voyages in which the two ships were together for more than a month were used. This fulfilled two requirements. The first was statistical and ensured a suitably large sample of observations. The second was to provide as much scope as possible for a variety of weather conditions that would test the data across the full range of the measurement scales.

Attention is focussed on the two principal elements of wind force and direction. Both are key variables that provide the basis for pressure field reconstructions with which insight can be given to the nature of past climates (see Chapter 6) and demand careful assessment. For each paired voyage there are parallel daily series of both variables. The wind force terms required calibration and standardisation to Beaufort Force equivalents numbers using the CLIWOC dictionary (see Chapter 3) but, this having been done, the comparisons can be made. By this means the various archaic terms and descriptions are expressed in modern





Figures 4.4a and 4.4b Routes of two of the pairs of ships in company the observations from which were used to test for consistency of record. a) HMSs Victorious and Sphinx. b) HMSs Lancaster and Rattlesnake

equivalents and as numbers on the Beaufort Scale (these range from 0 for a calm to 12 for a hurricane). Two statistical aspects had to be considered. Firstly, to what extent were the day-to-day variations of wind force and direction echoed in each set of paired observations? Secondly, what were the absolute differences between each of the paired series? The two are quite different, as a moment's reflection will reveal, and a paired series may be perfectly correlated, showing the same daily variations, but being different in magnitude. For example, one set of wind forces might always two units more than the other, but otherwise perfectly correlated.

The results of these two exercises are summarised in Tables 4.2 and 4.3. In the case of wind force, the differences between the series (Table 4.2) are consistently less than one unit on the Beaufort Force scale. More generally, taking all 500 pairs of observations in the data set, no fewer than 43 per cent are identical, and a further 33 per cent differ by only one unit of force. The situation for the degree of correlation between the series is equally encouraging. The correlation coefficients, although having to be used cautiously because of the peculiarities of the data set, strongly suggest that in all eight samples, the paired sequences of rising and falling wind forces are closely associated. The maximum possible correlation is 1.0, those in Table 4.2 are between 0.61 and 0.84 and all are statistically

Sub-sample (see Table 2)	Mean force (Larger ship)	Mean force (Smaller ship)	Difference of sample means	*t*-statistic (two-tailed *p*-value)
1	3.89	3.61	0.28	1.46 *(0.15)*
2	4.60	4.21	0.39	2.39 *(0.22)*
3	4.87	4.75	0.12	0.71 *(0.48)*
4	4.65	5.04	–0.39	–2.24 *(0.04)*
5	4.25	4.08	0.17	1.29 *(0.20)*
6	3.91	3.36	0.55	2.73 *(0.01)*
7	3.38	3.77	–0.39	–2.06 *(0.05)*
8	3.15	3.59	–0.44	–2.81 *(0.01)*

Table 4.2 Summary of wind force differences in the series of observations from ships in company.

significant at the 0.01 level. An additional point of interest brought out by Table 4.2 is that the differences reveal no relationship with the size of the vessel. There was a concern that the perception of wind and waves might be greater in smaller vessels, leading to those logbook entries having inflated estimates and introducing thereby a degree of bias. On the basis of the samples to hand, this seems not to be the case and the preference for higher wind force

Sub- sample	vessels (and tonnage)	vessel (and tonnage)	Sample size	correlation coefficient	mean difference in wind directions*
1	*Victorious* (1657)	*Sphinx* (429)	65	0.70	1.69
2	*Jupiter* (1044)	*Star* (365)	197	0.77	3.88
3	*Diana* (652)	*Calypso* (337)	54	0.75	1.72
4	*Lancaster* (1430)	*Rattlesnake* (330)	53	0.84	5.54
5	*Ceres* (1430)	*Inglis* (1298)	77	0.74	2.20
6	*Warley* (1460)	*Ceres* (1430)	33	0.75	2.91
7	*Belleisle* (1889)	*Decade* (918)	41	0.67	2.03
8	*Neriede* (892)	*Camel* (879)	41	0.61	1.78

Table 4.3 Summary of difference between logbook wind force and wind direction series.
** these differences are in terms of compass points, where a point is 11.25°.*

estimates was shared equally between the larger and smaller ships.

The situation for wind direction observations was similar. Over the whole data set, 20 per cent of the pairs are identical, and a further 25 per cent differ by one compass point, but it should be recalled that, in comparison with wind forces, which are measured on a 13-point force scale, direction is based on a 32-point compass in which a point is 11.25°. The average differences over the eight individual sub-series are mostly of the order 1 to 3 compass points. Where disagreements do occur they tend to be associated with light winds. In these circumstances the estimation of direction is made difficult by the uncertain and fitful nature of the airflow around the ship with its literally baffling mass of sails and rigging. It should, however, be noted that instantaneous wind direction cannot be estimated even today with any greater reliability, and anemograph records reveal only too clearly the rapid fluctuations to which this phenomenon is subject, and variations of 20 to 25° on a time scale of seconds are quite normal. Even this explanation does not, however, account for the greater differences found in sub-sample 4. This problem may alert the modern-day scientist to an issue not unknown to sailors of more distant times that possibly reflects the influence of the iron cannon on the local magnetic field. Mariners termed such influences 'deviation', in contrast to the 'variation' between true and magnetic north. The most probable explanation was that the compass of one of the ships was badly situated with respect to the disposition of nearby cannon, the magnetic field of which interfered with the terrestrial field.

The Dutch East Indies convoy of 1796

No suitable paired voyage logbooks could be found for the French or Spanish collections, but a notable opportunity existed to examine the consistency of record in Dutch logbooks. Eight of the logbooks have survived of a fleet that set out from The Netherlands on early 1796. A large part of this fleet was sailing for the East Indies via the Cape of Good Hope. The ships, whose size varied between the principal 64-gun vessels and smaller

Figure 4.5 The EEIC ship Hindostan. By C. Brooking . A typical ocean-going vessel of the late eighteenth century.
By courtesy of the National Maritime Museum, Greenwich

ships of just 20 guns, took a route northwards around Scotland before heading south. However, the fleet reached only Cape Town, where it was taken by an English fleet in September of the same year. Nevertheless, the length of voyage and the inevitable range of conditions encountered across the two hemispheres provided a valuable data set and are summarized in Figure 4.6 in which daily mean wind force through the voyage is plotted and reveals the disturbed and variable nature of the two hemispheres' mid-latitude but more settled conditions close to the Equator.

Correlations of the wind force series were produced (Table 4.4) and the degree of agreement is generally high, and was low for only one vessel, *Revolutie*, suggesting a systematic problem with the observations made on this ship. The differences between the eight mean wind forces estimated over the whole voyage were small, the maximum mean force being 3.28 (for the *Castor*) and the minimum 2.92 (for the *Vrouwe Marie*), a range of only 0.36 units on the Beaufort Scale.

	Dordrecht	*Braave*	*Sirene*	*Revolutie*	*Havick*	*Castor*	*Vrouwe Marie*
Braave	0.582						
Sirene	0.624	0.486					
Revolutie	0.303	0.332	0.350				
Havick	0.824	0.643	0.682	0.396			
Castor	0.605	0.414	0.631	0.144	0.665		
Vrouwe Marie	0.429	0.372	0.453	0.217	0.501	0.475	
Tromp	0.679	0.517	0.524	0.220	0.565	0.486	0.192

Table 4.4 Correlation coefficients for the wind force series of the Dutch East Indies convoy of 1796. Sample size = 130.

Wind directions for the Dutch fleet were compared on the basis of taking the mean direction for each day and calculating the degree of departure of individual observations for the day from its respective mean. The differences were similar to those for the English data. Overall, 39 per cent of all observation differed by less than one compass point from the daily mean, and the average difference from the day's mean of 2.19 compass points (24.6°).

These findings are important. It must be recalled that they are drawn from subjectively estimated observations and do much to quantify the accuracy of such methods of securing meteorological data. These objective findings also give statistical substance to the assumptions made by scientists and hydrographers who over the centuries drew heavily upon logbook data when pursuing their various studies. It is clear that there are occasional departures from the generally high standards set by the officers of the day, and scientists need to be alive to this difficulty but without diminishing the value of the majority of the data.

In addition to assessing the intrinsic consistency and accuracy of the logbook observations, the CLIWOC team gave attention to other corrections that had to be applied to the data before they could be used for scientific analysis. These issues, related

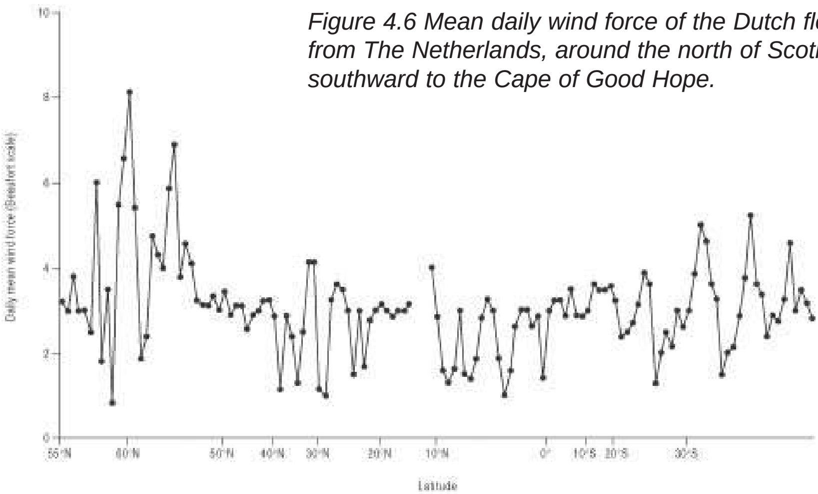


Figure 4.6 Mean daily wind force of the Dutch fleet of 1796 sailing from The Netherlands, around the north of Scotland, then southward to the Cape of Good Hope.

principally to the question of adjustments to the recorded direction and location of the ship at the point of recording, need now to be reviewed.

Wind directions and magnetic variation

In Chapter 1 it was noted that logbook entries for wind direction were made by reference to magnetic and not to true north. It is known that courses, derived from dead reckoning estimates would be plotted as 'true' directions, and that this was required by nautical charts on which the lines of longitude were printed with respect to the geographic North Pole. It is also known from contemporary texts on navigation such as Robertson (1786) that the navigation officer would correct the logbook wind directions to 'true' only during the course of his calculations, and that magnetic variation was measured regularly and accurately to enable this conversion to be made. Indeed, so assiduous were the officers in this respect that logbooks, here used for climatic studies, have also served a useful purpose for geophysicists in their attempts to reconstruct past changes in the earth's magnetic field (Jackson, *et al.,* 2000). The problem with variation is that it changes over space and time (Bloxham and Gubbins, 1985). It is generally modest, varying between zero and 20 degrees in the low latitudes, but can rise to 35 degrees of more in the high latitudes (Figure 4.7). In order that the wind direction data can be incorporated correctly into the database, corrections had to be applied by making reference to the now well-understood patterns of variation over the past few centuries.

The problem of longitude and fixing observations in space

The problems of fixing the observations in space were more challenging. Chapter 1 has already discussed how latitude and longitude were estimated. The former can be regarded as reasonably accurate throughout the logbook period and could be measured directly with sextants or octants. Longitude, on the other hand, was a more vexed issue on two counts. Firstly, until well into the nineteenth century when accurate chronometers

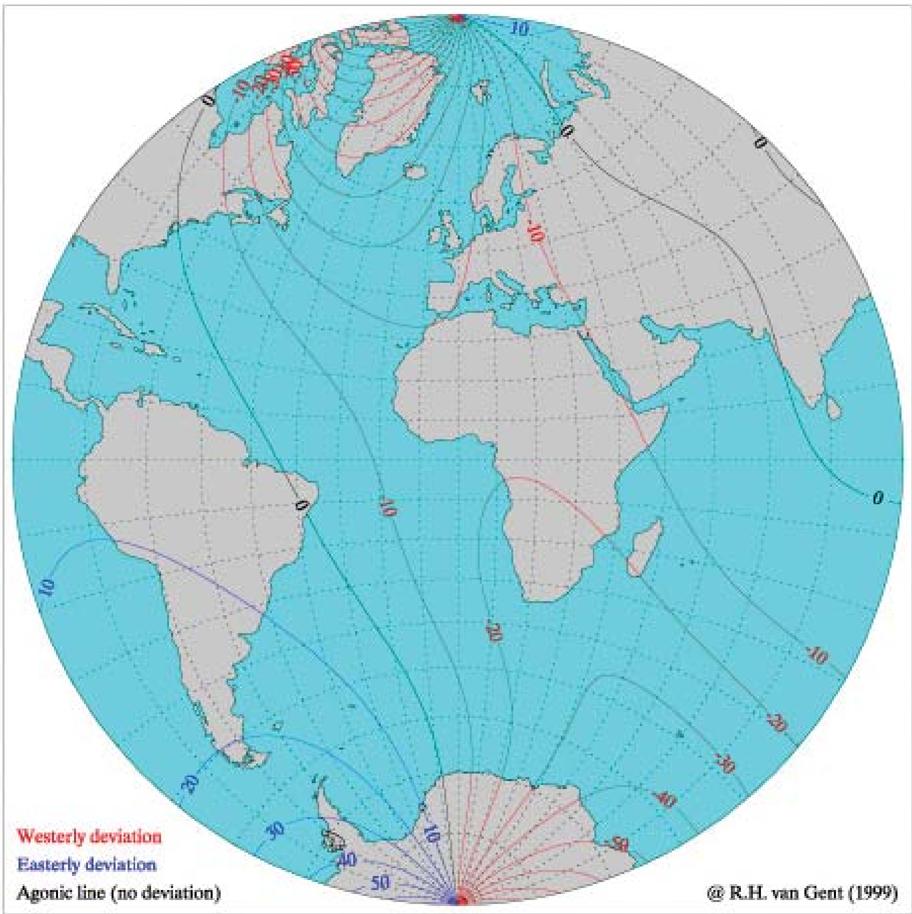


Figure 4.7 Map showing magnetic variation for 1800. By courtesy of R.H. van Gent.

became cheaper and more widely available, longitude could only be determined in an approximate manner by the methods of dead reckoning outlined in Chapter 1. Secondly, throughout most of the period that formed the focus of the CLIWOC study there was no agreed prime meridian. Greenwich became the world standard only in the late nineteenth century. Before that time there were a number of national standards; the Spanish often used the Canary Islands for example, or Cádiz. More commonly, each voyage had a number of meridians determined firstly by the port of departure or by the last sighted landmark before taking to the open sea. Thus, Lands End or the Lizard were popular zero meridians for English ships. The zero meridian would then change if landfall were made at some known place, for example, St Helena or the Cape of Good Hope, which then became the new meridian for the next leg of the voyage. Seemingly confusing to the present-day reader of logbooks, this was in fact a sensible solution to the problem of the inevitable accumulation of error in daily longitude estimates that occurred on long voyages. It allowed the navigation officer to reset his bearings, and start again confident in the knowledge that he had a new and reliable meridian.

One of the problems with the changing of meridians was that they were not always noted in the logbooks, and only became apparent when the routes of ships were plotted, occasionally providing some quite bizarre trajectories, as in Figure 5.4a in which the ship in question apparently negotiates the Sahara Desert! It was therefore necessary to check the voyages for this sort of obvious error. During the course of the project, the team found over 600 different meridians that had been used, often not exclusively by one national group. The full list of these can be found on the project website at www.ucm.es/info/cliwoc. Where doubts existed about the zero meridian in use at the time, careful checks of the routes and other data in the logbooks generally provided the answer.

In conclusion, it can be confidently asserted that logbook data, even when derived from subjective assessments of the conditions at the time, provide an acceptable basis for scientific investigation. Most certainly there are occasional exceptions to this judgment, but this conclusion would have come as no surprise to Beaufort, Dalrymple and others, but it is important that is confirmed for scientists in this more skeptical age.

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CHAPTER FIVE

THE CLIWOC DATABASE: DESIGN AND STRUCTURE

Most of the things worth doing in the world had been declared impossible before they were done.

Louis D. Brandeis, Supreme Court Justice (1856-1941)

Introduction

The CLIWOC database consists of 280,000 entries, each of which includes coding and information for a range of data and information abstracted from the logbooks. The system also includes supplementary, non-climatological material and metadata relating to the logbooks. Appendix II summarises the individual elements available for each 'entry', where an entry is defined as a day's observations from a single vessel's logbook; it usually, therefore, consists of several items. The CLIWOC database is one of the largest of its kind, and the only one to focus on observations from sailings ships from before the mid-nineteenth century. Its development took place alongside the data abstraction process and was started four months into the project, at which time the data abstraction procedures had been largely decided upon. The completion of the database was one of the principal objectives of the CLIWOC project and upon completion the coverage was extensive over the North and South Atlantic and Indian Oceans. Figure 5.1 summarises the distribution of the 280,000 days of observations that were included in the database

The project partners started with the abstraction of the data from the logbooks in their own countries. This initial phase generated 'working databases' that were sent to the Dutch partners for processing and inclusion in the final CLIWOC database. This initial data

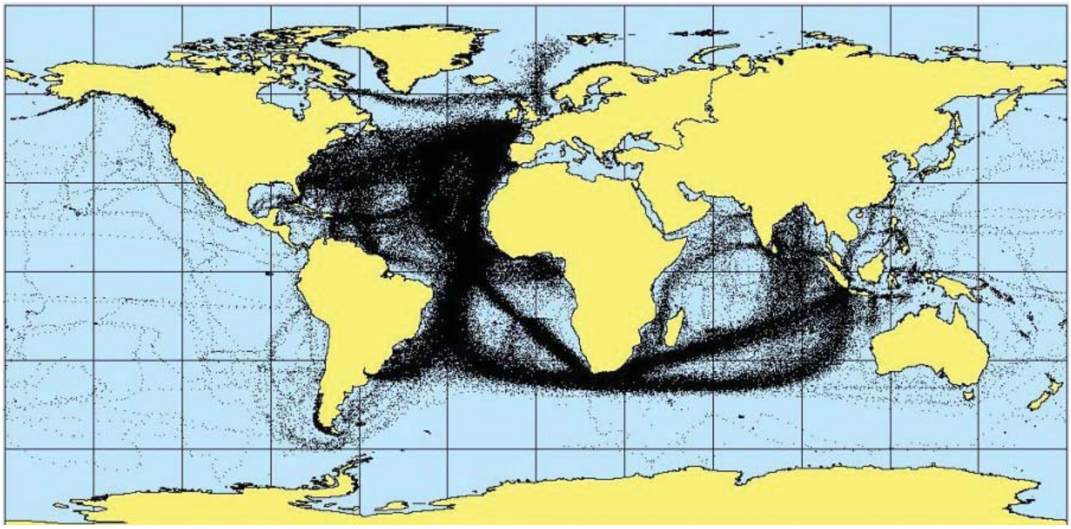

Figure 5.1 Geographical coverage of the CLIWOC data (1750-1854).

abstraction exercise was performed using MS Access (in the case of the Spanish, French and Dutch logbooks) but, and in order to meet local needs, MS Excel was used for the British logbooks. These 'working' file were for use only within the project, and were not released as part of the database. Quality checks were performed at all stages. Those for the abstraction process required double transcription of a 5 per cent sample from each member of the abstractor team to check for consistency. This process of primary abstraction and transcription was carried out by skilled and informed teams and, reflecting their enthusiasm and application, errors accounted for less than 1 per cent of the transcribed raw data. Further checks on the quality of the data were carried out before they were entered into the database.

Difficulties were encountered in the integration of datasets from the different sources. In particular, the system of sampling from the British documents, where the number of logbooks was more than 100,000, necessitated a different system of file management to that used for the other sources where the majority of the available logbooks could be called upon (see Chapter 2 for a discussion of the general question of logbook availability). In response to these issues the database passed through several preliminary stages before a final version was agreed. These pilot versions were not released, but served a very useful purpose for the team not only in helping to design an effective database structure but in also providing some preliminary results.

The database: strategic considerations

The principal focus was, of course, on the meteorological observations, but it was apparent from the outset that logbooks contained a much wider range of material (see Chapter 7) and it was decided that the opportunity should not be missed of providing material of interest to other disciplines. Such information included notes on the conditions of life on board and descriptions of vegetation and animal life at sea. Comments on disease amongst the crews and notes on stores and supplies were also abundant. Additionally, encounters and voyages with other ships were mentioned. This was of particular interest because it gave an opportunity to cross-refer with weather observations on more than one ship at the same place and time.

One of the objectives of the CLIWOC project was to make these various forms of data and information freely available to the academic and wider community. The wisdom of this decision was evident in the high level of interest aroused in the media and general public. The preparation of newspaper articles, TV and radio programmes figured to an unexpected degree in the team's activities. Additional impetus was provided by the interest shown in the CLIWOC project by the ICOADS (International Comprehensive Ocean Atmosphere Data Set) team of NOAA. Together with this highly experienced group, the database team worked on a general ASCII format system of encoding data that offered the advantage of being accessible to most individuals and groups. Beyond this general requirement, the IMMA (International Maritime Meteorological Archive) format (Woodruff, 2004) was adopted. This system was developed by NOAA under the auspices of WMO specifically to archive historical ship data that cannot be managed by other formats. The IMMA format overcame the problems posed by the lack of uniformity among countries, shipping companies or owners in recording weather observations before the first maritime conference in Brussels (Quetelet, 1854). It does so by allowing the use of the present-day unit conventions in a 'core' record along with the original reports in readily accessible attachments that are 'tagged' to the aforesaid core entries. In this case, the core contains the basic coordinates and meteorological elements transformed into standard SI ('Système International') units, together with pointers to attachments where all data are stored in the original languages and units. The attachments also give access to metadata, miscellaneous observed data and pathways to the available digital images. A reference table links the old geographical names to modern English names and positions. In this fashion the system it meets the multi-disciplinary needs of the database objectives noted above and reflects the range of information that is needed to make the its components understandable.

Because not all potential users of the CLIWOC data were able to work with direct access to large ASCII files, it was decided that the final database should be available in MS Access as well as in the IMMA format. To overcome additional problems of different versions of MS Windows being in use, the Access release was offered in Access 97 and Access 2000 formats. All the database variants were made available in downloadable form from the CLIWOC website. Looking to the future, the Spanish partner will maintain the database, but it is also available through KNMI as a separate data set. In due course it is planned that these data will be incorporated into the monthly summary statistics of ICOADS and integrated with the data set derived from late eighteenth and early nineteenth century sailing vessels of different nations by the US naval officer Matthew Maury in the mid-nineteenth century (García Herrera *et al*., 2005).

Composition and character of the database

As a consequence of the contributions by the different countries, the final database contains material drawn from original text expressed in a variety of languages, sometimes using a specialist vocabulary. In addition, there were changes and evolution over of the vocabulary of the century-long CLIWOC study period. All such differences had to be resolved to a uniform set of descriptors before the final database could be drawn up. The *CLIWOC Multilingual Dictionary* that was designed to accomplish this aim is described in Chapter 3.

Despite the problems of database management posed by such diverse and varied sources and the need for uniformity, it was important that reference could always be made back to the original material and its wording. These primary elements have been retained taking advantage of the IMMA format. The transformations were originally made in each language group before inclusion in the database, which contains conversion tables for the wind force and wind direction for all four partner languages (English, Dutch, Spanish and French). But, importantly, because of the transparency of the processes of translation, should any improvements be necessary in the future, it will be easy to trace those changes through the system.

One of the features of this project was not the shortage of data but the abundance. As noted in earlier chapters, not only were there a very large number of logbooks, only a proportion of which could be examined, but observations were often made several times each day. Limitations on time required some rationalisation of the data set, and it was decided to confine attention to the noon observations. This was the most important of the day and, for many years, marked also the start of the nautical day (see Chapter 1). This restriction offered the important advantage of further standardising the data set, on this occasion by time of observation.

Checks were made to avoid duplicate entries and a small number were identified. Nevertheless ships 'in company' did provide the paired data sets discussed in Chapter 4 with which checks could be made for consistency of the observational procedures. Moreover, many Dutch data were abstracted from the so-called 'extract logbooks' prepared from older originals during the 1860s (these are discussed also in Chapter 2). The extract logbooks provide consistently recorded information until 1854 and these allowed the database to be extended until that date. The extracts mostly contain meteorological data supported by time, date and position variables. In cases where both the original logbook data and the 'extracted' data were available, they could be compared and used for interpretation of the many abbreviations and symbols that were used in the extract documents. A large number of such codes were used, and these have been drawn together in Appendix III. Figure 5.2 shows a typical page from an extract logbook.

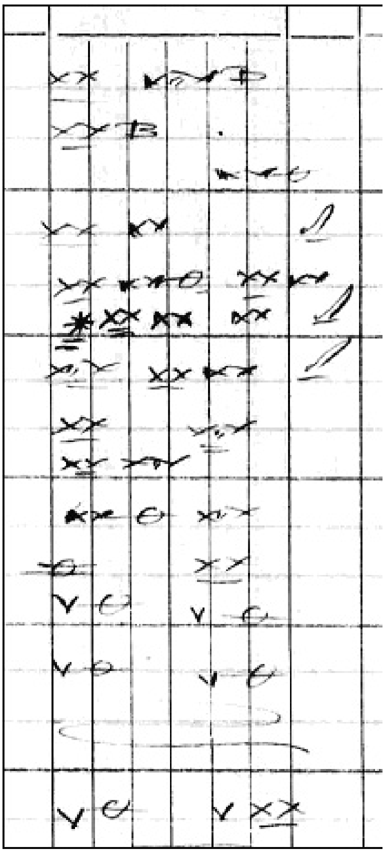

Figure 5.2 Sample of an extract logbook, showing symbols, used for the description of the weather. This example is taken from the record for HMS Panther, March 1839. See Appendix IV for the meaning of the symbols used in this logbook.

Even after the above issues had been resolved, technical questions arose at the point of merging all the information into a single database. Perhaps most importantly, it was necessary to ensure that the information was correctly disaggregated into the three constituent sub-areas of wind force, wind direction and weather descriptions. The latter offered the greatest problems as it included many phenomena and variables connected not only directly with the weather (cloudiness, precipitation, fog, etc.) but also the state of the sea, iceberg sightings and other occurrences. The database had to be designed to accommodate these various phenomena, and the fashion in which they were included in the system is summarised in Appendix II. Because this was the first attempt at any comprehensive survey of archaic logbook-based information, many of these problems arose only as the project unfolded. Nevertheless, at the conclusion of these, often lengthy,

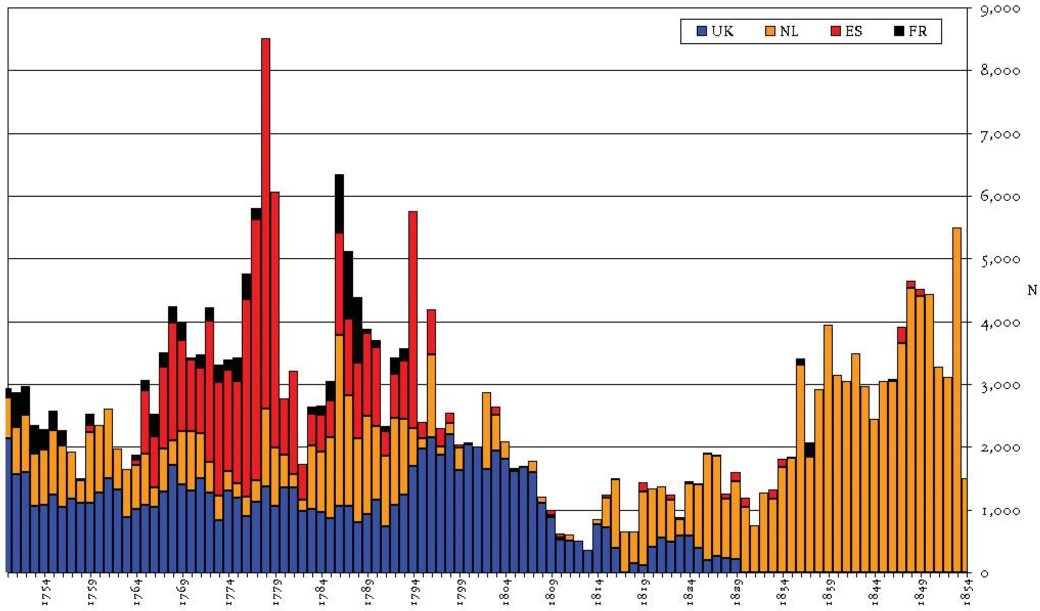

Figure 5.3 Temporal coverage of the CLIWOC data (1750-1854), displayed according to origin by country. British data - blue; Dutch data - orange; Spanish data - red; French data - black.

deliberations, a database was produced that is valuable and wide-ranging and to which further data can be added in the event of future developments or undertakings of this nature. The temporal pattern of contribution of data from the different groups is summarised in Figure 5.3 which clearly shows those periods on which future efforts should be focussed.

The database: operational factors

The CLIWOC database comprises several tables. The principal one is denoted as 'cliwoc' and contains the fields with the keyed and coded climate, location and metadata summarised in Appendix II. Some fields were not used, but are retained for convenience and possible future use. It was decided not to allow a complex structure to develop but to provide one with, as far as possible, a 'user friendly' character that allows those who consult it to employ the database to meet their own needs. The 'cliwoc' component of the latest release is in MS Access format, while the IMMA format version is in ASCII format with its attendant advantages of possessing a core element with one or more linked attachments as noted above. With this facility, it is possible for the user to start working with the meteorological data without having to invest much time in understanding the conversions or data derivation.

Chapter 1 has introduced the theory behind the other adjustments that had to be made to some of the data before they can be included in the final database. These relate principally to the date/time of the observations, and to their geographic location determined by latitude and longitude. They can now be reviewed within the context of their inclusion in the database.

The ship's position: latitude and longitude

In most logbooks, the noon position was noted in degrees, minutes and seconds of latitude and longitude. If landmarks, coastline elements or similar recognizable features were visible, the ship's position can be regarded as fixed with a higher degree of accuracy. As soon as the ship was too far from land to obtain such a bearing and distance, there was a decrease in the accuracy with which it could be located. Latitude presented few problems, and could be determined using instruments such as the octant or sextant. Nevertheless, they required sighting on the midday sun and long periods of cloudiness compelled mariners to fall back on dead reckoning methods with their attendant and, as the days went by, accumulating errors. A common source of error was the 'drift' caused by ocean currents. In many cases ships' navigators were aware of this source of error and could make the necessary corrections. Greater difficulties were presented by the determination of the longitude. The nineteenth century was well advanced before the chronometer became widely available (May, 1976) and longitude was widely calculated with an accuracy that approached that with which latitude was measured. Before that time, and therefore for much of the CLIWOC period, longitude was determined by dead reckoning - a mathematical combination of estimated traveled distances and courses sailed over the past 24 hours, all adjusted to take account of the effect of the wind on the ship's speed and direction of travel.

Latitude is defined as the number of degrees relative to the equator, with a maximum of 90 degrees at either the North or the South Pole, and this was a well-established convention long before the start of the CLIWOC period. Longitude, however, has been noted in different ways. Today the so-called 'prime meridian' runs from the North to the South Pole through Greenwich in South East London. Longitude can be counted up to 180 degrees to the east and 180 degrees to the west, joining in the Pacific Ocean at the International Date Line. Another way of presenting the longitude is to follow one direction, starting from Greenwich and move 360 degrees to the east. Both methods were used aboard ships but the real problem lies in the fact that use of the Greenwich meridian was not universal or even widespread before 1850. Other popularly used zero meridians were Tenerife, Paris and Cádiz, but more than 450 others were identified (these can be found in the database). It was vital to know which zero meridian was being used for each voyage or, more commonly, leg of a voyage. In many cases this was noted in the logbooks. Although about 80 per cent of all records could be fixed by reference to a known point, there were some 50,000 that could not and required additional research. Plotting the original positions in a chart without adjusting for the correct meridian would often draw attention to the problem, with ships often appearing to sail over land or to cover impossible distances in the course of one day. The ships' positions were plotted using a GIS (geographical information system - ArcMap by ESRI) that was connected to the database. The correction could usually be applied by careful study of the plotted (false) route and comparison with the nearest known or most likely meridian that would heave been used. Often the name of a new prime meridian was found in the observed bearings and distances that were written in the logbooks. Figures 5.4a and b illustrate the nature of the problem, and its correction. The accuracy of such corrected routes was readily apparent when they were mapped.

When plotting ship routes another problem became apparent; the methods of dead reckoning were not, as noted above, accurate and allowed for a cumulative increase in the daily error in estimating the ship's position. This often led to a notable change in the ship's position toward the end of the voyage as it made landfall and the final set of observations could be quickly corrected by reference to newly-sighted landmarks with known longitudes.

The database contains much positional data and includes two entries ('LatInd' and 'LonInd') that provide important keyed information on the methods used to determine respectively the latitude and the longitude. These are then given, in decimal form by 'Lat3' and 'Lon3'. Information on the use of these indicators, ranging from 1 to 6, is given in Appendix II. The decimal position (rather than degrees and minutes) was chosen as it provides for easier manipulation by the user. In all cases the longitude is corrected for the Greenwich meridian, but the original positional information, derived from the logbooks, is present and 'tagged' to the final, corrected, data. By convention, if 'Lat3' is negative, the ship's position is south of the equator; positive values are north of it. Negative values for 'Lon3' place the ship in the western hemisphere, while positive values are east of Greenwich.

Dating and timing the observations

One of the problems for the first few years of the CLIWOC period was the different calendar system used in Britain as opposed to that adopted in most other countries. The former persisted with the less accurate Julian Calendar until September 1752, after which if fell into line with most other nations in using the Gregorian Calendar. By that time the Julian date was 11 days behind that of the Gregorian Calendar. A further change that took place at that time was the date of the New Year. In Britain it was taken as 25th March (Lady Day) and the period between 1st January and that date was usually denoted by the year annotation, for example, 1750/51. The Gregorian Calendar set the New Year to begin on 1st January. In the database the value in the field 'Calendar' indicates which of the two was used. The planned date of the

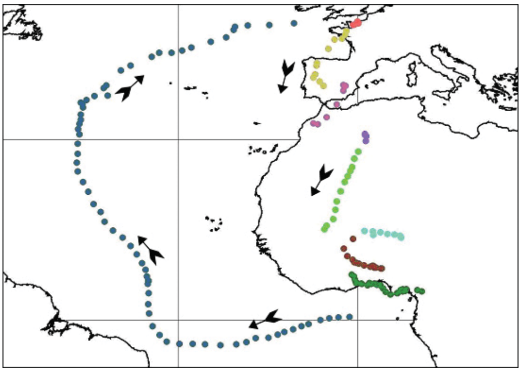

Figure 5.4a The positions of HMS Surprise (1750-1751) on a round trip from England to St. Thomas (Gulf of Guinea) without correcting the longitude to the current standard. On the return voyage the meridian did not change but the changing meridians on the outgoing leg are given by colour codes.

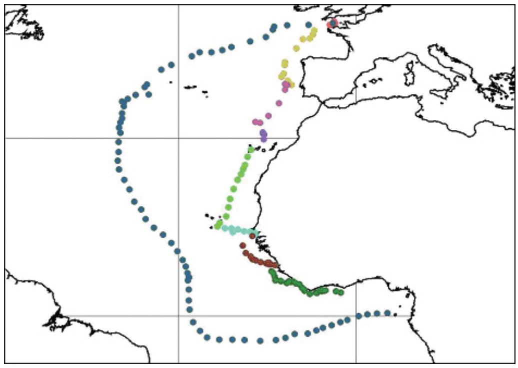

Figure 5.4b The positions of HMS Surprise after converting the longitudes to conform to the Greenwich Meridian.

adoption of the new system was known well in advance and most documents made the switch on the stipulated date so that 2nd was followed by 14th September (Duncan, 1998). In case the event was missed at sea, a manual check was performed using the day of the week and the date to determine which one was applicable.

The original (unmodified) dates were retained in the original database, but the formal date and time relative to Greenwich UTC (Universal Time Coordinated, formerly known as GMT, Greenwich Mean Time) was calculated using the date and time of the observation from the logbook, the calendar information and the ship's longitude. When no longitude information was available, the UTC time of observation was set at 00:00 hours. In this connection it should also be remembered that the nautical day began 12 hours ahead of the civil day; a difference for which allowances had also to be made, but was complicated by the protracted period of time, and different dates, at which the change was made in the different national sources.

Chapter 1 has already indicated that corrections had to be applied to convert wind directions, conventionally measured by reference to magnetic north into the more useful convention of bearings from true north. The database indicates which of these systems applies in each case.

Technical tools and abstraction procedures

While the database has been designed to be as accommodating as possible, some skills in the field of SQL (Standard Query Language) are helpful in working with the Access form of storage. Although MS Access offers many tools, a few additional items are offered by CLIWOC and may be freely used and adapted. Note should be made, however, that the table name 'cliwoc', used in the examples, may vary slightly depending on the release version. Procedures can also be written in SQL to perform specific tasks. With the following statement, for example, a table with the number of observations per 5 × 5 degrees squares is created.

```
TRANSFORM Count(*) AS N
SELECT Int([Lat3]/5)*5+2.5 AS Latitude
FROM CLIWOC
WHERE LatInd<6 AND LonInd<6
GROUP BY Int([Lat3]/5)*5+2.5
ORDER BY Int([Lat3]/5)*5+2.5 DESC , Int([Lon3]/5)*5+2.5
PIVOT Int([Lon3]/5)*5+2.5;
```

The SQL statement below displays the yearly number of observations, barometer readings, air temperature and sea surface temperature recordings in the complete database.

```
SELECT Round(UTC/1000000) AS [Year], Count(*) AS N, Count(BaroReading) AS N_Bar,
        Count(TairReading) AS N_Tair, Count(SSTReading) AS N_SST
FROM CLIWOC
GROUP BY Round(UTC/1000000);
```

With the following 'transform' SQL statement, a table of the number of records per year per ship's nationality is displayed.

```
TRANSFORM Count(RecID) AS N
SELECT Year, Count(RecID) AS Total
FROM CLIWOC
GROUP BY Year
ORDER BY Year
PIVOT Nationality;
```

The next, more complex SQL statement, will provide the records (ship, zero meridian, date, time, latitude, longitude, wind direction, wind speed and air temperature) from the database that are not coastal, have no duplicates and are in the Dutch language. Both wind direction and wind force are abstracted from lookup tables ('Lookup_NL_WindDirection' and 'Lookup_NL_WindForce').

```
SELECT CLIWOC.ShipName, CLIWOC.ZeroMeridian, CLIWOC.UTC,
    CLIWOC.Lat3, CLIWOC.Lon3, Lookup_NL_WindDirection.ProbWindDD,
    Lookup_NL_WindForce.Beaufort AS ProbWindspeed, CLIWOC.ProbTair
FROM (CLIWOC LEFT JOIN Lookup_NL_WindForce ON CLIWOC.WindForce =
    Lookup_NL_WindForce.WindForce) LEFT JOIN Lookup_NL_WindDirection
    ON CLIWOC.WindDirection = Lookup_NL_WindDirection.WindDirection
WHERE CLIWOC.PosCoastal = False AND CLIWOC.Duplicate = 0 AND
    CLIWOC.LogbookLanguage=”Dutch”;
```

Obviously, many more examples can be shown here, but enough has been

Release #	Number of records	Valid by	Used for	Remarks
0.4	178,040	7 Oct 2003	Preliminary analyses	Limited availability
1.0	181,027	20 Nov 2003	Final presentation to EU	Also made available on Internet
1.1	239,853	23 Jan 2004	Jones and Salmon, 2005	Update on Internet; Documented in García-Herrera et al. 2004
1.5	280,195	15 Apr 2004	Final EU product on CD-ROM	Update on Internet
2.0	287,649	1 October 2005	Under review	Update on Internet

Table 5.1 Summary of CLIWOC database releases and details.

presented to indicate the potential for data management and structured abstraction using these more specialised approaches. These are more fully discussed in texts such as Taylor (2003).

The database is available from the project website and its links at www.ucm.es/info/cliwoc. It can also be obtained on CD_ROM. The database will be brought up-to-date at regular intervals if more data becomes available or if adjustments, corrections or improvements can be introduced. At present several releases of the CLIWOC database are available and an overview of them is given in Table 5.1. At the time of releasing this publication, the last version number of the database is 2.0.

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CHAPTER SIX

LOGBOOK DATA IN CLIMATOLOGICAL STUDIES

Some are weather-wise, some are otherwise

Benjamin Franklin (1706-1790)

Introduction

The previous chapters have described the processes by which eighteenth and nineteenth century logbook data have been made available for use by present-day scientists. Although the principal objective of the project was the preparation of a database that many could call upon, the team was nonetheless able to conduct some analyses of their own. It must, however, be acknowledged that so large is this data source that the full exploitation of logbook information will demand years of effort by different research groups before its full potential can be realised. Attention is here confined therefore to the analyses made within the formal period of the project, but this is not to suggest that earlier endeavours using logbook data for climatic studies have not been successfully undertaken. Both Oliver and Kington (1970) and García Herrera *et al.* (2000) have demonstrated the scientific value of logbook data, while several investigations have produced detailed reconstructions, including weather maps, for specific dates and periods often related to storms and naval battles (e.g. Douglas *et al.*, 1978; Kington, 1988, 1998; Lamb, 1991; Wheeler, 1985, 1992, 1999, 2001, 2003; Chenoweth, 2003). Useful though such studies might be, they are limited in their temporal and geographical scope. The matchless advantage offered by CLIWOC is its century-scale time span and near-global coverage.

Two applications of logbook information are offered here. The first focuses on the everyday observations that comprise the bulk of the database and provide wind climatologies for the 1750 to1850 period. These reconstructions can be usefully compared with present day conditions to gauge the degree and character of climatic change over the intervening years. The second application turns attention to observations of specific phenomena in the form of extreme events. By doing so, this application illustrates the adaptability of the database through the more selective use of its contents. Particular attention is here given to two episodic phenomena: icebergs and hurricanes, but others such as heavy rainfall, fog or lightning could equally be used, each of them providing data with which changing frequencies and patterns can be discerned.

Reconstructing wind climatology with logbook data

One of the advantages of using wind data derived from observations made at sea is that they are not influenced by frictional effects to the same degree as those over land, where both speed and direction are modified within the boundary layer. They are, therefore, of peculiar reliability in reflecting pressure field patterns. Although Edmund Halley had used logbooks to prepare some of the world's very first maps of wind fields as long ago as the eighteenth century (Figure 6.1), until completion of the CLIWOC project large volumes of wind data from marine sources earlier than 1850 were not generally available. Conversely, wind data from terrestrial sources, some from as early as the seventeenth, are abundant but rarely used (Jönsson and Holmquist (1995) is a rare example), preference being given to instrumental data for air pressure and temperature (Camuffo and Jones, 2002) or other non-instrumental documentary information such as vine harvest dates, dates of freezes, snowlines etc. (Le Roy Ladurie, 1971, 2004; Pfister, 1992).

One of the main achievements of the CLIWOC project is the development of methods that allow the interpretation of the old logbook records to conform to present day

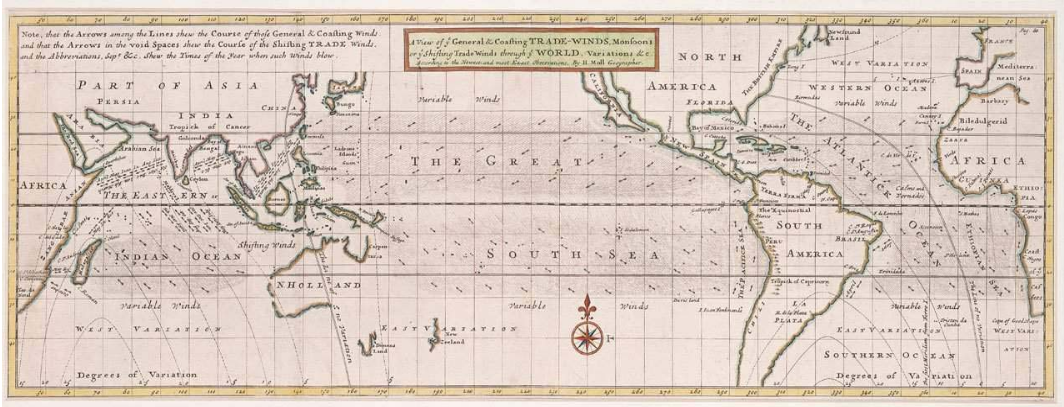
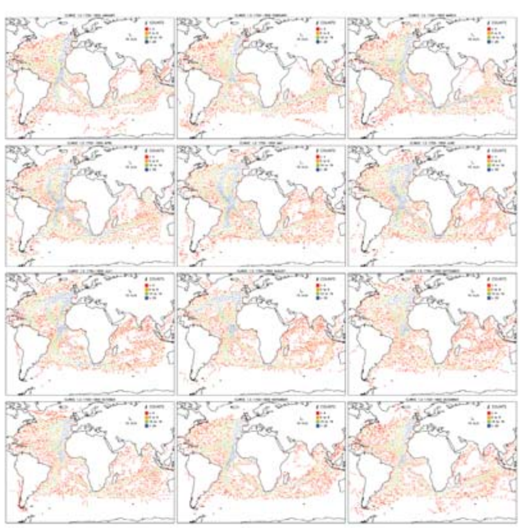


Figure 6.1 The trade winds plotted by Edmund Halley, using logbook information from the eighteenth century. By courtesy of the National Maritime Museum, Greenwich

wind data conventions. This, with the availability of more than 280,000 observations of wind force and direction, offers the possibility of building the first, if provisional, wind climatology for the world's oceans for the immediate pre-industrial period 1750 to 1850. This opportunity is of particular significance because wind force and direction data are of special importance being second only to barometric measurements in their ability to describe synoptic scale climatic elements (cyclones and anticyclones). Wind strength estimates are a direct measure of pressure and circulation variability and offer advantages over the more ubiquitous temperature and precipitation observations that are themselves partly determined by synoptic conditions. Furthermore, as a development from the wind field reconstructions it is possible also to estimate contemporary atmospheric circulation indices, of which those of the North Atlantic Oscillation and the Southern Oscillation indices (NAOI and SOI respectively) are the most important. The latter affects the Pacific Ocean, but both are major pressure and, consequently, wind field configurations that control respectively aspects of temperature and rainfall in western Europe and El Niño events in the tropical Pacific region. Their general characteristics are described in texts such as O'Hare *et al.* (2005), while details of the means by which these indices are fashioned from logbook data can be found in Jones and Salmon (2005).

For these exercises the first CLIWOC version (v1.1 released in February 2004) was used. Because these data cover the period 1750 to 1850 only, it was necessary to prepare corresponding wind data for the post-1850 period. These could then be used to extend the derived indices and reconstructions (using the same methods as with the CLIWOC data) to overlap with modern instrument-based wind field data and NAO and SO indices. Fortunately the ICOADS database (Díaz *et al.*, 2002) provided the necessary wind statistics. These took the form of *u* and *v* (north-south and east-west) wind components for 2 degree latitude and longitude grid-box averages. These data were expressed as monthly means for the period 1851 to 1997. To allow a direct comparison with ICOADS, the CLIWOC data were spatially averaged in a similar way, thereby providing a series of wind-based measures that now extend from 1750 to the present day. Figure 6.2 shows wind field reconstruction averaged over the century from 1750. Figure 6.3 is an important development of this theme and is an example of the use to which such information can be put. It shows the difference in vector



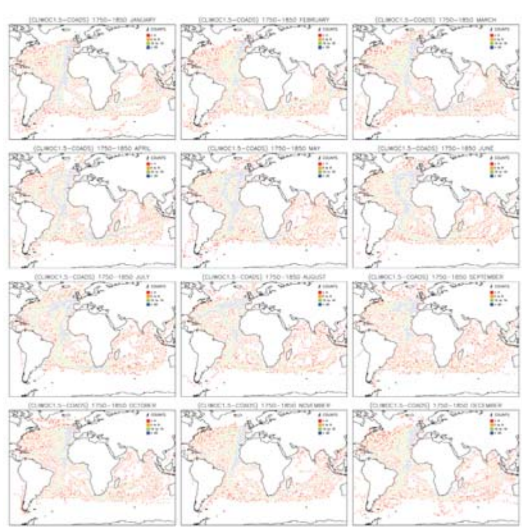


Figure 6.2 Average wind force and direction in 2º x 2º boxes from CLIWOC database for the period 1750-1850.
Figure 6.3 Differences in wind vectors for each of the 12 months (CLIWOC minus ICOADS for 1961-1990) based on a 2° grid. The colours on this plot represent the number of observations during the 101 years (dark red, <20; red, <50; light green <100 and dark green > 100).

winds for each of the twelve months of the year derived from the CLIWOC dataset for the period 1750 to 1850, and ICOADS for the period 1961 to 1990. As such it is a coarse summary but here, for the first time in the history of climatological studies, direct comparisons can be made between average conditions as they prevail today, with those of the distant past. The comparisons can, of course, be reproduced by this method for any two periods. In this instance there is little disagreement between the two fields, and the difference vectors (CLIWOC minus ICOADS) are small compared to the absolute values. The larger differences occur in regions where data coverage is sparse and where day-to-day variability is high, for example in the Atlantic Ocean north of the Azores sub-tropical anticyclone. Such anomalies accepted, the results are interesting and reveal an otherwise consistent behaviour between the CLIWOC data and those from present-day.

Useful though such comparisons are, they are not the only applications to which logbook data can be subjected. Further analysis was possible and, after applying statistical techniques of orthogonal spatial regression or OSR (see Jones *et al.*, 1987; Briffa *et al.*, 1992; Cook *et al.*, 2004 for discussions of these procedures), the wind field reconstructions were used to estimate the indices that generalize the changing character of the North Atlantic Oscillation (NAO) and Southern Oscillation (SO). Fortunately OSR methods allow their indices to be estimated using logbook data. The results from 1750 to 1821 are summarized in Figure 6.4, which compares the NAO index (NAOI) derived from CLIWOC with estimates made by Luterbacher *et al.* (2002) that are multi-proxy and use a range of European documentary and early instrumental sources but, significantly, not data with a logbook or similar maritime provenance. The CLIWOC-based NAOI series was extended beyond 1820 by using pressure data from the Gibraltar and Reykjavik series (Jones *et al.*, 1997). It would, therefore, be expected that this latter sub-series would correlate closely with that produced by Luterbacher's team who used similar pressure data. Although correlation for the period before 1820 is less clear, it must be recalled that the CLIWOC

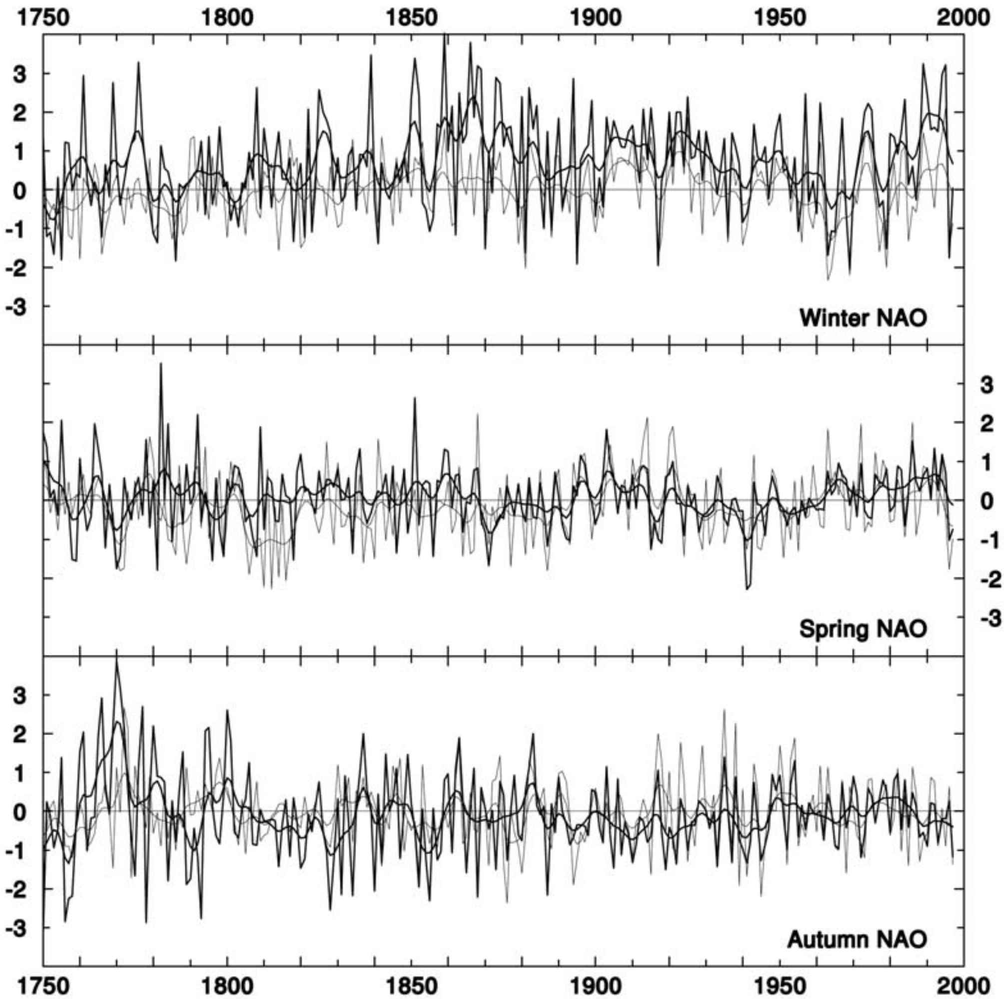


Figure 6.4 Comparisons of the wind-based reconstructions (black) for the NAO with those (grey) from Luterbacher et al. (2002) for winter (December to February), spring (March to May) and autumn (September to November). By courtesy of Springer.

series is based on different statistical premises that draw on wind field rather than air pressure and multi-proxy data. Such findings raise important questions of definition with respect to measures such as the NAOI, and open a rich area of debate when trying to gain a better understanding of their past history.

The corresponding results for the SOI are summarized in Figure 6.5 that compares the CLIWOC reconstructions with those from US/Mexican tree-ring widths developed by

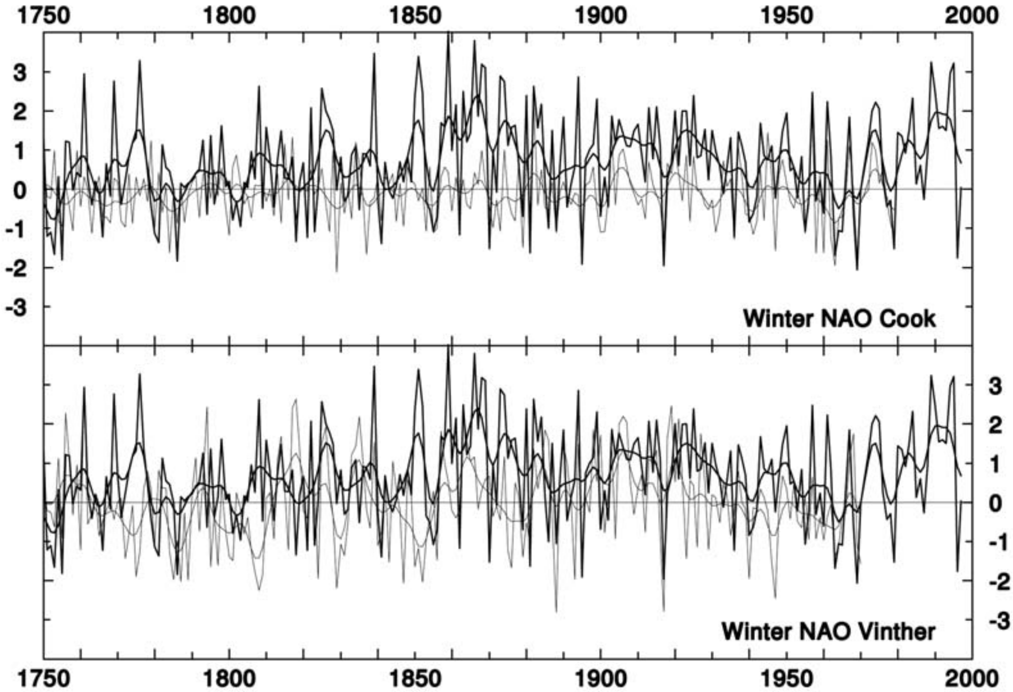


Figure 6.5 Comparisons of the wind-based reconstructions (black) for the SOI (October to March) with the natural proxy reconstructions (grey) of Stahle et al. (1998) and Mann et al. (2000 a and b). By courtesy of Springer.

Stahle *et al.* (1998) and by Mann *et al.* (2000a and b) from multi-proxy sources. The SOI reconstruction indicates four major El Niño events in the CLIWOC period (1751, 1761, 1833 and 1834). In the series of El Niño events from Peru given by Quinn (1992) and Ortlieb (2000), one of these years (1751) is classified as moderate, and another (1761) as strong. The years 1833 and 1834 are not classified as El Niño events in these sources although the former is classified as a low SOI year by Song (1998). Given the imperfect knowledge of past El Niño events demonstrated by these disagreements, it is interesting to note how the CLIWOC series is able to help confirm and clarify those years identified as such in other sources, adding thereby to the confidence that can be placed in the overall picture of the history of climatic phenomena. However, CLIWOC data have the advantage over some other sources in allowing for the reconstruction of ENSO in its La Niña as well as in its El Niño phases. This puts it in a different class to proxy data such as rainfall which is much more sensitive to the El Niño events.

It has already been noted that CLIWOC-based indices correlated less strongly with NAOI and SOI series than did other proxy-based measures drawn from terrestrial sources. There are additional reasons for this contrasting degree of statistical association, but it must first be noted that the wind field reconstructions did not indicate any bias when compared with the ICOADS series long-term averages, so the differences are unlikely to be due to errors in the transformation of raw observations into Beaufort Scale equivalents, or to other forms of data treatment. The most likely reason is the more pragmatic one of small number of observations in some of latitude/longitude grid boxes on which the OSR procedures were conducted. Even with 280,000 data entries, when such numbers of observations are dispersed over the three oceanic areas of the North and South Atlantic and the Indian Oceans, and over a span of 100 years, there will inevitably be regions and times when the data are in short supply. This, however, is by no means an insoluble problem as huge quantities of logbook data have yet to be digitized and included in the CLIWOC database, and endeavours in the direction of meeting this need form the core of future developments, some of which are discussed later in a later chapter.

The above methods draw upon the whole of the CLIWOC dataset, but the system is a flexible one and information can also be garnered from a more selective choice of data, using observations for specific phenomena.

Extreme events 1: icebergs sightings in the South Atlantic Ocean

The records of iceberg sightings in the high latitudes in the South Atlantic Ocean are infrequent before the twentieth century. Some of the earliest are provided by the logbooks of Captain James Cook, written in the 1770s during his voyages of exploration (Beaglehole, 1968). Setting those remarkable documents to one side, Towson (1858), when trying to improve the routes between Britain and Australia, could find no more than

100 recorded iceberg sightings for the period 1772 to 1858. More recently, Burrows (1976) studied the occurrence of icebergs in the Southern Ocean, particularly those that reached further northward than most. He, also, could call upon little in the way of evidence. Fortunately, the CLIWOC project was able to add to this limited fund of information using Spanish logbooks from ships in those remote waters during the second half of the eighteenth century. More details can be found in Prieto *et al*. (2004).

Spain was the first European power to create a large overseas empire and from the sixteenth century settlements in Peru and Chile required regular communication with Madrid and Seville. This duty fell inevitably to the Atlantic Fleets, the vessels of which sailed between Spain and the Atlantic coasts of Mexico, Panama and Central America once a year. This system extended to the Pacific coast via Panama, where passengers and cargo travelled by land to the Pacific ports, and from there to Callao or Valparaiso. The 'southern' route, discovered very early by Magellan when travelling around the world, was less commonly used and only occasional voyages took the risks that were attendant in journeying as far south as Cape Horn before turning northward again into the Pacific (Figure 6.6).

Throughout the sixteenth and seventeenth centuries only a small number of ships were allowed to sail directly between Cádiz (Spain) and Callao in Peru. Until the close of the seventeenth century they chose to pass through the Magellan Strait, but later adopted the Drake Passage as a safer and faster option. The situation changed in the second half of the eighteenth century when the royal monopoly on trade between Spain and the American colonies came to an end, and in 1778 the Free Trade Rule (*Reglamento de Libre Comercio*) opened trade between a number of ports in Spain, Argentina, Chile and Peru. There was an immediate increase in the volume of trans-Atlantic activity and, importantly, in the number of voyages through the Drake Passage. A letter written by the famous explorer Alejandro Malaspina to his colleague Antonio de Ulloa (Reed, 1936),

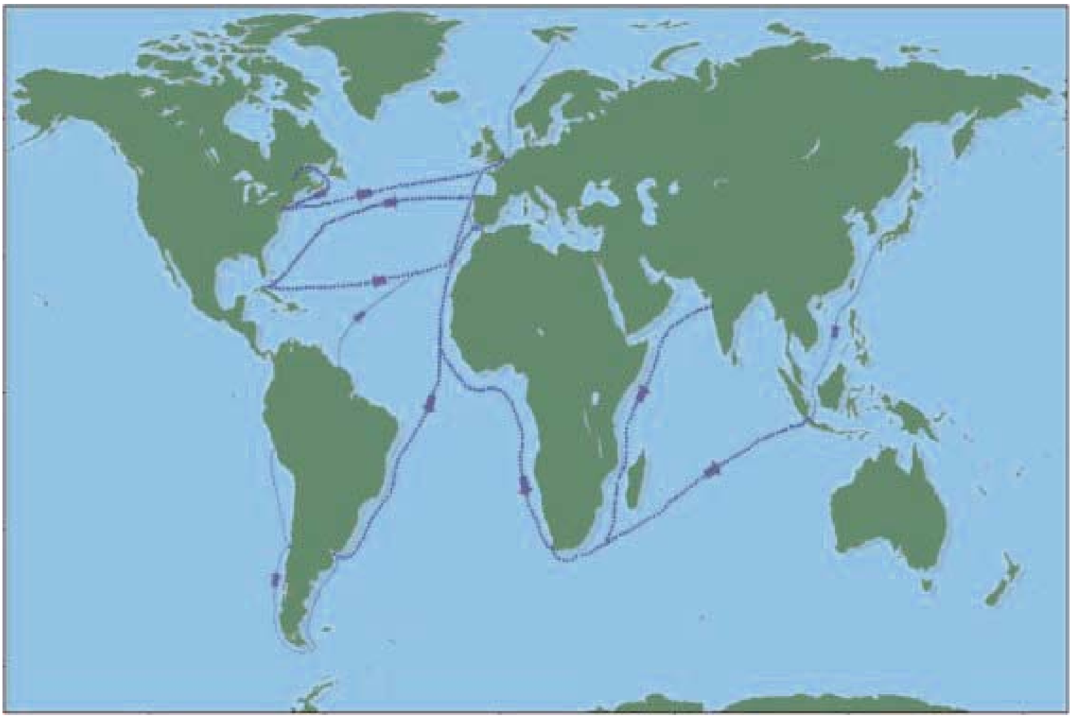


Figure 6.6 The most frequently used routes taken by sailing ships. The Spanish route when negotiating the southern oceans around Cape Horn and sailing to the ports of the Spanish American Empire is also shown.

shows that Spanish mariners were only too aware of the probability of encountering these fantastic phenomena, which may not have been as unusual as the paucity of available written observations might suggest:

> "One of the most terrible obstacles for the merchant marine going south has been until present to meet snow banks [icebergs]. Finding myself in the high meridional [southern] latitudes, do you believe it would be useful to continue our route to the south until meeting icebergs in a season like the months of December and January?" (p.17).

All the logbooks abstracted in the CLIWOC database covering this southern route were examined. They amounted to 45 items, mostly derived from the Cádiz-Montevideo-Valdivia-Valparaiso-Callao and return route. Five reports of iceberg reports were found in these documents. Two of them correspond to isolated icebergs in the year 1769. The first one occurred in January when the merchant frigate *Ventura* collided with an iceberg close to Cape Horn (56º S), suffering heavy damage. The second one occurred on October 7th, when the *San Miguel* sighted icebergs at 59º S, 63º W. The others relate to marked iceberg episodes, one occurring in 1770 and the other in 1794 (Prieto *et al.*, 2004). The former represent the earliest documentary evidence that is known to exist for icebergs in the Southern Atlantic Ocean.

Iceberg sightings in this sector are not abundant and they are registered in only 35 of the years between 1770 and 1990. The analysis of the documents indicates that both the 1770 and 1794 episodes were of an unusual character. Their descriptions use superlative terms such as *cordillera* (mountains) of ice, and the logbooks draw attention to the great number of icebergs. So notable were the latter that maps were prepared to plot their positions. A quotation from one of the contemporary logbooks is illustrative of the sentiments of those who witnessed these outbreaks:

> "... this terrible mass that would have fallen from the pole in some earthquake, some hurricane or another not common cause, had to overcome many obstacles to reach this point. If it went through the west to pass the channel formed by the Georgias and the Falklands, there were some days when such passage was obstructed and when one would have believed the entire Austral Atlantic was..." (from documents by Arcadio Pineda, AMN MS181, 479 and 610[1])

The mechanisms leading to the presence of such outbreaks are not completely understood. Satellite imagery has revealed that in few cases the icebergs approach the Falkland Islands and reach close to 60º S. These are moved by a northern drift of current towards the South American sector but start melting in the warm waters to be encountered there. Burrows (1976), when trying to explain irruptions of icebergs into unusually low latitudes during historical periods, suggests they were associated with a

(1) References to manuscript sources in the Archives of the Museo Naval in Madrid (AMN) are denoted by the initials, followed by the archive manuscript number

strengthening of this north-eastward current which, in turn, is intensified by an increased temperature gradient between equatorial and polar regions during anomalously cold periods. This association between cold periods and low latitude iceberg activity has also been suggested by Heap (1972). Antarctic ice core records (Aristarain *et al*. 1990 and Peel *et al*. 1996) indicate both 1770 and 1794 to have been colder than normal. This independent corroboration of the climatic record emphasises again the importance of logbook data not only as a single source but as one that can be examined in helpful association with others.

Extreme events 2: hurricanes

Logbooks are a rich source of information about hurricanes, the trajectories of which were interwoven with those of the principal ship routes of the North Atlantic, both tending to move clockwise around the Azores sub-tropical high pressure system. It is hardly surprising therefore that the earliest records of a hurricane were provided by the first trans-Atlantic navigator to reach the West Indies, Christopher Columbus. He encountered them on his later voyages in 1495 and 1502 (Millás, 1968) and a lengthy account appears in his report *Copia de la relación del cuarto viaje a América (de 1502) de Cristóbal Colón. Isla de Jamaica, 7 de Julio 1503.*

It was soon apparent to Spanish sailors that such violent storms presented a threat to their ships, and they adopted the term *huracán* from the Carib language to describe them. Its first use came in the sixteenth century when Fernandez de Oviedo wrote: "Huracán, in the language of this island, is precisely defined as a very excessive storm or tempest but being in reality nothing more than a very great wind with heavy and intense rainfall." *(*AGI Indif. Gral. 108 -BIB. L.A. Siglo XVI – 7-)[2]. As noted in Chapter 3, this term soon passed into other European languages. It has been adopted into English by the early seventeenth century and is found in John Smith's *A Sea Grammer* of 1627 and again in the dictionary *Boteler's Dialogues* from the 1680s when of storms it observes:

(2) References to manuscript sources in the Archivo General de Indias (AGI) are denoted by the initials, followed by the name of the section of the Archive where the manuscript is located, and a number identifying the legajo, or bundle, to which the manuscript belongs.

> *" [a] hurricanoe may be said to be the most enraged prince amongst them, and the lion of tempests… true it is that these whirlwinds [sic] in the West Indies and those parts, are exceeding extraordinary, as well in regard of their violence as lasting. And it is very observable that in some places these devastating winds are found very frequent, and so extreme outrageous that, if reports misreport not, some ships that have been taken with them, near some of those coasts, have been rather thrown than driven, even far into the land…" (Perrin, 1929, p.164)*

Even their geographic concentration has been understood by this time, and the book goes on to describe how they are to be found in the tropical latitudes rather than "…in other parts where the sun looks not down so perpendicularly."

The Spanish colonization of the Americas was initiated in the Caribbean area. By the mid-sixteenth century, most of the present-day territory overlooking the Gulf of Mexico and the Antilles were occupied together with Florida and present-day Louisiana. Occasional, usually piratical, intrusions by English mariners left little useful information for climatologists. The picture changes, however, in the latter half of the reign of the English Queen Elizabeth I (1558-1603) when the first attempts at English colonization were made along the coast of North Carolina and Virginia (Milton, 2000). Formal English colonization in the Caribbean began only in 1655 when the English captured Jamaica. Gradually the Caribbean area became one of intense sailing activity and interest by European powers. Fortunately, this has left a rich legacy of hurricane records (García Herrera *et al.*, 2004 and 2005). Some of these are from land-based reports, but logbooks, too, offer much useful information. Most importantly they provide precise dates and location for such events helping to construct a more reliable hurricane chronology that can extend back to the earliest days of 'deep sea' marine exploration.

Hurricane reports from English ships

Although permanent English settlement in the Caribbean region began only in the mid-seventeenth century, it soon burgeoned and brought with it much naval activity, and it wasn't long before Royal Navy logbooks began to record hurricanes. The following is an abridged, but typical description. It comes from the logbook of the frigate HMS *Andromache* (National Maritime Museum, ADM/L/A.264), and was written by Commander Charles Mansfield when the ship lay some 500 miles north-east of Bermuda on July 29th 1795.

> "Strong gales with squalls at 5 o'clock.....at 8 o clock very heavy gales with squalls and rain At 9 the gale still increasing at 11 it blew a perfect Hurricane of wind and rain the Mizen & Mizen staysail blown quite to ribbons......at 12 quite calm with a very heavy sea from the SW and the Ship labouring much ½ past Twelve the wind freshened up and blew with great violence from all the points of the Compass At 1 o'clock a savage Hurricane with incessant hard rain.."

The degree of detail that such logbook entries contain is remarkable and include the times of events, with attention to changing wind force and direction. Notice, too, that the 'eye' of the hurricane is also described. The true value of such information lies not so much in the individual detail, which is interesting but routine, each officer having to account for damage and repair costs, but in the collective picture and continuity of account that several such documents create. The mapping of the daily winds, their strengths and the direction of sea (swell) can also be used to help define the reconstructed path of the hurricane(s), to identify previously unknown events, and to confirm, or otherwise, independent reconstructions from other sources. An example is offered by the conditions of October 1780, a month of notable hurricane activity; that which struck the Lesser Antilles between October 14th and 16th is considered to be one of the most damaging of its time (Rappaport and Fernández-Partagás, 1997). Logbook entries, fragmentary in themselves, combine to give a more comprehensive, if terse, view:

HMS *Hector* (74 guns) was cruising off the east end of Hispaniola in October 1780. On 6th the logbook entry was: "Winds: EbN [east-by-north], strong gales and squally, at 7 [pm] the gale increasing, at 12 [midnight] increasing to a hurricane. The sea running high."

> On 7th the situation had moderated and the winds veered with the entry "Winds: W, hard gales. Heavy sea from the west."
>
> On 16th the entry was: "Winds: EbN, strong gales. Heavy swell from the east" and on 19th: "Winds: NbE, fresh breezes. Heavy swell from the north."

The value of such information increases when it is corroborated by additional evidence. In many cases this is not lacking, although many logbooks may have to be searched to find it. British naval interest in the region was well developed at this time, and additional evidence was found from the logbook of HMS *Ajax* then sailing off nearby Dominica. The entry for 12th reads:

> "Winds: all around the compass. Strong gales and heavy squalls. At 6 [am] violent squalls of wind. At noon less wind. Very heavy sea. At noon the sea very high and confused.lightning."

While that for HMS *Charon* (44 guns), then off Charleston notes for 17th

> "Winds: NNE and NbE strong gales and heavy seas."

These accumulated data allow the movement of the hurricane to be traced by paying attention to wind directions, which change as the storm passes by. To a limited degree, this form of climatic (severe storm) reconstruction has already been explored by Reid (1849), but CLIWOC's greater documentary resources will allow such studies to be fully developed. For example, it is known that hurricane activity is variable at different time scales and is influenced by climatic oscillations such as the El Niño-Southern Oscillation

(ENSO) and the NAO. Logbook evidence can now be gathered with which to examine the variable incidence of hurricanes and, it should not be forgotten, Indian Ocean cyclones, and test their correspondences with other independently-derived series for the SO and NAO.

Hurricane reports from Spanish documents

Of all the European powers, the Spanish had the longest and most enduring interest in the Caribbean region. For that reason an examination of some of their older documents repays attention, and points to useful future developments using many forms of climate information from historical archives. The following report dates from 1620 and was submitted to the then Governor of Yucatan and formed part of journal written Andrés de Aristizábal on board on *Nuestra Señora del Juncal* off shore of the Mexican coast.

> "On October 20th a gale approached from the southeast at nine in the night which seemed more than a hurricane. The night was so dark and full of thunder and lightning from the four quarters that we had to offer prayers to Our Lady Virgin of Carmen... Later the hurricane veered to the north and a quarter, at dawn it blew away the foremast and jibsail..." (document AGI, Mexico 360).

It is typical of the detail found in logbooks that the changing direction of the wind, one of the principal features of the passage of a hurricane, is clear in this record.

The long period during which the Spanish controlled the region allows such investigations to go back much further than is the case with other national sources. A good example is provided by the document AGI Contratación, 730, written in 1689 by the ship's master, Juan Ferrer when he pleaded with the Casa de Contratación in Seville to be exonerated from responsibility for the damage suffered by his ship the *Santa Inés*:

> "…being dismasted in the Bahamas channel between Cape Cañaveral and Saint Helena we survived a violent sea hurricane [sic] with north-east

and east-north-east winds of such ferocity that they lasted six days during which time we thought ourselves lost together with the naos[3] of the fleet"

The document AGI Contratación 5108 provides another description of a hurricane. This example dates from 1589 close to the Florida coast The account is contained in a letter from General Martín Pérez de Olázabal, issued at Sanlúcar de Barrameda, and refers to a strong hurricane which affected the Nueva España and Tierra Firme fleets on their way to Spain:

"…sailing out of the channel with the wind large on our quarter we encountered a great storm of wind from the east-north-east that, finding us in the narrows between Florida and the Bahamas, we were battered for five days during which we lost contact with the large naos".

A Dutch example of an encounter with a typhoon

Dutch interests in the Far East brought them into regular contact with the dangers of the Indian and Pacific Oceans. Here again, logbook records are a fertile source of scientific descriptions. The following was recorded on 31st July 1772 by the senior officer on board the *Vrouwe Margaretha Maria* when she lay not far from Nagasaki, Japan.

"During the morning watch, the wind or storm increased to a hurricane with heavy rains falling from Heaven like salt water, also high enraged sea. Forenoon watch: the wind to flying hurricane with thick sky that made it impossible to look up. At 09:00 the topmast went overboard due to the enraged high seas, causing the ship to roll and labour heavily, also the topgallant mast and its running rigs, jib, flying jib and the topgallant staysail went overboard. The hurricane continued and increased... During the afternoon and dog watch the wind, or strong hurricane still continued; winds are shifting from NW to W with high, enraged seas. The ship laboured and rolled so heavily that the starboard main topmast rigging

(3) A nao was an ancient, high-sided sailing vessel. Saint Helena refers to St. Helena Sound, between Charleston and Savannah

came loose that we resolved to cut the main topmast to, if possible, safe the mainmast....A six pound canon broke from its horses and went overboard as well. We tried immediately to get rid of the debris before it could bring more dammage to the ship. Had the sea anchor thrown overboard right away to keep the ship on the waves. The ship laboured very heavy. While the ship lacked support in the mid section, we set the reefed mizzen sail to support the ship..."

Colourful though such accounts might be, they are also of scientific value. They provide dates, times and wind directions, together with clear evidence of the ferocity of the winds, leaving little doubt as to their cause. The above are but a few examples of a notably rich source of information in European archives that waits a comprehensive analysis by climatologists.

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CHAPTER SEVEN

LOGBOOKS: A MULTI-DISCIPLINARY SOURCE FOR THE HUMANITIES

The autocratic sway of the West Wind, whether forty north or forty south of the Equator, is characterised by an open, generous, frank barbarous recklessness.

Joseph Conrad (The Mirror of the Sea).

Introduction

The CLIWOC project is not the first to have used large numbers of logbooks for climatic studies. Previous instances of this interest are a part of maritime history itself, and have been described briefly in Chapter 1. This is not, however, to suggest that logbooks have been the sole domain of climatologists or of scientists in general. Their application, more potential than fulfilled at present, extends far beyond those disciplinary boundaries. Logbooks and journals contain both anecdotal and statistical data relevant to research that embraces medical science, the development of navigation, social and economic history, warfare, and imperial and environmental studies. Moreover, many of these themes can be pursued in a multi-national and multi-disciplinary context, drawing on sources from different nations and calling upon the skills of different specialists. One of the problems for the historian, if it is indeed a problem, is the huge number of documents available for study. The number of logbooks for the 'age of sail' extant British archives is estimated to be in the region of 150,000. Elsewhere in Europe many thousands more exist. This is helpful for those wishing to study the career of an officer, the history of a particular vessel, or the course of a battle or some other incident. For these sorts of enquiries a fairly small number of journals suffice. However, in order to study, for instance, shipboard mortality and disease or improvements in navigation over a period of time, the examination of many hundreds if not thousands of journals is desirable, with its inevitable demands on labour, time and expense. Probably because of this requirement, logbooks constitute a much under-used resource in the humanities.

For historians not specializing in maritime history, there can be the additional challenge of the technical nature of many logbook entries as well as observations made frequently in a language now archaic and often using professional nautical terms unfamiliar to non-specialists. It should be stressed however that in both the humanities and the sciences, logbooks should be studied on two different levels. There is much tabular and statistical data to be gleaned from them, and more than sufficient numbers of these to draw reliable conclusions about such features of life on board as navigation, health, mortality, crime and punishment. These aggregated data from large numbers of logbooks can provide new insights to a number of sub-disciplines of history. With such data however it is possible to overlook the unique, but similarly informative, experience of individual officers and vessels. One might for instance use aggregated data to conclude something significant about the climate of the North Atlantic in the 1790s yet miss the interesting and important fact that HM ship *Andromache* sailed through the eye of a hurricane in the summer of 1795 (see Chapter 6 for a description of this event). Yet this event might be dismissed as little more than 'background noise' to the bigger climatological picture, but it is just such discoveries that make important a balanced approach in which the careful examination of individual logbooks is not to be neglected. Significantly, this hurricane does not appear in any published series of such events, and its discovery is a reinforcing example of the importance of the individual observer and his legacy. When examining the potential of logbooks for historical studies in particular it is important to bear these two approaches in mind.

Logbook keeping and non-climatic information

Chapter 1 has already reviewed the factors that prompted the keeping of logbooks and the general manner of their preparation. Other sections have described the meteorological character of much of that activity. But logbooks contain also much other information. In addition to navigational and tabled information, each daily logbook entry had a section in which was described not only aspects of the weather, of which wind force was the most important, but also other features of life on board. These activities might include the setting and reduction of sail, sightings of land and other vessels, a note of the number or names of any ships sailing in company (frequently employed while convoying ships under escort), signals given and received, and battle with an enemy. Contrary to popular belief, the latter was an uncommon event even in wartime. All such incidents would, nevertheless, be recorded as a matter of course by the officers. Less frequently recorded, and more usually by the commanding officer, would be the state of provisions on board, or the amount of fresh water remaining. The captain in particular would record any matters concerning the management, discipline and general running of the ship. He was ultimately accountable to his superiors for his personal conduct as well as the conduct of his officers and crew. At a court martial or any form of enquiry, the journals of officers would be called for as evidence. In the event of wreck or sinking, mutiny or capture by an enemy, logbooks and journals would supplement the formal accounts submitted to the court by the surviving officers. Therefore logbooks should be considered an accurate and truthful, account of the management of a vessel as well as of the weather it experienced. The most frequent entries found in logbooks under this administrative heading are concerned with the discipline and health of the crew. All officers recorded incidents of indiscipline and crime. These could range from the commonly recorded accounts of insolence and drunkenness, to the more serious crimes of theft, striking a superior officer, desertion or mutiny. The punishments that were a consequence of such misdemeanours were always recorded and provide an unambiguous record of this aspect of service at sea (Figure 7.1).

Officers would diligently record shipboard health and mortality. Death was most

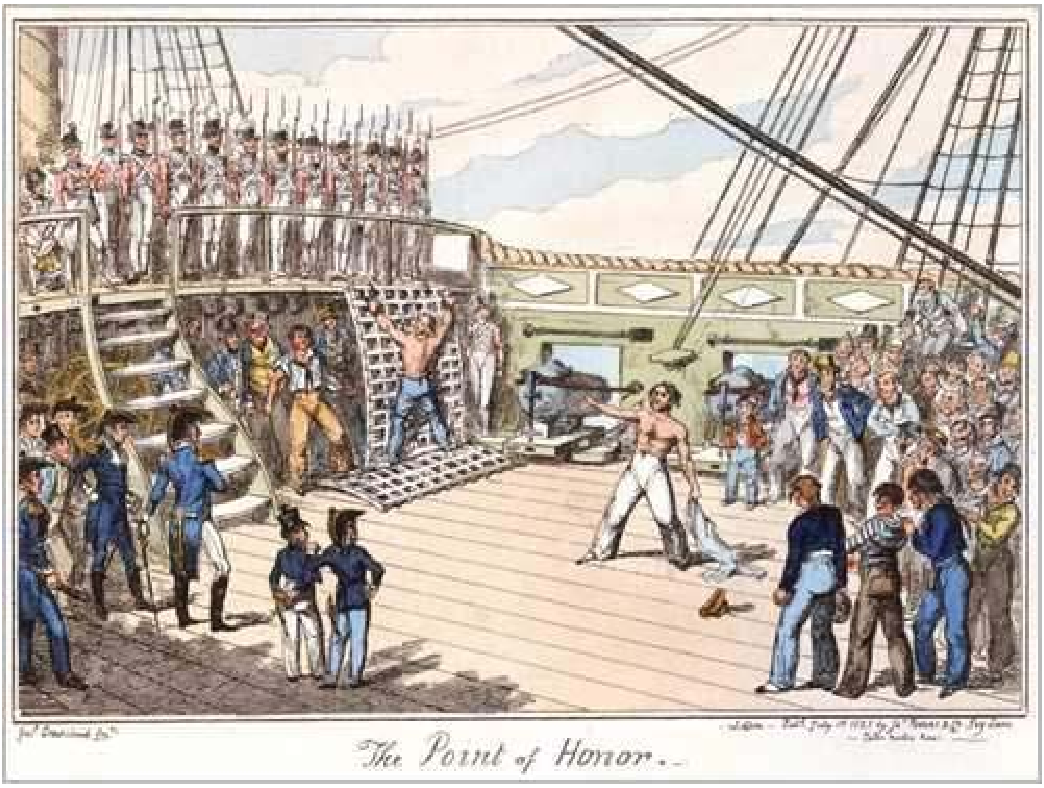


Figure 7.1 Flogging on board a Royal Navy ship. By G. Cruickshank. By courtesy of the National Maritime Museum.

frequently the result of disease, although incidents such as falling on to the deck from the yards, falling overboard and drowning, killed in action or meeting with some other misfortune were also, though less commonly, recorded. Where shipboard diseases were recorded, the general nature of the disease would be stated along with the number of men incapacitated. Surprisingly, specific mention of scurvy was rare, and most disease was described as either fever or 'flux' making it clear that dysentery and typhus were the most serious diseases with which they had to contend.

To a casual observer logbooks might appear to be repetitive documents, following a prescribed pattern of narrative and information. This is to miss the point that each journal is has a unique character and that there are insights to be gleaned from the very nature of the logbook-keeping process as well as from the daily entries themselves. Careful study can give clues to the character of the journal writer. To some officers the keeping of a logbook was a chore and the effort put in to their journal-keeping was the minimum required to satisfy the Navy Board and ensure payment of wages. The land-based Navy Board clerks were usually alive to such carelessness and it is clear that logbooks submitted to the Board were subject to at least some degree of scrutiny. In 1799, the logbook of Captain Michael Seymour of the *Spitfire* was endorsed 'Acct. of Ships way deficient in many places' (NMM: ADM/L/S388[1]). In the same year, the logbook of Lord Augustus Fitzroy of the *Sphynx* was endorsed 'On account of the days reckonings not being inserted, the Board would not pass this journal'. This was despite the fact that Fitzroy had noted at the end of the log that 'day work book lost by accident'. A dispensation was eventually granted (NMM: ADM/L/S358).

Where a vessel was large enough to carry several lieutenants, their individual journals indicate that though much information, especially from the rough or deck logbook, was shared, officers made their own individual observations and calculations. Slight differences in the recorded longitude indicate that this must have been so. Again, different logbooks in the same handwriting indicate that some officers paid somebody, possibly the captain's clerk, to produce a fair copy of their journals. In fact it should never be assumed that a logbook is in the handwriting of the officer whose name appears on the front cover. The logbook of Captain Robert Parker of the *Intrepid*, recorded his own demise in the same handwriting as the rest of the journal! In a heavy swell, the unfortunate Parker, clutching his portable desk, had fallen through an open gunport in his cabin and drowned. Parker's logbook was kept by his secretary or a clerk and he had merely signed it.

Logbook contents and style reflect the general approach to duty of an officer. Lieutenant Isaac Smith of the sloop *Weazle* was prize master of the captured merchant brig *Hester* in 1776, and his journal (NMM: ADM/L/W162) was not only well kept but indicates that Smith was a keen observer, painstaking in his duties and unusually

(1) NMM refers to document catalogue numbers in the National Maritime Museum, Greenwich

proficient in navigation and surveying. On his own initiative he was making surveys and lunar observations off the coast of West Africa and recording all his work in the logbook. As a midshipman he had served with James Cook on the *Endeavour* and it was under Cook's instruction that he had become proficient in hydrography. An example of one of his logbook pages from his West African voyage is given in Figure 7.2. It is quite unlike other documents of its time (see Figures 1.4 and 1.5) and is rich in navigational detail. In contrast is the logbook of the unfortunate John Okes (NMM: ADM/L/L168). Lieutenant Okes was a young man in his mid twenties and first lieutenant of the frigate *Liverpool*, commanded by Captain Edward Clarke. Okes' logbook was immaculately kept with exceptional copperplate handwriting. In May 1764, the *Liverpool* was in the Indian Ocean on her way home. The Captain, apparently ill, locked himself in the main cabin and shot himself. Okes, now in command, had the responsibility of taking the ship home and facing an enquiry into the death of Captain Clarke. As the voyage progressed his daily

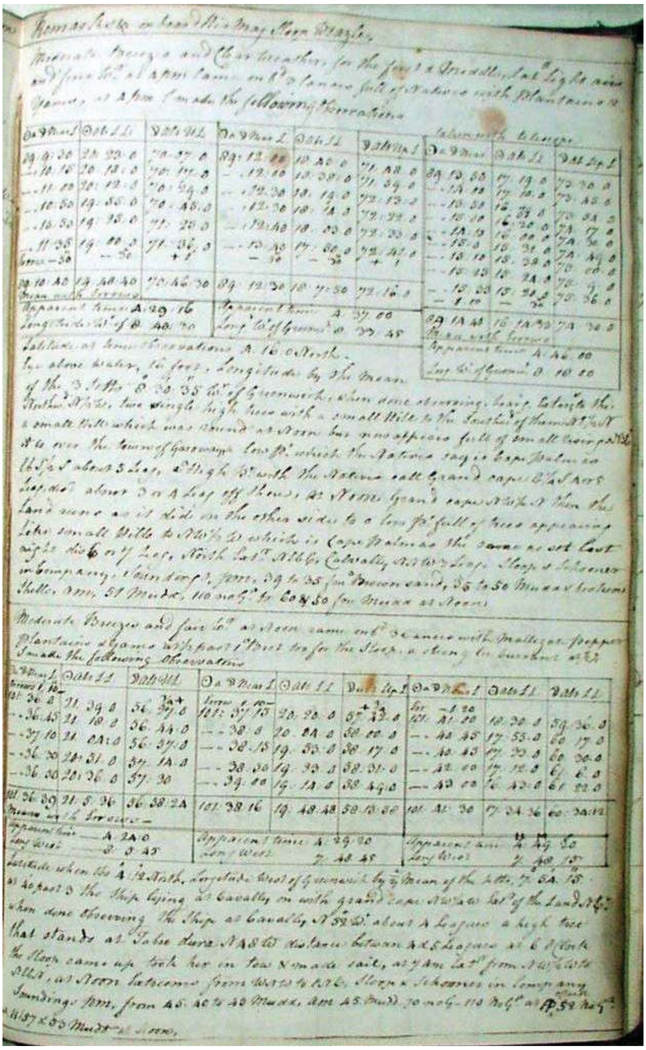


Figure 7.2 Page from the logbook of Lieutenant Isaac Smith showing an unusual degree of attention to recording navigational detail. By courtesy of the National Maritime Museum

entries became shorter and his handwriting less legible. He was clearly under great stress and it is likely that he was not sufficiently skilled and confident to command a ship. This is borne out by his subsequent career and over forty years later in 1805, he retired from the navy, still only a lieutenant.

Logbooks in the history of navigation

The study of many logbooks in the age of sail can provide an insight into the history and development of navigational science and how officers responded to technological innovation. Moreover, multi-national logbook studies provide the opportunity for comparative research of the naval and mercantile services of competing maritime powers. Of particular interest is the development of the various methods for determining longitude, that is, the position east or west of any given meridian. What is clear from a survey of many hundreds of logbooks is that the East India Company officers were more precise in recording navigational detail than were those of the Royal Navy or other services.

The standard EEIC pre-printed logbook pages provided for such precise daily entries such as 'meridian distance', and 'difference in longitude' as well as many others of this nature. This was a degree of detail that was not usual in most contemporary Royal Navy logbooks. Evidence suggests also that EEIC vessels were carrying marine chronometers many years before Royal Naval vessels regularly

Figure 7.3 John Harrison's fourth marine chronometer from 1760. By courtesy of the National Maritime Museum

took them to sea. Yet few were supplied by the Company and, in common with charts and navigational instruments; individual captains supplied their own timepieces (Cook, 1985). As late as the 1790s Royal Naval vessels were not carrying marine chronometers even on distant voyages. Commodore Peter Rainier, for instance was still applying for a chronometer from the Admiralty six weeks before sailing to Madras in 1794 and it is clear from his logbook and those of his officers that no chronometer was on board the *Suffolk* and that longitude was estimated by dead reckoning and by lunar distances. During the voyage Rainier would often check his position by signal with one or more of the EEIC vessels he had under convoy (Wilkinson, 2005).

The precision with which EEIC officers recorded their position makes it possible to study the use and accuracy of the marine chronometer itself. Many officers would record their longitude by both chronometer and by dead reckoning. Many also estimated their position by the method of lunar distances, giving three possible positions. Comparing these observations over the course of an entire voyage and noting the sighting of landfalls indicates clearly the general accuracy of chronometers and the limitations of navigating by dead reckoning alone. In extreme cases, differences of up to four or five degrees between estimated and observed longitude can be noted, an error of up to several hundred miles, depending on the vessel's latitude!

Another navigational observation recorded in logbooks was magnetic variation. This was the difference in degrees between magnetic north as indicated by the compass and true north. The compass on English ships was uncorrected and the observed magnetic variation formed part of the arithmetic used to calculate leeway, which was important in determining the ship's position. The Dutch, on the other hand, corrected their compasses for this variation (Davids, 1986) under the strict regulations of the VOC. This was applied to the steering compasses by rotating the compass roses over an angle equal to the calculated difference between true and magnetic north. It is not always clear, however, if other compasses on board (bearing and azimuth compass) were corrected equally and whether the wind directions recorded in the logbooks were relative to true or to magnetic north.

In English logbooks, variation was not usually recorded until it exceeded about 10° or approximately one compass point (which is 11.25°), indicating the scale of resolution in the arithmetic required for safe navigation. In the 1750s, one ingenious EEIC officer successfully navigated his ship from India to England by the daily recording of his latitude and the magnetic variation. He presumably used one of the later editions of the isogonic chart produced by Halley in the late seventeenth century to determine his longitude. If the earth's magnetic field had been constant – sadly it wasn't – this would have proved a simple method of determining longitude making the invention of the chronometer unnecessary, but it was a method of navigation advocated as late as the 1790s (Churchman, 1794)

Large sample studies of logbooks indicate the consequences of these improvements in navigation. From the mid-1780s onwards journey times from Europe to India and China decreased and by the early nineteenth century they were up to 25 per cent shorter than they had been twenty years earlier. Some of this was due to improvements in ship design but it is equally likely that improvements in the determination of longitude, and therefore a greater certainty of the ship's position, gave commanders confidence to sail onwards secure in the knowledge that they were not going to strike some navigational hazard. This point is offered with the caveat that until well into the nineteenth century, marine charts were not prepared to the same degree of accuracy as those based on later surveys carried out with the assistance of the chronometer.

There is also evidence from logbooks to suggest that sailing routes altered, also improving journey times. Before the 1780s, the usual route to India was through the Mozambique Channel. Both Royal Navy and EEIC vessels would use this route stopping at the Comoro Islands or St. Augustine in Madagascar both for refreshment and more importantly to fix their position before embarking on the remainder of their voyage. One of the Comoro Islands was frequently used as a zero meridian by English ships sailing north from the Mozambique Channel towards India. Gradually this route fell out of favour, except for those vessels bound for Bombay. Ships for Madras or Calcutta would usually make a wide sweep out into the Southern Ocean to about the longitude of Sri Lanka before making a northerly course for the Bay of Bengal. This was a shorter route, making best use of the prevailing winds and was rendered easier by a more accurate determination of longitude by lunar observation and chronometer.

Logbooks and medical history

Logbooks routinely recorded mortality, always naming the victim, giving their rank or occupation and usually the cause of death. Cross referencing this information with the

Figure 7.4 Life on board a sailing ship around 1800, By G. Cruikshank. By courtesy of the National Maritime Museum.

ship's muster, many of which have survived in English archives, will often provide the victim's age, where he joined the ship or from which vessel he was transferred. In later muster books there might be a note of his place of birth or origin. In the case of the English East India Company, the muster was frequently bound with the corresponding logbook and included a passenger list. Between them, logbooks and muster books have the potential to yield much statistical information useful for the study of disease and mortality amongst seafarers. The most noteworthy feature to emerge from the examination of many logbooks is the shocking rate of shipboard disease and mortality in the early and mid eighteenth century, particularly on Royal Navy vessels. This was not just confined to very long voyages in the tropics. There were thousands sick in the fleet commanded by Edward Boscawen which in 1755 was sent to make a pre-emptive strike against the French in Canada at the start of the Seven Year's War. Vessels making voyages through the tropics, or crossing the equator before the 1770s, could expect to bury the dead at sea on an almost daily basis.

What is most noticeable however is the remarkable improvement in mortality rates evident in logbooks by the end of the eighteenth century. The last decades of the century saw significant improvements in ship-board ventilation, diet and hygiene (Morriss, 2003). Far-sighted officers, and eventually the authorities, adopted a holistic approach to the improvement of health at sea. This approach, at least within the Royal Navy, was one based on organization and discipline with the gradual introduction on naval vessels of the divisional system. This system divided crews into small groups placed under the direct control of both commissioned and junior officers who were then responsible for the welfare, cleanliness and discipline of the men directly under their command (Lavery, 1998). Advances were made in ventilation, first in the 1740s with Sutton's air pipes, and later with the introduction in the 1750s of the Hale mechanical ventilator (Zuckerman, 1976). Improvements in the supply of victuals were also critical. The notable benefits to be gained from logbooks is that they provide the evidence with which to gauge the success of these various measures. It is also possible with logbooks to measure the effectiveness of individual commanding officers in keeping their men healthy, in particular by making comparisons between vessels sailing in close company on long voyages.

Because logbooks contain such a wealth of weather information, it is also possible to measure the effect of environmental conditions on the health of crews. The length of a voyage would often depend on the weather conditions and a slow passage through the doldrums could have serious consequences for shipboard health. Skill was needed to approach the equatorial line in the Atlantic at the most advantageous time of year and at the approximate longitude where the Doldrums were likely to be least troublesome (Seller, 1703). One example is that of the EEIC vessel *Busbridge,* which made three voyages to the East Indies between 1785 and 1789 (BL: L/MAR/B 413a-c[2]). During these three voyages her progress from England towards the equator varied from a matter of weeks in one instance to several months in another. How the varying length of the equatorial passage affected health and discipline on board the *Busbridge*, along with other similar examples, is an example of how logbooks can be used to examine specific aspects of ship-board health. Another interesting case study is provided by the logbooks of HM ship *Colchester* (NMM: ADM/L/C165). In 1757, 1758 and 1760, the *Colchester* sailed to St. Helena in the South Atlantic to collect and escort the East India Company's ships to England. On all three voyages she sailed a similar route at about the same time of year. On one voyage her crew suffered heavy rates of mortality yet on another voyage relatively few of the crew were taken sick. On one voyage there was a change of officers and another of the voyages recorded the working of the new Hales mechanical ventilators. These factors along with a study of the duration of the voyage and the general environmental conditions would yield interesting insights and possibly explain the remarkable difference in death rates between two of the voyages. There are hundreds of similar case studies that can be re-constructed from logbooks of British vessels in all latitudes and in all parts of the

(2) BL refers to documents catalogued in the British Library

world. Observations on health and mortality were also recorded in Dutch, French and Spanish ships making it possible to conduct multi-national comparative studies.

Shipboard crimes and punishments

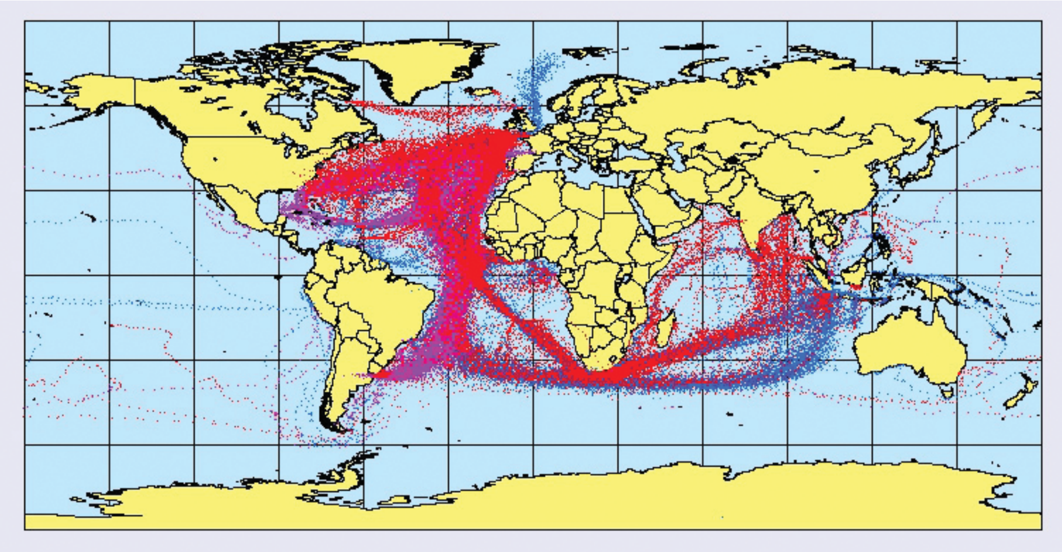
Ships were floating communities and, as with contemporary communities ashore, suffered petty crime, unsociable behaviour, drunkenness and violence. Crews were for the most part made up of young men living in crowded and often damp conditions, with little to do off watch apart from sleeping, drinking or gambling. Moral or intellectual improvement was probably a forlorn hope. Officers maintained discipline either by earning the respect of the men or, if lacking skill in leadership, by force. Perfect order was impossible and the general impression from many logbooks is that vessels were seemingly disorderly societies that nevertheless worked effectively in a crisis. Petty crimes and misdemeanours occurred most frequently when there was little to engage the attention of crews. Easy or slow sailing or being becalmed for long periods would often betoken trouble, whereas the demands imposed rough weather or by any similar periods of intense activity would keep a crew occupied and individuals out of mischief. It was the responsibility of the captain and his officers to make sure that the crew were busy other times thereby sustaining a degree of order. In English logbooks the phrase 'men usefully employed' was frequently used to indicate that the officers were not neglecting this part of their duties. Unfortunately such useful employment might include such tedious tasks as picking oakum or 'working up junk'. Junk was pieces of old rope used to make matting or swabs and oakum was unravelled rope, picked apart in order to caulk or seal gaps in planking. The effect that this had on the ordinary crew went largely unrecorded. When crime was recorded in a logbook the offender and his rank or position was always noted. The most frequent crimes were insolence, neglect of duty, mutinous expressions, fighting and drunkenness. Less frequent and far more serious crimes were desertion, theft, striking a superior officer and mutiny. Violent crime such as a stabbing, or murder was not unknown but was rare. All such instances were recorded in the logbook. The consequent punishments were also recorded, and were usually some form of public flogging, often a dozen lashes or more. Punishments exceeding a dozen lashes were common as several crimes would often be committed together. Drunkenness for instance would nearly always lead to the additional acts of insolence and neglect of duty. Dutch logbooks are equally clear on the willingness of officers to maintain order, and even minor offences were firmly dealt with.

Strict discipline was not confined to Royal Navy vessels, and evidence is found also in the logbooks of the EEIC though such incidents were seldom as common as on ships of the Royal Navy. Royal Navy logbooks contain abundant entries concerned with discipline though their frequency differs from vessel to vessel, depending on the character of the captain and his officers. On the other hand, indications of brutality are not common, but do exist. Some officers were particularly severe, such as Penhallow Cumming who commanded the *Blandford* in 1758 (NMM: ADM/L/B103) and who was dismissed from the Royal Navy for oppression (Rodger, 1986). Others, such as Hugh Pigot of the *Hermione*, inflicted such brutality that the crew murdered him and his officers (Pope, 1963). These extreme instances are rare but recent studies of logbooks have brought to light several hitherto forgotten examples of severe mutiny and disorder. One such found in the progress of the CLIWOC project is the mutiny on board the sloop *Hope* in 1799 when her commander Augustus Brine and his officers were forced to maintain an armed watch on the crew for several weeks. The officers survived an attempt to poison them, before reaching the Cape of Good Hope where most of the crew were placed under arrest. (NMM: ADM/L/H21) Such studies would put events such as the great naval mutinies of 1797 within a wider context and usefully form the basis of a revision of the social history of the British navy.

Warfare, conflict and commerce

The study of large numbers of logbooks has highlighted many themes of interest to the naval and maritime historian. When reading journals, one gets a striking impression of the vastness and emptiness of the oceans. It is apparent that even during wartime, contact between opposing vessels was an infrequent occurrence. The CLIWOC study period from 1750 to 1850 includes the Seven Years' War from 1756 to 1763, the War of American Independence from 1776 to 1782 and the French Revolutionary and Napoleonic Wars 1793-1801, 1803-1815 not to mention other lesser conflicts. Yet it was rare for the UK research team to chance upon the logbook of a ship involved in action with an enemy vessel unless the incident was already known and the logbook was one of the very few pre-selected with this in mind. This reflects the fact that the abstraction process for climate data covered for the most part the deep oceans and most naval actions, whether between fleets or single vessels, occurred close to land. Even in the major shipping routes there were virtually no sightings of other vessels in the deep oceans, all such instances were recorded near major landfalls whether islands, capes or ports. But the emptiness of the ocean could be seasonal and is reflected in the fact that during the months of November and December there would be very few ships in the South Atlantic. This is primarily due to the nature of the circulation patterns in the Indian Ocean. Nearly all sailings in the Indian Ocean were seasonal and dependent on the monsoon to give a fair wind. The timing of sailings to and from Europe and the East reflected this seasonal rhythm which was such that towards the end the year, few Dutch or British ships entered the South Atlantic if they were en route for the Far East or returning. Such patterns appear obvious when attention is directed to them, but it is through the study of logbooks and thereby the individual sailing and trading patterns of vessels that these points come to the fore.

Generally, however, and over the CLIWOC period the geographic coverage (the Pacific Ocean accepted) is good. The Dutch team has produced a number of plots showing the daily positions of vessels by nationality over the CLIWOC study period. Figure 7.5 shows the national differences reflecting the geography of political and



Figures 7.5 CLIWOC data coverage by national sources. Dutch - red; British - blue; Spanish - purple.

economic interests and clearly indicate those areas of the ocean where there were larger concentrations of vessels. These include the English Channel and its western approaches, the Cape of Good Hope, Cape Finisterrre, the Azores, Canary and Cape Verde Islands, Barbados and the Cape of Florida. These shipping routes were determined by the circulation patterns of the atmosphere and the ocean. The routes between Europe and the West Indies, for instance, were dictated by the sub-tropical anticyclone, usually centred near the Azores. The route to the West Indies made use of the NE trades on its eastern and southern sides, while the return voyage made use of the westerlies on the northern side of the circulation. The nature of these winds was well known to mariners, as were the most likely landfalls to be used by shipping. Such knowledge was useful to detect and intercept enemy vessels as well as to prevent an enemy preying on ones own shipping. For the historian, knowing this helps to understand and evaluate strategic and tactical decisions and more importantly to appreciate how and why events took place when and where they did. For example, it should be no surprise to find that the US frigate *Constitution* should choose to cruise for

British merchantmen off the Cape Verde Islands in March 1815. It was the month when many outward-bound Indiamen were likely to be passing close to the islands and fixing their position before the next leg of their voyage south towards the Cape of Good Hope. It is equally unsurprising that the Royal Navy frigates *Leander*, *Newcastle* and *Acasta,* in pursuit of the American, should also be directed to these waters (James, 1859). The *Constitution* managed to escape her pursuers.

A more familiar example is that of Admiral Robert Calder's interception off Cape Finisterre of the Franco-Spanish fleet on its return from the West Indies in the summer of 1805. This was a few weeks before the defeat of this fleet by Nelson at Trafalgar. Cape Finisterre was the most likely landfall to be made by the ships of the Combined Fleet as they negotiated the northerly side of the Azores anticyclone, and the logical place for the British to attempt to intercept them.

Naval officers were greatly concerned with the weather and navigation and this was taken into account in their decision-making whether on board ship or in the Boardroom of the Admiralty. The close study of logbooks, with their first-hand record of the officers' preoccupations with navigation and weather, brings the historian closer to his or her subject, giving a clearer appreciation of the problems and challenges faced by mariners and a better understanding of a courses of action that were decided upon.

Logbooks and environmental factors in history

Logbooks from before the mid-nineteenth century cover a key period in expansion of European empires and in the growth of knowledge of the planet. Sorrenson (1996) went so far as to claim the sailing ship to have been a scientific instrument in its own right. Whether this is true or not, logbooks have proved an essential resource for the study of historical marine climatology and the only one that can give high-resolution daily and even hourly meteorological data over the oceans. Equally, logbooks are the first place to begin any study of the role of the marine environment in history. Not only does the plotting of hundreds of ship

Figure 7.6 Tahiti bearing south-east 1773. By W. Hodges. For the first time, Europeans were exposed to such exotic landscapes.By courtesy of the National Maritime Museum

tracks clearly indicate how mariners exploited the ocean and atmosphere circulations but, equally, they provide clues as to how those circulations were perceived and understood. Many subjects of interest to historians have been touched on above, particularly health and mortality, but the study of the environmental history of the sea can give insights into patterns of trade and colonization, with the attendant spread of diseases, plants and animals, culture and ideas. It is an area of scholarship largely overlooked but to which logbooks can make a valuable contribution.

Exploration, trade, colonization, the clearing of land and peoples for settlement, the movement of crops, plants and animals, and imperial conflict all had an impact on the environment. Yet these actions and movements were themselves sometimes determined by the environment. Admittedly, the confinement of most Spanish imperial expansion to the western hemisphere was a political decision dictated by the Treaty of Tordesillas in 1494. Apart from this however the patterns of territorial acquisitions of the French, Dutch and British must in some degree have been environmentally determined particularly when 'discovery' as the term implies, can be as much by chance as design. Once an acquisition was deemed strategically or commercially advantageous it became an object of desire amongst competing imperial powers. Commercial advantage might come from the type of produce to be grown as a result of a particular climate. Strategic advantage might come from the position of a port or island within the greater circulation patterns of an ocean basin. Barbados for instance was an important landfall on the route from Europe to Jamaica or the Antilles and was to windward of the French, Dutch and Spanish West Indies. Barbados was therefore of strategic as well as commercial advantage to Britain. Likewise the Cape of Good Hope was an important waypoint between Europe and Indonesia for the Dutch East India Company (VOC), to the extent that Britain acquired the place by force of arms first in 1795 and again in 1806. There is no better example of circulation patterns determining the importance of a colony than St. Helena in the South Atlantic. It served as a place of refreshment for homeward bound Indiamen and a point of rendezvous for their naval escorts. More importantly, St. Helena provided a navigational reference for the final leg of the voyage to Europe. Its utility was entirely dictated by its position in the SE trades nearly midway between the Cape and the Equator. Had the prevailing winds blown from some other direction the island would have been of less interest to a maritime power such as Great Britain. This is not argue for any rigid philosophy of geographical determinism, but it is important to recognise the role that the marine environment has had in the growth of empires and international interests.

Caviedes (2001) discusses another aspect of environmental history to which logbooks and journals can make an important contribution when he studied the tele-connections between historic ENSO events and severe weather events in other parts of the world. Part of his methodology was to study accounts of shipwrecks particularly off Chile, South Africa and in the North Atlantic. Although incidents of shipwreck, if used selectively, are a perfectly acceptable proxy for severe weather, the examination of logbooks can yield a far greater quantity of data and be much more precise concerning the location and severity of weather events.

Conclusion

The daily recording of events at sea, across the world's oceans, have been preserved in the logbooks and journals of mariners. They have proved of great utility in the study of historical climatology but more than this, they are a unique and under-exploited resource for the study not only of maritime but also of medical, social and environmental history. What makes them particularly valuable is the fact that they have survived in large numbers in the national archives of the historically major imperial and maritime powers, thus providing an opportunity for multi-national as well as multi-disciplinary studies.

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CHAPTER EIGHT

PROJECT REVIEW: EVALUATION AND ASSESSMENT

Science is nothing but trained and organised common sense

T.H. Huxley (1825-1895)

Introduction and general review

There can be little doubt that scientific endeavour can no longer take place in a closed academic world, and that research results must be made available not only to colleagues in the world of climatology but also to the wider academic and public communities. It is the latter, in particular, who elect governments, sway policy by their collective views and, ultimately, bear the cost of research. As much as the scientists, the public need to be informed or at least possess the means to gather information on the progress that scientists are making. The growth of the World Wide Web has unquestionably made this an easier task and created an expectation that such availability forms part of the philosophy of scientific research. In this important respect the CLIWOC project has enjoyed particular success in communicating its activities to a wider world. There are many reasons for this; at a time when there is a widespread preoccupation with climatic change, it is inevitable that such projects should excite particular attention. But the raw material, the logbooks, on which the research is based has been no less, if accidentally, advantageous. Western Europe's preoccupation with the oceans that wash its shores and for centuries linked it with the overseas empires has left a legacy of interest, even fascination, in nautical history. Epic tales of adventure on the high seas continue to be popular, and the age of sail now enjoys a romantic quality. It is hardly surprising therefore that when such a popular interest is harnessed to scientific research of such immediacy as climate change that the project assumes an unusual appeal. It is within this wider definition of success that the CLIWOC project should be evaluated.

The obvious starting point is to review the degree to which the project's objectives have been achieved:

1) To produce and make freely available for the scientific community the world's first daily oceanic climatological database for the period 1750 to 1850.

The design and preparation of the database have been described in Chapter 5. Its completion marks arguably the most important feature of the project. Yet the term 'complete' fails to convey its most significant attribute; that it is, ironically, far from complete in terms of the data that it can call upon. Fewer than 10 per cent of the logbooks that were available for the study period have included. Nevertheless, a foundation has been laid upon which future developments can be built using the tens of thousands of logbooks that remain unopened.

2) To realise the potential of the database to provide a better knowledge of oceanic climate variability over the study period.

a) To prepare summary and derivative measures from the database to complement and integrate with other contemporary series

b) To use the database to determine the character and scale of oceanic climatic change and variability at various time scales during the final stages of the pre-industrial period

Chapter 6 has demonstrated how this unlikely source of data, that is characterised in its raw form as narrative judgements of the weather, can be processed and expressed in a form that allows them to be subjected to sophisticated numerical treatments. Among the most important of these derivative measures are the indices of the North Atlantic (NAO) and the Southern Oscillations (SO). Both are governed by the spatial patterns of air pressure and are faithfully reflected in the wind fields. Both, in turn, govern important aspects of regional, even global, climate. CLIWOC's newly developed ability to tease out these signals from the logbooks records is one of the more important achievements of the project.

3) To use the information to extend and enhance existing oceanic-climate databases

It is important that the CLIWOC database is not seen as an isolated undertaking. From an early stage in its development, a close working relationship was established with representatives of the important ICOADS (International Comprehensive Ocean-Atmosphere Data Set) database that is supported by the activities of NOAA. The ICOADS database has some similarly early data but is in essence a system that promotes the storage and processing of instrumental data from the mid-nineteenth century onwards. Nevertheless, the CLIWOC-based techniques of data management have an application for the early ICOADS data and have offered scope for important developments in that field of their work.

4) To disseminate the proposal's findings and to stimulate interest and awareness in this source with a view to fostering its further development and realising its scientific potential

One of the most encouraging aspects of the CLIWOC project was the manner in which its activities could be promoted both in the academic and wider world. The following sections list the publications and media items that have emerged from the project. Whilst there is no doubt that the purely scientific material is of significance, it should be noted that a very considerable number of newspaper, magazine and radio and TV items appear in this list. The degree to which the project excited public interest was wholly unexpected but, importantly, provided an opportunity for the work of the EU and the scientific community to be brought to a much wider audience than is the case for many research projects.

Papers in scientific publications that contain references to CLIWOC

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- García Herrera, R. *et al.* (2004) The use of Spanish and British documentary sources in the investigation of Atlantic hurricane incidence in historical times. In R. Murmane and K-b Liu (eds) *Hurricanes and Typhoons: past, present and future*. Columbia University Press, New York.
- Garcia Herrera, R. *et al.* (2005) Mediterranean climate variability over the last centuries; a review In P. Lionello, P. Malanotte-Rizzoli and R. Boscolo (eds*) The*

Mediterranean Climate: an overview of the main characteristics and issues. Kluwer, Dordrecht (in press).

Forthcoming papers from CLIWOC studies

An important recognition of the contribution that the CLIWOC project has made to climatic studies is the agreement to prepare an issue of the internationally recognised journal *Climatic Change* devoted exclusively to its work. This opportunity provides the ideal means by which to communicate with a wide audience. The expected publication date is late 2005, and the provisional contents are:

1. García Herrera, R., Können, G.P., Wheeler, D., Prieto, M.R., Jones P.D., and Koek, F.B. *CLIWOC: A climatological database for the world's oceans 1750-1854*
2. García Herrera, R. *et al*. *Description of logbooks*.
3. Prieto, M.R. *et al*. *Determination of terms for wind force/present weather. The Spanish and French cases.*
4. Wheeler, D. *Determination of terms for wind force/present weather. The English case.*
5. Koek, F.B., and Können, G.P. *Determination of terms for wind force/present weather. The Dutch case.*
6. Wheeler, D., and Wilkinson, C. *The accuracy and consistency of logbook weather observations and records.*
7. Können, G.P., and Koek, F.B. *Description of the CLIWOC database.*
8. Jones, P.D. and Salmon, M.I. *Interpretation and Preliminary Results.*
9. Wilkinson, C. *Non-climatic uses of logbook information.*
10. Woodruff, S. D., Diaz, H. *et al*. *Early ship observational data and ICOADS.*

Presentations in scientific meetings and Conferences

- R. García Herrera, E. Hernández, F. Rubio and M. R. Prieto. Historical sources from English Archives. Oral presentation at: *Workshop on Atlantic Basin Hurricanes Reconstruction from High Resolution Records*. Columbia, S. Carolina, USA. 25- 27, March, 2001.
- R. García Herrera, D. Wheeler, G.P. Können, M.R. Prieto and P.D. Jones. R. García, D. Wheeler, G.P. Können, M.R. Prieto and P.D. Jones. CLIWOC: A climatological database for the world's oceans 1750-1850. Poster at: *AGU NAO Chapman Conference.* Ourense, Spain. 28th November – 1st December 2001.
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- R. García Herrera, D. Wheeler, G.P. Können, M.R. Prieto and P.D. Jones. CLIWOC: a cooperative effort to recover climate data from oceanic areas (1750-1850). Oral presentation at *2nd International Conference of the European Society for Environmental History*. Prague, Czech Republic, 2nd – 7th September 2003.
- D. Wheeler. The CLIWOC project: important steps in providing reliable climatic data from logbook accounts. Oral presentation at *2nd International Conference of the European Society for Environmental History*. Prague, Czech Republic, 2nd – 7th September 2003.
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- Proxy, documentary and early instrumental marine climate data. *European Geophysical Union 1st General Assembly,* Nice, France 25th – 30th April, 2004, convened by R. García Herrera, S.D. Woodruff and P.D. Jones.
- R. García Herrera. Unexplored documentary sources to assess climate variability in the Mediterranean sea. *US-Italy Workshop on Historical Reconstruction of Climate Variability and Change in Mediterranean Regions*. Bolonia, Italy, 5th – 6th October 2004
- D. Wheeler. UK logbooks: imaging and digitising possibilities. *Joint Meeting of CDC and NCAR*, Asheville, NC, 26th – 27th August, 2004.

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- 'Klimaatkenners gebruiken oude scheepsjournalen', *Nederlands Dagblad*, 20 April 2001, The Netherlands

- 'Zoektocht naar scheepsjournalen'**,** *De Telegraaf*, May 2001. The Netherlands.
- 'CLIWOC'**,** NIWI Nieuws, No. 50, december 2001 The Netherlands.
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- 'Klimaatonderzoek in scheepslogboeken', *De Telegraaf Online*, 31 July 2003, The Netherlands.
- 'Weerkundigen bestuderen logboeken', *Trouw*, 31 July 2003. The Netherlands.
- 'Scheepslogboeken inzicht oud klimaat', *Spits,*31 July 2003. The Netherlands.
- 'Oude logboeken bron voor klimaatonderzoek', *Algemeen Dagblad*, 31 July 2003. The Netherlands.
- 'Logboeken navlooien op weergegevens', *Utrechts Nieuwsblad*, 1 August 2003. The Netherlands.
- 'De computer als tijdmachine', *Automatisering Gids*, 15 August 2003. The Netherlands.
- 'Bramzeilskoelte uit 't zuidoosten', *Eindhovens Dagblad Online*, 18 August 2003. The Netherlands.
- 'Weersinformatie in oude scheepslogboeken', *Zeilen*, September 2003. The Netherlands.
- 'Logbook project comes alive at the Museum'. *The Martime Year Book* 2002-3 (National Maritime Museum, Greenwich), vol. 10, 15-17.
- 'Whatever the Weather'**,** *Maritime Life and Traditions* 19, 76, Summer 2003.
- 'Nelson's Weather Eye'**,** *New Scientist* 180, 40-43. December 2003.
- 'Nelson helps in battle to understand climate crisis'**,** *Eastern Daily Press,* December 2003.
- 'Weerbericht uit logboeken'; *Intermediair-2*, 8 January 2004. The Netherlands.
- 'Bovenmarszeilskoelte ofwel windkracht 2'; *Het Parool*, 22 January 2004. The Netherlands.

- 'Los cuadernos de bitácora de los siglos XVIII y XIX, claves en el estudio del cambio climático', *ABC*, 19 January, 2004
- 'Logging a Century of Climate Change'; *Science*, 30 January 2004.
- 'Navigeren met de natte vinger, oude scheepsjournaals brengen 1800 dichterbij'; *Quest*, June 2004.
- 'Tijdingen: Klimaat wereldzeeën in kaart met dank aan Hollandse zeevaarders'; *Holland, Historisch Tijdschrift*, **36** (2004), no. 4, 353-357.

TV and radio presentations

- D. Wheeler, *'Battlefield Detectives: the weather at the Battle of Waterloo'*, Granada TV, UK, March 2003 (rebroadcast Sept 2003).
- F.B. Koek; *'Short news'*, RTV Utrecht (TV), The Netherlands, 31 July 2003.
- F.B. Koek, F. Barnhoorn; *'Stem van Nederland'*, SBS6, The Netherlands, 31 July 2003.
- F.B. Koek, G.P. Können, F. Boekhorst; *'Twee Vandaag'*, TV2, The Netherlands, 6 August 2003.
- BBC news.bbc.co.uk/2/hi/science/nature/3344749.stm (Ranked in the BBC top-30 most visited websites).
- D. Wheeler; Channel 4 National News item, UK, 10 February 2004
- D. Wheeler and C. Wilkinson '*Captain's log*'. BBC Radio 4 on 10 September 2001. (rebroadcast July 2002, BBC Radio 4) UK.
- F.B. Koek*, 'MaDiWoDo'*, VPRO radio 747, The Netherlands, 22 May 2003.
- F.B. Koek, *'Short news'*, RTV Utrecht (Radio), The Netherlands, 31 July 2003.
- F.B. Koek; *'Short news'*, Business News Radio, The Netherlands, 5 August 2003.
- F.B. Koek, *'Short news'*, Wereldomroep, The Netherlands, 7 August 2003.
- R. García Herrera, **"***El Laboratorio***",** Telemadrid Radio, Spain, 19 January 2004.
- R.García Herrera, *'La tierra a tus pies'***,** Onda Cero, Spain, 21 January 2004.

- R. García Herrera, *'Esto es vida'*. Radio Intereconomía, Spain 21 January 2004.

Conferences and lectures for a general audience

- C. Wilkinson. '*Exploiting the Scientific Research of National Museums'* Natural History Museum, London, UK, 22 July, 2001.
- F.B. Koek, *'CLIWOC'*, NIWI, Amsterdam, The Netherlands, 15 January 2002.
- C. Wilkinson. Sept 2003. "*Investigating past Climate from Ships' Logbooks*" National Maritime Museum, Greenwich, London UK; (Archives Awareness Month) in association with the Open University.
- F.B. Koek, *'CLIWOC, Onderzoek naar klimaatverandering op de oceanen'*, Stichting Kaap Hoorn-vaarders, Hoorn, The Netherlands, 19 October 2003.
- C. Wilkinson. Nov 2003. *'Royal Navy Logbooks and the American Revolution'*, Charleston Museum, Charleston South Carolina, USA.
- C. Wilkinson. Nov 2003. '*Ships' Journals: Evidence of the changing Experience of Sea Voyages in the 18th Century*' National Maritime Museum, Greenwich London, UK.
- D. Wheeler March 2003 '*Diarios de navegacion – Fuentes antiguas para datos climatologicos',* University of Barcelona, Spain.

Miscellaneous items

- CLIWOC figures have been included in the book: *'Patrick O'Brian's Navy'*; R. O'Neill (ed). 2003 Salamander Books, London 160pp.
- More than 2900 web pages contain citations to CLIWOC. The most relevant being:

www.ucm.es/info/cliwoc

www.knmi.nl/~koek/cliwoc.htm

www.nmm.ac.uk/site/navId/005002007004

www.knmi.nl/onderzk/hisklim/CLIWOC/CLIWOC.html www.worldchanging.com/archives/000256.html

www.niwi.knaw.nl/en/geschiedenis/projecten/cliwoc/toon

www.cdc.noaa.gov/~sdw/cliwoc/

www.cosis.net/abstracts/EAE03/00098/EAE03-J-00098.pdf

dss.ucar.edu/datasets/ds530.0/docs/cliwoc/

www.nationaalarchief.nl/nieuws/pers/klimaatonderzoek.asp?ComponentID=7404&SourcePageID=5084

www.port.nmm.ac.uk/ROADS/subject-listing/hier/res.html

www.ifremer.fr/envlit/actualite/20040105.htm

www.scitech.org.au/sciencewa/current_stories/int/story_int_sailing.html

www.sunderland.ac.uk/caffairs/noticeb.shtml

www.innovations-report.com/html/reports/earth_sciences/report-23950.html

www.rnw.nl/wetenschap/html/klimaat030909.html

The CLIWOC products

The CLIWOC multilingual dictionary

Chapter 3 has discussed the dictionary and its preparation. The initial print run for this item was 500, and copies are freely available from the project partners, or can be downloaded (see below) from the website as a pdf document. Copies are also distributed at appropriate conferences and have been used in some teaching projects in the UK.

The CLIWOC database CD version

At an early stage in the project's execution, the decision was made to make the database and supplementary documents available on a specially prepared CD. These discs are now available and are packaged in designed covers with the project and EU logos. Version 1.5 of the database is currently included in its MS Access and ASCII/IMMA formats, but the CD provides also copies of the look up documents to assist in understanding the output. Copies of the dictionary and of the opening and closing CLIWOC brochures are also included, both in pdf format. The CD can be obtained by contacting the Spanish partners, although the UK and Dutch teams also have a limited number for distribution at meetings and conferences. In common with the other products, they are free of charge.

The CLIWOC websites

Attention has already been drawn to the project's principal website that can be found at www.ucm.es/info/cliwoc. This site is supported by the Spanish team, but an additional site is operated by the Dutch partners and can be found at www.knmi.nl/cliwoc. The websites have been designed not only to meet the needs of the more general enquirer but also as the means by which the database and the CLIWOC dictionary can be made available. The latter can be downloaded as a pdf file while the database is also accessible. The websites provide an avenue for direct e-mail communications, should they be needed. They have recorded a significant number of 'hits' that are summarized in Table 8.1 and testify to the continued interest in the work of CLIWOC.

country	Spanish site hits	percentage	Dutch site hits	percentage
USA	3308	35	1303	19.7
Spain	1358	14.5	332	5.0
UK	1153	12.4	594	9.0
The Netherlands	960	10.3	3244	49
Canada	365	3.9	148	2.2
Germany	264	2.8	124	1.9
France	247	2.7	105	1.6
Australia	211	2.3	112	1.7
Denmark	166	1.8	77	1.2
others	1023	11.3	642	8.7
total	9055		6681	

Table 8.1 Number of hits (by national groups) to the Spanish and Dutch CLIWOC websites (2001 to date)

CHAPTER NINE

CONCLUSIONS AND FUTURE DEVELOPMENTS

Man is a history-making creature who can neither repeat his past nor leave it behind.

W.H. Auden (1907 – 1973)

Concluding review

Although the CLIWOC project has come to an end in terms of direct funding, it continues to function in a number of different ways.

1) The database provides an enduring feature that can be called upon freely by anyone interested in logbooks and their climatic and historical content, and will continue to do so into the foreseeable future.

2) The skills developed by the team are of value beyond the immediate needs of the project and are already (see below) being called into use in new research undertakings funded by the EU. The *CLIWOC Multilingual Dictionary* also serves this wider purpose and is generally available for projects both large and small.

3) The project has given important publicity to a source of climatic data that whilst not being claimed as wholly 'new', has not hitherto been properly acknowledged. Whilst logbooks cannot match the potential offered by the almost inexhaustible possibilities for acquiring data that can be found with tree ring, coral or ice core studies for example, a large number of logbooks from before 1850 (more than 100,000) remain unexplored and some may yet be discovered in other archives.

This abundance raises a huge challenge to those who might want to pursue this line of research. They should, however, be encouraged by the findings of the CLIWOC project to take up that challenge.

This continuity of activity is perhaps one of the most important and positive features of the CLIWOC project. More so than had been anticipated at the outset, a new avenue of climatic research has been opened. In addition, the creation of the database and the development of methods by which the data can be further processed to give a climatological picture of the past provides a basis on which this 'new' source can be developed. The question is, in which precise direction should the efforts be concentrated?

Future developments

Future developments depend largely upon the availability of logbooks. Table 9.1 summarises the situation at present with regard to the pre-1850 logbooks used and those that have had to remain unopened. These figures, however, do not include sources outside the partner nations or take account of the possibility that further sources might be found in the UK, Spain, France or The Netherlands. Whilst these quantities presented in Table 9.1 are approximate and subject to a number of caveats to be discussed later, there is little doubt that future efforts will need to be concentrated on the UK and French sources, both

National source	Data keyed by CLIWOC	Data available	Exhaustion %
Spanish	0.1M	0.1M	100
Dutch	0.1M	0.2M	50
UK	0.1M	1.5M	6
French	7K	0.5M	1
total	0.31M	2.3M	13

Table 9.1 Summary of approximate quantities of used and potential climatic data from logbooks. The units are expressed as ship-day observations, where each 'observation' will contain a number of variables.

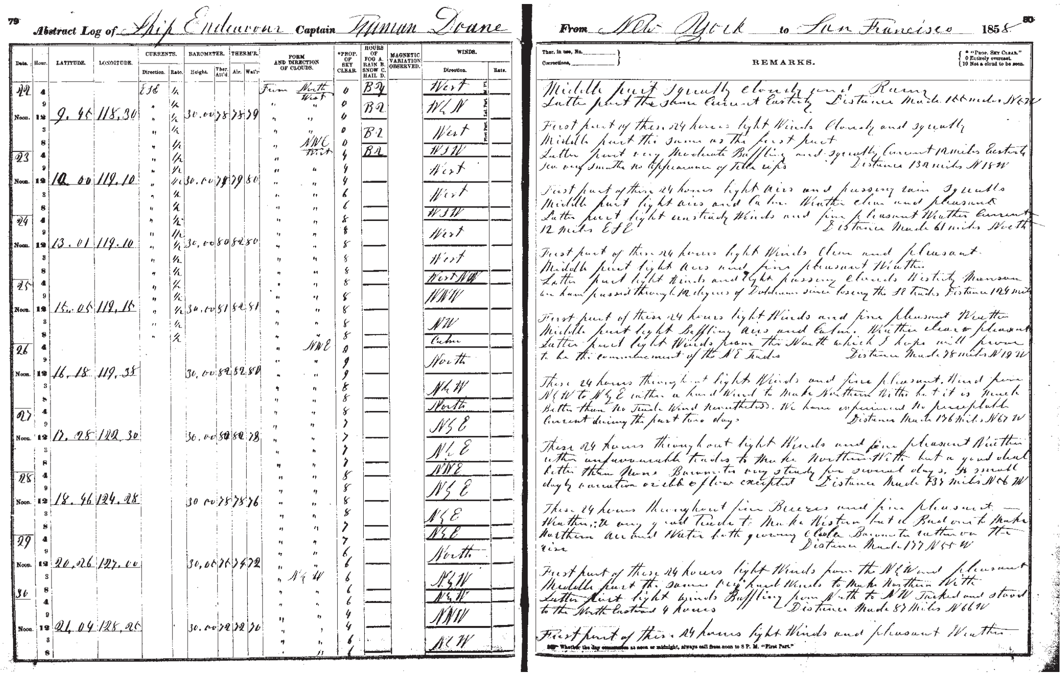

Figure 9.1 Example of abstract logbok pages from the German Maury Collection for the ship Endeavour, en route from New York to San Francisco, 1858.

of which have been little exploited. Some work can continue with limited Dutch material, but the Spanish logbooks have been all but exhausted, although, as noted in Chapter 6, the Spanish archives contain much non-logbook documentation, some of great antiquity, but all of which offers the possibility of recovering important climatic information.

An additional source is provided by the "Abstract Log" collection accumulated under the direction of the US naval officer, Matthew Fontaine Maury (1806 – 1873), an example of which is shown in Figure 9.1. A proportion of the data from this so-called "US Maury" collection, which is multinational in origin, has already been incorporated within the ICOADS database. However, the process is far from complete, because it was possible to translate only limited amounts of the US Maury data into modern scientific units. Therefore a reprocessing effort capitalizing on CLIWOC's expertise should significantly augment the amount of usable (particularly wind force) data. The US Maury Abstract Logs (forms containing meteorological data abstracted from original ship logbooks) and other US sources are scarce for the pre-1800 period, partly because the US Navy was only in its formative years, but become more abundant as the nineteenth century progresses (Woodruff *et al*., 2005). Future efforts must, therefore include closer cooperation with US colleagues. Fortunately the CLIWOC team have already forged important working links with the ICOADS group. Given these broad, strategic, considerations, the more detailed plans and proposals for future work can be itemised as follows:

Developing links with ICOADS and US partners

From an early stage in the project the CLIWOC team worked closely with a representative from the ICOADS group based in Boulder, Colorado who attended the twice-yearly meetings and acted also in an advisory role. It was soon apparent that CLIWOC data, although non-instrumental in character, would make a significant contribution to the ICOADS database extending its period back to 1750 (Woodruff, *et al*., 2005). Indeed the US team has included the US Maury collection of sailing ship logbook data within their data set, and the inventory of voyages can be found at:

www.cdc.noaa.gov/coads/e-doc/other/transpec/maury/maury_invoy

In addition to this source, there is also an archive of Abstract logbooks that has become known as the 'German Maury' collection and which covers the period from 1845 to 1867. These consist of forms that were apparently brought together by Matthew Maury but which have found their way to Germany. These have yet to be fully explored and are the subject of the future plans discussed in the following paragraphs. Current estimates suggest that these sources are similar in size to those in the UK for the CLIWOC period.

There is little doubt that the experience of the CLIWOC team, as well as the data already abstracted, will assist ICOADS in its plans to utilise to its fullest extent the US Maury and German Maury collections in the forthcoming years. The immediate plans are, however, of a more practical nature. A meeting was held in the National Climate Data Centre (Asheville, NC) in August 2004 with NCDC and ICOADS staff, together with representatives from

CLIWOC, the UK's Hadley Centre and the German Meteorological Service. Discussions focussed on the availability of logbooks in Europe and the means by which those data could be prepared for inclusion in ICOADS. Interests ranged between the archaic sources from sailing logbooks to the need to use more recent material to fill major gaps in the instrumental database for the Second World War (1939 – 1945) and to extend the instrumental record back beyond the mid-nineteenth century. In this latter context it should be noted that the UK's National Archive will be a vital resource in any such future developments. It continues to be the repository for government papers more than 30 years old, including those of the Royal Navy, and all logbooks from the earliest in the 1670s to those of 1975 are available for consultation – a truly remarkable three century-long documentary series – and one that can be exploited for more recent as well as archaic data. To these can be added the logbooks of the EEIC that between 1780s and the close of the company in 1834 provide a rich source of daily instrumental observations of air pressure and temperature from a period when such data are less abundant in other resources (see Chapter 1).

The plans for this development are now well-advanced and provide an excellent example of how the CLIWOC team's skills and expertise can be called upon. Funds have been made available from the US Government and work has begun on the preparation of an exhaustive directory of the UK logbook collections that will, amongst other things, categorise and describe logbooks according the nature of the climatic information that they contain. This will allow any future undertakings to identify quickly those items of the 100,000 and more logbooks that meet their requirements. The directory will include much additional material on the practical aspects logbook usage, data management and processing. It is planned to make it freely available. Future developments also include the imaging and digitisation of large numbers of UK logbooks, using the directory to optimise the selection and sampling process.

In association with these developments, the Dutch partners agreed to organise the processing of as much as possible of the 'US' Maury collection to which they have access for transfer to the ICOADS team. Techniques developed during CLIWOC will be used to create a more complete and accurate translation of the data (archaic wind force terms for example) into modern scientific units.

Knowledge dissemination for future studies

Future developments may not be executed by the current team, and it is important that the scientific nature of the project becomes a matter of widely available record. The directory mentioned in the previous section helps to meet this need, and the websites will also assist in this task. The invitation for CLIWOC teams to contribute to a special edition of the international journal *Climatic Change* makes an equally enduring contribution. This publication (see Chapter 8 for a list of the contributions) covers most aspects of the work and provides a lasting record of the scientific accomplishments of the project. The more practical aspects of archive searching and logbook interpretation will be covered in the directory currently being prepared through the US funding as described above. The *CLIWOC Multilingual Dictionary* is already available but the US-funded directory will serve also as a more general user's guide for those unfamiliar with the idiosyncrasies of logbook layout and preparation.

CLIWOC members in new EU projects

Such has been the publicity surrounding the CLIWOC project, that logbooks are already being used in another major EU-funded project. Approval was given in 2005 to fund the MILLENNIUM (European climate of the last Millennium) programme submitted under FP6 (proposal number 017008-2). One of the five work packages within the project uses documentary sources, and logbooks are now included under that heading. This is the first occasion when these data will be cross-referenced to other documentary sources and marks, therefore, a significant acceptance of this long-overlooked resource.

Additional logbook sources

The CLIWOC team are confident that they uncovered the major logbook sources in their own countries, but others may yet be found and the team have publicised at numerous conferences the need to for colleagues to be alert to this possibility. This has already produced some benefits in the UK where the work of the Scott Polar Research Institute has successfully identified in British archives approximately 200 logbooks of whaling ships. Although not great in number these logbooks are of importance because they cover the very high latitudes for which data are in relatively short supply. When complete, it is hoped to include this catalogue on the CLIWOC websites.

It is known that collections of logbooks, not as large as those already used but possibly helpful, exist in Denmark and in Belgium. These too will require scrutiny if funds can be made available. More speculatively, it might be expected that material in Italy, the Scandinavian countries and Russia might yet be found. It has, however, been confirmed that records from Portugal cannot be expected and that they have been either lost or dispersed to private, untraced, collections.

<u>Extending the database beyond 1750</u>

The CLIWOC period covered the years from 1750 to 1850 (1854 including the Dutch data). The data from logbooks written after 1850 are more commonly instrumental and fall more firmly within the domain of ICOADS, but the antiquity of European logbooks allows the record to be extended back beyond 1750. The earliest UK logbooks date from the 1670s and those of the 1680s and 1690s have already been the subject of valuable research (Wheeler and Suarez-Dominguez, 2005). The latter study is limited in area to the seas around the British Isles, but could be expanded to include the whole of the North Atlantic and it has been confirmed (see Figure 2.4) there are several hundred logbooks in the UK alone for the decades before 1750. Chapter 6 has also drawn attention to older Spanish documents. Inevitably, the data become more sparse as one moves back to the seventeenth century, but it is far from negligible in quantity. It possesses also the important property of providing information on the important climatic phase known as the Little Ice Age.

Further proposals

The above developments have, or are, taking place. There are, nonetheless, other areas that await development and offer possibilities for developing additional themes in the post-CLIWOC phase.

a. Development of the database: it is clear from Chapter 6 that additional data would provide greater confidence with which to gauge the wind field reconstructions and estimates of the North Atlantic Oscillation and Southern Oscillation indices. Any opportunity to increase the store of processed and reliable data should be taken.

b. The geographic range of the database could be extended. At present it excludes the Caribbean, Mediterranean and Baltic Seas, but interest in the Mediterranean region is growing as is witnessed by the invitation for CLIWOC team representatives to contribute to a new text on this theme (García Herrera, *et al*., 2005) and to contribute to an international conference held in 2004 in Bologna, Italy. French and British logbooks are abundant for this area but remain largely unexplored. Similar progress has been made with regard to using logbooks from the Caribbean region to improve the hurricane chronology for the past five centuries. Here again, the team have contributed to a major publication (García Herrera, *et al*., 2004) and to a US-sponsored workshop held at the University of South Carolina in 2001.

c. Chapter 7 has indicated the great potential of logbook information for non-scientific applications. Whilst not falling within the scope of the CLIWOC project, this remains an important aspect to emerge from its activities. To this should be added the possible availability of a large number of logbook images 'on-line' should image funding of the type discussed above become available. This will open the source material not only to direct scrutiny by scientists but to those from other disciplines and areas of interest. There is huge scope for statistical studies of crime and punishment at sea and some synthesis of this material has already been carried out for a study of discipline in the Royal Navy in the Leeward Islands (Byrn, 1998). In addition there is more than adequate material to construct datasets to examine shipboard crime, both over periods of time and on different types of vessels, under particular officers, or under various environmental conditions. It would also be particularly fruitful to track officers from vessel to vessel to examine their ability to maintain discipline.

Some of the above items are potential rather than realized. Nevertheless they point clearly to a number of avenues that have opened in response to the achievements of the CLIWOC team between 2000 and 2003. The final word should lie with our US partners who observed "There is a wealth of climate information in the early historical ship records. This information is vital for climate and climate change studies…efforts should be continued to recover as much information as possible from historical archives." (Woodruff *et al*., 2005).

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APPENDIX I

THE MODERN-DAY BEAUFORT WIND FORCE SCALE

Beaufort Number	Term	Description of the state of the sea	Wind speed (knots)	Range	Sea state	Wave height (m)
0	Calm	Sea like a mirror	0	<1	Calm	0
1	Light air	Ripples with the appearance of scales are formed, but without foam crests.	2	1-3	Smooth	0.1
2	Light breeze	Small wavelets, still short but more pronounced. Crests have a glassy appearance and do not break.	5	4-6	Smooth	0.2
3	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Scattered white horses.	9	7-10	Slight	0.6
4	Moderate breeze	Small waves, becoming longer, fairly frequent white horses.	13	11-16	Moderate	1
5	Fresh breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.	19	17-21	Rough	2
6	Strong breeze	Large waves begin to form; white foam crests are more extensive everywhere. Probably some spray.	24	22-27	Very rough	3
7	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.	30	28-33	High	4
8	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind.	37	34-40	Very high	5.5
9	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.	44	41-47	Very high	7
10	Storm	Very high waves with long over-hanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of wind. On the whole the surface of the sea takes a white appearance. The 'tumbling' of the sea becomes heavy and shock-like. Visibility is affected	52	48-55	Phenomenal	9
11	Violent storm	Exceptionally high waves (small & medium sized ships might be lost to view for a time behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Every-where the edges of the wave crests are blown into froth. Visibility is affected.	60	56-63	Phenomenal	11.5
12	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected	64+			14

BEAUFORT'S ORIGINAL WIND FORCE TERMS AND CRITERIA

(SEE ALSO FIGURE 3.6 AND TABLE 3.2)

Beaufort Number	Term	Beaufort's criteria (devised in 1808)
0	Calm	Calm
1	Light air	Just sufficient to give steerage way
2	Light breeze	That which in a well-conditioned man-of-war with all sail set and 'clean full' would go in smooth water from 1 to 2 knots
3	Gentle breeze	Ditto from 3 to 4 knots
4	Moderate breeze	Ditto from 5 to 6 knots
5	Fresh breeze	That to which she could just carry in chase 'full and by': Royals, etc.
6	Strong breeze	single-reefed topsails and top-gallant sails
7	Moderate gale	Ditto: double-reefed topsails, jib, etc.
8	Fresh gale	Ditto: triple-reefed topsails, etc.
9	Strong gale	Ditto: close-reefed topsails and courses.
10	Whole gale	That which she could scarcely bear with close-reefed main topsail and reefed foresail.
11	Storm	That which would reduce her to storm staysails.
12	Hurricane	That which no canvas could withstand.

APPENDIX II

LAYOUT AND SEQUENCE OF THE FIELDS IN THE CLIWOC DATABASE

Column Name	Type	Size	Description
RecID	Long Integer		Automatically generated record number
InstAbbr	Text	8	Abbreviation of the institute where the original data is stored
InstName	Text	50	Name of the institute where the original data is stored
InstPlace	Text	25	Place of the institute where the original data is stored
InstLand	Text	25	Country of the institute where the original data is stored
NumberEntry	Text	15	Administrative number under which the data is found within the institute
NameArchiveSet	Text	100	Administrative name under which the data is found within the institute
ArchivePart	Text	50	Part of the archive set in which the data is found
Specification	Text	50	Specification of the part of the archive set in which the data is found
LogbookIdent	Text	30	Identification of the logbook that holds the underlying data; e.g. a number or code
LogbookLanguage	Text	30	Language used in the logbook
EnteredBy	Text	50	Name of the person who entered the record
DASnumber	Text	50	Dutch Asiatic Shipping Number
ImageNumber	Text	50	Identification Number of the original image
VoyageFrom	Text	50	Ship departed from
VoyageTo	Text	50	Ship sailed to
ShipName	Text	30	Name of the Ship
ShipType	Text	35	Type of ship; e.g. schooner, barque, frigate
Company	Text	75	Company which owns or manages the ship
OtherShipInformation	Memo	-	Other ship information
Nationality	Text	25	Nationality of ship
Name1	Text	30	Name of principal observer
Rank1	Text	25	Full rank of principal observer
Name2	Text	30	Name of second observer
Rank2	Text	25	Full rank of second observer
Name3	Text	30	Name of third observer
Rank3	Text	25	Full rank of third observer
ZeroMeridian	Text	50	Meridian that is used as the reference for the ships' longitude (prime meridian)
StartDay	Text	15	Start time of the ships' day (midnight or midday)
TimeGen	Text	100	Spanish field
ObsGen	Text	255	Spanish field
ReferenceCourse	Text	15	Reference that is used for the ships' course (e.g. true north or magnetic north)
ReferenceWindDirection	Text	15	Reference that is used for the wind direction (e.g. true north or magnetic north)
DistUnits	Text	20	Units of distances, given in the logbook
DistToLandmarkUnits	Text	50	Units of the distance to landmarks, given in the logbook
DistTravelledUnits	Text	50	Units of the distance travelled, given in the logbook
LongitudeUnits	Text	25	Longitudes used (180 degrees = 180E-180W; 360 degrees = 0-360E)
VoyageIni	Long Integer		Date of the start of the voyage in the database. 8 characters with respectively year (4), month (2) and day (2); according to the original calendar. This date can differ from the actual sailing date from the port of departure.
UnitsOfMeasurement	Text	50	Other units that are used in the logbook, e.g. current speed units
Calendar	Byte		Calendar used in original logbook: 1=Julian; 2=Gregorian

Year	Integer		Year of the observation
Month	Byte		Month of the observation
Day	Byte		Day of the observation
DayOfTheWeek	Text	50	If available from the logbook, the weekday is given (Monday, Tuesday, etc.) in the original language
PartDay	Text	20	If applicable e.g morning, evening or night may be noted
TimeOB	Byte		Time on board when the report was made
Watch	Text	5	Watch, shift of duty on board the ship. Usually a time span of 4 hours
Glasses	Single		Number of glasses within a watch (two glasses is one hour)
UTC	Long Integer		Date and time of the observation, expressed in UTC (if possible) corrected for longitude. If no longitude is given, the time is set to 12:00 hours.
CMG	Text	15	Course made good. Corrected course of the ship, usually over the last 24 hours.
ShipSpeed	Single		Ships' speed, usually over the last 24 hours.
Distance	Single		Distance travelled, usually over the last 24 hours.
drLatDeg	Byte		Dead reckoning degrees latitude
drLatMin	Byte		Dead reckoning minutes latitude
drLatSec	Byte		Dead reckoning seconds latitude
drLatHem	Text	5	Dead reckoning hemisphere (N/S)
drLongDeg	Integer		Dead reckoning degrees longitude
drLongMin	Byte		Dead reckoning minutes longitude
drLongSec	Byte		Dead reckoning seconds longitude
drLongHem	Text	5	Dead reckoning hemisphere (E/W)
LatDeg	Byte		True degrees latitude
LatMin	Byte		True minutes latitude
LatSec	Byte		True seconds latitude
LatHem	Text	5	True hemisphere (N/S)
LongDeg	Integer		True degrees longitude
LongMin	Byte		True minutes longitude
LongSec	Byte		True seconds longitude
LongHem	Text	5	True hemisphere (E/W)
Lat3	Single		Final decimal latitude
Lon3	Single		Final decimal longitude
LatInd	Byte		Position Indicator, i.e. the origin of the given decimal latitude; 1 = dead reckoning; 2 = true latitude derived from bearing/distance or celestial calculation; 3 = interpolated manually; 4 = recalculated using other start or destination; 5 = from atlas; 6 = missing
LonInd	Byte		Position Indicator, i.e. the origin of the given decimal longitude; 1 = dead reckoning; 2 = longitude derived from bearing/distance or celestial calculation; 3 = interpolated manually; 4 = recalculated using other start or destination; 5 = from atlas; 6 = missing
PosCoastal	Yes/No		True if position is considered to be in coastal waters (in port or near coastal disturbances).
EncName	Text	25	Name of ship that was encountered
EncNat	Text	25	Nationality of ship that was encountered
EncRem	Memo	-	Remarks on encountering
Anchored	Yes/No		Is true when ship is at anchor or moored
AnchorPlace	Text	50	Name of the place where the ship is anchored/moored
LMname1	Text	50	Name of first landmark of which a bearing was recorded
LMdirection1	Text	15	Bearing of the first landmark
LMdistance1	Single		Distance to the first landmark
LMname2	Text	50	Name of second landmark of which a bearing was recorded
LMdirection2	Text	15	Bearing of the second landmark
LMdistance2	Single		Distance to the second landmark
LMname3	Text	50	Name of third landmark of which a bearing was recorded
LMdirection3	Text	15	Bearing of the third landmark

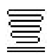
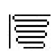
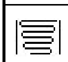
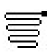
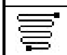
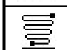
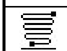
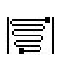
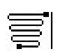
LMdistance3	Single		Distance to the third landmark
EstError	Text	20	Established error of the compass
ApplError	Text	20	Applied correction to the compass
WindDirection	Text	50	Wind direction valid for the time of the observation
AllWindDirections	Text	150	All reported wind directions
WindForce	Text	50	Wind force (descriptive terms) valid for the time of the observation
WindForceScale	Byte		If given, the number of the wind force
AllWindForces	Text	250	All reported wind forces
WindScale	Text	20	Name or reference of the wind scale that was used
Weather	Text	150	Weather description
ShapeClouds	Text	50	Shape of the clouds
DirClouds	Text	50	Directions of the clouds
Clearness	Text	50	Clearness/brightness of the sky
PrecipitationDescriptor	Text	100	Description of the precipitation
CloudFrac	Byte		Clouded part of the sky
Gusts	Yes/No		Wind gusts and/or squalls reported
Rain	Yes/No		Rain reported
Fog	Yes/No		Fog reported
Snow	Yes/No		Snow reported
Thunder	Yes/No		Thunder reported
Hail	Yes/No		Hail reported
SeaIce	Yes/No		Sea ice and/or ice bergs reported
Duplicate	Single		Duplicate record. 0 = original, 1 = 1st duplicate, 2 = 2nd duplicate, etc.
Release	Text	20	Number of the most recent CLIWOC release in which this record was inserted or updated
SSTReading	Single		Reading of the sea surface thermometer
SSTReadingUnits	Text	15	Units of the sea surface thermometer reading
StateSea	Text	150	State of the sea
CurrentDir	Text	15	Direction of the current
CurrentSpeed	Text	50	Speed of the current
TairReading	Single		Reading of the (outside) air thermometer
AirThermReadingUnits	Text	15	Units of the (outside) air thermometer reading
ProbTair	Single		Probable air temperature, expressed in Celsius, calculated dirctly from TairReading and AirThermReadingUnits.
BaroReading	Single		Reading of the air pressure
AirPressureReadingUnits	Text	25	Units of the reading of the air pressure. "Millimeter Mercury"; "Inches Mercury"; "English Inches Mercury"; "DLS10"; "DLS12"
BarometerType	Text	15	Barometer type
BarTempReading	Single		Reading of the attached thermometer
BarTempReadingUnits	Text	10	Units of the reading of the attached thermometer
HumReading	Single		Reading of the humidity instrument
HumidityUnits	Text	15	Units of the reading of the humidity instrument
HumidityMethod	Text	25	Method of measuring the humidity
PumpWater	Single		Amount of water reported at the pump
WaterAtThePumpUnits	Text	15	Units of the amount of water reported at the pump
LifeOnBoard	Yes/No		
LifeOnBoardMemo	Memo	-	Memo field of all interesting remarks on the life (and health) on board
Cargo	Yes/No		
CargoMemo	Memo	-	Memo field of all interesting remarks on the ship's cargo and/or trade
ShipAndRig	Yes/No		
ShipAndRigMemo	Memo	-	Memo field of all interesting remarks on the ship's structure, sails and rig
Biology	Yes/No		
BiologyMemo	Memo	-	Memo field of all interesting remarks on any matter of biological origin

WarsAndFights	Yes/No		
WarsAndFightsMemo	Memo	-	Memo field of all interesting remarks on events that involved fighting etc.
Illustrations	Yes/No		
TrivialCorrection	Yes/No		Set when an obvious keying error was encountered and corrected. It may also be used (but with caution) when a clear error was found in the original logbook.
OtherRem	Memo	-	All remaining remarks

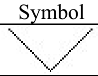
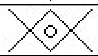
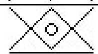
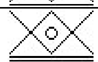
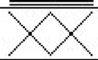
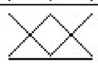
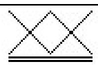
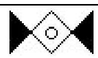
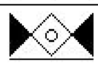
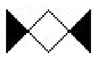
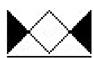
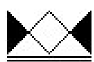
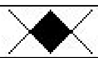
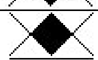
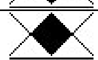
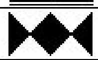
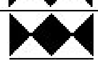
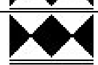
APPENDIX III

CODING SYMBOLS AND KEY USED IN THE PREPARATION OF DUTCH ABSTRACT LOGBOOKS

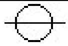
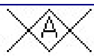
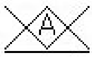
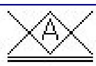
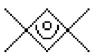
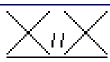
Appendix III.1 Symbols in the 'weather' column of the Dutch extract logbooks and their codes in the CLIWOC database.

Symbol	Explanation(s)	Code	Symbol	Explanation(s)	Code
	Light showers	W00	**D**	Light hail	W26
	Showers; moderate showers	W01	**D̲**	Hail	W27
	Heavy showers	W02	**D̳**	Heavy hail	W28
–	?	W03		Light lightning	W30
\	?	W04		Moderate lightning	W31
	Showers increasing	W05		Heavy lightning	W32
	Showers continuous	W06		Increasing lightning	W33
	Showers decreasing	W07		Lightning continuous	W34
A	Foggy	W10		Decreasing lightning	W35
A̲	Thick fog	W11		Light thunder, thunder and lightning	W40
A̳	Very thick fog	W12		Light thunderstorm, thunder and lightning	W41
B	Drizzle	W20		Light thunderstorm, thunder and lightning	W42
B̲	Rain	W21		Moderate thunderstorm, thunder and lightning	W43
B̳	Heavy rain	W22		Heavy thunderstorm, thunder and lightning	W44
C	Light snow	W23		Increasing thunderstorm, thunder and lightning	W45
C̲	Snow; moderate snow	W24		Thunderstorm, thunder and lightning continuous	W46
C̳	Heavy snow	W25		Decreasing thunderstorm, thunder and lightning	W47

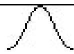
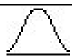
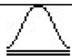
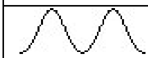
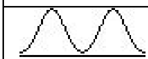
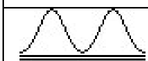
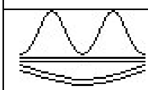
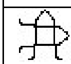
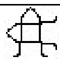
Appendix III.2 Symbols in the 'shape of clouds' column in Dutch extract logbooks and their codes in the CLIWOC database.

Symbol	Explanation(s)	Code
	'Floating' clouds	V00
	Slightly changing amount of cloud	V01
	Moderately changing amount of cloud	V02
	Strongly changing amount of cloud	V03
	Clouded	V04
	Overcast	V05
	Completely overcast and 'dark' clouds	V06
	Slightly changing amount of cloud and showery sky	V07
	Moderately changing amount of cloud and showery sky	V08
	Light showery sky; appearance of a thunderstorm; increasing amount of clouds	V10
	Moderate showery sky; appearance of a thunderstorm; increasing amount of clouds	V11
	Heavy/strong showery sky; appearance of a thunderstorm; increasing amount of clouds	V12
	Light 'densely' sky; 'dirty' air	V13
	Moderate 'densely' sky; 'dirty' air	V14
	Heavy/strong 'densely' sky; 'dirty' air	V15
	Thickly/densely sky	V16
	?	V17
	?	V18

Appendix III.3 Symbols in the 'clearness' column in Dutch extract logbooks and their codes in the CLIWOC database.

Symbol	Explanation(s)	Code
	Clear sky	H00
	Damp air; 'Dewy' weather	H01
	Dew	H02
	Heavy dew	H03
	Light hazy air; Mist	H10
	Moderate hazy air; Mist	H11
	Strong hazy air; Mist	H12
	'Dewy' weather with clouded sky	H13
	?	H20
	?	H21
	?	H22

Appendix III.4 Symbols in the column 'sea state' in Dutch extract logbooks and their coding in the CLIWOC database.

Symbol	Explanation(s)	Code
	Sea	Z00
	High sea	Z01
	Wild sea	Z02
	Swell	Z03
	High swell	Z04
	Heavy swell	Z05
	Continuous heavy swell	Z06
 or 	Crossing swells	Z07

Appendix III.5 Symbols in the 'sea current' column in Dutch extract logbooks and their codes in the CLIWOC database.

Symbol	Explanation(s)	Code
	Light tide rips	S00
	Moderate tide rips	S01
	Strong tide rips	S02

European Commission

EUR 21236 — CLIWOC — Climatological database for the world's oceans: 1750 to 1850

Luxembourg: Office for Official Publications of the European Communities

2006 — VIII, 190 pp. — 17.6 x 25 cm

ISBN 92-894-8279-6

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KI-NA-21236-EN-C

CLIWOC – Climatological database for the world's oceans: 1750 to 1850

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ISBN 92-894-8279-6
9 789289 482790