

The Isles of Scilly and the Channel Islands: "bench-mark" hydrographic and geodetic surveys 1689-1980

Everard, Cyril

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The ISLES of SCILLY and the CHANNEL ISLANDS:

**'bench-mark' HYDROGRAPHIC and GEODETIC
SURVEYS**

1689-1980

IN TWO VOLUMES

VOLUME ONE

CYRIL EVERARD MSc FGS Hon FRGS

QUEEN MARY, UNIVERSITY OF LONDON

PhD

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ABSTRACT

The English Channel has been both a major maritime artery and a navigator's nightmare for many centuries. Two archipelagoes, the Isles of Scilly to the north and the Channel Islands to the south, have been and remain major hazards. The two archipelagos have long cartographic histories which have yet to be fully documented.

The present study is, with two limited exceptions, confined to British official hydrographic surveys and more specifically to those that may be regarded as 'bench-mark' surveys, *i.e.* surveys that made significant advances in ~~the~~ charting the two archipelagoes.

The study is further restricted to describing and assessing the progressive attempts to fix accurately the latitudes and longitudes of the two archipelagoes and their relationships to west Cornwall on the one hand and the Cotentin peninsula on the other. The emphasis is upon the MS charts, Remark Books and notes *etc.* of the surveyors.

The earliest survey discussed here is that of the Isles of Scilly by Capt Collins in 1689, published in 1693 in his *Great Britain's Coasting Pilot*, followed by Tovey and Ginver (1731), Robert Heath (1744/1750), Graeme Spence (1792-c1812) Joseph Huddart (1795); Ordnance Survey (Mudge: 1796; Clarke 1858; 1959). The first Channel Islands official hydrographic survey was initiated by Capt Martin White, as late as 1803, but not officially recognised until 1812 and not published until 1824/6; other surveys mentioned are Carte de France (1818-45;) Bégat (1829); Beck (1942-3); Service Hydrographique (1948); Ordnance Survey (1980).

TO MY WIFE

VOLUME ONE - CONTENTS

ABSTRACT	2
ACKNOWLEDGEMENTS	5
PREFACE	7
LIST OF TEXT FIGURES	9
LIST OF TEXT TABLES	13
INTRODUCTION	16
 PART ONE: THE ISLES OF SCILLY	
Chapter One Captain Greenville Collins	36
Chapter Two Captain Robert Heath	66
Chapter Three Mr Nicholas Gincer	93
Chapter Four Mr Graeme Spence	108
Chapter Five Captain Joseph Huddart	149
Chapter Six Ordnance Survey	165
 PART TWO: THE CHANNEL ISLANDS	
Chapter Seven Anglo-French Prelude	194
Chapter Eight Admiral Martin White	210
Chapter Nine Channel Islands 1829-1980	247

VOLUME TWO - CONTENTS

APPENDICES	261
CONCLUDING REMARKS	353
SELECT BIBLIOGRAPHY	355
DESCRIPTIONS OF FOLDED CHARTS IN POCKET	366

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The writer is indebted to many individuals and organisations for generous help and advice during the preparation of this thesis. It was encouraging to be welcomed when visiting libraries and other centres of learning and to be provided with archival material at short notice. Sadly, personal visits have had to be curtailed but the writer has enjoyed correspondence with unexpected sources of information, such as the archivist of HM Customs and Excise and the Secretary of the Jersey Island Federation of Women's Institutes.

Acknowledged below, in no particular order, are some of the friends and colleagues who have encouraged the writer. My supervisor, Professor B W Atkinson, deserves special mention as but for his personal intervention the thesis would not have emerged and the writer is very grateful for the support provided by the authorities at Queen Mary, University of London. The Department of Geography has given much practical support and without the expertise of Edward Oliver the thesis might never have been completed.

Peter Lawrence, H G B Bilcliffe, Andrew David, Andrew Cook, Adrian Robinson, Francis Herbert (RGS), Frances Woodward, Dr Peter van der Krogt (Utrecht), Steve Archer, Dr Renouf, (Jersey), Rural Dean (Penwith), Dr D Thynne (NMM), Tony Campbell, Dr M I Gurr, (IoS), Steve Ottery IoS, Ms Alison Lloyd IoS, Dr A E Mourant, Ellis Rafferty, Ron Jones, Adrian Kelland, Adrian Webb (UKHO), Paul Davies (Alderney), GJD Wildman (Amsterdam).

Personal circumstances made it impossible for the writer to visit Scilly and he is indebted to the Staff of the Isles of Scilly Museum, the residents and friends of the Islands for their advice and comments. As a member of the La Société Jersiaise and La Société Guemesiaise it was possible to consult their archives during several visits to the Channel Islands and Cotentin. to

Many organisations made their collections available and are listed below. It would be remiss of the writer not to single out the Hydrographic Data Centre, Research Administration, UK Hydrographic Office, Taunton and Adrian Webb and his predecessors who willingly met many requests for archival material.

Public Record Office (National Archives) Kew
 Maritime Information Centre, the National Maritime Museum, Greenwich
 British Library
 British Museum
 London University Library, Senate House, London
 The Corporation of Trinity House, Trinity House, London
 (archives transferred to the London Guildhall Library).
 Duchy of Cornwall Office, London
 Archives Centrales au Service historique de la Marine à Vincennes
 La Bibliothèque National, Paris.
 Cambridge University Library
 Geological Society of London Library
 Bodleian Library, Map Section, Oxford
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 La Société Jersiaise, Lord Coutance Library, Jersey
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The Priaulx Library, Guernsey
 The Cornwall County Record Office, Truro,
 The Hampshire County Record Office, Winchester
 Portsmouth City Council, Museums and Records Service
 The Isles of Scilly Museum, St Mary's, Isles of Scilly
 The Somerset County Record Office, Taunton
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 Trinity House Depot, Cowes, Isle of Wight
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~~Rotterdam~~
 National Meteorological Library and Archive, Bracknell
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 Guernsey Press
 The Alderney Society
 The Corporation of Trinity House
 University of Utrecht, Faculty of Geographical Sciences,
 Scheepvaart Museum, Amsterdam
 Maritime Museum 'Prins Hendrik', Rotterdam
~~The National Meteorological Library, Bracknell~~
 The former Institute of Oceanographic Science, Godalming, Surrey
 States of Jersey Library Service
 States of Jersey Harbours Dept.
 States of Guernsey Archives Service
 Institute of Cornish Studies, University of Exeter
 University of British Columbia
 University College London, Rare Books Dept
 The Society for Army Historical Research
 Royal Observatory, Cambridge
 Christ's Hospital, Horsham, Surrey: David Young
 London Guildhall Library
 Norfolk County Record Office, Norwich
 Royal Observatory, Edinburgh
 Royal Astronomical Society
 Medway Area Archives office, Rochester
 Centre for Kentish Studies, Maidstone
 Établissement Principal du Service Hydrographie et Océanographique de la Marine, Brest
 Library of Congress, Washington, DC
 The Alderney Society Museum C I
 Imperial War Museum, London
 H M Customs and Excise, London
 Charles Close Society for the Study of Ordnance Survey Maps
 The Royal Navy Museum Library, Portsmouth

PREFACE

This selective study of mainly official hydrographic and geodetic surveys of the Isles of Scilly and the Channel Islands identifies and assesses those which, in the writer's opinion, marked fundamental advances in the plotting and locating of the two archipelagoes. These surveys marked the initiation of, and subsequent advances in, the scientific charting of the two island groups. A small number of individuals who also made unique contributions are included. The emphasis is on the frameworks of the surveys, and the determination of position, *ie* latitude and longitude, rather than detailed descriptions of charts.

The study is further selective in that attention is focused on topics that appear to have received little critical attention in the past. Examples are i) Greenville Collins's 'Great Britain's Coastal Pilot': accounts of his appointment, his surveying instruments and techniques and the various editions of the 'Pilot' are readily accessible, but less attention has been paid to the primacy of his chart of Scilly, its scale and the reasons for the deletion of figures from its latitude gradations; ii) the same lack of interest has been shown in the Robert Heath's charts of the Isles of Scilly and his early measurement of their longitudes; iii) the haphazard origins of Capt Martin White's survey of the Channel Islands. Although some biographical details of the surveyors are essential to the discussions of their charts, additional biographical material, incorporating previously unexamined sources, has been transferred to Appendix B.

Both archipelagoes flank and threaten the shipping lanes of the English Channel, for long the main maritime commercial artery to and from N W Europe. Not surprisingly, one of the earliest British lighthouses was erected in 1680 on Agnes, one of the southern Islands of Scilly and another on the Casquets, one of the northernmost Channel Islands, in 1724.

The period covered begins in the late 17th century, when the principles of modern hydrographic surveying were being established (Robinson 1952 and 1962, *passim*) and when the two official sea atlases to include the archipelagoes were published (1693): 'Great Britain's Coasting Pilot' and 'Le Neptune François'. It ends c1980, when the satellite-based Global Positioning System radically changed both hydrographic and terrestrial surveying, particularly the role of geodetic triangulation, the basis of many of the surveys here discussed. 1693 was also the birth year of the British clockmaker William Harrison, who finally solved the problem of determining longitude at sea (and offshore islands) using his 'time pieces', developed between 1735 and 1760.

Following the Introduction, **VOLUME ONE** is divided into two Parts:-

Part One examines the eight selected 'bench-mark' surveys of the Isles of Scilly, from the survey by Capt Greenville Collins in 1689 to the third and last geodetic link observed by the Ordnance Survey between the Islands and the mainland ~~observed~~ in 1980.

Part Two, in examining the selected 'bench-mark' survey of the Channel Islands, has to take into account the proximity of the Islands to the at times hostile coast of France. It examines the problems of [Admiral] Martin White's surveys close to the hostile French coast

and concludes with the Anglo-French geodetic link between the Channel Islands and the south of England via the northern Cotentin peninsula in 1980.

Following common British usage, the English Channel is referred to as 'The Channel', unless there is a risk of confusion with another seaway.

Manuscript material is abbreviated MS or Ms, according to the policy of the depository.

Units of measurement.

In general metric measurements are used but when different units occur in primary sources, such as leagues (British, Dutch, French etc.), nautical or statute miles, yards, feet, toises, fathoms, meters metres etc these are quoted first, followed by their metric equivalents. From 1968 new or revised British Admiralty charts record depths in meters, not in the traditional fathoms. Latitudes and longitudes are increasingly replacing degrees, minutes and seconds by degrees, minutes and tenths of minutes.

LIST OF TEXT FIGURES

INTRODUCTION

- Fig I-1. The Western English Channel. 17**
- Fig I-2. The Isles of Scilly. 18**
- Fig I-3. The Channel Islands. 19**
- Fig I-4. For the purposes of hydrocarbon exploitation, the Channel Islands (a Crown dependency) are part of the French zone. 21**
- Fig I-5a. Les Casquets lighthouse. © By kind permission of V Coysh. 25**
- Fig I-5b. Les Roches Douvres lighthouse. (Courtesy of the Guernsey Evening Press and Star) 25**
- Fig I-6a. The Isles of Scilly. (Goos, after Waghenaer, 1666-7). 27**
- Fig I-6b. The Isles of Scilly. (Davis c 1584: note latitude and longitude). 27**
- Fig I-7. The Isles of Scilly and Mainland. Waghenaer 1588. 33**

CHAPTER ONE

- Fig 1-1. The Islands of Scilly...1689, Cap'n G Collins. 37**
Early edition, no reference to Sir Cloudesley Shovell's wreck in 1707.
[See CHART 1-4]
- Fig 1-2. The Islands of Scilly... Capt'n G Collins. 38**
Date deleted. c 1738. 'Sir Clousley lost' on south west rocks.
[See CHART 1-4]
- Fig 1-3. Cartouche of Collins' chart of Scilly. 48**
No numbers in D and M columns, except '1.' in 3rd row of M column.
- Fig 1-4. Extract from [Approaches to Lands End and the Lizard including Scilly Isles]. UKHO B887 ot* 58**
Reproduced from Admiralty Publications/Charts by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office.
- Fig 1-5. Extract from John Nordon's 'Description of Cornwall' 1584 (Graham 1966). 60**
- Fig 1-6. Reproduced from 1:50 000 sheet 203, 2002, Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office, © Crown Copyright NC/02/40390. 61**

CHAPTER TWO

- Fig 2-1. A New and Correct Draught of the ISLANDS of SCILLY... 68**
From 'A Natural and Historical account of the Isles of Scilly. Robert Heath 1750. © RGS-IBG Library
- Fig 2-2. Cha. Price. A CORRECT CHART of SCILLY ISLANDS.c 1730. 69**
©The British Library. C.26 f 21(3)

Fig 2-3. N Gincer. A MAP OF SCILLY ISLANDS. 1731.
© Copyright The British Library. ADD 60393 D 76

Fig 2-4a Star Castle, St Mary's, Scilly. 880107. © Gibsons of Scilly. 78

Fig 2-4b. The Lighthouse, St Agnes. 880082. © Gibsons of Scilly 78

CHAPTER THREE

Fig 3-1. N Gincer 1731. The Isles of Scilly: Latitude and Longitude according to text. 94

Fig 3-2. N Gincer. A MAP OF SCILLY ISLANDS. 1731. 96
© Copyright The British Library. ADD 60393 D

Fig. 3-3. A Tovey and N Gincer.
A NEW CHART of the ISLANDS OF SCILLY 1779 104

CHAPTER FOUR

Fig 4-1a. St Buryan Church. 410258. Tower c29m. © acknowledged. 113

Fig 4-1b. Sennen Church. 356255. Tower c18m. © acknowledged. 113

Fig 4-2. Spence's Triangulations. 115

Fig 4-3. Longships lighthouse. 124

Fig 4-4. East Lizard lighthouse 128

Fig 4-5. Lizard Peninsula. Collins/Mackenzie 1789 130
(Meridian through West Lighthouse.)

UKHO 702 Dc. Reproduced from Admiralty Publications/Charts by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office.

Fig 4-6. Lizard Peninsula. (East Lighthouse 705115). 131
Reproduced from 1:25 000 Explorer sheet 103, 1996, Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office,
© Crown Copyright NC/02/40390.

CHAPTER FIVE

Fig 5-1. Porth Hellick, St Mary's : 926105. 151
Reproduced from 1:25 000 Explorer sheet 20, 1996, Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office,
© Crown Copyright NC/02/40390.

Fig 5-2. Site of Sir Cloudesley Shovell's grave, Porth Hellick, St Mary's 925108
© Gibson of Scilly 154

Fig 5-3. John Arnold's Watch No 21/68. Probably owned and used by Edward Everard of King's Lynn, 1785-1787 and later (see End Note 17).
© Copyright The British Museum. 159

Fig 5-4. Watch No 21/68. Note : 'This is famous watch mentioned in Arnold's & [William] Mudge's books'. 161
© Copyright The British Museum.

Fig 5-5. Huddard's Longitude of Sir Cloudesley Shovell's grave, Mudge's extrapolation to Agnes Lighthouse and other longitudes for the Isles of Scilly. 162

CHAPTER SIX

THE GRAND TRIGONOMETRICAL SURVEY

(W MUDGE) 1796

Fig 6-1. Extract from Mudge and Dalby,
Phil Trans Roy Soc 1797, Plate p 442. 167

Fig 6-2. Based on Mudge and Dalby,
Phil Trans Roy Soc 1797, Plate p 442. 168

THE PRINCIPAL TRIANGULATION

(A R CLARKE) 1858

Fig 6-3. Extract from Clarke 1858 :
Principal Triangulation ...v 2, Plate X (Fig 13). 180

Fig 6-4. Based on Clarke 1858 :
Principal Triangulation ...v 2, Plate X (Fig 13) 181

THE RETRIANGULATION

(ORDNANCE SURVEY) 1960 188

Fig 6-5. Extract reproduced from Ordnance Survey map with the permission of the
Controller of Her Majesty's Stationery Office, © Crown Copyright NC/02/40390.
Based on Block SV/91. OBS. DIAG. with the permission of the Controller of Her
Majesty's Stationery Office, © Crown Copyright NC/02/40390.

Fig 6-6. Isles of Scilly triangulation stations. 193
This map plots the triangulation stations used by 'bench mark' surveyors from
Robert Heath (1744/50) to the Ordnance Survey (1960). for simplicity, the inter-
island stations are not separated from the island – mainland stations. These, of
course, were located and described in the preceding chapters.

CHAPTER SEVEN

Fig 7-1. Based on 'Cartes Des Côtes de Bretagne..' Musée de Brest 1982. 196

Fig 7-2. Map of Jersey's Signal Stations (© Societe Jersiaise). 204

Fig 7-3. Jerbourg Signal Station c1810. 206

CHAPTER EIGHT

Fig 8-1. Plan of Principal Triangles. 213

*Reproduced from Admiralty Publications/Charts by permission of the Controller
of Her Majesty's Stationery Office and the UK Hydrographic Office.*

Fig 8-2. White's detailed Triangulation. 224

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of Her Majesty's Stationery Office and the UK Hydrographic Office*

Fig 8-3. White's Two Meridians. 232

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of Her Majesty's Stationery Office and the UK Hydrographic Office*

Fig 8-4. Site of White's base-line, Royal Bay Jersey, looking south from Fort
William. 236

Fig 8-5. Detail of Cartouche, RGC 1829, Augmented 1826. 240

*Reproduced from Admiralty Publications/Charts by permission of the Controller
of Her Majesty's Stationery Office and the UK Hydrographic Office.*

Fig 8-6. St Catherine's Breakwater. 244
By Permission © Rosemary Brown.

CHAPTER NINE

Fig 9-1. White, Daussey and Bégat Survey: 1828-1829. 248
(based on chart in archives of IGN, Service de Géodésie. © acknowledged)

Fig 9-2. Sidney and Richards survey: 1850-1868. 252
Reproduced from Admiralty Publications/Charts by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office

Fig 9-3. German survey : 1942-1943. 254
(based on chart in archives of IGN, Service de Géodésie. © acknowledged)

Fig 9-4. Geodetic connection: 1980. 256
Reproduced with the permission of the Controller of HMSO © Crown Copyright 1980

LIST OF TABLES

INTRODUCTION

- TABLE I-1. Isles of Scilly: Early Latitudes - Agnes Old lighthouse 22**
(unless otherwise stated)
- TABLE I-2. Isles of Scilly: Early Longitudes - Agnes Old Lighthouse 23**
(unless otherwise stated) Adjusted to the Greenwich prime meridian
- TABLE I-3. Channel Islands: Early Latitudes - St Aubin town 23**
(unless otherwise stated)
- TABLE I-4. Channel Islands: Early Longitudes - St Aubin town 24**
(unless otherwise stated) Adjusted to the Greenwich prime meridian
- TABLE I-5. Isles of Scilly 29**
Sample gradients from c 70m depths to chart datum
- TABLE I-6. Isles of Scilly 29**
Summit heights, with National Grid References.
- TABLE I-7. Channel Islands 30**
Summit heights with National Grid References
- TABLE I-8. Channel Islands 31**
Sample gradients from c 55m (Alderney and Guernsey) and 35m (Jersey) depths to chart datum
- TABLE I-9. Channel Islands 32**
Maximum visible distance to land from 4.6m above the waterline

CHAPTER ONE

- TABLE 1-1. Isles of Scilly Latitudes from Collins' Chart Plate 19 44**
- TABLE 1-2. Mainland Latitudes from Collins' Chart Plate 19. 44**
- TABLE 1-3. Latitudes of Agnes Lighthouse on Collins' four small scale charts of the Isles of Scilly 45**
- TABLE 1-4. Latitudes on Plate 19 transferred to and plotted on Collins Plate 20 53**
- TABLE 1-5. PLATE 20: Assuming distances are in nautical miles. 55**
- TABLE 1-6. PLATE 20: Assuming distances are in statute miles. 55**
- TABLE 1-7. Mainland (Cowlo) to Agnes Lighthouse. 62**

CHAPTER TWO

- TABLE 2-1. LATITUDES: Renshaw [Whiston] (insert 1741-2, published ?1745) and Heath (compiled 1744, published 1750) compared. 67**
- TABLE 2-2. LONGITUDES: Renshaw [Whiston] (main chart compiled 1741-2, published ?1745) and Heath (compiled 1744, published 1750) compared; Greenwich prime. 67**
- TABLE 2-3. (statute miles) 75**

- TABLE 2-4.** Heath's latitudes compared 80
- TABLE 2-5.** Heath resolved the latitude problem to high degree of accuracy 81
- TABLE 2-6.** The earliest reference to the latitude of 'Fanal de Ste Agnes' 81
- TABLE 2-7.** Latitude of St. Agnes (lights): [also separately listed as Scilly Isles (lights)] 81
- TABLE 2-8.** Connaissance des temps / London 84
- TABLE 2-9.** Cary 1794 map of Scilly (Palmer 1963, p 12 and plate viii). 86
- TABLE 2-10.** Longitude errors on Heath's 1744 chart (Greenwich prime) 87
- TABLE 2-11.** Cary 1794 map of Scilly (Palmer 1963, p 12 and plate viii). 88
- TABLE 2-12.** Latitude 89
- TABLE 2-13.** Longitude 89
- TABLE 2-14.** Latitudes 89
- ~~**TABLE 2-15.** Longitudes (Greenwich meridian)~~

CHAPTER THREE

- TABLE 3-1.** Latitudinal limits of the Isles of Scilly: Ginver and Heath compared 100
- TABLE 3-2.** Longitudinal limits of the Isles of Scilly: Ginver and Heath compared, Greenwich prime 101
- TABLE 3-3.** Ginver 1731: Longitudes of the Isles of Scilly from Land's End (Greenwich meridian). 101
- TABLE 3-4.** Summary: Latitudinal and Longitudinal limits of the Isles of Scilly: Ginver (presumed locations) and Heath compared (Greenwich) 102
- ~~**TABLE 3-5.** Ginver 1731: longitudes of the Isles of Scilly from Land's End (Greenwich meridian). 103~~

CHAPTER FOUR

- TABLE 4-1.** Suggested relationships between Spence's MS and printed charts of Scilly and Scilly -mainland 119
- TABLE 4-2.** Pollard Rock (Seven Stones) 127
- TABLE 4-3.** Selected distances 129
- TABLE 4-4.** Examples of 'Lizard' latitudes 133
- TABLE 4-5.** Position of the Wolf Rock (Chart 4-4b) 136
- TABLE 4-6.** Position of the Longships Lighthouse (Fig 4-3) 137
- TABLE 4-7.** Position of Runnelstone, South Beacon 137
- TABLE 4-8.** Positions:- 1791-modern 140
- TABLE 4-9.** Agnes Lighthouse to west Lizard Lighthouse: longitude difference 140

CHAPTER FIVE**TABLE 5-1.** Huddart and the Longitude of the Porth Hellick Grave **150****TABLE 5-2.** Scilly lights-latitude **153****TABLE 5-3.** Agnes Lighthouse: Mudge's extrapolation **154****CHAPTER SIX****TABLE 6-1.** Isles of Scilly: triangulation objectives **173****TABLE 6-2.** (Williams *et al* 1797, p 503) **173****TABLE 6-3.** (PHIL TRANS ROY SOC, 1800, P 673) **175****TABLE 6-4.** Longitudes, Agnes Lighthouse **176****TABLE 6-5(a).** Longitude of the Lizard: Clarke (1858, p 780) **184****TABLE 6-5(b).** Longitude of the Lizard: Mudge (1800, p 671) **184****TABLE 6-6.** Agnes Lighthouse **190****CHAPTER SEVEN****TABLE 7-1.** Maraldi et Cassini **198****TABLE 7-2.** Le Neptune Français 1753: Latitudes **199****TABLE 7-3.** Le Neptune Français 1753: Longitudes (adjusted to Greenwich) **199****TABLE 7-4.** Sample Latitudes: de la Rochette 1781 **201****TABLE 7-5.** Sample Longitudes: de la Rochette 1781 **201**
West from London (St Paul's). Add 5' for Greenwich.**TABLE 7-6.** (V.11 7th feuille) Nouvelle Neptune François, 1792 **202****TABLE 7-7.** Le connaissance des temps, IN 1786/9 AND 1791/3 **203****TABLE 7-8.** Dobrée Latitudes **205****TABLE 7-9.** Dobrée Longitudes ('London' St Paul's) **205****TABLE 7-10.** Sample Latitudes: Dessiou 1805 CHART **207****TABLE 7-11.** Sample Longitudes: Dessiou 1805 CHART **207**
West from London (St Paul's). Add 5' for Greenwich.

INTRODUCTION

1

The greatest danger to 18th and 19th century seafarers came not from foreign navies but from the chart table. [1]

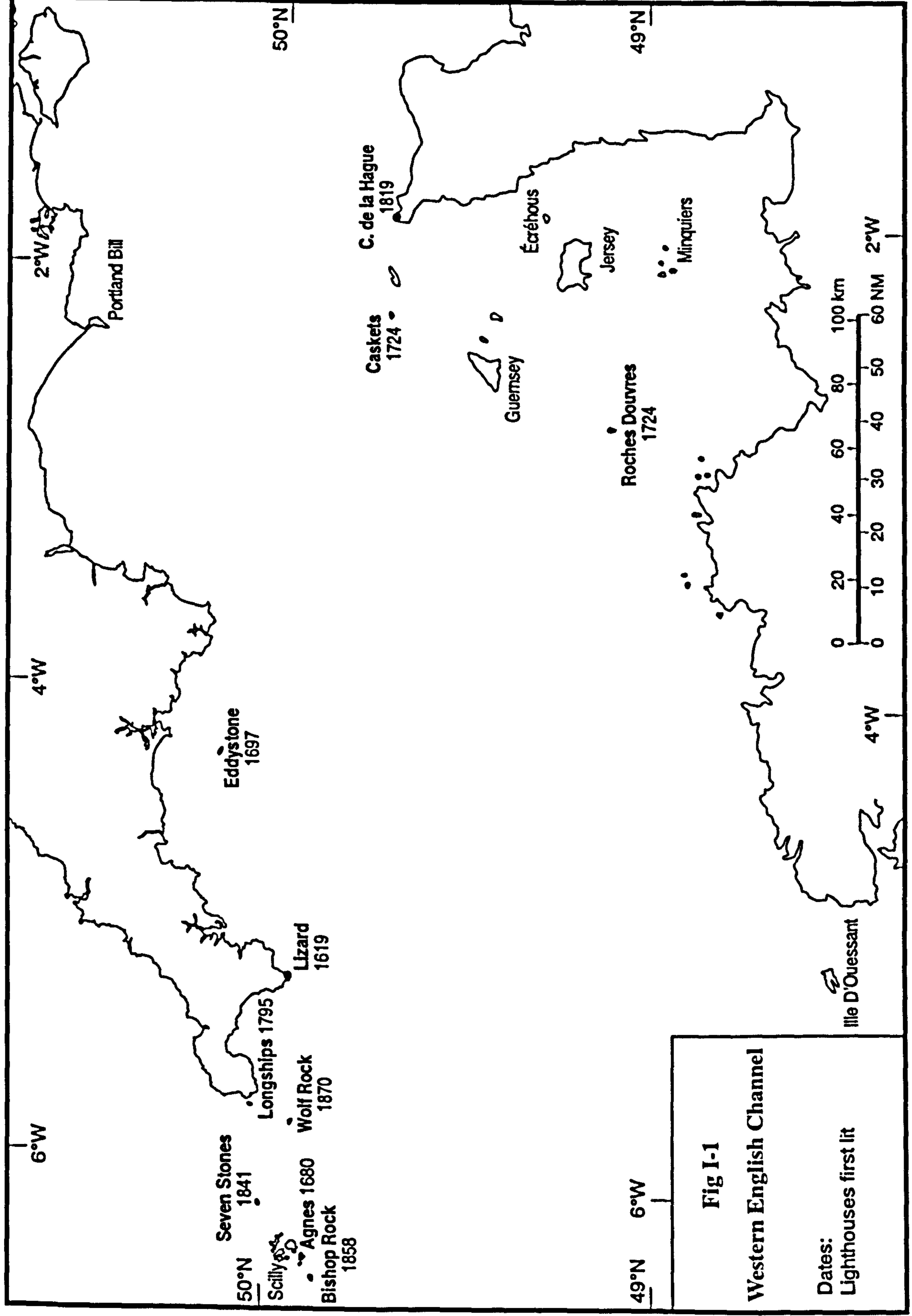
The Isles of Scilly and the Channel Islands are known primarily as popular holiday destinations. This Introduction to selected hydrographical surveys is a brief review of relevant geographical, historical and political aspects of the two island groups, including the natural hazards facing ships in the Western English Channel. Even with today's highly accurate charts and sophisticated means of navigation shipwrecks still occur [2].

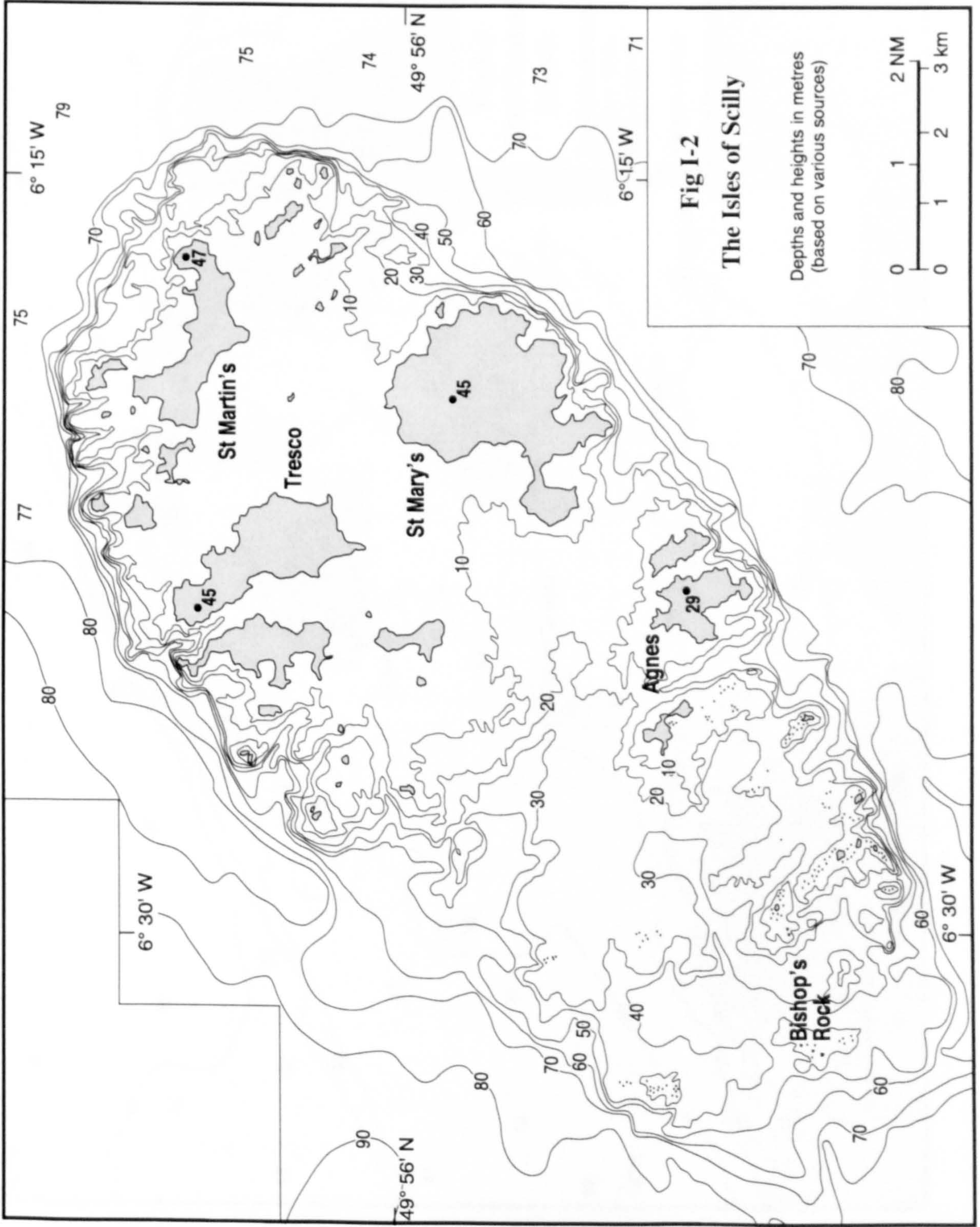
The English Channel has for long ~~the~~ the main maritime commercial artery to and from NW Europe. *BÉEN* It is c 300nm / 560km in length from the Strait of Dover to an arbitrary western limit, a line from the Bishop Rock (Scilly), to Pointe de Créac'h (Île d'Ouessant). Here it is about 100nm/185km wide but it narrows to about half this distance between Portland Bill and Cap de la Hague (Cotentin). Dangerous headlands and islands project into it from both the English and French shores).

Flanking the main shipping lanes in the western Channel (Fig I-1) are, to the north, the Isles of Scilly, the Seven Stones and the Wolf Rock and, to the south, Île d'Ouessant and the Channel Islands. The northern group presents the greater danger; it lies further from the mainland and is a hazard not only to English Channel shipping but also to that leaving or entering the Irish Sea and Bristol Channel. One of the earliest British lighthouses was erected in 1680 on Agnes, southern Scilly, guarding the north flank of the shipping lanes and another in 1724 on the Casquets (northern Channel Islands) guarding the south flank. Les Roches Douvres lighthouse, the most westerly islets of the Channel Islands, was not built until 1867.

The Isles of Scilly (Fig I-2) are a small, compact, isolated archipelago, c 21nm / 39km westwards of Land's End, covering a surface area of c 34nm² / c 118 km², of which c 14% is land. They enclose a relatively sheltered haven but most mariners sailing in and out of the Channel seek to avoid these dangerous islands.[3]. Their compactness aided surveys of them but their distance from the mainland long delayed the fixing of their exact position.

Conversely, the Channel Islands (Fig I-3) are a very large area of scattered islands, islets and innumerable reefs and shoals, covering a sea area of c 2 600nm² / 8 800km² of which c 3% is land.[4]. Charting the archipelago is therefore a major task. There are no natural havens and the dangers are compounded by tidal races among the islands and some of the largest tidal ranges in Europe (St Helier, Jersey; mean spring range 9.8m). International shipping keeps to the north of the archipelago but navigation around, within and across it is essential for inter-





island trade and to give access to the French ports of Carteret, Granville and especially St Malo, formerly a major naval base. The eastern islands lie within sight of the French mainland: Alderney is only 8nm/15km from Cap de la Hague (Fig I-4) and for the purposes of hydrocarbon exploitation the Channel Islands lie in the French zone (Fig I-4; Couper 1985, p 323). The northern and western limits of the Channel Islands are Les Casquets and Les Roches Douvres (Figs I-5a and I-5b).

'Scilly Isles' is not favoured locally: the 'Isles of Scilly' or simply 'Scilly' are normally used. The derivation of the name is discussed fully by Thomas (1985, p 60). 'St Agnes' is properly named 'Agnes', the name used in this study. 'Saint' is a late addition in imitation of St Mary's etc Thomas (1985, p 43). The inclusive name 'Channel Islands' [5] appears to be of recent origin (Hocard, 1995). A French chart by Jean Guerard (1627) names the archipelago 'ylles an gllfes'. The main islands are Jersey and Guernsey: for origins of names see Stevens *et al.* 1986 and Coats 1991. To the French the archipelago is Îles Anglo-Normandes.

The choice of the late 17th century as the starting date of this thesis could legitimately be questioned. It was a deliberate choice, however, to confine the main discussions to the first official surveys, with brief references to significant contributions by individuals. *'...biographical studies of individual cartographers...form an essential complement to bibliographical research. We cannot know too much about the men who made maps...'* (Harley 1967, p 8). The lives of some of the surveyors discussed here are well documented (e.g. Joseph Huddart) others (e.g. Robert Heath, Martin White) are less well known. Biographies are in Appendix B.

Invaluable but incomplete accounts of the cartographic history of the Isles of Scilly are to be found in Palmer (1963;1967), Quixley (1966) and Baxter (1974) and in a broader context in Robinson (1962) and Margary (1977). Representations of the Isles of Scilly have appeared on maps and charts since at least the 13th century. From the 16th century charts have tended to plot the Islands either diagrammatically as a circle (Fig I-6a:Goos 1666-7 after Waghenaer, 1584: Fig I-7) or with some semblance of realism, (Fig I-6b: Davis's chart of c1585; note reference to latitude and longitude).

Private or semi-private surveys were the main source of Channel Island charts until the first Admiralty survey of 1812. A major contribution to cartobibliography, mainly for Guernsey, is by Warren (1962); Mills (1992) has summarised Jersey cartography to the end of the 17th century. Limited information is in 'Cartes des Côtes de Bretagne' (Brest 1982).

The French were well ahead of the British in organising official charting. By 1720 the French had established 'Le Dépôt des Cartes et Plans de la Marine' It was led for 50 years by the distinguished hydrographer, J N Bellin. He supervised later editions of 'Le Neptune Français', which include charts of the Channel Islands. In Britain the office of Hydrographer to the Board of Admiralty was not established until 12th August 1795. It was limited to preparing for publication the mass of MS material which had accumulated at the Admiralty. Admiral Hurd

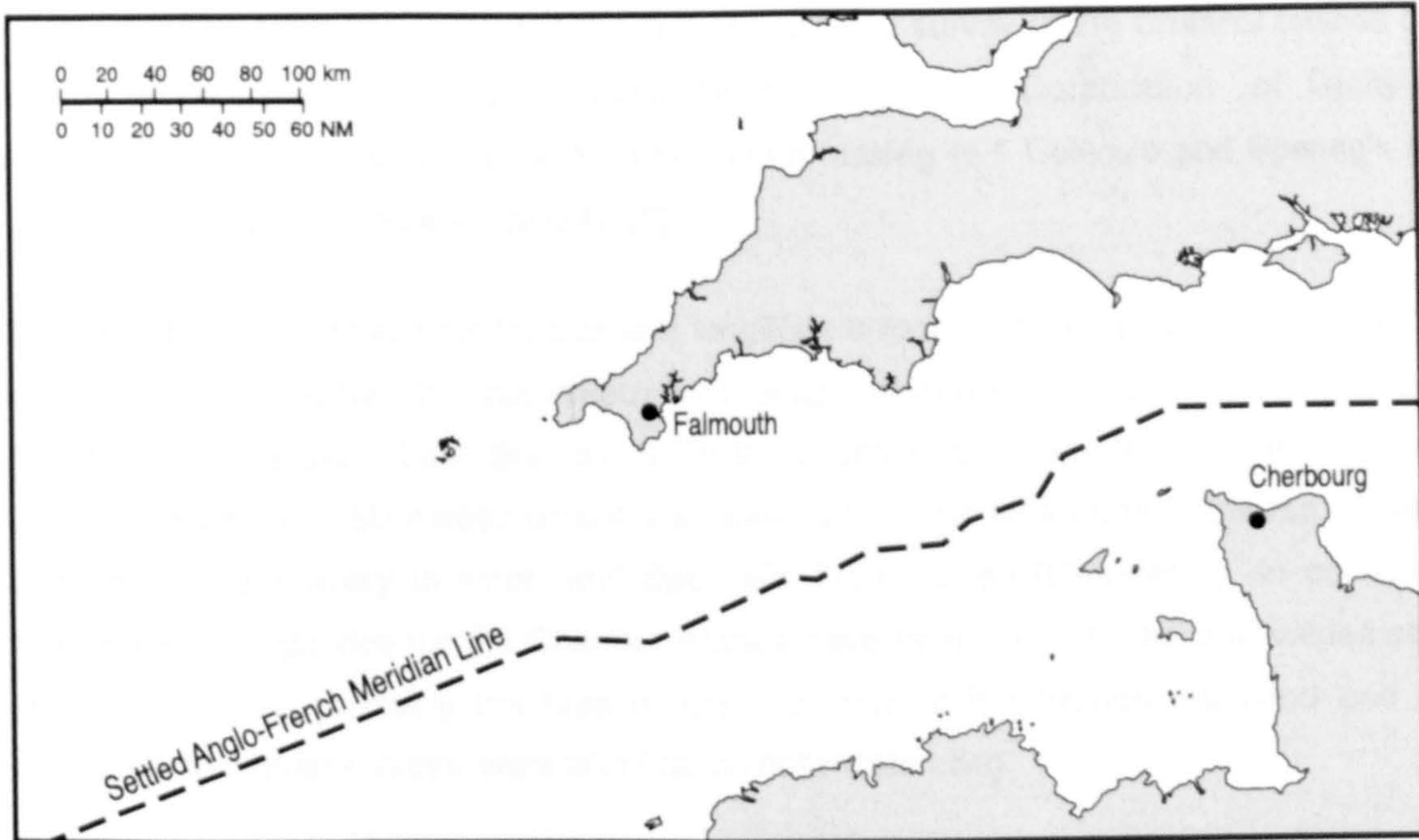


Fig I-4 For the purposes of hydrocarbon exploitation, the Channel Islands (a Crown dependency) are part of the French zone.

(Hydrographer 1808-23) supported the first official 1812 survey of the Channel Islands by Capt Martin White (which had begun unofficially in 1803). The Corporation of Trinity House endeavoured at times to influence Admiralty chart-making (c.f. Collins's and Spence's surveys of the Isles of Scilly, Chapters 1 and 4). [6]

Tables I-1 and I-2 list sample latitude and longitude errors for both groups of Islands. Scilly is usually represented by the old (1680) lighthouse on Agnes and the Channel Islands by St Aubin Town, Jersey. Latitudes for Scilly increased in accuracy from the mid-18th century onwards; Heath's 1750 measurement was almost true but was largely ignored (Chapter 2). Longitudes were wildly in error until Spence's 1791 survey (Chapter 4). In contrast, both latitudes and longitudes for the Channel Islands have been close to the true values since the late 17th century, probably because of the proximity of the French mainland and its well developed terrestrial surveys, wars with France notwithstanding.

TABLE I-1

**ISLES OF SCILLY: EARLY LATITUDES - AGNES OLD LIGHTHOUSE
(unless otherwise stated)**

DATE	SOURCE	LATITUDE	ERROR: naut miles ¹
MODERN	Ad chart 34	49° 53' 31" N	-
C 1585	Davis	51° 00' 00" ²	+ 66.5
1625	Blaeu	50° 03' 00" ²	+ 9.5
1646	Dudley	50° 00' 00"	+ 6.5
1671	Seller	50° 07' 10"	+11.2
1689	Collins (chart 11)	50° 20' 10"	+ 8.7
1693	De Hooge	50° 30' 00"	+ 36.5
1731 ³	Ginver	49° 52' 00"	+ 6.5
1744	Heath	49° 53' 30"	- 0.2
1755	Kitchin	49° 53' 00"	- 0.5
1777 ⁴	Conn des Temps	49° 58' 00"	+ 4.5
1779	Tovey & Ginver	49° 55' 00"	+ 1.5
1781	Nautical Almanac	49° 56' 00"	+ 2.5
1784	Walpole	49° 52' 00"	+ 0.5
1791-2	Spence	49° 53' 47"	+ 0.3
1797	Mudge (Ord Sur)	49° 53' 36.8"	+ 0.1
1800	Conn des Temps	49° 56' 00" ⁵	+ 2.5
1802	Nautical Almanac	49° 53' 47"	+ 0.3
1858	Clarke (Ord Sur)	49° 53' 30.8"	-0.002

NOTES

1. + is northward error , - is southward error
2. Centre of archipelago
3. Ginver's most southerly point, assumed to be Pednathise Head
4. Date of publication
5. Observed at sea

TABLE I-2

ISLES OF SCILLY : EARLY LONGITUDES - AGNES OLD LIGHTHOUSE
(unless otherwise stated)
Adjusted to the Greenwich prime meridian

DATE	SOURCE	LONGITUDE	ERROR (naut miles) ¹
MODERN	Ad chart 34	6° 20' 40" W	-
1731	Ginver ² [Peak Rock]	6° 49' 0"	+ 18.1
1744	Heath	6° 43' 06"	+ 14.4 *
1755	Kitchin	7° 14' 00" (S P) ³	-
"	"	7° 19' 00"	+ 37.3
1777 ⁴	Conn des Temps	9° 33' 00" (Pans)	-
"	"	7° 14' 00" ⁵	+ 34.1
1781	Nautical Almanac	6° 46' 00"	+ 16.2
1784	Walpole	7° 14' 00" (S P)	-
"	"	7° 19' 00"	+ 37.3
1791-2	Spence	6° 19' 21.8"	- 0.83 *
1795	"	6° 23' 16"	+ 1.67 *
1796	Huddart	6° 23' 10" ⁶	+ 1.5
1797	Mudge (Ord Sur)	6° 19' 23.4"	- 0.82
1800	Conn des Temps	9° 6' 00" (Pans)	-
"	"	6° 45' 45" ^{6,7}	+ 16.1
1802	Nautical Almanac	6° 20' 30"	- 0.1
1858	Clarke (Ord Sur)	6° 20' 40.6"	+ 0.06 *

NOTES

- * see relevant Chapters for discussions of these measurements
 1. Based on one minute of longitude at 50° N = 0.64nm
 + is westward displacement: - is eastward displacement
 2. Ginver's most westerly longitude
 3. Dome of St Paul's London
 4. Year of publication
 5. Corrected for Greenwich (-2° 20') using contemporary data
 6. Measured by chronometer
 7. Corrected for Greenwich (-2° 20' 15") using contemporary data

TABLE I-3

CHANNEL ISLANDS: EARLY LATITUDES - ST AUBIN TOWN
(unless otherwise stated)

DATE	SOURCE	LATITUDE	ERROR(naut miles) ¹
MODERN	Ad chart 62 B	49° 11' 18" N	-
1671	Seller	49° 12' 00"	+ 0.7
1689	Pagerie	49° 10' 30" ²	- 0.7
1693	Neptune Francais	49° 11' 00" ²	- 0.3
1693	Collins	49° 13' 00"	+ 1.7
1744	Maraldi & Cassini	49° 12' 42"	+ 1.4
1753	Neptune Francais	49° 11' 00"	- 0.3
1781	De La Rochette	49° 09' 30"	- 1.8
1781	Nautical Almanac	NO REF	
1786 ³	Conn des Temps	49° 12' 59" ⁴	+ 1.7
1802	Nautical Almanac	NO REF	
1806	Dessiou	49° 11' 00"	- 0.3
1809 ³	Conn des Temps	49° 12' 59" ⁴	+ 1.7
1821	White (MS chart)	49° 11' 00"	- 0.3
1841	'Estate Major'	49° 42' 18" ⁴	(see note 5)
1868	Richards (Ad chart)	49° 11' 08"	- 0.16

NOTES

1. + is northward displacement: - is southward displacement
 2. St Aubin Fort (adjusted for Aubin Town)
 3. Publication date
 4. Measured by triangulation
 5. ALDERNEY TELEGRAPH, modern 49° 42' 18": therefore no error

TABLE I-4

CHANNEL ISLANDS : EARLY LONGITUDES - ST AUBIN TOWN
(unless otherwise stated)
Adjusted to the Greenwich prime meridian

DATE	SOURCE	LONGITUDE	ERROR naut miles ¹
MODERN	Ad chart 62 B	2° 10' 12" W	-
1744	Maraldi & Cassini	2° 12' 52" ²	+1.7
1753	Neptune Francais	2° 11' 59" ²	+1.2
1781	De La Rochette	2° 11' 30" ³	-0.6
1781	Nautical Almanac	NO REF	
1786 ⁴	Conn des Temps	2° 11' 59" ²	+1.2
1802	Nautical Almanac	NO REF	
1806	Dessoiu	2° 10' 30"	+0.2
1809 ⁴	Conn des Temps	2° 10' 44" ²	+0.3
1812	White (MS chart)	2° 10' 40"	+0.3
1841	'Estate Major'	2° 13' 09" ^{2,5}	-0.3
1868	Richards (Ad chart)	2° 10' 12"	-

NOTES

1. Based on one minute of longitude at 49° N = 0.65 nm
+ is westward displacement: -is eastward displacement
2. Adjustment re. Paris: 1744, 1753, 1786 = -2° 19' 00"
1809 = -2° 20' 15"
1841 = -2° 20' 24"
3. Originally 'LONDON': adjusted for Greenwich
4. Publication date
5. ALDERNEY TELEGRAPH (modern = 2° 13' 18")

The descriptions and analyses of the surveys included in this study are based as far as possible on MS material, either the working charts or fair copies made by the surveyor, together with Survey Remarks Books, Sailing Directions, Ships' Logs or Journals, Minute Books, personal letters, Wills etc. Some MS charts, maps, records etc. of Scilly are in the Isles of Scilly Museum or in the Cornwall County Record Office and general MS material about the Channel Islands is preserved in the two States' archives and the Libraries of La Société Guernesiaise and La Société Jersiaise. Nevertheless, the relative paucity of MS material relevant to this study preserved in the above, emphasises the dominant influence of mainland authorities in initiating and prosecuting official surveys of the two archipelagos, which were often made in the context of wars with various European powers [7]. Details are in the Acknowledgements.

Where possible the (mainly temporary) trigonometrical stations occupied for the various surveys, particularly in the Channel Islands and the Cotentin, have been located and examined in the field (Appendix G).

At times in both groups of islands there has been uncertainty as to whom was legally responsible for charting and mapping. The Isles of Scilly are an integral part of the United Kingdom but also part of the Duchy of Cornwall, which has the right to lease them to individuals. The main lessees, until 1835 were the Godolphin family, who probably probably commissioned a map of the Islands as early as 1640 (Chapter 1). Both Collins (the first official Admiralty surveyor, 1689) and Spence (1792-) were obliged to map the islands *de novo*. as a basis for their hydrographic surveys. The latter made a remarkably detailed and undervalued

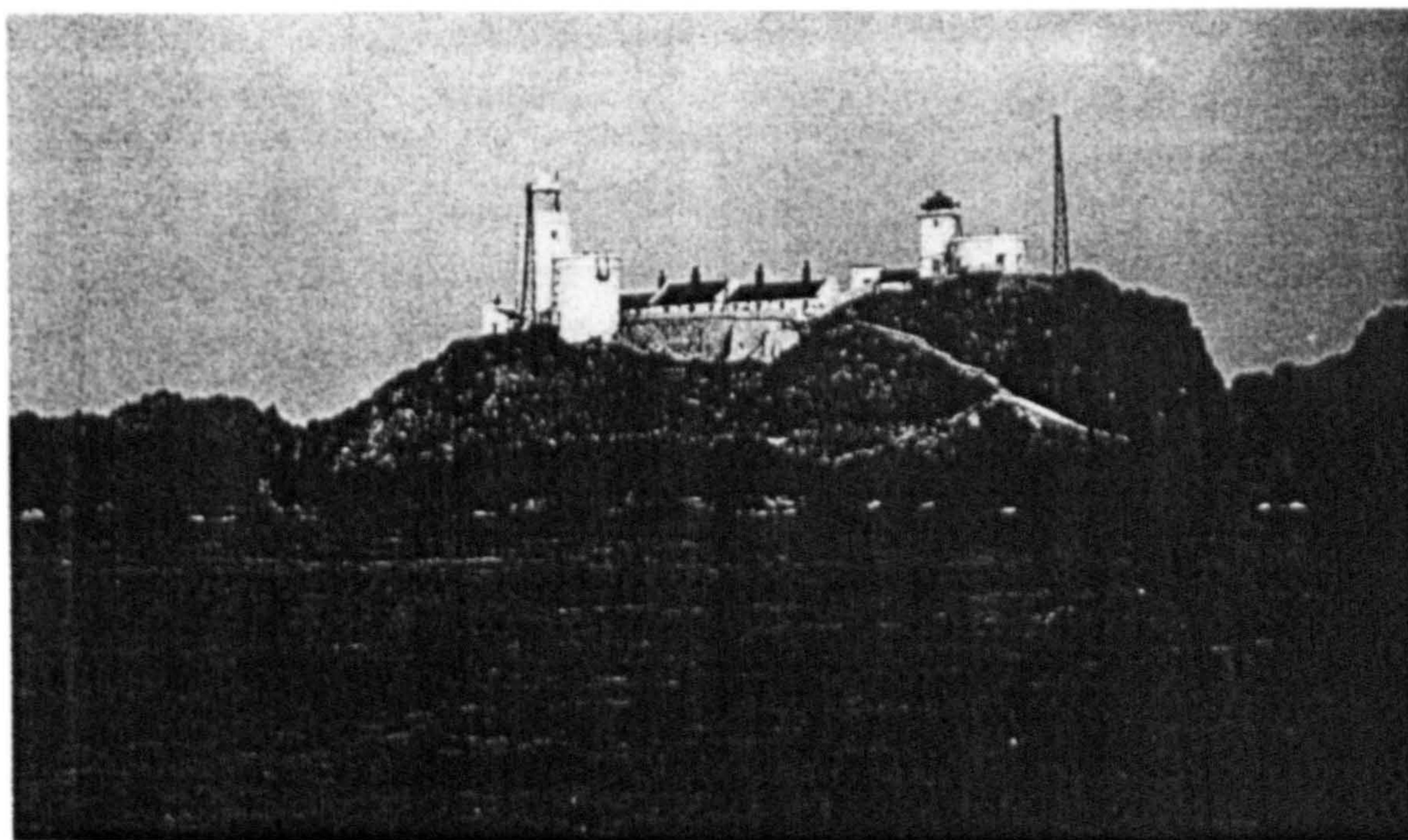


Fig I-5a Les Casquets lighthouse. (By permission; © Priaux Library, Guernsey).



Fig I-5b Les Roches Douvres lighthouse. (Courtesy of the Guernsey Evening Press and Star).

six inches to the mile MS map of the Islands' topography (Chapter 4). Ordnance Survey topography data were not available [8] to Admiralty surveyors until as late as 1887, when the Islands were first mapped by the Ordnance Survey at the 25 inch and six inch scales.

The Channel islands are Crown Dependencies and are not in the United Kingdom. They were part of the Duchy of Normandy from 933 A.D. and retain strong cultural links with France. The Crown appoints Lieutenant Governors, but the Islands are largely self-governing, divided into the Bailiwicks of Guernsey (*Guernsey, Alderney, Sark, Herm and Jethou*) and Jersey (*Jersey, Les Écréhous and Le Plateau des Minquiers*).[9].

Official mapping, for strategic reasons, began with the excellent Board of Ordnance 6" maps by Gardner in 1787 (Guernsey) and 1795 (Jersey) but they lack latitude and longitude and were apparently never used as a basis for a hydrographic survey. A naval squadron was frequently stationed at Guernsey or Jersey in the Napoleonic era to deal with French sorties from Cherbourg and St Malo. The first official hydrographic survey had its origins in the (unofficial) work of Capt Martin White in 1803. Surveys of the archipelago should logically be combined with surveys of the adjacent Cotentin peninsula but full co-operation was not possible until after the defeat of Napoleon Bonaparte in 1815. In the second world war the Islands were occupied by the Germans. They became part of the 'Atlantic Wall' and so far as German geodetic surveys were concerned, they were an integral part of France, the only time that this has occurred (Chapter 9).

The Islands are not in the Ordnance Survey's remit as their inhabitants do not pay UK taxes. In the 20th century the old War Office, for strategic reasons, at times surveyed Guernsey ostensibly as a Royal Engineers' training exercise. By invitation, and partly at the Islands' expense, the Ordnance Survey mapped Guernsey in 1898-9 and Jersey in 1900. After these dates the Admiralty was able to use up-dated Ordnance Survey material for land topography. The Ordnance Survey continues to map the States by invitation and at their expense and has no say in what subsequently happens to its surveys. In contrast, Admiralty hydrographers had no restrictions (Kemp 1988, p 8). When defining the modern marine boundaries of the United Kingdom, the Anglo-French 'median line' (Fig I-4) virtually ignores the Channel Islands. They are also within the French claim for a 12nm wide territorial sea. Neither of these affects the UK's responsibility for their charting. Perkins and Parry (1996, pp 92-97) give a useful summary of the present state of mapping in the Channel Islands, including publications by the British Directorate of Military Survey. Unlike the Isles of Scilly, the Channel Islands are not in the (British) National Grid, but lie in the UTM Grid Zone 30U, 1100Km squares WA (Alderney and Casquets) and WV(rest of the Islands).

There has, of course, been a progressive improvement in the quality of the surveys discussed here as surveying instruments have improved and techniques have developed and this must not be overlooked when assessing the earlier attempts at charting. Taking the Isles of Scilly as an example, Collins (1693) used a chain for land details, a magnetic compass for bearings and a quadrant (backstaff) to determine latitude. He had no means of measuring

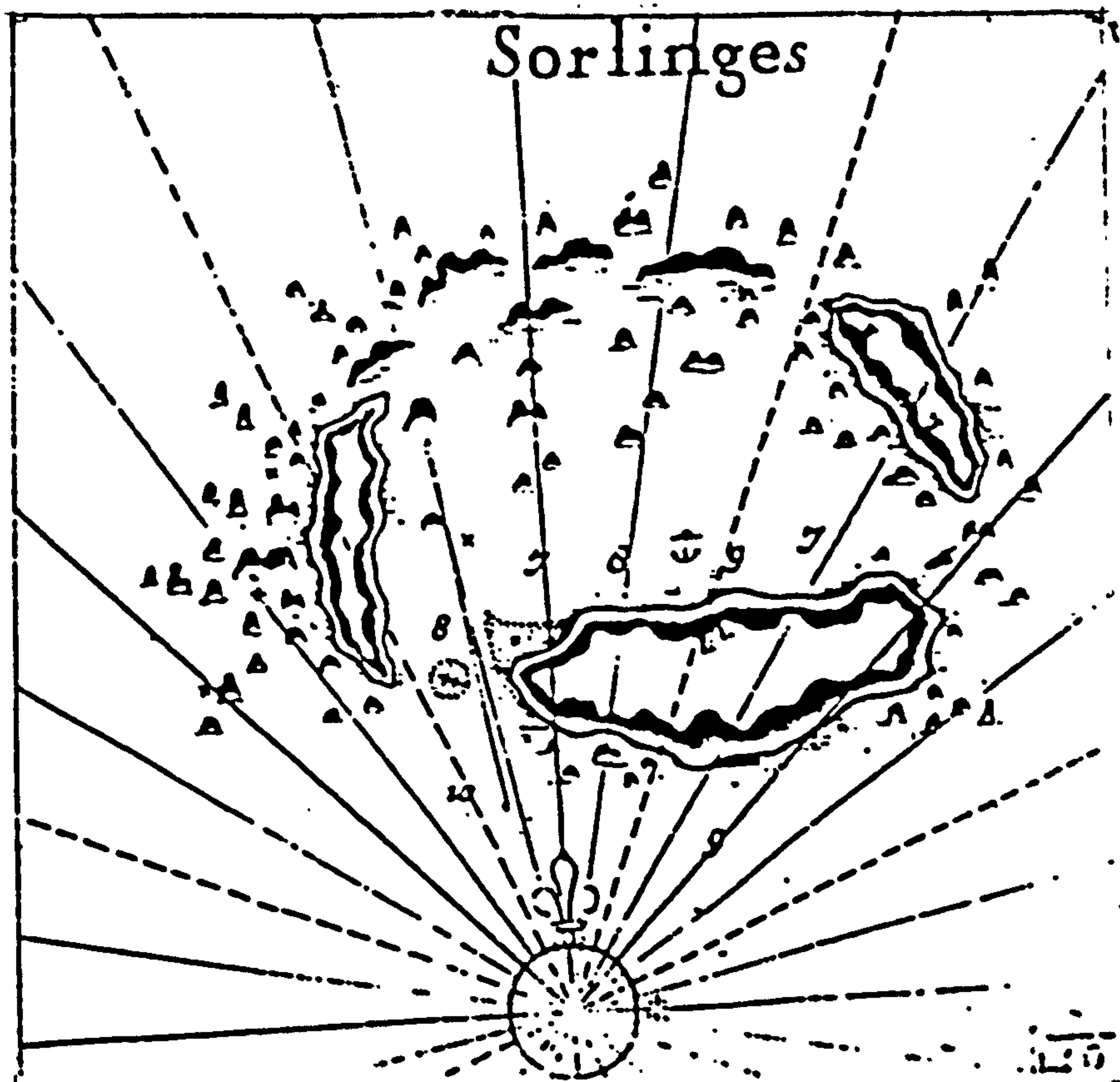


Fig I-6a The Isles of Scilly. (Goos, after Waghenauer, 1666-7).

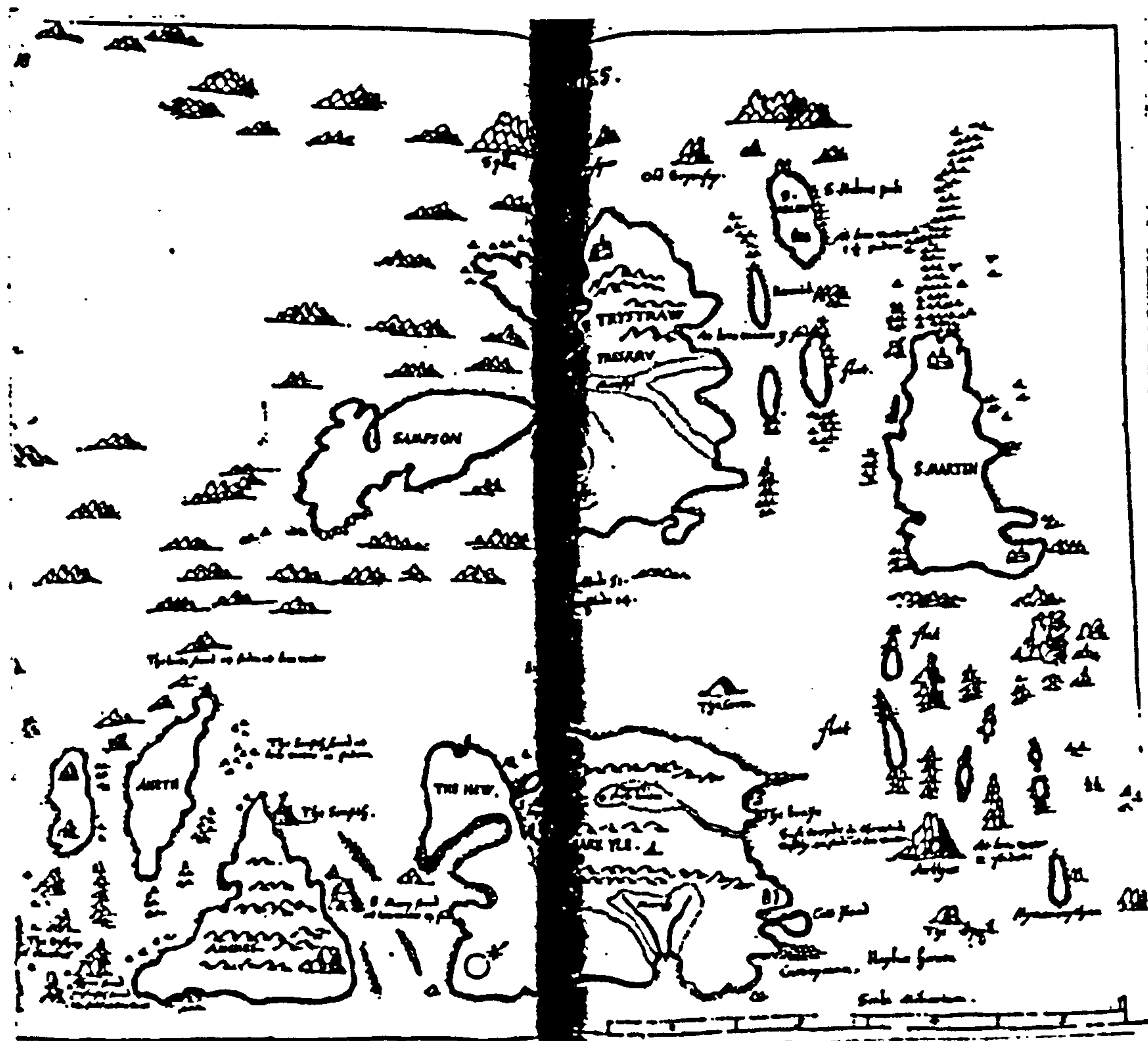


Fig I-6b The Isles of Scilly. (Davis c 1584: note latitude and longitude).

longitude. Heath (1749) used a quadrant to measure latitude and determined longitude by observing the eclipses of the satellites of Jupiter (Cassini's method). Spence (1792) used a theodolite triangulation to plot both the archipelago and its relation to mainland England (and therefore its longitude). Huddart (1795) measured the longitude of Scilly with a chronometer. Successive Ordnance Survey observations (from 1796 onwards) to and from the mainland have been based on theodolite triangulations, with the addition of tellurometer measurements in 1959.

Scilly, with Cornwall, has played a part in the wider field of maritime navigation. The wreck in 1707 of a British fleet [10] on and near the western Gilstone, SW Scilly, led indirectly to the establishment of the British Board of Longitude in 1714 and to the development of chronometers to determine longitude. Much of the manual computation for early editions of the British Nautical Almanac and Astronomical Ephemeris, first published in 1766, ~~were~~ *was* carried out by 'computers' [*those employed to make calculations in or for an observatory, OED*] working in Cornwall (Dunkin, 1889).

2

The progressive demand for more and more accurate charts of Scilly and the Channel Islands arose because of the natural hazards facing ships entering or leaving the western English Channel. An analysis of recorded wrecks is in Appendix A. As late as the 18th century the average ship was a mere 110 tons and was navigated with little more than an inferior compass and a sounding line and relied on the somewhat crude pilot books and charts then available (Stevenson, 1959). These small sailing ships were difficult to handle in storms, fog and darkness. The larger ships carried better instruments; latitude was no problem but longitude could not be measured until the mid-18th century and ships' chronometers were not generally available until a century later.

The English Channel and its Western Approaches are part of the shallow seas of the continental shelf of western Europe. Sea floor depths generally decrease eastwards, but are still c 70m to 80m in the vicinities of Scilly and the Île de Ouessant. As the Channel Islands are approached average depths decrease to c 55m off Guernsey and Roches Douvres, c 33m off Jersey and c 18m before the shallows off the coast of Cotentin are reached.

Given clear weather, the distance from which land becomes visible to an approaching ship is the sum of the distance to the horizon from an observer's eye on the ship and the distance to the horizon from the highest point of the land (listed in Nautical Almanacs). For example, prior to the building of the Agnes lighthouse in 1680, in the best of weather a small ship would have sighted the summit of Agnes (c. 29m ASL) at a distance of c 16nm / c 29km. After the building of the Agnes Lighthouse (top 51.5m ASL) in 1680, this distance would have increased to c 31nm / c 57km. A good chart would indicate the depth of water between ship and land.

THE ISLES of SCILLY

'Although the Scilly Islands may be easily discerned in fine weather from the Land's End, they lie too low to be seen from the deck of the little steamer until the passage is half completed, when a day mark on the nearest island, St Martin's, makes its appearance, and almost simultaneously with it the lightship of the Seven Stones...' (Courtney 1897, p 3).

They are an almost completely submerged granite batholith. Graeme Spence in 1792 was the first to demonstrate that a line enclosing all the islands, rocks and reefs of the Scilly archipelago was a simple oval, which subsequently was shown to follow closely the edge of the outcrop of the granite. The long axis is c 10nm / c19 km and the short axis c 5.3nm / c 9.7 km. They cover a surface area of c 34 nm² / c118 km², of which only c 4.8nm² / c16.4 km² or c13.8%, is land. The batholith rises steeply from the surrounding sea bed (Fig I-2 and Table I-5), giving a ship little warning of approaching danger.

**TABLE I-5
ISLES OF SCILLY**

Sample gradients from c 70m depths to chart datum

LOCATION	SAMPLE GRADIENT
SW of Bishop's Rock	1 in 4
N of Round Island	1 in 6
N of St Martin's	1 in 1.4
S of St Mary's	1 in 8
SW of Rosevear	1 in 5

Source: Admiralty chart No 34, 1911

The majority of the larger islands of Scilly rise locally to 40-50+m and are not easily sighted, especially in bad weather (Table I-6).

**TABLE 1-6
ISLES OF SCILLY**

Summit heights, with National Grid References.

ISLAND	SUMMIT	NGR
St Martin's	47m	942161
St Mary's	50m	913120
Tresco	44m	887157
St Helen's	41m	901069
Round Island	44m	902176
Samson	42m	879124
Bryher	42m	876156
Agnes	29m	883083
Gugh	32m	888087
Great Ganilly	34m	946146
Castle Bryher	26m	864140
Maiden Bower	21m	849144
Annet	18m	860090
Rosewean	17m	840056
Bishop Rock	5m	807065

Source: 1:25,000 OS Outdoor Leisure Map, 1992

The larger islands lie in the east of the archipelago. Ships approaching from the westward and sighting the islands have a false sense of security, unaware of the hazards of the maze of semi-submerged reefs and rocks of the Western Rocks which stretch almost unseen c 5.4nm/10 km west of Agnes. This danger was partially rectified with the building of the Bishop Rock lighthouse (1847-50; rebuilt in 1858) but the Western Rocks still remain a hazard to the unwary.[11]

When approaching Scilly from the north, east or south the sailor has the possibility of sighting land (rising up to 50m OD) from some distance off shore (Table I-6), but of course faces the hazard of the very rapid shallowing of the sea bed. Approaching from the SW or W, the sailor has little warning of danger as the main islands are c 5.4nm / c10 km. east of the Bishop Rock and sighting them might well give a false sense of safety to a navigator unaware of the hazards of the maze of semi-submerged reefs and rocks of the Western Rocks which lay in his path. There is a further point: when coming towards Scilly from the east the sailor has had some guidance from his last landfall of the Lizard but when coming from the west out of the Atlantic there would have been little opportunity for position fixing and so little awareness of the approach to Scilly.

The Seven Stones are a small steep-sided boss of granite (c 500m x c 300m) in the fairway between the Isles of Scilly and Land's End. Their summits barely rise above sea level. They rocks were virtually invisible in darkness, fog or 'thick' weather before the placing of the lightship 2nm to the NE in 1841[12]. The Wolf Rock lava outcrop, rises steeply to 3.4m above sea-level about 8nm/15km SW of Land's End. It became more visible with the building of the present lighthouse in 1870, which rises to a height of 41.1m ASL [13].

THE CHANNEL ISLANDS

These are part of the Armorican Massif, a complex of hard, ancient rocks that make up Brittany and the western part of Normandy and which extends northward roughly to a line from Alderney to the Île d'Ouessant. (Jee, 1982 and de Pomerai & Robinson 1994).

Like Scilly, the Channel Islands are a drowned landscape but one which covers a far greater area, the western and northern outposts being Les Roches Douvres and Les Casquets (Fig I-1). The largest islands, Jersey and Guernsey, resemble tilted blocks, Jersey sloping to the south and Guernsey to the north. The summits of both are much higher than Scilly (Table I-7). The real hazards are the innumerable rocks, shoals and partially submerged mini-archipelagoes (e.g. Les Écréhous, Les Minquiers, Îles Chausey), the result of the differential erosion of the original rugged terrestrial landscape, subsequently intensely scoured by powerful tidal currents and aided by the largest tidal ranges in the English Channel (e.g. 9.8m at St Helier).

TABLE I-7
CHANNEL ISLANDS
Summit heights with National Grid References

ISLAND	SUMMIT	NGR
Alderney - Le Rond But	87m	WA 579069
Casquets	27m	
Guernsey - airport	105m	VW 295760
Jersey - N E of masts	140m	658650
Les Écréhous	8m	
Minquiers	9m	
Chausey	20m	
Roches Douvres (LH)	68m	

NGR Sources: Alderney: MOD 1:10 560. 1966
Guernsey: MOD 1:25 000. 1986
Jersey: OS 1:25 000. 1982
Other Islands: HONP 27. 1971

The waters surrounding the Channel Islands are shallower than those around Scilly but the offshore gradients can be as steep. The sea shallows rapidly all round Alderney but for Guernsey and Jersey gradients are steepest off the south and north coasts respectively. The gradients (Table I-8) are from depths of c 54m off Guernsey and c 27m off Alderney and Jersey

**TABLE I-8
CHANNEL ISLANDS**

Sample gradients from c 55m (Alderney and Guernsey) and 35m (Jersey) depths to chart datum

LOCATION	SAMPIE GRADIENT
W of Alderney	1 in 14
S of Guernsey	1 in 7
N of Jersey	1 in 6

Sources: Admiralty charts 262a, 1964; 3367, 1981

Maximum visible distance to land from 4.6m above the waterline

**TABLE I-9
CHANNEL ISLANDS**

ISLAND	SUMMIT	DISTANCE
Alderney	87m	30nm / 56km
Casquets	27m	21nm / 39km
Guernsey	105m	31nm / 57km
Jersey	140m	34nm / 63km
Chausey	20m	19nm / 35km
Roches Douvres*	68m	26nm / 48km

*Top of lighthouse, built by French Government 1867

WEATHER

(The Tables are in Appendix A)

It could be argued that, as this study covers a period of over 200 years, published modern average weather statistics are of little use in assessing past weather in the western Channel. The problem is compounded by the fact that the, statistics for the various stations noted below are from a variety of sources and are not for uniform periods. In addition some data are from airport stations, well above sea-level. Only the St Helier (Tables A -7 and A-15), Cap de la Hague stations (Tables A-8 and A-16), and Western Approaches Area 14 (Table A-1) and Region 5 (Table A-9, A-17, A18) are close to or at sea-level and therefore strictly applicable to shipping. As with the data on shipwrecks (Appendix A), the data has to be analysed with caution.

Winds

Spence notes (re Scilly) that '*... the Wind is generally more boisterous [than in England]... which with strong tides makes the ...sea generally very tempestuous.*' (Spence 1812, p.167).

The average monthly frequency of near gales or gales (Beaufort scale force 7 and above) is summarized for representative stations in Scilly, west Brittany and the Channel Islands in Tables A-1 to A-8. They illustrate how stormy are the seas in the Western Approaches, seas crossed in the past by weary seamen after a long voyage from the west or south and uncertain

of their true position in relation to the mouth of the Channel. The winter months experience the most gales, especially November to February. The greatest danger often comes from the sudden extreme gust within gale conditions.

Fog

(Visibility less than 1 km)

The Channel Pilot (UKHO NP 27, 1971) warns ships not to approach Scilly in thick or hazy weather to within c.18nm / c.33km) westward or c.22nm / c.41km) southward. Spence notes (re Scilly) that the air is warmer than in England '*...but much more foggy...*' Thick or foggy weather '*...is very common thereabouts for a Week constant.*' (Spence 1812, p155 and p167). Heath (1750) refers to sudden fogs off Scilly and comments that Admiral Shovell's fleet was wrecked in thick foggy weather.

Most sea fog is advection fog and most common in the western Channel during the early summer (UKHO NP 27 1971, p 44). Details are given in Tables A-9 to A-16. The lowest annual averages are for St Helier (Table A-15), Île de Bréhat (Table A-12) and Cap de la Hague (Table A-16), all of which are close to sea-level and possibly reflect the true occurrence of fog in these waters. One of the few detailed accounts of fog around the Isles of Scilly was discussed in the official report of a helicopter crash into the sea 1.5nm/ 2.8km from the east coast of St Mary's on 16th July 1983 at 11.35 hours (HMSO 1985). On that occasion there was a flat calm sea; the pilot reported that thick haze restricted forward visibility with '*...no discernible horizon...*' The aircraft was slowly descending and it struck the water. A rescue helicopter reported fog banks below it near Scilly and during a 180 degree turn this pilot also became disoriented due to poor visibility. The prevalence of fog banks with clear air between is probably a greater hazard than blanket fog, as the clear zones give a false sense of security, hiding dangers ahead. The analogy with motorway crashes is obvious.

Waves and Swell

'In general, rough seas may be expected in the English Channel on about 6 to 7 days a month in winter and about 2 to 3 days a month in summer' (UKHO NP 27, 1999, p 25). In the winter months the seas are almost daily 'high' and would render navigation difficult for small ships. Lee and Ramster (1981) estimate '*...the heights of the highest individual waves which are likely to occur in the worst storm in any 50-year interval...*' For Scilly the figure is 28m, for Île d'Ouessant 25m and for the Channel Isles 20m. This gives some idea of the ferocity of the extreme conditions faced by the small sailing ships of the past.

Tides and Tidal Streams

Isles of Scilly.

In the vicinity of Scilly the tidal range at mean spring tides is c 4.5m This presents problems to those unfamiliar with the area. Spring tidal streams may reach 1.5 knots (2.8kmph) or more. Greenville Collins (1689) was one of the first to plot these.

Channel lands,

Actual tides do not necessarily coincide with those predicted in tide tables. '*Nowhere is this more obvious than in the Channel Islands.*' (Robson 1989, p 18). There are a number of



Fig I-7 Isles of Scilly and Mainland. Wagenhaer 1588.

extremely dangerous fast local tidal currents e.g. the Swinge between Alderney and Burhou, and the Alderney Race. Of the former the Channel Pilot (1971a, p 498) states: *'Owing to the very great strength of the tidal streams, which often set directly on to and across the numerous reefs and drying rocks, the passage...is extremely dangerous and should not be attempted without local knowledge.'* Of the latter, the Pilot notes that south west going tidal streams can reach 5.5 knots at spring tides (6.3 mph).

Surface Currents

Having taken into account storms, fogs, darkness and poor navigation as contributors to Scilly being a maritime Valhalla, one factor remains to be noticed, the barely perceptible surface currents. In 1832 [14] James Rennell published a seminal book on the currents of the North Atlantic, (recently re-assessed by Gould 1993), which included *'Observations of a current that often prevails to the westward of Scilly, endangering the safety of ships that approach the English Channel; and now generally known by the name of Rennell's Current.'* This current is apparently split off from the Canaries Current by the Iberian peninsula and heads northwards towards and past the Isles of Scilly. Ships aiming for the mid-English Channel are carried by the Current towards Scilly (Pingree and Le Cann, 1990, Gould 1993). Fowles (1981, p) notes the current was *'...not fully appreciated until very recently.'* Its speed is no more than a knot, but enough to carry ships north of their supposed course. He attributes the 1875 wreck of the 3000 ton steamship *Schiller* to it.

END NOTES

1. Adapted from the *Navy News* 1995, p 17.

2. In the spring of 1997 the container ship 'Sita' was wrecked and on the 16th May 1997 the Cruise liner 'Albatross' was holed on St Bartholomew's Ledge while being guided out of the Sound, Isles of Scilly.

3. Only five of the estimated 50 islands are inhabited; St.Mary's (the largest and most important), Tresco, Bryher, Agnes with Gugh, and St. Martin's. The permanent population is about 2000. Thomas (1985) has cogently argued that until the end of the Roman period much of Scilly was a single land mass. Rising sea level (c 9.5" or c 24cm per century), a combination of eustatic, isostatic and diastrophic influences, led to progressive submergence, largely complete by the early Tudor period, and forming the archipelago of islands and rocks seen to-day.

4. All the main Channel Islands are populated. Jersey alone has over 80, 000 residents and the total number for the archipelago exceeds 137,000.

5. According to Hocard, R (*Trans Soc Guern* 1995, p 976) the collective name 'Channel Islands' was not in use in literature before 1800. Berry's 'History of Guernsey' (1815) has one reference to the 'Channel Islands.' The first book with 'Channel Islands' as a title appears to be by Inglis (1834). The first use on a published official British chart is probably White, 1821.

6. This is in no way intended to belittle charting and mapping by private surveyors, especially in the Channel Islands, but simply to establish the role and chronology of official surveys.

7. The causes of these wars are not relevant; suffice to say that Britain was at war with France for 54 of the years between 1689 and 1815, ending with the defeat of Napoleon. These wars of course threatened the Channel Islands.

Wars with Spain were brief, one in the 17th century and five in the 18th. These caused particular concern for the safety of the Isles of Scilly, where the fortifications were greatly strengthened in the mid-18th century.

There were three short wars with the Dutch in the 17th century and two in the 18th. These also threatened Scilly and by an oversight a peace treaty between the Isles of Scilly and the Netherlands was not signed until the 20th century.

8. The Ordnance Survey included the Isles of Scilly in the national triangulations in 1796 and 1864. The delay in mapping them may have been strategic or to avoid expense, the published Admiralty charts possibly being deemed satisfactory .

9. French fishermen occasionally raise the French flag on the British Les Écréhous (N.E. of Jersey) and Minquiers, (S. of Jersey). These 'occupations' are usually about fishing rights.

10. Shovell was convinced that he was near Île d'Ouessant, 81nm /150 km to the south of his actual latitude, and that the open Channel lay eastwards. As a result he sailed into the Western Rocks (Graham, 1980; some of the more outrageous navigational errors are recorded in this publication). The false assumption that Shovell's disaster was caused by an error in longitude is still repeated (e.g. Sobel, 1995).

11. Spence ('Description of Scilly...'. 1812, p 164) claimed that the highest part of Scilly (unspecified), being 172 ft./ c52m above LW, could be seen 19 $\frac{3}{4}$ [English] miles, (c 33km) at 10 feet above ground level. He also gives the distances St Martins Head and Agnes Light can be seen from the sea (pp 165-6).

12. The Seven Stones were first included in a triangulation in 1792 (Spence, 1792).

13. The Rock has been incorporated into at least three Scilly-mainland triangulations (Chapters 4 and 6). On early charts it is named either 'De Wolff' (e.g. Waghenauer, 1583) or 'The Gulfe' (eg Mariners' Mirror, 1588; see Thomas 1985, p 276). It is described by Seller (1672) and Collins (1693).

14. Based on earlier work in Trans. Roy. Soc. 1793; 1815. Rennell analysed mainly ships' logs and errors in dead-reckoning.

PART ONE

THE ISLES OF SCILLY

CHAPTER ONE

CAPTAIN GREENVILLE COLLINS R N (fl. 1669-1693/4)

Surveyor and Compiler of

'GREAT BRITAIN'S COASTING PILOT' (1693-1792)

This Chapter is divided into four sections:-

- 1. Introduction**
- 2. The plotting and accuracy of Isles of Scilly latitudes on Collins' four small scale charts, given that the measurement of latitude was the first of the well known 'Proposals' for the Coasting Pilot (*To measure the seacoast with a chain, taking exact bearings and latitudes of all headlands*). [1]**
- 3. Collins' large scale chart (Plate 20) of the Isles of Scilly:- dates of survey, chart scale and, most importantly, the apparent deletion on the MS and published charts of latitude numbering. (Further discussion of the primacy of this chart and its possible sources will be found in Appendix C).**
- 4. Given Collins' inability to measure longitude, his perception of the westward position of the Islands in relation to the mainland, as deduced from the four small scale charts.**

1

INTRODUCTION

Captain Greenville Collins' [2] unique contribution to navigation was as the surveyor and compiler of the Sea Atlas Great Britain's Coasting Pilot. The charts were surveyed 1681-88 and the first of 21 editions of the Coasting Pilot was published in 1693 [3]. It was a benchmark in British hydrography, being the first marine atlas of British coastal waters based on original surveys and engraved and printed in London [4]. The second edition was not published until 1723. Previously the British had relied mainly upon Dutch charts.

The Isles of Scilly were a particular hazard at this time. Samuel Pepys had called for a new British survey, citing Narborough's fleet inadvertently '*sailing within the Islands of Scilly*' (Tanner 1926, p 314) and Trinity House had appealed to Charles II for a new coastal survey

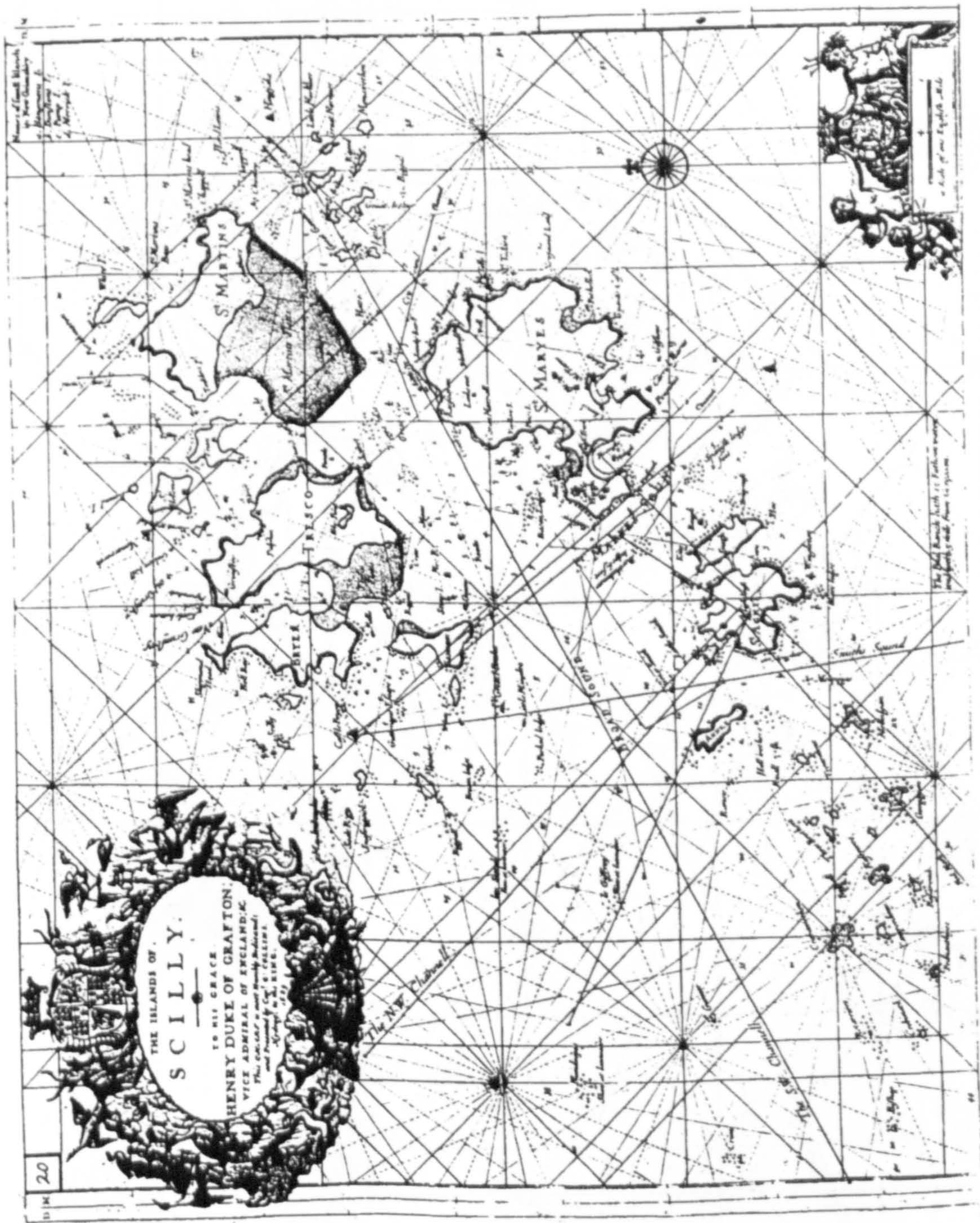


Fig 1-1 THE ISLANDS OF SCILLY ... 1689, Cap'n G Collins.
 Early edition, no reference to Sir Cloudesley Shovell's wreck in 1707

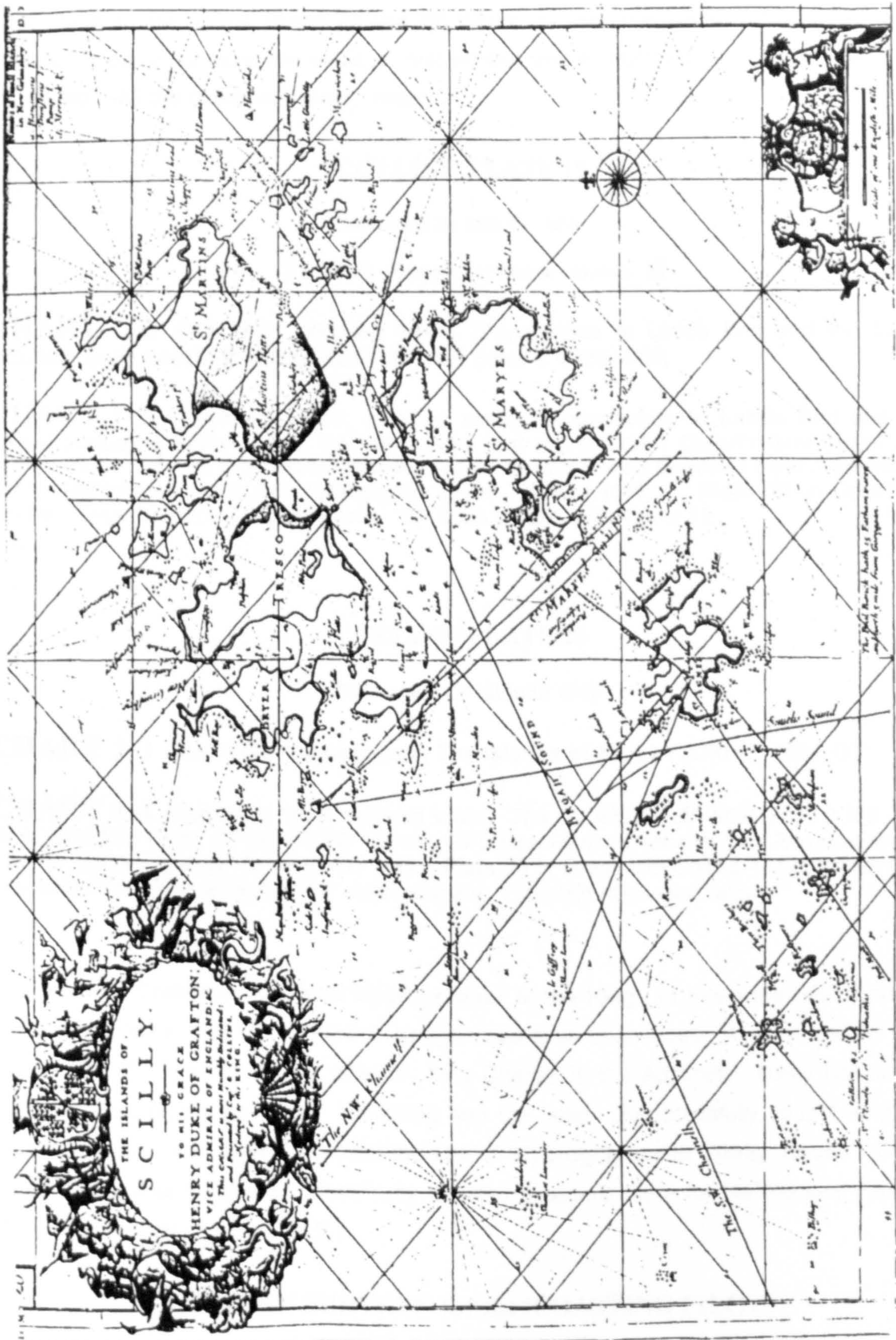


Fig 1-2 THE ISLANDS OF SCILLY ... ¹⁶⁸⁹ 1869, Capt'n G Collins.
 Date deleted. C 1738. 'Sir Clousley lost' on south west rocks.

[5], '...particularly Scilly 10 minutes more north than it ought to be...' (Tanner 1926, p 221). Verner (1969) has made the definitive study of the editions of the 'Coasting Pilot' and the various 'States' of its charts. Of the five **Coasting Pilot** charts which include Scilly, the two

most important are Collins' Plates 19 and 20. Where relevant, the UKHO MSS numbers, 'Pilot's Plates or numbers and dates of first printing and as numbered by Verner (1967) are added. All the charts are plain charts.

COLLINS' PLATE 19

Graduated for latitude only

[CHARTS in pocket at end of volume, 2]

CHART 1-1. (MS 1686; reduced scale). [Approaches to Lands End and the Lizard including Scilly Isles] 9: UKHO B887 ot* ; RF Scale c 1:285, 000.

CHART 1-2. (Published 1686; reduced scale). [Approaches to Lands End and the Lizard including Scilly Isles]. TO THE HON'ble THE GOVERNOR / DEPUTY GOVERNOR AND COMMITTEES / OF THE EAST INDIA COMPANY / *This Chart is Humbly Dedicated / and Presented by CAP't. GREENVILLE / COLLINS Hydrographer to the / KING / 1686. / . . . Plate 19 in Greenville Collins' 'Great Britain's Coasting Pilot.'* RF Scale c 1:285, 000. Verner 11.

COLLINS' PLATE 20

Graduated for latitude only

CHART 1-3 (MS 1689; reduced scale) The Islands of SCILLY. UKHO B887 OT*

CHART 1-4 (Published 1689; reduced scale) *The ISLANDS OF SCILLY / TO HIS GRACE / HENRY DUKE OF GRAFTON / This CHART is most Humbly Dedicated / and Presented by Capt. G. Collins / Hydrogr. To the KING / 1689. Plate 20 in Greenville Collins' 'Great Britain's Coasting Pilot.'* Verner No12. RF scale uncertain, 1:32 000 (discussed below).

The choice of Greenville Collins as 'Hydrographer to the King' to make the new survey of the British coasts was by no means straightforward or unanimous. At the time he was Master of *HMS Resolution*. The roles of King Charles II, the Admiralty, Trinity House and Samuel Pepys [6] were at times conflicting and the latter unsuccessfully sought long and hard to control the survey. Granted the title of 'Hydrographer to Trinity House' Collins never added it to his charts, steadfastly refusing to submit them for the House's approval (Discussed further in Appendix B.)

COLLINS' SURVEYS for the 'COASTING PILOT'

There are very few accounts of Collins at work. The diarist John Evelyn (1683) records the result of 2 summers' work by Collins from the mouth of the Thames to Wells (at least 167mn / 268km) '*...exactly measuring every Creeke [sic], Islands, Rocks, Soundings, Harbours, Sand, Tides and intends next Spring to proceede til [sic] he has finished the whole Island.*' (E.S.de Beer ed; *The Diary of J Evelyn*, iv 1955; p 301: c.f. Robinson 1962, p 53).

Collins claimed to have surveyed Scilly and the Severn, with Milford Haven, in just one year, 1683. Graeme Spence took over four years just to complete his survey of the Isles of Scilly but Collins may have had access to earlier charts (*infra.*).

For Collins surveying instruments and methods see:- Collins' own 'Proposals' ; Robinson's expert assessment (1952, p 365; 1957, p 4501 and note 8; 1962 Ch 3, especially John Love's 1688 book), together with Ritchie (1995, p 33) and Ravenhill (1989, p 32). According to Robinson (1962, p 49) *'The first really serious attempt to place hydrographic surveying on a firm theoretical basis and develop the necessary instruments for carrying it out, coincided with the founding of the Royal Society [1662].'* In 1674 and in 1685 papers were read to the Society on resection or the three point problem (which avoided the use of the magnetic compass for locating offshore positions) but no practical instrument existed in Collins' time for this method to be used at sea. Robinson (1962 p 53) notes that Collins, contributed little directly to the theory of hydrographic surveying but realised the importance of reasonably accurate land maps as necessary pre-requisite to operations at sea. [7]

Collins, as a ship's Master, [8] became a skilled navigator and hydrographer (Robinson, 1952), honed on exploratory voyages to the Straits of Magellan and the Chilean coast as Master of the 'Sweepstakes' (1669-71). Here Sir John Narborough passed on to Collins his own enthusiasm for navigation. The charts were essentially compass-based coloured profiles or silhouettes of coasts as seen from offshore. The best examples are the 36 in his MS 'Algerian Journal' 1676-79, but nowhere does he refer to them or their compilation. [9] On the outward voyage to Algiers Collins made, in two days, a coastal profile chart of Falmouth (Journal p 7) including soundings, anchorages, etc. at a scale of 'Two English Miles' .

Nowhere in the Journal is there a plan chart but at least ten of the drawings depict the shore in profile, with soundings, anchorages, reefs, compass roses etc. added seawards. They are in 'English Miles', excepting that of the Maiorca chart which is in leagues. Collins routinely recorded observed latitudes in the text, probably using a Davis quadrant, [10] but no latitudes are on any profile drawing or chart (Ritchie 1995 pp 32-3).

Between 1681 and 1687 Collins⁴⁵ made 120 MS draught charts of the British coasts and from them came the 47 plan charts published in the Coasting Pilot (Verner 1969, p 7). His instruments were *'...a five foot radius brass quadrant for use ashore, a Gunter's quadrant for hand held use offshore, a measuring chain or wheel, a meridian compass and a leadline.'* (Ritchie 1995, p 33). Collins *'had no land surveys worthy of the name as a basis for his work'* (Ritchie 1995 p32; Blewit 1957, p 163) and had to spend excessive time on preliminary triangulation land surveys. There are no traces of his triangulation stations on the Isles of Scilly either on the MS or printed versions of his large scale chart. All offshore observations were by compass and therefore less accurate. *'...serious doubts must be raised as to whether the prescribed survey techniques were universally practised.'* Ravenhill (1989, p 32).

The first edition of the *Coasting Pilot* was not well received. '*...it proved beyond his means and power to do the work thoroughly.*' (Taylor 1954, p 259). Trinity House referred to the '*III Performance of the Book of Charts*' (Tanner 1926, p 388). The Royal Society attacked his survey methods (Robinson 1962, pp 49-52). Pepys was dismayed that the French, even when at war with Britain and the Dutch, could produce '*Le Neptune François*' (1693) '*... a most august set of sea charts...*' (Tanner 1926, p 316).

The chronology of Collins' surveys and publications:

- 1681-2 The survey of the Channel from Dover to Lands End [*includes extreme east of MS of Plate 19*].
- 1683 The survey of the Isles of Scilly, with Severn and Milford Haven. [*includes extreme west of MS of Plate 19*].
- 1686 Publication of Plate 19 [*MS has same date and number ?contemporary. Based on the surveys of 1681-1683*]
- 1689 Publication of Plate 20 [*MS has same date and number ? contemporary. Based on the 1683 survey*]

Plate 19 was based on surveys made in 1681-1683 but not published until 1686 and the important Plate 20 on a survey made in part of year 1683 but not published until 1689.

[1889 MS Journal, Home waters, 1688-1689]

2

THE SMALL SCALE CHARTS

Collins' Plates 4; 5 6 7; 19; St Georges Channel

SCALES AND LATITUDES

It was widely accepted that contemporary charts placed the Isles of Scilly c 10 minutes of latitude (ten nautical miles) north of their true position. Collins in his '*Sailing Directions*' (1693, p 17), advised sailors to keep south of latitude 49° 30' N when approaching Scilly, evidence that he was well aware that other Directions and charts falsely placed the southernmost islands at 50° N. For example, Sellers's chart '*A Draught of the Landsend of England / and Islands of Scilly...*' (English Pilot... 1671) covers much the same area, RF Scale c1:192 400. [Lands End 50° 20'; modern 50° 4']

All four of Collins' small scale or regional charts which include the Isles of Scilly are graduated for latitude. The latitude of Agnes Lighthouse (built 1680) was frequently used in the past to represent the position of the whole Island group. and its latitude on these charts is summarised in Table 1-2. These charts were in many respects more important to navigators than the large scale chart (Plate 20), as they would have been used when entering or leaving the English Channel. Errors in the position of the Isles of Scilly as plotted on them could have catastrophic consequences. Inexplicably, the long suspected 10 minute northward error in the latitude of the Islands, which Collins himself acknowledged, is repeated on these four charts. It is difficult to find an explanation for the perpetuation of the error but it may stem from an error in the survey for, or engraving of, Plate 19 in 1682, or

Plate 20 which was carried out very rapidly in less than one year. This will be examined further in the section on Plate 20 (*infra*).

Collins had a 5 foot quadrant and a smaller one for use at sea (Ritchie 1995). These charts are all plain charts', unlike those of the English Channel in the 'Neptune' based on the Mercator projection (1693 edition) and its coastal charts were much more professionally surveyed than Collins'. '*...le plus grand nombre a été levé par des Ingénieurs & des Pilotes habiles, avec les instruments très exact, & par des observations facile sur terre, & de Cap en Cap, & ainsi n'y est négligé...*' Cassini had observed most of the longitudes. However, this precision applied only to the charts of the French coast. In the 1693 edition of 'Le Neptune' the 'Carte de la Manche...' (scale c 1:855,000) the latitude of Agnes lighthouse is 50° 04' N, a northward error of 10' 30".

COLLINS' MS 19 and Plate 19. (CHARTS 1-1 and 1-2)

The most important of these regional charts in the present context is Collins' MS 19. [Approaches to Land's End and Lizard Including Scilly Isles.]. 1686. The MS of this chart is UKHO MS B 887ot*. (CHART 1-1 at end of volume.) The published version (CHART 1-2) appeared in the same year. [11]. As already noted, Robinson believes that Collins' MS charts held at the UK Hydrographic Office, Taunton, were the basis of the printed versions. This is Collins' largest scale chart to show the Isles of Scilly in relation to the mainland and is also the largest scale chart to plot latitudes.

The MS has no dedication or title, but covers approximately the same area as the printed chart and is 44.7cm x 55.1cm. In the top left-hand corner is written '19' and below it '1686'. This suggests that the completed MS and printed chart both date from 1686. However, it is suggested here that the MS number and date are in a modern hand (? for library use) and the MS may have been completed earlier than 1686. Collins had surveyed the Lizard and Land's End in 1681-2 and the Isles of Scilly in 1683 and the MS may have been compiled c 1683-4, prior to printing in 1686. The chart was clearly intended to locate the Isles of Scilly in relation to the Cornish mainland and to aid navigation safely past the Lizard, the Lands End and Scilly, for ships entering or leaving the English Channel.

In the bottom left corner is a written scale: 'A scale of Three leagues' [or 9nm], 5.8cm long. 9nm in the chart margin are also 5.8cm. Assuming here that each league is 3 nautical miles, the RF is c 1:284 500.

The mainland is crudely drawn and far from accurate and in places hard to match Collins' names with modern ones (Figs 1-4, 1-5, 1-6 and Section 4). Collins did not have the advantage of a national land survey and his mapping of the mainland may reflect the speed with which he completed his south coast survey.

The Isles of Scilly are simple outlines of the islands, only St Mary's has a hint of relief. Other names are Crim, Agnes(?lighthouse), Broad Sound, Bryer, Tresco and St Martin's (no day-

mark). There are numerous rhumb and leading lines and soundings. Surrounding and close to Scilly, are sea depths of 40 or 50 fathoms, indicating the sudden rise in depth discussed in the Introduction.

The printed version of the MS [Approaches to Land's End and Lizard including Scilly Isles.] 1686 is Collins Plate 19; Verner No 11. RF c 1:285 000. (1/2 scale printed version CHART 1- 2). It is 49.1cm x 57.6cm. As with the MS there is no printed title but it has been carefully re-drawn and retains most of the details of the MS. Additions are number 19 in the top left corner and in the top right corner is a large cartouche (Fig 1-3) occupying much of the mainland and in early editions the date 1686, which had faded out by 1753. A compass rose pointing north has been added near the bottom right. The Isles of Scilly are more prominent, the outlines being thicker.

In the bottom left corner is a bar-scale 6.2cm long: 'A Scale of three Leagues.' [9nm]. Unusually it lies N-S. It is supported by two nymphs, one holding a pair of dividers. 9nm on the latitude scale are also 6.2cm. The RF is c 1:285 000, calculated from the latitude gradations.

LATITUDES.

On both charts Latitudes are named and graduated in degrees and minutes along the east and west margins, numbered by script on the MS and neatly printed on the Plate. [on Chart 1-1 the detailed latitude minutes for Scilly have been added by the writer]. There is, however a discrepancy between the two charts. The extreme latitudes on both are 49° 17' N and 50° 26'N but a minute of latitude on the MS is c3.2 cm and on the printed chart c3.4cm. These are 41.8cm apart on the MS and 44.1cm on the printed plate, a difference of 2.3cm. As a result, the span of the MS is c44.7cm and c49.1cm on the printed version. There is, therefore a cumulative northward 'shift' of the parallels of latitude. There is no obvious explanation (?paper shrinkage) but as the engraver appears to have plotted the coastlines using the 'new' latitude scales, the latitudes of places remained unchanged in relation to those on the MS. All the latitudes quoted below were measured from the printed chart.

TABLE 1-1

Isles of Scilly latitudes from Collins' chart Plate 19

Location	Collins	Modern	Error
St Martin's	50° 07' N	49° 58' N	9' /nm
Agnes	50° 02' N	49° 54' N	8' /nm
Star Castle	50° 03' N	49° 52' N	11' /nm
Bishop Rock	50° 01' N	49° 52' N	9' /nm
Seven Stones	50° 15' N	50° 03' N	12' /nm
Wolf Rock	50° 01' N	49° 56' N	5' /nm

Average error 9' /nm

Assuming for the moment that the latitudes of the Isles of Scilly had been accurately observed during the 1683 survey, it is difficult to understand why the Isles of Scilly are plotted c 9 nm north of their true position on Plate 19, possibly compiled some two years after the survey of the Islands.

Collins' s latitudes on Plate 19 for the mainland nearest Scilly (the west Cornwall peninsula) are no more accurate than those for Scilly (Table 1-2), yet Collins was using a five foot radius quadrant on land, which should have allowed reasonably accurate observations of latitude.

TABLE 1-2

Mainland Latitudes from Collins' chart Plate 19

Location	Collins	Modern	Error
Cape Cornwall	50 19' N	50 08' N	11' /nm
The Longships	50 14' N	50 04' N	10' /nm
Rundlestone	50 08' N	50 01' N	7' /nm
Lizard	50° 01' N	49° 55' N	6' /6nm

Average error 8.5nm

Heath, writing some years later (1750, p 316) about surveys in west Cornwall recommended the use of a six foot quadrant for land observations. He must have travelled in Cornwall on his journeys to and from Scilly, but does not appear to have made observations at any known place.

Collins' Plates 4; 5 6 7; St Georges Channel

These are on a much smaller scale than Plate 19, but continue the northward error in the position of the Isles of Scilly, which suggests a fundamental error in Collins' measurement of latitudes.

Collins Plate 4; [English Channel from Pembrokeshire to South Brittany.]. *To the Right-Honourable / Admirall Killegrew / this Chart of the Channell is Humbly / Dedicated and Presented by / Cap't G. Collins / 'Great Britain's Coasting Pilot.'* 1693. Verner No 2. RF.c.1:1,200 000). There is no title or date on the printed chart, which is 47.8cm x 60.5cm. The (c 9.2 cm) is 'A Scale of English Leagues' (20 leagues; nautical leagues). Latitudes (degrees and minutes) are marked along the east and west margins. The RF is c 1:1,207,000. Scilly is 10.5 nm north of the true position. The chart is only in the 1693 edition of the atlas.

Collins Plates 5/6/7 [English Channel - Southwest Peninsula to Brest, Straits of Dover.] *To the Right Honourable / The LORDS COMMISSIONERS / For Executing the Office / of LORD HIGH ADMIRALL / OF ENGLAND . This Mapp is most humbly Dedicated and / Presented / by Cap,t Greenville Collins. / Hydrographer to the KING and QUEENS most / Excell't Majestie* 1693. 'Great Britain's Coasting Pilot.' (the chart appears only in the 1693 Edition). Verner No 3; RF Scale c 1: 600 000. The chart is printed from three plates, numbered 5, 6, and 7 in the border and is 59.2cm x 137.6cm. There is no title but it is dated 1693. Latitude is given in degrees and minutes along the east and west margins. The , 13.7cm long and representing 15 leagues is 'A Scale of English and French leagues 20 in a Degree.' (i.e. nautical leagues). The RF is c 1:608 000. The small scale makes the precise measurement of latitudes on the Isles of Scilly difficult but their northward displacement appears to be 7.5 nm.

No Atlas plate number; Verner No 45; Robinson No 13). [St. George's Channel] To Sr RICHARD ROOTH / Kn.t Late Governor of their Maties Fort / Castle...near Kinsale...Humbly Dedicated ...Capt GREENVILE COLLINS. 1693. RF 1:983 000. The printed chart, 57.9cm 5.4cm, has no title.. The RF scale, based upon the spacing of the latitudes in the east and west margins, is Scilly is displaced 8.5nm northwards. RF 1:980 000.

TABLE 1-3

Latitudes of Agnes lighthouse on Collins' four small scale charts of the Isles of Scilly

Plate No.	Collins	Modern	Northerly Error
19	50 02' 15" N	49 53' 31"	08' 44" / 8.7nm
5/6/7	50 01' 00" N	49 53' 31"	07' 29" / 7.5nm
4	50 02' 00" N	49 53' 31"	10' 29" / 10.5nm
(Verner 45)	50 02' 00" N	49 53' 31"	08'29" / 8.5' / nm

The average northward error in latitude on the four charts is 8.8 nm, perpetuating the long suspected c 10 minute northward error in the latitude of the Islands. Collins, for all his experience and awareness of the error, had clearly done nothing to correct it, yet determination of latitude headed the list of his 'Proposals'.

3

THE LARGE SCALE CHART: PLATE 20

**THE ISLANDS OF SCILLY/ TO HIS GRACE/ HENRY DUKE OF GRAFTON:/
This CHART is most Humbly Dedicated:/ and Presented by Capt. G. Collins./
Hydrogr. to the KING/ 1689.'**

The MS of the first edition is UKHO MS B888: no number but MS date 1689 (*CHART 1-3*).

The printed chart (Fig 1-1) is Collins Plate 20; Verner No 12. (*CHART 1-4*).

So far as Collins' large scale chart was concerned, the Isles of Scilly had the advantage of being a small, compact and isolated area, unaffected by the fact that the mainland coastline of most of Collins' other charts had to be set down with a measuring chain unrelated to any national framework. It was a plain chart.

It may seem paradoxical to devote much discussion on the position of the Isles of Scilly on a chart which has serious deficiencies namely, a) the apparent deletion of the latitude gradation figures, b) the absence of longitude gradations and c) a bar-scale of miles which might be queried. These peculiarities are inter-related and do not appear to have received the attention they deserve. They are discussed here in an attempt to explain the absence of latitudes on what is undoubtedly a 'bench-mark' chart.

This chart is probably the most reproduced and described of all of the charts in the *Coasting Pilot*. First published separately in 1689, it is usually described as the first large scale printed chart devoted to the Islands. It was a model available to subsequent surveyors for over a century up to, and possibly including, Graeme Spence (1792). For descriptions and critiques of the chart see *inter alia* Palmer (1963, p 7), Quixley (1966, pp 246), Verner (1969, p 24), Howse and Sanderson (1973, pp 76-7), Baxter (1974 p 23). Collins' Plate 20 is found in all editions of the *Coasting Pilot* (1693-1792).

Collins' chart of the Isles of Scilly stands above much of the criticism of the *Coasting Pilot* noted earlier. It was a remarkable compilation for its time and far superior to any chart, MS or printed, that had preceded it, even though it lacked latitudes and longitudes. Palmer (1963,) lists 16 issues of Plate 20 up to 1792. When first published (Fig 1-1; *CHART 1-4*) there were errors in naming some of the Eastern Isles (e.g.) Little Ganilly for Nornour), the misspelling of names (e.g. Pednanthyes for Pednathis), and the absence of any indication of the Gilstone among the south western rocks. These and other mistakes were widely copied. By 1723 the 'first state' errors had been corrected (Fig 1-2) and the south western Gilstone, with the phrase 'Sir Clousley [sic] Lost', added (Baxter, 1974). From 1738 Abraham Tovey's tide tables were added in various forms. Lack of revision was a serious limitation as time progressed, as Capt Salisbury of *HMS Termagant* found in 1788. (Appendix B) . The chart was to remain the definitive official printed chart of the Islands until

1810, when Graeme Spence's surveys of 1789-1793 were eventually published (Chapter Four).

The SURVEY of SCILLY

The 1753 edition of the *Coasting Pilot* records (p 24) the dates of Collins original surveys. The relevant extracts are [with the number of charts completed added] :-

'1681-2 I surveyed the Channel from Dover to Lands End in Cornwall'. [11 separate charts; Verner p 6]

'1683 Surveyed the Islands of Scilly and the Severn, with Milford Haven.' [6 separate charts; Verner p 6).

The MS of the large scale chart is dated '1689' in the top left hand corner. As with the small scale chart 19 the writer believes this to be in a modern hand and that the MS was compiled before 1689.

Collins' 1683 surveys of Scilly, the Severn and Milford Haven were published in five printed charts and it is surprising, to say the least, that he had sufficient time in the same year for a completely new survey of the complex Scilly archipelago. The survey season lasts only about eight months, probably less off the stormy west coasts. Collins may in fact have begun the survey of Scilly in mid-1682. A letter from Trinity House dated 4th May 1682, to Elkins [12] (the Lord Proprietor's Agent or Bailiff in Scilly) states:-

'I have sent by the 'Merlin' yacht Cap Collins Commander who is now bound to Survey all ye Scilly Islands (to whom you would do well to give what assistance you can) [our emphasis] a bundle of Rodd Iron... Your servant R.V.' (LGL TH Select Entries 1681-84. MS. 30,051). The 'Rodd Iron' may well have been for Collins' use in setting up temporary survey points on islands, rocks etc. The implied threat is intriguing but unexplained. 'Assistance' possibly meant active collaboration in the field work and possibly encouraging Elkins to provide the the services of the employees of the of the Lord Proprietor of the Islands.

Even with the extra time in Scilly that the above letter suggests, Collins worked remarkably swiftly, possibly spending no more than a total of eight months in the Islands. In contrast the second official survey of the Isles of Scilly, by Graeme Spence, took almost four years to complete, from August 1789 to March 1793 (Chapter Four). It is generally assumed that there were no large scale maps of Scilly to help Collins in his survey and that it was wholly original. He had to make both terrestrial and hydrographic surveys of Scilly, the former as the basis for the latter. It is well known that he had to spend excessive time on preliminary land surveys.

As was customary at this time, Collins makes no reference to earlier sources, printed or MS but the short time in which Collins made his survey of Scilly, may suggest that he may have seen earlier MS surveys. These are briefly noted here and described more fully in Appendix C. Many charts of the English Channel include small inserts of the Isles of Scilly but

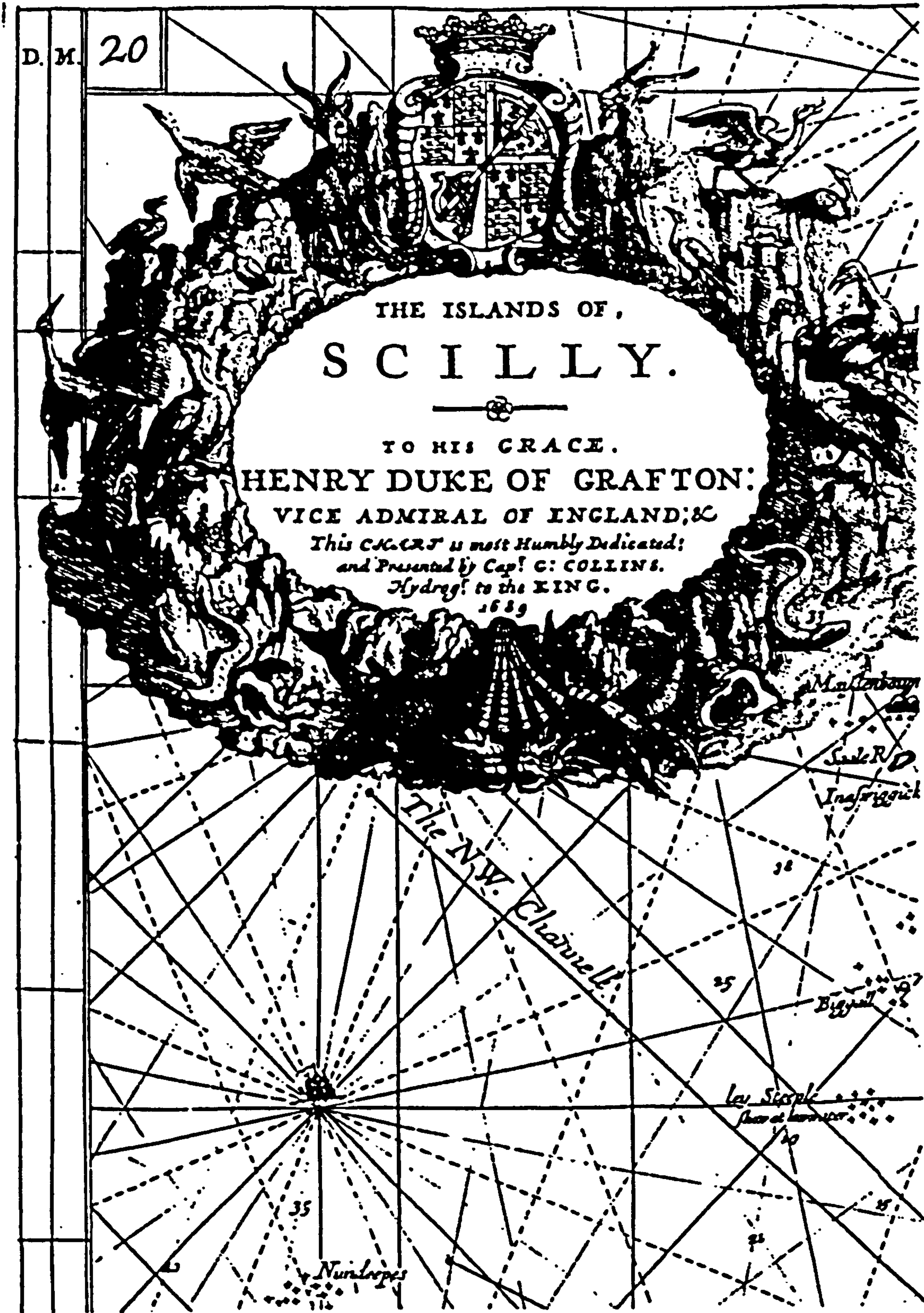


Fig 1-3 Cartouche of Collin's chart of Scilly.
 No numbers in D and M columns, except '1.' In 3rd row of M column.

three larger scale charts may have been available to Collins but one is of very doubtful provenance. All lack latitude and longitude.

a) The Godolphin archive in the Cornwall County Record Office includes a map of Scilly (Cornwall CRO GO 574) Fig C-1. It is c40cm x c27.5cm and dated 1655. The is one inch to $\frac{3}{4}$ of a mile, an RF of c 1:46 900. The map was presumably made on the orders of the Godolphin family, who were the lessees of the islands and, as Lord Proprietors, also responsible for defence. A map would have been essential. Cornwall CRO GO 575 (Fig C-2) is a large scale plan of The Star Castle, St Mary's. As the King's Hydrographer Collins would have shown these MSS. *been*

b) An untitled map of the Isles of Scilly in the British Library (Fig C-3) [13] is a remarkably fine representation of the archipelago, c31cm x c45.5cm (Add 15737 33 9352899). The scale is Six English Miles, RF scale c1:68 000. The BL catalogue dates it as c 1680. The St Martin's Beacon, built 1683, is absent as is the 'Agnis' lighthouse built 1680. The map would have provided Collins with a valuable basis for his land surveys. Latitudes and longitudes are absent. *SCALE*

c) It was claimed by the late Richard Baxter (c.f. Palmer 1963, addenda; Palmer 1967, p 9; Baxter 1974, p 2) that a chart displayed in the Isles of Scilly Museum, St Mary's, (Figs C-4 and C-5) is the first printed large scale chart of Scilly. This has been disputed (Appendix C).

SCALES AND DELETED LATITUDES

It was widely accepted at the end of the 17th century that contemporary charts placed the Isles of Scilly about ten minutes of latitude (ten nautical miles) north of their true position. The measurement of latitude was one of Collins' 'Proposals' in the *Coasting Pilot* and latitudes are plotted on some of his charts. Clearly he had a mandate to detect and correct this error but failed to do so on his large scale chart of Scilly, Plate 20.

The Hydrographic Office has 24 MS charts by Collins and in Robinson's opinion (1952, p 364) they are '*...the original compilation drawings prepared by Collins for the engraver...*' Only two include Scilly:- UKHO B 887 (Land's End - Scilly) and UKHO B 888 (Isles of Scilly).

The Isles of Scilly MS, UKHO B 888 (*CHART 1-3*) is 44.2 cm x 55.2 cm, [the latter dimension being shorter than on the printed version as the neat lines are more closely spaced]. It has no cartouche or plate number, but the original MS title 'The Islands of / Scilly' is in the top left hand corner. As noted earlier, the Islands were surveyed in 1683 or possibly 1682-3. This MS must have been compiled either by Collins or under his supervision and the presence of the gradation lines may be taken as evidence that latitude figures were to be inserted. Beneath is a MS date '1689' (the date of the printed version) apparently in a modern hand.

There is no scale on the MS; it appears to have been torn away from the bottom right hand corner. This is most unfortunate, as the relationship between the scale and the marginal gradations is crucial to the true scale of the chart. There are nine unnumbered gradations in the side margins, spaced as on the printed chart, and the columns they cross are headed



D and M, also as in the printed version. Unlike the latter, the chart extends 0.8 cm north of the DM letters. It must be emphasised that on the MS chart there is no evidence whatsoever that the gradations were numbered and the figures later deleted; it may be concluded that they were never present. The MS chart extends 1.5cm north of the printed chart but adds no more detail.

The printed chart Plate 20 is 44.5 cm x 56.4 cm. (**CHART 1-4**) There are eight uniform gradations on both side margins, with columns headed D and M. The spacing is as on the MS version but to the south there is a ninth gradation only 4.6 cm in length. On this chart the archipelago is plotted in considerable detail, including many small islands and rocks, in addition to the main islands. There are numerous '...leading and clearing lines along which ships could safely sail to enter harbour.' (Howse and Sanderson 1973, p 12). These avoided the many rocks and large areas of shallow sand-banks south west of St Martin's and between Tresco and Bryer. Useful aids to navigation, such as the lighthouse on Agnes, the two windmills on The Hugh (St Mary's) and the chapel on St Martin's were plotted. For descriptions and critiques of this chart see inter alia Palmer (1963, p 7), Quixley (1966, pp 24-6), Verner (1969, p 24), Howse and Sanderson (1973, pp 76-7), Baxter (1974, pp 2-3).

In the bottom right-hand corner of the printed chart is a bar-scale 4.9 cm or 2 inches long:- 'Scale of one English Mile.' In fact it is 4.95 cm or 1.95 inches. It is generally assumed to be A nautical mile, which would mean an RF scale of c 1:37 500 (Howse and Sanderson 1973, p 77), but this is questioned later.

Deletion of Latitudes

It is known that Collins had a five foot radius quadrant (Richie 1995) which would have been ideal for the measurement of latitudes and it is therefore all the more surprising that their numbering is missing from both MS and printed versions of this chart. It would appear that the error lies in either the numbering or the spacing of the latitude gradations, or possibly both.

On certain charts in the **Coasting Pilot** latitudes were clearly never intended to be plotted (e.g. Plate No 8, Rye). The layout of Plate 20, however, shows that Collins intended to insert measured latitudes. In the two side margins are what appear to be nine latitude gradations (including top and bottom margins) drawn across two columns headed 'D' and 'M' (presumably 'Degrees' and 'Minutes') but, with one exception, there are no figures in the gradations. This omission has not passed unnoticed but seems to have excited little interest. Howse and Sanderson (1973, p 77) reproduce an early edition of the chart and simply note '*For some reason, the figures giving degrees and minutes on the latitude gradations have been expunged on this plate.*'

Given their importance, it is strange that the latitude figures were not restored at a later date. The 1738 edition corrected early many errors and in 1781 the plate was re-cut but no latitude figures were included. A French version of Plate 20, Verner map F 9, was published

in the *Neptune Francais* in 1757, based on the 1723 British edition and on the same scale, but omits columns 'D' and 'M' and latitude gradations and figures. No attempt was made to re-plot this plain chart on to Mercator's projection.[14]

On examples of the printed chart indecipherable traces of figures can be seen above some of the latitude gradation lines; e.g. the figure '1' survives in the west 'Minute' column, just to the left of the cartouche (Fig 1-3) and in places the gradation lines are damaged. These may be taken as proof that figures were originally engraved on the copper plate. The obvious response is when and why were the figures deleted from the printing plate.

The timing of the removal of the figures is not easily established. Verner (1969, p 24) has recorded the following States of the chart [15].

'State 1 1689 Latitude figures are in the side borders of the plate.

State 2 1693 Latitude figures have been deleted.

State 3 1781 The plate has been re-cut with onshore hachuring added in several places and the cartouche frame re-cut with a hard line that eliminates much of the underlying detail'.

Verner clearly believed that the latitude figures were removed between 1689 and 1693, his assumption being that, as the deletions proved that latitude figures were originally engraved on the printing plate, the earliest printed charts (State 1) must have had latitude figures.

Verner's research papers were donated to the University of British Columbia, but unfortunately there is no further information in them relating to any of the charts in the *Coasting Pilot*, other than that appearing in Verner 1969. His interest was the atlases rather than charts. Verner's Table Two (*op. cit.* p 14), lists the whereabouts of the earliest States of charts at six major libraries; Plate 20 is not included. Enquiries at the remaining five libraries listed on Verner p15 failed to uncover any examples of his State 1. Verner also lists 17 charts which he found in a proof state (now in the Hanson collection, Cambridge) but Plate 20 is not among them. It is possible that a copy of State 1 issued separately in 1689 may yet be found but in spite of extensive enquiries, none has been reported to the writer. BE

There could have been several reasons why the figures were deleted from the printing plate, ranging from the simple to the complex. The explanation offered by the writer is, perhaps, too simple.

1). Collins did not complete the latitude observations or he did not submit them to the draughtsman, so no figures would have been engraved on the Plate. It is known, however, that they were.

2). Collins used a five foot radius quadrant on land but had a second, smaller, quadrant '*...for use at sea*' (Ritchie 1995, p 33) and it may be that Collins decided not to risk the

transport of the larger instrument in the stormy seas around Scilly but to use the smaller, less accurate, quadrant to determine latitudes, which perhaps later proved to be too inaccurate to engrave. Heath (1750, p 316) dismissed as inadequate a two foot quadrant for measuring latitude on land and Collins' more portable second quadrant was probably about this size. Heath favoured one of at least six feet. However, as noted earlier, Collins' latitude errors are also found on the mainland of west Cornwall (Fig 1-4) where it might be assumed that the larger quadrant would have been used.

3). Collins was under constant pressure during the seven years of his surveys and the latitude figures may have been engraved on the plate from verbal or written instructions, which were misunderstood and the incorrect figures had to be deleted.

4). The latitudes of the Isles of Scilly on Plate 19 (surveyed 1681-3; printed 1686) may have been plotted on Plate 20 (date 1689) when it was being compiled and engraved. Subsequently those on Plate 19 were found to be faulty . The latitudes plotted on Plate 19 cannot be transferred to chart 20 as there is no common numbered gradation.

If any of the above assumptions are correct, it follows that either the incorrect latitude figures on the printing plate were quickly and crudely removed before any copies were printed or that printed copies with the wrong latitudes were immediately destroyed. In this case Verner's chart State 2 should be chart State 1. Initially, of course, there would have been a printing plate in Verner's State 1. The deletion of latitude figures from charts in the **Coasting Pilot** appears to be confined to the chart of the Isles of Scilly. Given their importance, it is strange that they were not restored at a later date. Errors could have been easily corrected on the malleable copper plate. The 1738 edition corrected early many errors and in 1781 the plate was re-cut but in neither case were the missing latitude figures added (Pascoe 1964; Cooney 1986).

In the following, attempts have been made to 'resurrect' the missing latitude figures.

i). MS UKHO B 887 (Land's End - Scilly) and Plate 19 cover the area between Land's End and Scilly and on both latitudes are plotted in the margins (Fig 1-1). The only common latitude is that of Agnes Lighthouse, which could have been used on Collins' chart as a nominal base line. It would have been possible by calculation to adapt the differences to the latitude gradations on Collins' Plate 20.

TABLE 1-4

Latitudes on Plate 19 transferred to and plotted on Collins Plate 20

Location	MS and Printed 19	Collins 20	Difference
St Martin's north	50° 07' 20"	07' 50"	+30"
St Martin's Head	50° 07'	07' 20"	+30"
Samson	50 04' 30"	05' 00"	+30"
Star Castle	50° 03'	03' 40"	+40"
Agnes LH	50° 02'	02' 20"	+20"
Crim	50° 01'	02' 30"	+1' 30"

There are no degrees on Plate 20, so its 'latitudes' are based on Agnes Lighthouse, the only common parallel with Plate 19.

The differences are surprisingly small, 30" of latitude is only 0.5nm. Plate 19, with its latitudes, was published in 1686, three years before Plate 20 in 1689. The Isles of Scilly are drawn very crudely on Plate 19 but their latitudes must have been known to the draftsmen compiling Plate 20. They were not, however, plotted on the MS of Plate 20 (c1683). This would support a view that the Plate 19 latitudes became available just before engraving and the error was not discovered until they had been engraved onto the printing plate.

The scale of One English Mile

On Plate 20 (but not on the MS) there is a bar-scale 4.9 cm long, being 'A Scale of one English Mile' divided into quarters. The length of the bar-scale is exactly equal to the spacing of the gradations in the side margins of the printed chart. They also equal those in the margins of the MS but its bar-scale was either never added or was removed.

Collins' chart scales have attracted little attention. [16] Howse and Sanderson (1973), among others, have assumed that the marginal gradations are spaced at intervals of one minute of latitude or one nautical mile and that therefore the bar-scale of one 'English Mile' represents one nautical mile. The RF scale is then c 1:37 800. The scales on all but one of Collins' 'Algerian Journal' charts are in 'English Miles'.

The length of the 'English Mile' at this time is by no means clear.

The Old English Mile (Evans 1975, p 259) was on average 1.3 Statute Miles and seems to have been in use as late as 1695.

The English Mile as defined in 1571 by William Bourne was, in fact, the nautical mile. The nautical mile is traceable back to Pythagoras and Eratosthenes (Kemp 1990, p 575). Warning against the differences in length of foreign nautical leagues, Bourne asserted that a degree of latitude is '*...20 of our English leagues, 60 of our English Miles.*' i.e. the nautical mile used on today's charts. To Bourne, it seems, a nautical mile was an English mile (Williams 1992, p 34-5). Rodger (1960, p v) discussing British County maps, states that miles of 60 to a latitude degree were used on land maps until 1675/1721 (Ogilby and Senex *infra*).

The Statute Mile of 1760 yds had been legal since 1593 (Statute 35 Elizabeth) but was not enforced until 1824. There are $69\frac{1}{2}$ to an equatorial degree. It did not come into general use on maps until Ogilby (1675) and Senex (1721); the latter referred to them as '*English measured miles, $69\frac{1}{2}$ to a degree*'.

Colonel Christian Lilly's map of the 'Fortifications in the Plymouth Division' (1714-17), extended from Portland to the Isles of Scilly. There are no latitude or longitude gradations but the scales clearly differentiate between English Sea and Statute Miles, the English Sea mile being the nautical mile, 60 to the degree.

If latitudes and minutes are numbered on a chart, then the length of the miles can be checked. On chart Collins' Plate 19 (Verner No 11), for example, comparison of the leagues with the latitude gradations shows that the λ is in nautical leagues of three nautical miles. On COLLINS' Plates 5 / 6 / 7 (Verner No 3) the bar-scale is:- '*A scale of 15 leagues at 20 leagues to the degree.*' Clearly these are nautical leagues, each equal to 3 nautical miles.

As Collins used nautical or sea miles on some of his small scale charts, it might be assumed that the latitude gradations on Plate 20 represent nautical miles. The deletion of the numbers can be explained either that there were errors in the numbering or that the spacing of the parallels was wrong.

To test whether Collins' 'English Miles' on Plate 20 were nautical or statute miles, distances were measured on charts in the 'Coasting Pilot', equating his 'English Miles' first with statute miles and then with nautical miles. These were then compared with modern distances.

The writer selected eight of Collins' charts of the south and east coasts of England for comparative measurements:-

Plate 16 (Plymouth); Plate 17 (Fowey-Mounts Bay)

Plate 24 (Milford Haven); Verner 44 (Isle of Wight); Verner 47 (Bristol Channel);

Plate E (Harwich); Verner 48 (Dover-Spurn Head)

The results confirm modern opinion that the bar-scales on Collins' charts are unreliable. On the charts, 12 of Collins' distances were close to those measured in nautical miles and 5

were close to measurement in statute miles but the results were not necessarily consistent within a single chart. Thus on the chart of the Isle of Wight three of Collins' distances were close to statute miles and only two to nautical miles. It must be conceded that without a specific definition or latitude gradations, there can be no certainty of the length of an English Mile on any chart in the 'Coasting Pilot'. This fact may have been overlooked in the past as few, if any, discussions of the chart refer to the scale. In the following Tables (1-5 and 1-6) distances on Collins' chart are compared with modern distances, first assuming the to be one nautical mile and secondly assuming it to be a statute mile.

TABLE 1-5

Plate 20: assuming distances are in nautical miles

LOCATION	Collins' chart miles	Modern nm	Difference
Star Castle – Agnes Lighthouse	2.0	1.7	+0.3
Star Castle – Bishop Rock	6.7	5.4	+1.3
Star Castle - St Martin's Head.	4.4	3.7	+0.7
Star Castle – Cromwell's Castle	3.3	3.0	+0.3
Agnes Lighthouse – Bishop Rock	5.0	4.1	+0.9
St Martin's Church – Cromwell's Castle	3.7	3.2	+0.5
St Martin's Head – Bishop Rock	10.8	9.0	+1.8

The average distance error is + 0.82.

TABLE 1-6

Plate 20 assuming distances are in statute miles.

LOCATION	Collins' chart miles	Modern statute mile	Difference
Star Castle – Agnes Lighthouse	2.0	1.9	+0.1
Star Castle – Bishop Rock	6.7	6.2	+0.5
Star Castle - St Martin's Head.	4.4	4.3	+0.1
Star Castle – Cromwell's Castle	3.3	3.4	-0.1
Agnes Lighthouse – Bishop Rock	5.0	4.7	+0.3
St Martin's Church – Cromwell's Castle	3.7	3.7	0.0
St Martin's Head – Bishop Rock	10.8	10.3	+0.5

The average distance error is +0.194.

The errors are very small and could be considered insignificant. The Isles of Scilly, however, cover a very small area and distance errors may be expected to be small. Nautical mile

errors on the above Tables are four times larger than statute miles but some might argue that the difference is insignificant.

On what is admittedly very slender evidence, the writer suggests a simple explanation for the deletion of latitude numbers, namely, that the 'Scale of English Miles' on Plate 20 is in statute rather than nautical miles. The RF scale would then be c.1:32,800. The spacing of the marginal gradations, being the same length, is also one statute mile, rendering them useless to navigators, who would assume that they were minutes of latitude or nautical miles. If this supposition is correct, the error was clearly not recognised until after the latitude gradations, with figures, had been engraved on the printing plate. The chart's usefulness could have been restored either by correcting the λ or by removing the figures on the marginal gradations before any sheet had been printed. The latter was probably the easier choice. It was not necessary to erase the gradation lines as, no longer numbered, they would have been ignored by navigators. The numbering of the latitude gradations must have been introduced after the MS chart was compiled (there are no numbers) but before the printing plate was engraved. Collins employed '*...some of the most prominent craftsmen in London...*' as engravers (Verner 1969, p 7-8) but their task was to copy an MS as closely as possible, not to detect mistakes. The erroneous latitudes on the engraved plate were then removed. SCALE

If this admittedly controversial hypothesis is correct, the bar-scale representing a nautical mile should be 5.75cm, not 4.9cm, in length, and the latitude gradations should be 5.75cm, not 4.9cm apart, equal to one minute of latitude. A chart plotted in statute miles is by no means unusual. Examples are Robert Heath, 1750 (Chapter Two) for his chart of Scilly and more importantly, by Graeme Spence 1792-1805; (Chapter Four) for all of his MS 6" and 1" charts of Scilly, continuing the practice of his mentor, Murdoch Mackenzie jnr.

An alternative explanation is that Collins had finally realised in 1689 that all his latitudes for the Isles of Scilly were c 10 nautical miles too far north and had them deleted from Plate 20, the last chart to be published in the *Coasting Pilot* which included the Isles of Scilly on a significant scale. Collins presumably made his latitude observations at well known sites such as Agnes Lighthouse or Star Castle, St Mary's. For some reason they were faulty but nevertheless used to plot latitudes on the small scale charts.

Thus far it has been assumed that Collins' instruments were reliable and that his errors were observational. The consistency of the errors in his latitude both on land and on Scilly may have been due to faults in his two quadrants. The late realisation of this may have in part at least led to the deletion of the latitudes on Plate 20. The experience of Captain Martin White (Chapter 8) when surveying the Channel Islands c 1812 may be relevant. The chain issued to him at Portsmouth for land surveys was so inadequate that he had to have one made at his own expense. His sextant made by Gilbert was heavy and poorly constructed and compared unfavourably with those issued to other officers. The Naval Surveying

Service as it was known was not highly regarded by the rest of the Navy and White suspected that it was not issued with the best instruments.

Collins was unable to measure longitude and it must be assumed that he obtained the E-W dimension (Hanjague – Crim Rocks) of the archipelago by triangulation, probably using his smaller quadrant. One of his Proposals was to '*... to measure the seacoast with a chain, taking exact bearings and latitudes of all headlands...*'

Assuming that Collins' 'English Mile' is a statute mile, the archipelago is 11.5 miles E-W. Robert Heath (1750) was able to calculate longitude and his chart shows the Isles of Scilly as 10.25 statute miles E-W. The modern distance is 9.7 statute miles.

4

DISTANCE FROM THE MAINLAND

The small scale charts and their relevance to Collins' perception of the location of the Isles of Scilly in relation to the mainland.

At the end of the 17th century the measurement of the longitude at sea or of small off-shore islands like the Isles of Scilly lay in the future.

Two main methods of measuring longitude on land in the early 1700s were the 'Lunar Distance' and the 'Eclipses of the Satellites of Jupiter'. Descriptions of both methods are readily available (Aked, 1974; Cotter, 1968; Kemp, 1990; Williams, 1992; Howse, 1997; a more popular account is in Sobel and Andrewes, 1999). The instruments, tables (and the skills needed to use them) of the great observatories were not available to simple navigators like Collins. The 'Lunar' method was very demanding mathematically and led to many errors. It is said that it could take a skilled observer four hours to complete the calculations and still be only correct to within 20 miles. The Tables for the Satellites of Jupiter method '*were for the skillful and '...not to be undertaken by the less knowing'*

As longitude could only be estimated (*infra*) seamen at this time were totally unaware that there might be a westerly or easterly error in the longitude of the Isles of Scilly on charts and in Sailing Directions. All attention had been focused on the latitudinal errors. The wreck of Sir Cloudsley Shovell's fleet on the Western Rocks of Scilly in 1707 has mistakenly been blamed on an error in longitude on his part (Sobel 1995, p12). Shovell was relying on faulty latitude measurements; he had little knowledge of his own longitude as he approached the English Channel, let alone that of the Isles of Scilly. The western Gilstone, on which his ship was wrecked, was not plotted on Collins' 1689 large scale chart..

Collins' four small scale charts plot the westward position of the Isles of Scilly in relation to the mainland. He would have estimated their distance from the mainland by dead reckoning. The latter is:- '*...charting the position of a ship without the use of any astronomical observation...arriving at the ship's position by laying off on the chart courses steered and distances*

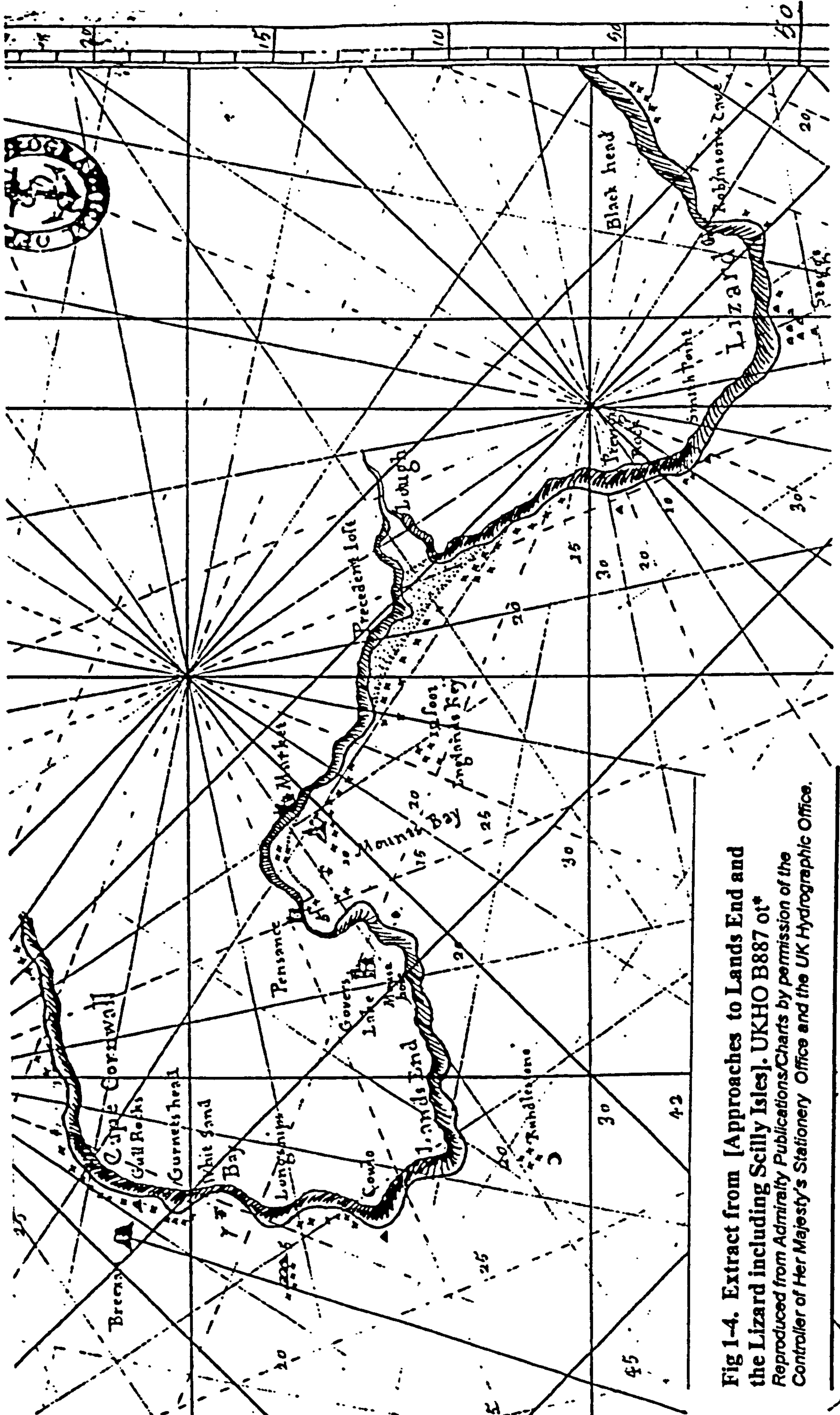


Fig 1-4. Extract from [Approaches to Lands End and the Lizard including Scilly Isles]. UKHO B887 of*
 Reproduced from Admiralty Publications/Charts by permission of the
 Controller of Her Majesty's Stationery Office and the UK Hydrographic Office.

run, with due allowance for currents, tidal streams, and leeway [the effect of wind and tide], from the

last fixed position.' (Kemp 1988, p 234; see also Williams 1992, p 21).

The course is given by the compass and the distance run was measured by the log, in simple terms a wooden board attached to a line. The board is dropped from the stern of the vessel and is assumed to remain stationary. The length of line run out in a given time gives the distance sailed. The method was used by all seamen and in Collins' time the log -lines were marked on the basis that a nautical mile was 6 120 feet (40 feet longer than the modern distance 6 080 feet). By using latitude and dead reckoning, it was believed that an approximation to longitude could be estimated but very large errors were common. Pepys, sailing to Tangiers in 1683 was very critical of the dead reckoning kept by the fleet's ship's masters (responsible for navigation) and that the differences were concealed, rather than made available for the correction of charts.

Collins made regular observations of latitude and longitude on his voyages and good examples survive in his *Algerian Journal* of a voyage to Tangier and back. The latitudes were measured with a Davis quadrant and longitude by dead reckoning. He had no concept of a prime meridian.

Outwardbound from London for Tangier, he sailed from Falmouth on 31st January 1676/7 and examples of entries in his 'Journal' are (p 7):-

1 Feb: latitude 49° 56'; longitude 0° 20'

2 Feb: latitude 49° 27'; longitude 1° 05'

6 Feb: latitude by judgement 43° 40', by observation 43° 35'; longitude 6° 01'

Collins does not name a prime meridian. Falmouth is c5° 01' W of Greenwich and it is obvious that Collins was estimating his longitude by dead reckoning from Falmouth.

On 12th May 1679 (p 83) he notes setting sail from Tangier [now Alger] for England and again a series of latitudes and longitudes are recorded for the voyage:-

? May 1679: Cape St Vincent: latitude 37° 00' [nearly correct] longitude 03' [Cape St Vincent is 12° longitude west of Tangier].

31 May 1679: latitude 'by judgement 44° 52' . longitude from Cape St Vincent 2° 39'

1 June 1679: longitude 0° 7'

4 June 1679: Land's End and six leagues off the Lizard.

Again Collins was obviously estimating his longitude by dead reckoning from his port of origin, Tangier, but over long distances his estimates were usually very inaccurate.

The distance between the Isles of Scilly and west Cornwall would have been measured by many navigators using dead reckoning. Collins would have made his own measurements while on passage to and from the mainland and presumably used these to estimate longitude when plotting the Islands on his small scale charts, represented by the Agnes Lighthouse.

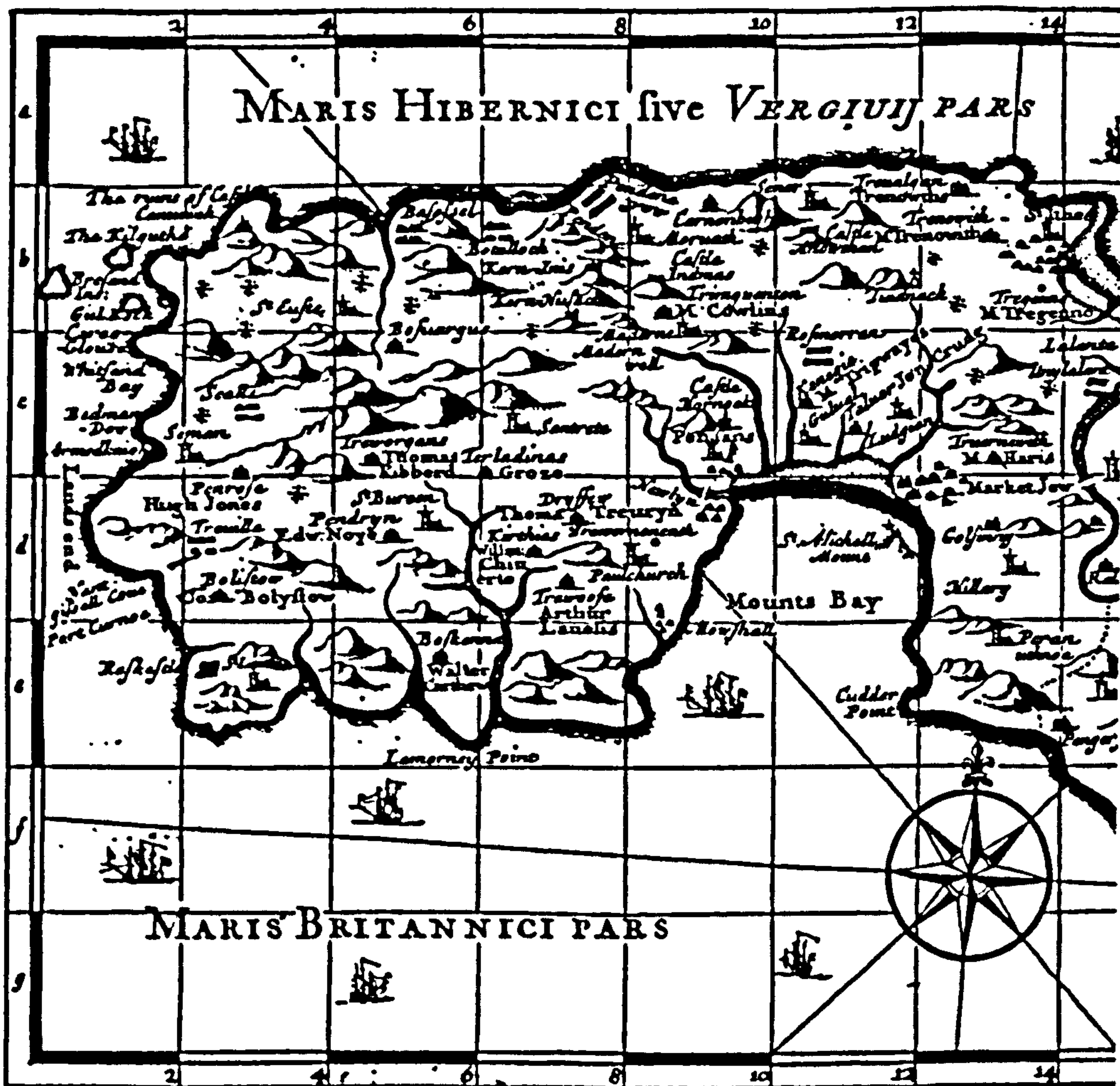


Fig 1-5 Extract from John Nordon's 'Description of Cornwall' 1584. (Graham 1966)

It would seem obvious that Land's End is the place on the mainland from which to make the measurement, being the nearest place to Scilly. However, there has been some confusion over the years as to which part of the mainland coast deserves to be named Land's End (see Figs 1-4; 1-5; 1-6). Heath (Chapter Two) notes that at one time Gwennap Head (Fig 1-6 ngr 362215; latitude $50^{\circ} 02' N$; longitude $5^{\circ} 40' W$) was regarded as Old Land's End, although it lies about three miles SE of the modern Land's End (latitude $50^{\circ} 04' N$; longitude $5^{\circ} 43' W$). Medieval navigators regarded the dramatic headland of Cape Cornwall (Fig 1-6; ngr 350319; latitude $50^{\circ} 08' N$; longitude $5^{\circ} 43' W$) as the most westerly point of Britain and the place where the English Channel met St George's Channel.

On MS and Plate 19, the coast of the westernmost part of Cornwall (Fig 1-4) is rather generalised. Whit [*sic*] Sand Bay and the Longships are in their correct relative positions, as are Breexan (The Brisons), the Longships and the Rundlestone. The westernmost part of the mainland on Collins' charts corresponds approximately with the position of the modern Land's End, but Collins names it Cowlo. There is, however, no recorded place-name

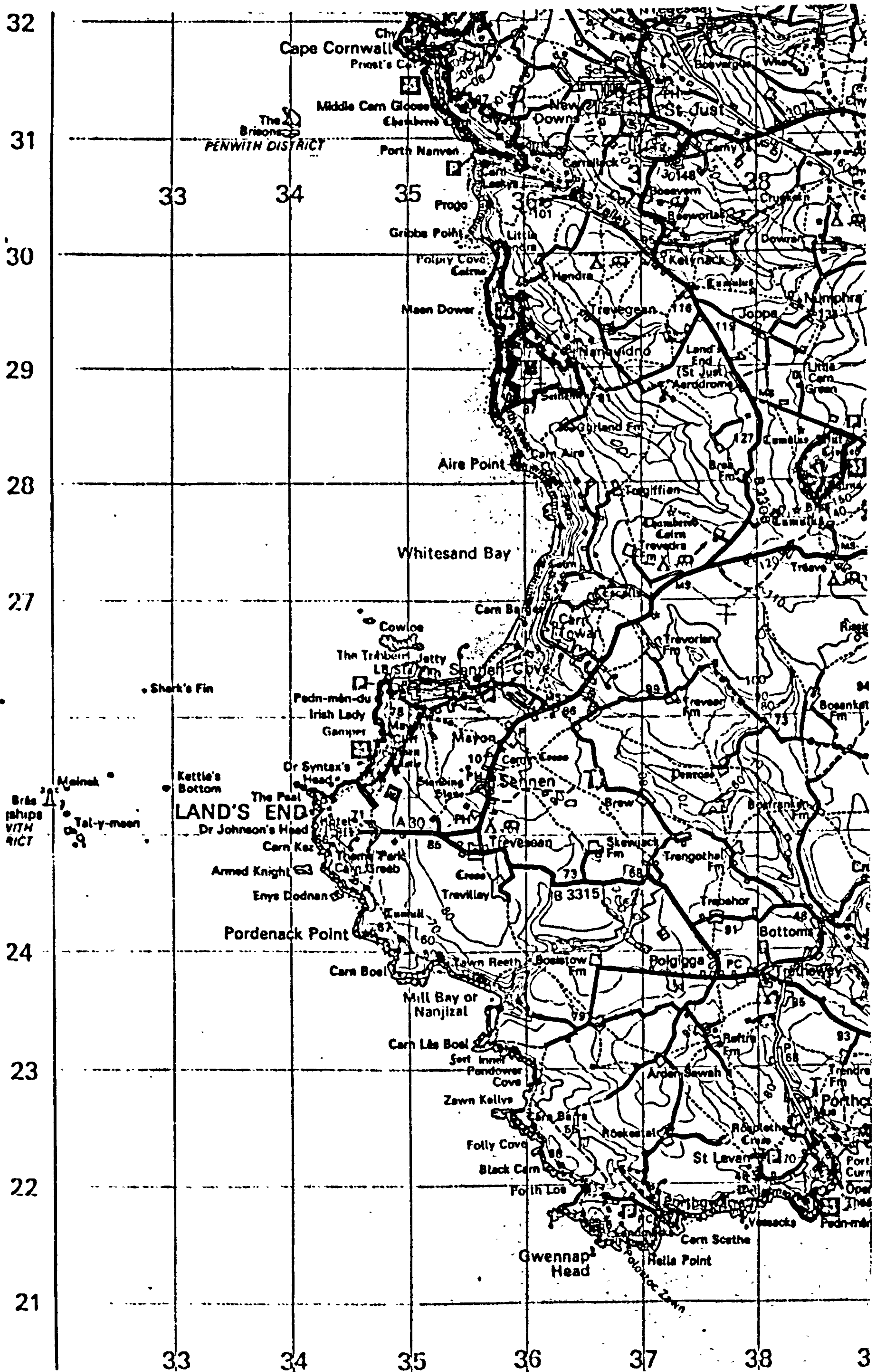


Fig 1-6 Reproduced from 1:50 000 sheet 203, 2002, Ordnance Survey map with the permission of the Controller of Her majesty's Stationery Office, © Crown Copyright NC/02/40390.

Cowlo in the Cornwall CRO. There are low lying rocks named Bo Cowlo and Cowloe off Sennen Cove to the north and east of the modern Land's End and Collins may have confused them with the Longships Rocks, which lie c 2½ miles west of Land's End. As Cowlo is Collins' most westerly point it is taken as 'Land's End' in the following [17].

The errors of latitude on Collins' small scale charts would obviously affect the compass bearing of Scilly from the mainland. According to the latitude gradations on Plate 19, the Cowlo headland is 50° 11' N, the modern land's End being 50° 04' N. Thus the modern bearing from Land's End to Agnes Lighthouse is 246° but on Plate 19 it is 255° (reflecting the northward error in Scilly's latitude). The distances listed in Table 1-7 are from Cowlo to Agnes Lighthouse.

TABLE 1-7

Mainland (Cowlo) to Agnes lighthouse.

Chart No	Collins	Modern	Error
19	32.3nm/59.9km	26.2nm/48.7km	6.1nm/11.2km
5,6,7	30.6nm/56.6km	26.2nm/48.7km	4.4nm/7.9km
4	31.6nm/58.7km	26.2nm/48.7km	5.4nm/10.0km
[Verner 45]	34.0nm/62.9km	26.2nm/48.7km	7.8nm/14.2km

Plate 19 is by far the most useful chart for determining Collins' location of Scilly in relation to the mainland.

Plates 5,6,7 The westerly error is unexpectedly small. The scale is known to be in nautical leagues, so that there can be no doubt about measured distances.

Plate 4 Distance measured from the (unnamed) most westerly point on the chart's mainland, using a scale of nautical miles.

Verner No 45 Distance measured from the most westerly point on the chart's mainland, using a scale of nautical miles.

As measured on small scale charts, the average dead reckoning distance between Cowlo/Land's End and Agnes lighthouse is c 33nm, c 6 nm longer than the modern distance. This westerly longitude error is just over half that of the well recognised northward latitude displacement of the Isles of Scilly on charts and in Sailing Directions but seems to have been unnoticed. A minor point is that each of Collins' nautical miles is 40 feet longer than the modern nautical mile. Over a distance of 33nm, this is an error of 1320 feet or 0.22 nm.

The dead reckoning distances might be more meaningful if they could be converted into a meridional distance between Land's End and Scilly (Agnes Lighthouse). As Collins' charts are plain charts, a very simplistic approach is to convert the average dead reckoning distance based on Collins' charts by simple trigonometry into an east-west distance. This distance is 24.5nm on modern charts and averages 29.7 nm on Collins' small scale charts, a difference of 5.2nm or 8 minutes of longitude (one minute of longitude = 0.64nm at 50° N).

The westward longitude errors of Gincer (1731) and Heath (1744) are much larger; c 20nm and c14nm respectively. Not until Spence's survey of 1792 was the longitude of Scilly nearly correctly measured. Collins' dead reckoning measurements for the Isles of Scilly are a credit to him.

CONCLUSIONS

It has been shown that Collins possessed the navigational and surveying experience for the survey entrusted to him. The influence of Trinity House on Collins' appointment, in addition to that of the King, Pepys and the Admiralty is discussed in Appendix B. It will never be known whether a better choice might have been made but it does seem that the exclusion of the expertise of Trinity House played a part in the limited success of the survey, even allowing for the lack of finance, suitable instruments and time. There seems to have been little comment on the ease with which Collins moved to the construction of plain charts for the 'Coasting Pilot' from the sketch profile charts of his earlier hydrographic work.

Given that Collins' charts are the starting point of any historical review of the fixing of the true position of the Isles of Scilly, attempts have been made to assess the accuracy of Collins' measurements. The latitudes on the smaller scale charts which include Scilly are wrong and Collins inexplicably failed to correct the known northerly error in the published latitudes of the Isles of Scilly. An explanation has been offered for the deletion of latitude figures on Collins' main chart (Plate 20).

Collins' success in placing the Isles of Scilly close to their true longitude from the mainland is an important addition, although it must be conceded that the calculations are simplistic. Few contemporary references were made to errors in the longitude of the Islands; seamen seemed unaware of this as a problem but it would have contributed to the navigational hazard as much as the latitudinal errors. Paradoxically, the wreck of Shovell's fleet on Scilly in 1707 because of a latitudinal error led to the setting up of the Board of longitude.

END NOTES

[1] In his over ambitious original 'Proposals' (1680) for his **Coasting Pilot** Collins, noting the want of a full and true survey of the Sea Coasts, and having sought the advice of mathematicians, he undertook :-

to measure the seacoast with a chain, taking exact bearings and latitudes of all headlands

to delineate harbours

to make new tide tables

to take exact soundings, with their correct bearings and distances etc.

to draw shadows or views of the seacoasts

to measure the degree

[2]. A short biography of Collins, including the background to his appointment is in Appendix B. It adds hitherto unused details from the Minute Books of Trinity House to the many important details of Collins' life and work to be found *inter alia* in Tanner (1926; Pepys Naval Minutes 1680-96), Dyer (1928), Taylor (1954), Robinson (1962), Verner (1969), the PRO Admiralty records *etc.*

[3]. The **Great Britain Coasting Pilot** was printed and probably published at Collins' expense (Verner 1969, p 10).

[4]. Robinson 1962, p 423; chart list, pp 158-62. Harley (1972, p 57) includes an index map of Greenville Collins' '**Coastal surveys and Charts**' but omits both the chart of Scilly (Pilot Plate 20) and that of Scilly with Land's End and the Lizard (Pilot Plate 19).

[5]. Early attempts to produce atlases of at least part of the British seas were by John Seller (fl1654-d 1697; Clifton 1995, p 247), His '**English Pilot**', (1671) and '**Coasting Pilot**' (1671-73) were not successful, being far beyond his resources. He used old Dutch copper plates in place of original surveys of the British coasts. In these '**Pilots**' the Isles of Scilly are merely inaccurate small scale inserts on regional charts, of a circle of islands in the style of Waghenauer (1588). Seller (appointed Hydrographer to Charles II) was *inter alia*, a successful maker of instruments for navigation and land surveying. (Taylor 1954, p 379; Robinson 1962, p 116). Later editions of Seller's atlases and those of his successors (Robinson 1962, p 181) extended into the first decade of the 18th century. Not until 1730 is there '**A Correct Chart of the Scilly Isles. By Cha. Price**' (successor to Seller) 23.5"x18.5" London. Mount and Page.

[6]. Samuel Pepys was elected a Younger Brother of Trinity House in 1662, his deeply committed interest in naval matters stemming from 1660 when he was made Clerk of the Acts of the Navy (Bryant 1967, p 108). In 1672 Pepys was elected as an Elder Brother of Trinity House and was twice Master, in 1672 and 1685 (Mead, Ch 8). In 1670 he had arranged that his younger brother became Clerk of Trinity House, a second invaluable source of information for him. In 1673 he was appointed to the powerful post of Secretary to the Office of the Lord High Admiral of England, his brother John replacing him as Clerk. For political reasons Pepys was removed from that Office from 1679 to 1684 but he remained influential in Naval matters. Pepys supported any attempt to improve navigation and to aid the discovery of the true longitude he encouraged the appointment of John Flamsteed as the first Astronomer Royal.

[7]. [*c.f.* Ravenhill 1972]. The principles of triangulation reached England c mid-16th century via Dee, a disciple of Frisius and in 1578 William Bourne described them and a suitable instrument. Norden's maps were made in 1584 but not published until 1728. 'Norden clearly had at his command the techniques and instruments for a trigonometrical survey' (Ravenhill 1972). His Land's End map was remarkably accurate for its time and an improvement on Collins'. Hydrographers were slow to adopt the new techniques but, to Ravenhill, Collins was '*...one of the heralds of the new era...*'. Not until Gascoyne (1699) were Norden's maps of Cornwall improved upon. See also Graham 1966.

[8]. *c.f.* Day (1967, p80) and BL Maps Ref. A.1.(I) '**The Commissioned Sea Officers of the Royal Navy 1660-1815**'. There is no entry for Greenville Collins. (V1 p186).

[9]. **Journal of his Maj's Roving Fryggot [sic] the 'Charles' by Greenville [sic] Collins Master of the said Fryggot.** (PRO ADM/7 688 and PRO MPI 1736). The frigate was built by Mr Phinis Pett at Woolwich. The timber came from Petts Wood, now a S.E. London suburb.

[10]. Capt John Davis (c 1550-1605), the famous Elizabethan navigator and explorer, invented the quadrant or backstaff. With improvements in design it was still in common use in the late 17th -early 18th centuries. It is known that Collins regularly recorded latitude and longitude in his '**Algerian**' journal and on the last page are some calculations '**By Mr Davis's quadrant.**' It seems probable that Collins used such an instrument on all his surveys. Clifton (1995) lists several instrument makers who might have provided Collins with a Davis quadrant.

[11] **Cartouche: TO THE HON;ble THE GOVERNOR / DEPUTY GOVERNOR AND COMMITTEES / OF THE EAST INDIA COMPANY / This Chart is Humbly Dedicated / and Presented by CAP:t GREENVILLE / COLLINS Hydrographer to the / KING / 1686.** EIC vessels often sheltered within the Scillies.

[12]. Elkins was baptised at Dartmouth in 1635. By 1667 he was on Scilly and steward to the Godolphin family. He may also have leased St. Martin's Isle, on which he built the famous Day-Mark or Beacon in 1683. (Thomas, 1985 p300).

[13]. This MS is bound in '**Coasts of India – Ports in the Mediterranean**' Presented by the Lords of the Admiralty. p 24=Plymouth and Fal estuary; p34=Isles of Scilly. see Geog Journ 1914 p 78 and Appendix B.

[14]. CARTE DES ISLES DE SCILLY ou LES SORLINGUES c1757, Bellin (Verner F 9). From a volume of charts and plans of the British coasts copied from by Bellin from Greenville Collins. Prepared in Paris about 1757 by Bellin, from the London edition of 1723, the charts were published without Collins' text, which is in Bellin's *'Essai Geographique sur les Isles Britanniques...'* 1757. (Verner 1969, p 42). The Isles of Scilly chart covers a slightly smaller area than the English original. Some names are translated, some quaintly eg 'S Clously l'ost'. The 'Echelle d'un Mile Anglais' (4.9cm long) is exactly the same as on the English original. The most notable change is the omission of the two columns headed 'D' and 'M' on the east and west margins and the associated 'latitude' gradations (and numbers), possibly recognition that something was wrong on Collins' original. There is no evidence that Bellin had transferred Collins' ~~plan~~ chart to the Mercator projection of other charts in the 'Neptune'. On some south coast charts in the 1757 edition there are minor revisions, such as the addition of the outline of Devonport dockyard on the Plymouth sheet but no changes have been noted on the chart of Scilly.

plain

[15]. The validity of Verner recording only three 'States' for Plate 20 has been questioned but only States 1 and 2 are relevant here.

[16]. The writer is indebted to Mr B D Thynne, Director of Hydrography, National Maritime Museum, Greenwich, for valuable comments on the scales in Greenville Collins' *'Great Britain's Coasting Pilot'*, which have been especially useful in this discussion on the scale of the Isles of Scilly chart.

[17] The maps of John Norden (1584) were commended for their accuracy by Ravenhill (1972, p 43). His map of the Hundred of Penwith (Fig 1-5) shows Land's End close to its true position and makes no reference to Cowlo (Graham 1966).

CHAPTER TWO
CAPTAIN ROBERT HEATH (1718-1778)
41st Regiment of Foot (Invalids)
(with NICOLAS GINVER)

CHRONOLOGICALLY, THE CHAPTER ON HEATH'S 1744 / 1750 CHART OF THE LATITUDES AND LONGITUDES OF SCILLY SHOULD FOLLOW THAT OF GREENVILLE COLLINS (1689), AS THE SECOND PRINTED 'BENCHMARK' CHART OF THE ISLES OF SCILLY.

IN 1978 AN UNPUBLISHED 1731 CHART BY NICH.^{OS} GINVER, DATED 1731, WITH A UNIQUE LONGITUDE AND LATITUDE 'FRAME' OF THE ISLES OF SCILLY, CAME INTO THE PUBLIC DOMAIN. THE RELATIONSHIP OF THE THREE AUTHORS WAS AN IMPORTANT EPISODE IN THE HISTORY OF THE CHARTING OF SCILLY.

IN THE WRITER'S OPINION THE ONLY SATISFACTORY APPROACH IS TO ACCEPT THAT GINVER'S CHART HAS TWO ROLES, THE FIRST AS ONE OF THE POSSIBLE HYDROGRAPHIC AND TOPOGRAPHIC SOURCES OF HEATH'S CHART AND THE SECOND, ITS CONTRIBUTION TO THE ASTRONOMICAL DATA ON THE ISLES OF SCILLY IN THE FIRST HALF OF THE 18TH CENTURY. CHAPTERS TWO AND THREE THEREFORE REFER TO COLLINS, GINVER AND HEATH. THE CHAPTER TITLES ARE SOMEWHAT ARBITRARY.

Although not specifically headlined, the following are the main propositions discussed in Chapters Two and Three.

1. *HEATH HAD NO KNOWLEDGE OF THE GINVER CHART AND COULD NOT, THEREFORE, HAVE USED ITS LATITUDES AND LONGITUDES. THIS IS UNLIKELY, AS GINVER WAS A GOVERNMENT OFFICIAL, WELL KNOWN IN THE ISLANDS, AS WAS THE POWERFUL ABRAHAM TOVEY, WHO IN TURN WAS CLOSE TO ROBERT HEATH.*
2. *HEATH CONSTRUCTED A GRID DEVELOPED FROM LATITUDE AND LONGITUDE OBSERVATIONS AT A FEW SELECTED SITES (e.g. St Agnes Lighthouse; St. Mary's Castle) UPON WHICH HE THEN PLOTTED HIS OWN SURVEY. CONTRARY TO HIS CLAIMS HEATH ADMITS THAT HIS IS NOT AN ORIGINAL SURVEY.*
3. *HEATH USED GINVER'S 'FRAME' AS THE BASIS OF THE LATITUDES AND LONGITUDES ON HIS OWN CHART. THIS LEAVES UNANSWERED WHO MADE THE ORIGINAL OBSERVATIONS, PRESUMABLY IN THE LATE 1720s. NO QUALIFIED OBSERVER HAS BEEN IDENTIFIED. HEATH (1750) IT MUST BE REMEMBERED, WAS THE FIRST TO DOCUMENT THE ISLANDS IN DETAIL*
4. *THE REFERENCES TO LATITUDE AND LONGITUDE ON THE GINVER CHART WERE TAKEN FROM HEATH'S 1744/50 CHART AND ADDED TO GINVER'S AT A LATER DATE, PRESERVING THE DATE 1731 ON THE CHART. WHAT WOULD BE THE ADVANTAGE OF ADDING 1744/50 DATA TO A 1731 BASE MAP, APART FROM TRYING TO MAKE HEATH'S SMALL SCALE CHART MORE ACCEPTABLE TO MARINERS?*

INTRODUCTION

Captain Robert Heath is best known as the author of the first descriptive book of the Isles of Scilly:- **'... Account of the Islands of Scilly ...and a General Account of Cornwall...'** (1750) [1]. He merits a place in this study as he appears to be the first to record a measured longitude on the Isles of Scilly and his two charts, bound with his book, appear to be the first printed with latitude and longitude graticules.

At first sight William Whiston [2] might seem have prior claim:- **'An exact Trigonometrical Survey of the British Channel from the North Foreland to the Scilly Islands and Cape Clear, SW Ireland. (The River Thames from the Buoy of the Norge to London Bridge.) Performed in the year 1741 and 1742 by John Renshaw under the directions of William Whiston'**. [BL MAPS 1068 (11)]. Published (c1745). RF c1:575 000.

There is an insert (22.1cm x 27.2cm: RF c 1:67 000,) of **'THE / ISLANDS OF / SCILLY / IN LATITUDE 49°- 47'**. This figure is the latitude of Agnes lighthouse on the main chart and contradicts a note on the insert which places Agnes lighthouse in latitude 49° 45' 30" N.

TABLE 2-1

Latitudes: Renshaw [Whiston] (insert 1741- 2, published ?1745) and Heath (compiled 1744, published 1750) compared.

Site	Renshaw [Whiston]	Heath	Modern
St Mary's Hugh (Star Castle)	49° 48' 00" N	49° 54' 44" N	49° 54' 54" N
Agnes lighthouse	49° 45' 30" N	49° 53' 30" N	49° 53' 31"N

TABLE 2-2

Longitudes: Renshaw [Whiston] (main chart compiled1741-2, published ?1745) and Heath (compiled 1744, published 1750) compared; Greenwich prime.

A note on the main chart re. Cape Clear refers to the satellites of Jupiter method of determining longitude, based on the Greenwich meridian.

	Renshaw[Whiston]	Heath	Modern
Agnes lighthouse	7° 15' W	6° 43' 10" W	6° 20' 41" W
St Mary's Hugh [Star Castle]	7° 13' W	6° 41' 30" W	6° 19' 14" W

There is no evidence that Renshaw, unlike Heath, visited the Islands. The inset (possibly based on Collins) lacks a latitude and longitude graticule. Renshaw's latitudes and longitudes were very inaccurate. (Tables 2-1 and 2-2). The primacy of Heath's observations and chart would seem secure.

The following account mainly refers to the years 1737-1750 but as details of Heath's long career and many publications before and after his Army service in the Isles of Scilly have some relevance to this Chapter, and as many have not been previously collated or made public, they are discussed in Appendix B. Heath was an enigmatic figure. Well-known for his ill-temper and social aspirations (Thomas 1985, p 62), he was for 35 years an undistinguished army officer in a very unfashionable regiment. Yet intellectually he was a perceptive and talented mathematician, who published several lengthy books on

astronomy, practical navigation and seamanship, probably stemming from close contacts with pilots, seamen and maritime officials during his Army posting on the Isles of Scilly and the then hazardous voyages between the Islands and the mainland.

According to Army records [3] Heath was born in 1718. In 1737 he joined the staff of the annual '**Ladies' Diary and Woman's Almanac**' (Appendix B) edited by the distinguished surveyor and cartographer Henry Beighton FRS, from whom he undoubtedly assimilated his knowledge of land surveying. Heath's frequent contributions to the 'Diary' always had a strong mathematical/astronomical content. Beighton died in October 1743 and Heath then acted as editor. His military career began when he was commissioned on 28th January 1743 (aged 25) as an Ensign (equivalent to a Second Lieutenant) in one of the Independent Companies of Invalids then forming the Isles of Scilly garrison.

1

THE CHARTS

Of Heath's numerous astronomical and navigational publications (Appendix B) only two are strictly relevant to his charts of the Isles of Scilly; his '**... Account of the Islands of Scilly ... and a General Account of Cornwall...**' (Upnor, 1750) and his *magnum opus* '**Astronomia Accurata...**' (Upnor, 1760).

The two charts are part of a single printed sheet 29.4cm x 38.3cm. (Fig 2-1) (**CHART 2-1**) folded to fit into Heath's 1750 book. It is divided into seven irregular parts which are, clockwise (see below)-: the dedication cartouche ; drawings of Agnes Lighthouse and St Mary's (or Star) Castle [both with latitudes]; titles of the two charts; the Regional Chart; the Isles of Scilly chart, with two sets of Notes. The sheet was published by J R Manby and H S Cox, booksellers, on Ludgate Hill, February 1st 1748/9, a year before the publication of Heath's book on the Islands, but it does not appear to have been sold separately. Both are plain charts.

CARTOUCHE

TO HIS ROYAL HIGHNESS / WILLIAM DUKE OF CUMBERLAND, / CAPTAIN GENERAL OF ALL
HIS / MAJESTY'S FORCES &c / This Plate is *most humbly / dedicated*, by His Royal Highness's /
most dutiful & most obedient Servt. / Robert Heath.

CHART of the ISLES of SCILLY

A New & Correct / DRAUGHT / of the ISLANDS of SCILLY. / according to the latest
Improvement / from an ACTUAL SURVEY, in the Year 1744.

RF scale c 1:84 200.

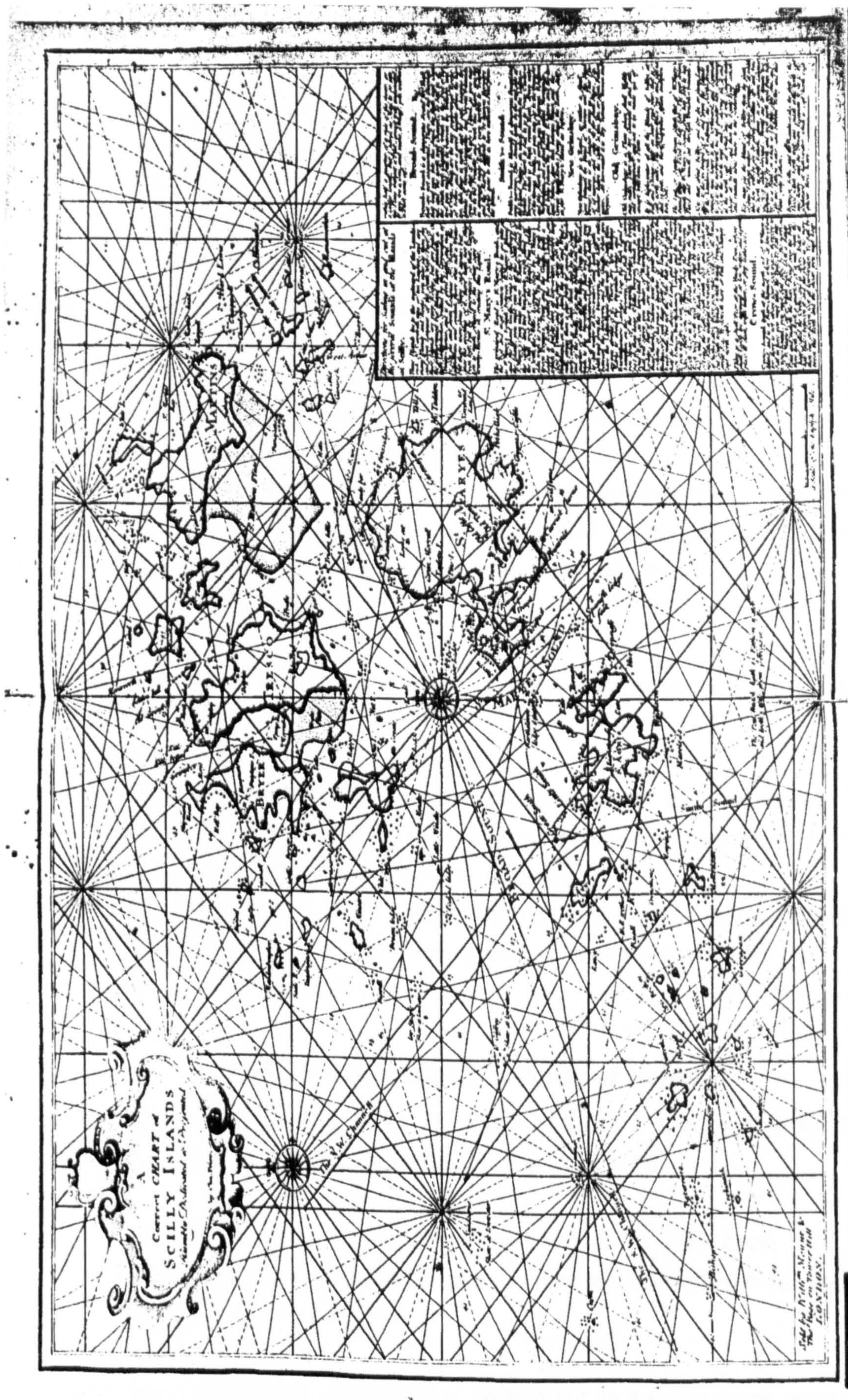


Fig 2-2. Cha. Price. A CORRECT CHART of SCILLY ISLANDS. C 1730.
 © Copyright the British Library. C.26 f 21(3).

THE REGIONAL CHART

A DRAUGHT of the LANDS-END. / Shewing the Bearings & Distances with the / ISLANDS of SCILLY . By Robert Heath.

RF scale c 1:564 000.

To Heath the charts were serious contributions to navigation:- *'That the skillful mariner may be able to sail with greater safety in these dangerous seas, I have here inserted a map, [two charts] by diligent attention to which, he will...avoid...hazards...'* (Heath 1750, p 22).[4] Although a milestone in the Island's cartographic history, Heath's **New and Correct Draught of the Isles of Scilly ...** failed to receive contemporary or subsequent recognition, to the extent of being omitted from the two best known carto-bibliographies of Scilly by Palmer (1963) and Quixley (1966). Palmer's omission was later corrected by Baxter (Palmer, 1967) and the importance of Heath's chart to the geography of the Isles is now acknowledged (Thomas, 1985). It is not really surprising that the chart was unknown to most contemporary navigators:-

- i). It was published in a book devoted to history, local customs and folklore and was not circulated separately.
- ii). Heath was not a recognised hydrographer.
- iii). The charts are in irregular and cramped frames, set in a miscellany of other information which would not commend it to professional seamen. Their respective latitude and longitude scales are easily confused.
- iv). The scale of the chart of the Isles of Scilly was too small in comparison with the much larger scale, popularity and pedigree of Collins' chart of 1689 and later editions, or Price's chart of 1730.

The Chart of the Islands of Scilly

A New & Correct / DRAUGHT / of the ISLANDS of SCILLY. / according to the latest Improvement / from an ACTUAL SURVEY, in the Year 1744.

Heath makes very few direct references to the chart in his 1750 book, apart from the landing place at Hugh Town, St Mary's and to minor locations elsewhere on the Island. There is no reference to its compilation.

The chart's overall dimensions are 19.5cm x 26.3cm but its irregular frame complicates the plotting of the latitude and longitude gradations. The north/south boundaries are approximately 50° 15' N / 59° 30' N, (9.25nm) with a scale of latitude minutes plotted along the left-hand margin only. The east/west boundaries are approximately 6° 32' 30" W / 6° 50' W, (11.2nm) with a scale of longitude minutes along the bottom margin but, because of the irregular shape of the chart, confined to its western half only. It is possible to confuse this

longitude scale with that along the bottom of the adjacent regional chart. This could lead to a serious navigation error. Note 5 on the chart states 'This Survey corrects that of Mr Whiston's of the English Channel about the Lands' End...' Whiston's survey of the English Channel was the only source named by Heath, who pointed out that Whiston had placed the Seven Stones south of Land's End.

Scales on both of Heath's charts have to be assessed with care. A Note in the SW corner of the main chart states:- 'Note, 1 Mile & about a sixth go to a Minute of 1 Degree of Latitude containing 69.5454 miles according to Norwood's Experiment, [5] by which the Errors in all former charts are herein corrected.' In other words, Heath is equating one and one sixth of a statute mile with one nautical mile (or one minute of latitude). The left margin of the chart is graduated in minutes of latitude or nautical miles, each equal to 2.2cm. On the bar-scale, however, one mile is 2.0 cm and so the bar-scale on Heath's main chart is in statute miles (c.f Graeme Spence 1792...). The RF scale is c1:84 200).

The Regional Chart's bar-scale (4.5cm), is 'A scale of Five Leagues.' Usually at sea...the league was taken as three nautical miles.' (Kemp 1990, p 472). This of no great consequence as this chart would never have been used for navigation. These small but confusing scale differences would not have appealed to navigators, given that larger scale charts by Price (1:33 000, 1730) and Collins (1: 32 000, 1738 edition) were available. Gincer (1:31 600, 1731 was an MS chart and possibly not available to Heath. The minutes of longitude along the bottom of the chart are c 0.68 of the latitude miles, Heath being aware of the poleward convergence of meridians.

The Isles of Scilly chart lacks an explanatory key . It plots all the major and minor islands, many off-shore reefs and the extensive 'Flatts' of sands exposed at low tide S W of St Martin's and between Tresco and Bryer. Depths, anchorages, leading lines and the times and directions of tidal streams are also shown. Detail on the Islands is largely confined to castles, churches and some houses, as well as the St Martin's Day Mark and Agnes lighthouse. There are many names (Thomas 1985).

Heath records two latitude and one longitude measurements on the Islands but makes no direct reference to the plotting of the latitude and longitude grids on his two charts. The 1750 book and charts were '*...the Production of my leisure hours, during the Intervals of my [military] Duty.*' (p i.) and during his stay on the Isles of Scilly he employed himself '*...assiduously, in making Observations of all kinds, ...there being no other Account of these Islands now extant...*', (p 22). His sources included the 'Tower Records' [untraced] and MS accounts (p vii). He gathered much original material, drawing extensively *FROM* visits to islands and upon local expertise and earlier surveys. His military duties seem minimal

There are at least two possibilities:-

- 1) Heath constructed a grid developed from latitude and longitude observations at a few selected sites (e.g. St Agnes Lighthouse; St. Mary's Castle) upon which he then plotted his own survey or

2) He copied or adapted existing published (?and MS) charts of Scilly which he adapted to his graticule.

Heath claims to have made his **New & Correct DRAUGHT ... from an ACTUAL SURVEY, in the Year 1744**, yet he also claimed that he only '*...resided twelve months upon the Islands.*' (1750, p xvi.), an unbelievably short time in which to have gathered the detailed accounts of Scillonian life described in his book and also to have carried out the surveys for his chart of the Islands. If true, then the first premise is impossible.

The second premise is supported first, by Heath's admission that his chart was '*... an Improvement and Correction of all the Latest Actual Surveys, [our emphasis] from Latitudes observed by the Author.*' (1750, p 451). Apart from passing references to Whiston, '*...latest actual surveys...*' are not named. Heath also mentions '*Norwood's Experiment, by which the Errors in all former charts are herein corrected.*' [our emphasis]. Given that Heath was at times economical with the truth, to the writer these are two of the most important statements by Heath. He acknowledges the use of existing surveys and that he adjusted them to his latitude [? and longitude] observations. The chart (s) came first, followed by corrections to fit his graticule.

Secondly, Heath was stationed on Scilly for nearly three years, from 28th January 1743 to 9th December 1745, when he was transferred to Upnor Castle on the River Medway, Kent. Heath contributed almost annually to the 'Ladies' Diary...' In the 1746 edition (printed 1745) is an article by Robert Heath, Scilly Islands, near Penzance, Cornwall. A second article by Robt. Heath, Upnor Castle, near Rochester, in Kent appeared in 1746, confirming his transfer to the mainland. [6]. There is a Note dated 1749 on the chart, so its compilation and engraving could not have been completed until then; publication was February 1st 1748/9. Heath, therefore, had plenty of time to make his own survey of Scilly and / or to plagiarise others. To sum up, Heath arrived on Scilly in January 1743, departed in December 1745 and spent the next five years at Upnor writing his book and completing his chart. The second of the above premises then becomes possible. Further comment on the origins of the chart are discussed later. The Regional Chart must have been copied; Heath had no time to survey the Cornish coast.

1

HYDROGRAPHIC AND TOPOGRAPHIC SOURCES OF HEATH'S CHART OF SCILLY

Before establishing that Heath, for his time, was competent to measure and plot a latitude and longitude grid, it is necessary to consider whether he was competent in the arts of land and hydrographic surveying, in order to compile his own chart, as he has claimed, or whether he used existing surveys.

There are no references in his many publications to hydrographic surveying, as opposed to navigation, upon which he wrote at length. However, he was a great friend of Abraham Tovey, Master Gunner of Scilly. Tovey's... *detailed knowledge of the islands, and the channels and sailing marks used for making a safe passage amongst them, made him a recognised authority on the navigation of the area. In 1738 he composed a text on the tides and channels of the Isles...* (Quixley 1966, p.44), being **'A true Description of the Setting of the Tides... in and about the Islands of Scilly, taken by Abraham Tovey'**. This impressive compilation was added to the 1738 and later editions of Greenville Collins' chart. The 1738 version would have been the last before Heath made his survey in 1744. Heath would have been able to learn many hydrographic details from it. Tovey had made an MS plan of the Garrison on the Hugh in 1752 for Lord Godolphin (Baxter 1974, p.4.) and corresponded with Trinity House: 'Letter of 2nd November from Abraham Tovey, Gunner, and Tovey, [Trinity House] 'Collector of Light dues' (LGL TH GCM 4th November 1758). Thomas (1985 p36) notes that Scottish and Irish master gunners and garrison sergeants married, stayed on Scilly and 'put down roots'. Tovey may have done the same.

Land surveying is not recorded as a part of Heath's military training or duties. Heath's knowledge of land surveying almost certainly stems from the years 1737-43 (prior to his joining the army) when he assisted Henry Beighton (1668-1743), owner of the **'Ladies' Diary and Woman's Almanac'**. Beighton was an eminent land surveyor and engineer, whose surveys had *'...few equals for elegance and accuracy...'*. He was made FRS in 1720. His one-inch map of Warwickshire (1725) was the first county map to be based upon a trigonometrical survey (Rodger 1960, pp vi and 24). *'He measured with both chain and compass and set down the medium scale'* and in 1723 he designed a new plane table (Taylor 1966, p 9). Given his mathematical expertise, the industrious Heath would soon have mastered the measurement of latitude and principles of land surveying under the guidance of his friend and editor.

Heath's grid was probably based on a framework of numerous latitude and longitude observations (*infra*), with some trigonometrical surveying (no doubt learned from Beighton). The instruments he used are not noted; in particular he fails to record the size or make of his quadrant. Heath was well acquainted with the manufacture and sale of scientific instruments and appointed a member of the Coles family of instrument makers as the executor of his Will (PRO PROB 11/1049 fol. 108) [7] and it is possible that he used a Hadley quadrant made by them. To conclude: Heath had the expertise to construct a grid upon which to plot an original map/chart, using his knowledge of land surveying. His knowledge of hydrographic surveying, however, was minimal and the hydrographic data on his chart must have come from existing sources.

HEATH'S CARTOGRAPHIC SOURCES

Support for the originality of Heath's chart comes from no less an authority than E G R Taylor. It *'... owed nothing to, and was a great improvement upon, Collins' chart of 1693.'* (Taylor 1954). Baxter (1966) was a well-known local authority on the Isles of Scilly and

claimed that Heath's chart was '*... not based on Collins and is valuable for the additional place-names it contains*'. At this point the following is worth repeating:

Surprisingly, Heath's admission that his chart was '*... an Improvement and Correction of all the Latest Actual Surveys, [our emphasis] from Latitudes observed by the Author.*' (1750, p 451). Apart from passing references to Whiston, '*...latest actual surveys...*' are not named. Heath also mentions '*Norwood's Experiment, by which the Errors in all former charts are herein corrected.*' [our emphasis]. Given that Heath was at times economical with the truth, to the writer these are two of the most important statements by Heath. He acknowledges the use of existing surveys and that he adjusted them to his latitude [? and longitude] observations. The chart (s) came first, followed by corrections to fit his graticule.

The writer hesitates to question such an authority as EGR Taylor but, with possibly three charts dedicated to the Isles of Scilly available to him, the theory that Heath started *de novo* loses much of its credibility. In his three years on Scilly Heath must have travelled extensively; he recorded many more place names than any of his other possible sources (Thomas 1985) and had ample opportunities to make his 'corrections' .

Plagiarism was routine in the 18th century. Heath must have seen printed charts by Collins (editions 1689-1738) and Price (1730). Given his close contacts with Abraham Tovey he may have seen the MS chart by Gincer (1731) and less likely, given his military background, he may have been shown Lilly's 1715 MS map of Scilly [8]. With such range of choices it is, in the writer's opinion, almost impossible to say which chart or charts were the basis of Heath's 1644 'corrected' chart of the Isles of Scilly. Pace Taylor, it could be argued that Collins' chart was the 'core' chart, probably the 1738 edition, as the wreck of Sir Cloudesley Shovell is plotted. The bearings and distances on Heath's chart from, say, Star Castle to major features such as the Bishop Rock, Bryer, St. Martin's Head etc. are identical to those on Collins' chart.

TABLE 2-3
(Statute miles)

	Heath	Collins
Star Castle – Bishop Rock	6.6	6.7
Star Castle – St Martin's Head	4.2	4.4
Star Castle – Cromwell's Castle	3.4	3.4

The leading lines are almost the same on the two charts, as are the positioning of names such as NW Channel and SW Channel. As regards depths and anchorages, in many cases Heath's are the same as Collins'. Given the Islands' dependence on pilotage, providing a safe haven for shipping, copies of Collins' chart must have been available to at least the leading local pilots and officials and the inquisitive Heath would certainly have seen them. The coastlines of the main islands are similar on Collins (1723), Lilly (1715), Price (1730), Gincer (1731) and Heath (1744/50).

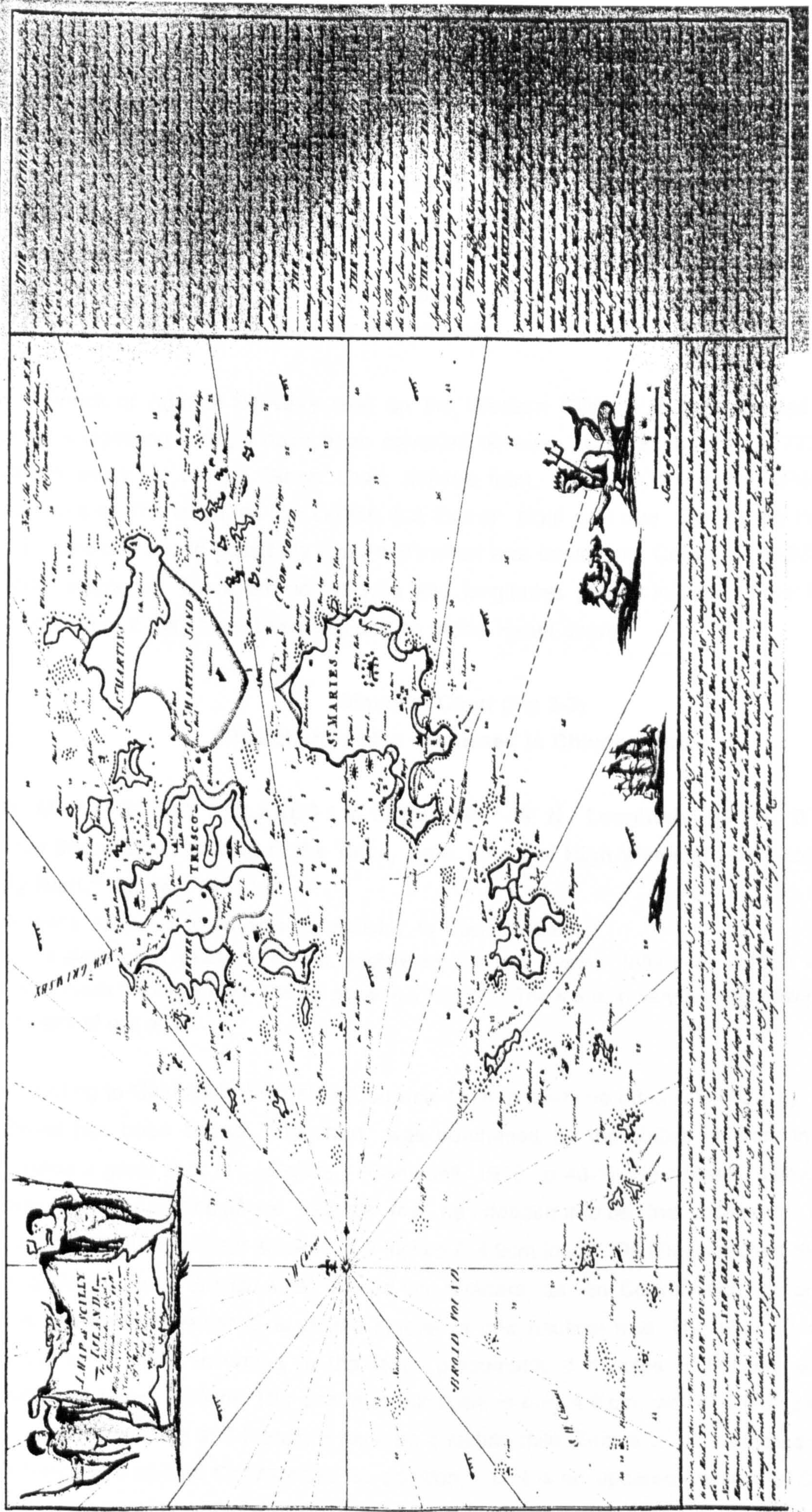


Fig 2-3 N. Gincer. A MAP OF SCILLY ISLANDS. 1731.
 By permission of the British Library. ADD 60393 D.

Price's chart (Fig 2-2)

A / CORRECT CHART OF / SCILLY ISLANDS / Humbly dedicated & presented / by Cha. PRICE' published c 1730

The overall size is c 45.8 cm x c 57.7cm, including a panel on the right '*Description for sailing in and out of the Several Soundings at the Islands of Scilly*'. These are clearly Sailing Directions, whereas Ginver's text is more of a geographical account. The bar scale 'A Scale of one English Mile', c 4.8cm long and divided into quarters, is the same as that on Collins and Ginver. The RF scale is c 1: 33 000. The chart being based closely on Collins, it may be presumed that the miles are statute miles

The wreck of Admiral Shovell's fleet on the Western Gilstone is not recorded on Price's chart, suggesting it might have been compiled between Collins' 1689 and 1723 editions, as the wreck is on the Ginver chart, derived from Collins' 1723 edition. Price has two windmills on The Hugh, as has Collins, but Ginver plots only one. Comparing Figs 2-1 and 2-2, there is a strong possibility that Price's chart was based on Collins' 1689/93 chart but better engraved. There are no latitudes and longitudes and its inclusion here is simply to indicate that it may have been one source of the Heath chart.

Ginver's Chart (Fig 2-3)

(This chart is also discussed in Chapter Three)

'A MAP of SCILLY / ISLANDS / in Latitude 49° 56' N / Longitude 06° 44' W / With the True Soundings / Setting of the Tides, and time / of High Water at Full / and Change / By Nich.^{os} Ginver 1731.'

(Ginver's 1731 MS chart was not available to Taylor or Baxter).

FLAM It is a ~~plane~~ chart c42cm x c55cm, slightly smaller than Collins' 1689 chart (c45cm x 57cm) and covers much the same area. The RF scale is c 1:31 600. The MS is in very good condition and shows no signs of use at sea.

According to Campbell (Weinreb & Douwma 1978, p 40-1) no other MS chart by a Nicholas Ginver has been traced. The chart was purchased by the British Library in 1978. It '*...owes a great debt to ... Collins.*' (Campbell, 1978, p 40-1). He notes: '*Ginver uses the same scale as Collins (if we assume that he intended it to be two inches to the mile)...*'. [on both charts the linear scale is 1.9 inches / 4.9cm long]. On Ginver's chart the bar scale is a '*Scale of one English Mile*', divided into quarters as on Collins' and, as on the latter, it is not stated whether it is of one statute or one nautical mile. The chart is 42 cm N-S, equal to 8 miles according to the text, presumably 8 minutes of latitude, each minute therefore being 5.25cm. The one mile bar-scale is only 4.9cm, well short of the length of one latitude minute and therefore must be a statute mile. This is to be expected if the chart is basically a revised Collins chart. In addition, as it is an updated version of Collins' chart **BE** the '*English Mile*' is ~~is~~ must be a statute mile. As Ginver's chart lacks latitude gradations, it does not repeat Collins' confusion between latitude gradations and the linear scale of English Miles.



Fig 2-4a Star Castle, St Mary's, Scilly. 880107
 © Gibsons of Scilly.



Fig 2-4b The Lighthouse, St Agnes. 880082
 © Gibsons of Scilly

Campbell (1978) notes that Ginver corrects some of Collins' errors in plotting the very dangerous SW rocks of Scilly but Heath ignores them and copies Collins. On Collins' 1723 chart the loss of Sir Cloudesley Shovel near the west Gilstone has been added; Ginver places the wreck further east; Heath reverts to the Collins' version, naming the Gilstone. Heath's shoals off Bryer, Tresco and St Martin's and tidal flow arrows SE of St Mary's are taken from Ginver. On St Martin's, Collins omits the land mark (built 1683) and shows the chapel only; Ginver has the land mark and the inland church; Heath, who must have wandered all over the Islands, has all three. Collins has little landward detail on St. Mary's. For example, Ginver plots (but does not name) a large house in the east surrounded by trees. Heath has a similar but improved representation and adds the name 'Mr. Crudge's'. Collins omits it. Ginver's 1731 MS chart is an up-dated version of Collins' 1689 and 1723/28 editions and would have been invaluable to Heath, especially as its existence was not widely known. Heath never mentions this family in his 1750 book, in contrast to many references to Abraham Tovey.

Ginver's chart and text note that the two windmills on the Hugh had lost their sails since Collins' initial 1689 survey, evidence that Ginver's 1731 MS chart is an up-dated version of Collins' chart of 1723. Ginver's MS chart, with its invaluable specific sailing directions, could have been engraved and published without any further changes. Possibly it was thought at the time that it could not compete with Collins' 1723 chart.

Although Campbell has pointed out the similarities between Collins and Ginver, even a brief examination shows that the information on the Ginver chart is sparse compared with that of Collins' and Heath. Heath's chart has more in common with Collins' and Price but the latter was probably published too late to be of use to Ginver. Ginvers' MS chart may well have been compiled and kept as a family secret, given the importance of knowing the detailed hydrography of the Isles of Scilly for pilots competing for the guidance of vessels into or through the archipelago, plus the activities of the collectors of dues. Being an updated version of Collins' chart, it is probable, but no more, that Heath had access to it.

11

HEATH'S LATITUDES on the ISLES OF SCILLY CHART

In the second (and longer) part of the 1750 book (Cornwall), Heath devotes several pages (pp 447-9) to criticisms of contemporary land surveys and surveyors of the county. These reveal that he was well acquainted with the methods and instruments used. He discusses the measurement of distances and points out that those measured by the wheel follow every rise and fall, whereas the use of the chain can avoid this '*...since 'tis not the several curved Surfaces, but the single Plane one, of any Territory, that we seek.*' (1750, p 448). He goes on to argue that the only safe method of surveying hilly country is

not to rely solely on wheel or chain, which surveys often '*...pretend...*' to measure base [i.e. the horizontal] but to observe the latitude of the hills and headlands. (*Practical Rules for finding the Latitude of a place...* 'Heath 1760, p 316). He advises using a large instrument [quadrant], duly allowing for refraction, parallax etc. in taking the sun's altitude, besides allowing for the variable declination, '*... by which means, allowing 69 1/2 Miles [Statute] to a Degree Difference of Latitude ... your distances (before a kind of dead-reckoning) will now be duly corrected, and the true Positions of Places ascertained.*' (Heath 1750, p 448).

This is an important comment, as it indicates how Heath constructed the latitude part of the graticules for his charts. Heath emphasises (1750, p 448) that Beighton in his trigonometrical survey of Warwickshire used an '*...Instrument [quadrant] of Six feet Radius...*' and he criticises Martyn's measurement of the latitude of the Lizard Point (49° 49' N), which differed from that of the great Halley (49° 55' N) by 6', pointing out that Martyn used a Hadley Quadrant of only two foot radius.

Heath was aware that the published latitudes of the Isles of Scilly showed little improvement since the days of Greenville Collins (1689): some sea charts laid down the latitude of the Lizard Point and Land's End as 10 nm /18.5 km north of the true latitude. Other charts placed Agnes lighthouse north of 50° N. and even north of 50° 10'N. Heath's claim '*... which mistake is here corrected in my new draft of these Seas and Islands.*' (1750, p 159) was fully justified (Table 2-3). Referring to two important sites on the Isles of Scilly, '*The Latitude of St Mary's Island [Star Castle] was... observed to be 49° 55' and that of the Light House Island [Agnes] 49° 53' 30"* (Table 2-3). '*The Lizard Point and St Mary's Island I then found to be nearly in the same parallel of latitude.*' (Heath 1750, p.159). These seem to be basic observations which could then have been extended over the Islands as part of the graticule. From the information given in his section on Cornwall in the 1750 book it may be presumed that he used a quadrant of 5 ft radius.

There are small discrepancies between the latitudes for St Mary's Castle and Agnes Lighthouse in the text and illustrations on the title sheet, and those taken from his chart of Scilly.

TABLE 2-4
Heath's Latitudes compared

	Text / illustration	chart of Scilly
Star Castle	49° 55' 00" N	49° 54' 44" N
Agnes lighthouse	49° 53' 30" N	49° 53' 20" N

These small differences may have been drafting errors. Of the two, the text latitudes are closer to the modern values and it may be that these were more carefully measured than others, scattered across the archipelago, used to plot the graticule.

Heath was realistic about the attainable standards of latitude accuracy. Two observers taking the Sun's altitude at noon, with a '*...good Quadrant of Reflection..., well rectified, should differ by only 3 or 4 minutes of a degree [3-4 nautical miles] when the greatest care is taken, and from 5 to 8 minutes of a degree even in rough weather.*' He avoids quoting the probable attainable minimum error and does not say how many latitude observations he himself made on the Isles of Scilly to plot his graticule (1760, pp 406-7).

TABLE 2-5
Heath resolved the latitude problem to high degree of accuracy
 [+ = northward displacement; - = southward displacement]

	Heath (chart)	Modern	Error
St Martin's Head	49° 58' 00" N	49° 57' 58" N	+2" / 0.03nm / 0.06km
Star Castle	49° 54' 44" N	49° 54' 54" N	-10" / 0.17nm / 0.31km
Agnes lighthouse	49° 53' 20" N	49° 53' 31" N	-11" /? 0.18nm / 0.34km
The Bishop Rock	49° 53' 15" N	49° 52' 20" N	-5" / 0.08nm / 0.15km

Heath has not received due credit for his work. The true latitudes of the Isles of Scilly should have been settled by Heath's observations, but as his efforts were not widely publicised and the c10nm northerly displacement of the Islands persisted on charts and in Sailing Directions for some years (c.f. Spence, Chapter 4).

Officialdom was slow to acknowledge Heath's accurate measurement of latitudes. As regards official nautical almanacs, the earliest reference to the Isles of Scilly is in the '**Connaissance des Temps**' for 1779, which ignores Heath's longitude published 27 years earlier:-

TABLE 2-6
The earliest reference to the Latitude of FANAL DE STE AGNES

Connaissance des Temps 1779	Heath	Modern
49° 58' 0" N	49° 53' 20" N	49° 53' 31" N

The Isles of Scilly first appear in the British 'Nautical Almanac' in 1781:- "**Tables Requisite to be used with the Nautical Ephemeris for finding Latitude and Longitude**". 2nd Ed 1781, Table XX pp 153-65 (Table 2-7).

TABLE 2-7
Latitude of St. Agnes (Lights): [also separately listed as Scilly Isles (Lights)]:-

Nautical Almanac 1781	Heath	Modern
49° 56' 0" N	49° 53' 20" N	49° 53' 31" N

III

HEATH'S LONGITUDES of the ISLES OF SCILLY CHART

There were two main methods of measuring longitude on land at this time, the 'Lunar Distance' or 'Lunars' and the 'Eclipses of the Satellites of Jupiter'. Descriptions of both methods are readily available (Aked, 1974; Cotter, 1968; Kemp, 1990; Williams, 1992; Howse, 1997 Appendix 1; a more popular account is in Sobel and Andrewes, 1999) and only the briefest summaries are given below.

The moon [9] moves relatively rapidly across the sky in relation to the fixed stars and the angular distance between them and the moon can be measured. Tables can be prepared which give the predicted time of a lunar distance for a standard meridian. The difference in time can then be converted in degrees, minutes and seconds of arc and the longitude from the prime meridian computed. Adequate tables were available in 1725 by Mayer of Gottingen and theoretically the lunar distance method could have been used to measure the longitudes of the Isles of Scilly in 1731. The method was very demanding mathematically and led to many errors. It is said that it could take a skilled observer four hours to complete the calculations and still be only correct to within 20 miles.

The alternative method stems from the observations of Galileo, who realised in 1710 that the eclipses of the satellites of Jupiter (which occurred some 1000 times a year) offered a natural celestial clock which could solve the longitude problem. Some of the first detailed observations were by Giovanni Domenico Cassini (1625-1714) and by 1668/9 he had completed tables for the Paris observatory, published in the *Connaisance de Temps* in 1690, and by 1700 the longitude of many places in the world was known relative to the meridian of the Paris observatory. In 1694 ~~of~~ **'New and Exact Tables for the Eclipses of the First Satellite of Jupiter reduced to the Julian Stile and the Meridian of London'** (Philosophical Transaction of the Royal Society 1694, pp 237-256) ^{WERE PUBLISHED} Internal evidence shows that the 'Meridian of London' was St Paul's Cathedral. The Tables were for the skillful and **'...not to be undertaken by the less knowing'**.

The largest satellite is hidden behind Jupiter for only $1\frac{3}{4}$ hours. An eclipse will occur at ~~at~~ ^{THE} same moment to any observer, irrespective of his position on earth. So if observations ~~at~~ ^{WERE MADE} AT Portsmouth and Jamaica according to each local time, the difference between these two ~~times~~ ^{THE} times would be ~~the~~ ^{the} same as ~~the~~ ^{the} longitude difference between the two places. It could show an error of 30 miles, partly because the satellites emerge slowly from ~~the~~ ^{the} shadow of Jupiter ~~the~~ ^{so} ~~so~~ ^{exact} ~~THE~~ ^{THE} time of immersion or emersion is ~~a~~ ^{THE} matter of judgement by ~~an~~ ^{THE} observer. It becomes more difficult if visibility is limited or the magnification of the two observing telescopes is not identical (Quill 1966 p 87).

By 1731, therefore, tables and instruments were available for the measurement of the longitudes of the Isles of Scilly from the meridians of Paris and London by either of the

above methods. Clearly only experts could measure longitude. Heath tried to win the prize for determining longitude at sea (Board of Longitude, 1714; Quill 1966, Chapter One) by preparing his own astronomical tables. Obtaining longitude by observing the eclipses of the satellites of Jupiter required a good telescope, a good quadrant to measure angular positions and some means of knowing the time of the necessarily night time observation. Heath makes no reference to any of these.

Cotter (1968, p187) notes: *'The long telescope required for the observation [of the satellites] would be almost unmanageable at sea.'* A portable telescope would be essential for observers such as Heath and Whiston, working far from the main observatories. The Curator of Astronomy at the Greenwich Royal Observatory (pers comm) has suggested that the type telescope most likely to have been used in the mid 18th century by observers such as Heath would have been portable refractors.e.g. one by James Short of London (c 1738-1768). It is an Astronomical Reflector, a portable telescope, length with eyepiece 52.5cm, mounted on three collapsible legs and accommodated in a box 59cm long; another also by James Short, 70.7cm long with the larger eyepiece, and mounted on collapsible legs. When dismantled it fitted into a box 68.5cm long. Robert Heath would have had no problems in conveying either of these to the Isles of Scilly. Robert Heath certainly had the mathematical expertise to measure longitude. Taylor (1966, p 180) notes that Heath had read critically all the major longitude publications of his day. He would have had access to Whiston's tables and other astronomical ephemerides were commercially available.

Determining local noon would have been no problem for Heath, being obtained in the course of fixing latitude with a quadrant. To use the satellites of Jupiter method, Heath needed to know the times of his observations but he does not explain how he obtained it. It was necessary to record the time of an eclipse of a Jupiter satellite to a second or less. John Harrison had made his first pendulum clock in 1713 and by the 1720s was making long case clocks to an accuracy of one second a month. Such accurate clocks were to be found initially at the great observatories but in Heath's time there may well have been one in the military base at Star Castle, St Mary's, cared for by the redoubtable Abraham Tovey (Chapter Three). Having determined local noon with a good quadrant, Heath may have set a pendulum clock to this time and after nightfall used the latter to time his observations of the eclipses of the Jupiter satellites. Trinity House considered a clock as an essential item in its lighthouses. On 5th. February 1686 Trinity House wrote to Thomas Elkins (1635-1705), resident steward for the Godolphin family, accepting the repair of the [Agnes] lighthouse [? pendulum] clock at a cost of 6 shillings. (LGL Ms p30 048 v.1. 1685-9; Trinity House letters).

Heath's recorded longitude measurement on Scilly is '*An eclipse of the Satellites of Jupiter was observed at Scilly [not located] which being also observed at Greenwich, the Difference of Time betwixt the two meridians was found to be 26' 40" which being turned into degrees (by allowing 360 to 24 Hours) gives 6° 40' for the difference of longitude between Greenwich and Scilly.*' (Table 2-9).

Unfortunately he does not say which satellite(s) were observed or where or when the observation was made. The accuracy of his measurement must be questioned as it was normal to make a number of observations, rather than just one (William Whiston, of whom Heath had a low opinion), has this Note on his (?)1745 chart:- '*NB. The Longitude of Cape Clear was found by several eclipses of Jupiter's Satellites to be 45 minutes or 11° 15' from the Meridian of Greenwich. The Latitude of Cape Clear is 51°.*'

So Heath was not alone in determining the longitudes of distant parts of the kingdom in the mid 18th century. When Heath was on Scilly, the first edition of the British Nautical Almanac with its astronomical tables was still 25 years away and Heath criticised the contemporary secrecy and non-publication of all the observations held at the Greenwich Observatory (1760, preface). He was '*... beholden to foreign Observations more than those made at Home*' (1760, p.1), most probably having to use those in the French '*Connaissance des Temps*', first published in 1679 by the Bureau des longitudes '*... l'usage des astronomes et des navigateurs....*' The Tables were published one or two years in advance. The prime meridian was of course the Paris Observatory. He drew attention to the unsatisfactory state of published tables when converting French longitudes to the Greenwich prime meridian.

TABLE 2-8
Connaissance des Temps / London

Year	Paris	Greenwich	Londres (St Paul's)
1715/16	-	-	2° 28' W
1722 / 23	-	-	2° 25' 15" W
1748	-	2° 17' 30" W	2° 25' 15" W

The 1722 / 23 figure would have been available to Heath. Halley's Paris/Greenwich longitude difference was 2° 20' and that of de la Caille, 2° 10'. Heath's text (1750, p 157) makes it clear that the longitude of 6° 40' W for the unspecified Scilly site was measured using the Greenwich Observatory as the prime meridian. In all his astronomical and navigational writings, he stressed the importance of using Greenwich. As they are specifically mentioned, Heath presumably used Halley or de la Caille. The 1749/50 edition of the *Connaissance des Temps* placed Londres (St Paul's) 7' 45" west of Greenwich (modern 5').

Heath's description of his unlocated longitude observation (*supra*) is followed by:- *'The Latitude of St Mary's Island was then observed to be 49° 55' and that of the Light House Island [Agnes] 49° 53' 30"'* In the writer's opinion the juxtaposition of the description of the measurement of longitude west of Greenwich and the naming of the sites of the two latitude measurements, strongly suggests that the longitude observation may have been either on St Mary's (the latitude in Heath's note is that of Star Castle) or Agnes Lighthouse. Agnes lighthouse is known to have had a clock, which could have been used for the longitude observations. Star Castle was the military headquarters and almost certainly would also have had its own clock. Measured on Heath's Isles of Scilly chart, the longitude of Star Castle is 6° 41' 20" W but Agnes Lighthouse is 6° 43' W. The observed longitude was 6° 40' W, which in the writer's opinion, favours it being measured at Star Castle

The wording *'... also observed at Greenwich...'*, indicates that, for this observation at least, Heath had access to tables predicting the eclipses of Jupiter's moons at the Greenwich Observatory. He may have left Scilly briefly during his three year posting and compared his observations with those at Greenwich. More probably, he waited to work on the data until he was settled at Upnor Castle (1745) and within reach of tables of eclipses held at Greenwich observatory, as the publication of his book and chart of Scilly was not until 1750.

Heath was to some extent a pioneer in using Greenwich Observatory as his prime meridian for his single observation although Whiston (1741/2) had also used Greenwich as his prime meridian. 'London', *i.e.* the dome of St Paul's Cathedral, had for some time been the choice for a prime meridian in Britain (*e.g.* Seller, 1676) to replace Ferro. Heath had criticised Parliament's failure to press for Greenwich as a universal prime meridian (1760, p 335). The Board of Longitude had, after all, been set up in 1714.

There is, however, an inconsistency on Heath's charts. Below the longitude scale on the regional chart (Fig 2-1) (**CHART 2-1**) is the statement: *'Longitude from London.'* This clearly applies to both charts as the longitude of say, Star Castle, is the same on both. Is it conceivable that Heath, a man of science and a supporter of Greenwich as the British prime meridian, would have published a measured longitude based on the Greenwich prime but used the London (St Paul's) prime for his charts? Heath placed St Paul's Cathedral dome 5' W of the Greenwich meridian (1760 p 1). If the former were the prime meridian for the charts, his measured longitude of 6° 40' 20" W Greenwich would become 6° 35' 20" W of London (St Paul's). When plotted on his charts, assuming a 'London' prime, the meridian passes through the seas to the extreme east of the archipelago, close to the little island of Menawethen, an unlikely site for an observation of some importance.

If it is assumed that the charts' prime meridian is Greenwich, the measured meridian, 6° 40' 20" W, lies across St Mary's Island, close to a lookout hut in the north and Old Town in the south. Neither site is in itself navigationally or astronomical significant but this meridian is only 1' 20" (c 0.8nm) east of the important Star Castle (known to have been used for a

latitude observation) and conceivably incorrectly measured as 6° 40' W instead of 6° 41' 20" W. If the above arguments are accepted, then 1748 / 9 the longitudes on Heath's two charts of the Isles of Scilly, surveyed 1744, dated and published 1750, were the first to be based on the Greenwich Observatory as the prime meridian. The reference to 'London' on the charts may be an error introduced by an engraver unfamiliar with the name 'Greenwich' as a prime meridian.

Heath has not been given credit for his early use of Greenwich Observatory as a prime meridian for longitudes on Scilly. Founded in 1675, the Observatory did not come into general use as the National Prime Meridian until the publication of the first British Nautical Almanac in 1767, and not internationally until 1884. Being more of an astronomer than a cartographer Heath may have instinctively preferred Greenwich Observatory to St Paul's Cathedral.

Heath was far less accurate in his measurement of longitude than of latitude. The 'Satellites of Jupiter' method of determining longitude is complex and errors can easily arise. Heath placed the Isles of Scilly on average 22' 30" of arc too far west. This can arise from only a 1.5 minutes error in the calculated time difference between two meridians, which puts Heath's errors into perspective. Surprisingly, his average error is larger than that estimated from Collins' charts based upon dead reckoning from Land's End.

Heath admits that large errors were accepted in the mid 18th century, the result of inadequate instruments and astronomical tables. Referring to the lunar distance method, *'...in a great number of cases when an Error of near 15 minutes of a degree in the Star's Altitude, will not make 1 Minute Error of Time in the Hour Angle, that we seek; and consequently not above 15 minutes of a Degree Error in the Longitude or 5 or 6 English Leagues.'* (1760, p 407).

Heath is here equating a minute of longitude with a nautical mile, true only at the equator. In the latitude of Scilly an error of 15 minutes of longitude would be about 10nm. Table 2-8 lists his longitude errors for Scilly. He does not record the number of observations taken to plot the longitude graticule for his chart of Scilly and also ignores earlier attempts to measure the longitude of the Islands. (c.f. Giver's MS chart of 1731, Chapter Three). In the case of the Cassini method, a 15 minute of time error at each point of observation could produce an error of 3° 15' of arc

TABLE 2-9
Longitude errors on Heath's 1744 chart (Greenwich prime)

(error based upon 1 degree longitude = 38.69nm at 50° N latitude)
+ = westerly displacement

	Heath	Modern	Error
St Martin's Head	6° 37' 40" W	6° 15' 57" W	+21' 43" / 14.0nm / 25.9km
Star Castle	6° 41' 30" W	6° 19' 14" W	+22' 16" / 14.4nm / 26.7km
Agnes lighthouse	6° 43' 10" W	6° 20' 41" W	+22' 29" / 14.4nm / 26.7km
The Bishop Rock	6° 50' 10" W	6° 26' 41" W	+23' 29" / 15.0nm / 27.8km

That there was much uncertainty in the 18th century about the choice of prime meridian is demonstrated by Gascoyne's important one inch to a mile map of Cornwall (1700; reprinted 1730). It has a large inset of Scilly (2x14in; 30.5 x 35cm) based on Greenville Collins' survey but, as on the main map, it omits longitudes "...perhaps because of confusion over the correct prime meridian..." (Quixley 1966, p 32). Possibly for the same reason, as late as 1779, the important chart by Tovey and Ginver (Chapter Three) of 'The Islands of Scilly' (19¹/₄ x 25in; 49.5 x 63.5cm) omits all longitudes.

That Heath's measurements on Scilly were even recently ignored is shown by Palmer (1963, p 12 and Plate VIII), who states that Cary's small (2¹/₂ x 3¹/₄ in; 6.4 x 8.3cm) 1794 map of Scilly (part of Cary's large scale map of England and Wales) is '*... Important in that it is the first to adopt the meridian of Greenwich in substitution for St. Paul's London. (Table 2-10)*'

This may be the first map to have *Longit. W. from Greenwich* printed on it. The source of the longitude measurement is not given.

TABLE 2-10
Cary 1794 map of Scilly (Palmer 1963, p 12 and Plate VIII).

'Longit. W. from Greenwich' is printed on the map.

	Cary	Heath	Modern
Star Castle	6° 44' 00" W	6° 41' 30" W	6° 19' 14"

As regards official nautical almanacs, the earliest reference to the Isles of Scilly (Fanal de St Agnes) is in the "**Connaissance des Temps**" for 1779 (published 1777). It placed the Agnes lighthouse 9° 33' W of Paris, Greenwich 2° 19' W of Paris and, therefore, the lighthouse 7° 14' W of Greenwich, compared with Heath's figure of 6° 43' 10" W, published 27 years earlier. The modern distance is 6° 19' 14" W.

The Isles of Scilly first appear in the **British Nautical Almanac** in 1781:- "**Tables Requisite to be used with the Nautical Ephemeris for finding Latitude and Longitude**". 2nd. Ed. 1781 Table XX pp.153-65. It gives the longitude of St. Agnes lights [also separately listed as Scilly Isles (Lights)] as 6° 46' W of Greenwich, (Heath 6° 42' 10" W of Greenwich; modern 6° 19' 14" W. The Tables also list St Mary's (Isle) [site unspecified] as in longitude 6° 43' W. [10]

IV

THE REGIONAL CHART

"ALSO / A DRAUGHT of the LANDS-END. / Shewing the Bearings & Distances with the / ISLANDS of SCILLY . By Robert Heath." (Fig 2-1) (**CHART 2-1**)

The overall dimensions of the irregular frame of this chart, Lands End and the Islands of Scilly, are 12.2cm x 22.4cm. Its boundaries are approximately 49° 48' 30"N / 50° 25' N

and $5^{\circ} 19' W / 6^{\circ} 55' W$. The latitude, 5' gradations, is plotted only along the eastern margin and continues inexplicably into the chart titles. There is a risk that it could be confused with the latitude gradations on the west margin of the Isles of Scilly chart. The longitude gradations, 5' intervals, are along the south margin only and can mistakenly be assumed to continue into the longitude scale of the Isles of Scilly chart. Measurements on the chart show that in the latitude of Scilly, 1' of longitude is c 0.68 of 1' of latitude (as on the main chart).

The scale on the right margin of the chart is graduated in 5 minutes of latitude, 60 minutes to a degree and that along the south of the chart is in 5 minutes of longitude, each minute c 0.68 of a minute of latitude. The linear scale of 4.5cm represents Five Leagues; a league is generally accepted as one nautical mile (Kemp 1976, p 772), so the scale of 4.5 cm represents 15nm (or $1\text{cm}=3.3\text{nm}$). On the latitude scale 5cm equals 15 minutes or nautical miles.(or $1\text{cm}=3.0\text{nm}$). Given that a league is a nautical measurement, it is accepted that this is the scale of the regional Chart. The RF scale is c 1:564 000.

There is no explanatory key. The small scale of course limits the detail that can be shown. The Isles of Scilly are rather crudely plotted, with little detail but the main islands are named. There are three references to tidal streams. There is little hydrographic detail around the mainland coast apart from some depths, reefs and one reference to the nature of the seabed. A number of headlands and inland settlements in west Cornwall are named.

Heath's latitudes and longitudes for the Isles of Scilly on this chart are comparable to those on his main chart.

This chart is on a much smaller scale than that of Scilly and is almost certainly derived from published charts and not from Heath's own surveys: no sources are acknowledged. There is no evidence that the coast of the west Cornwall peninsula on this chart was surveyed by Heath, although he did correct Whiston's chart around Land's End, possibly using the relevant sheet of Gascoyne's one inch to one mile map (1700). The latitude of the Lizard is the same as Halley's and may have been copied from him. One important correction is that, unlike Whiston, Heath names Land's End and plots it as the most westerly part of the Cornish peninsula; Whiston names Cape Cornwall as the most westerly headland.

TABLE 2-11

Latitude

— = southward displacement

	Heath	Modern	Error
Star Castle	$49^{\circ} 54' N$	$49^{\circ} 54' 54'' N$	-0.54" / 0.9nm / 1.7km
Land's End	$50^{\circ} 2'30'' N$	$50^{\circ} 4' N$	-1'30" / 1.5nm / 2.8km
Lizard	$49^{\circ} 55' N$	$49^{\circ} 57' 24'' N$	-2'24" / 2.4nm / 4.4km

TABLE 2-12
Longitude
 (Greenwich Prime)
 [error based upon 1 degree longitude = 38.69nm at 50°N latitude.]
 + = westward displacement

	Heath	Modern	Error
Star Castle	6° 40' 20" W	6° 19' 14" W	+21' 6" / 13.6nm / 25.2km
Land's End	6° 1' W	5° 43' W	+18' / 11.5nm / 21.3km
Lizard	5° 27' 30" W	5° 12' W	+15' 30" / 9.9nm / 18.4km

The Isles of Scilly errors are comparable to those on Heath's main chart. The distance between the Land's End and St Mary's Castle, according to the bar scale, is c 27nm/ 50km. In comparison, Collins' distance is c 31nm/ c.57km and the modern distance c 25nm/c.46km.

The following tables compare the positions of Cape Cornwall and the Lizard on Whiston's main chart with Heath's regional chart.

TABLE 2-13
Latitudes

	Whiston	Heath	Modern
Lizard	49° 47' N	49° 55' N	49° 57' 45" N
Cape Cornwall	50° 4' 30" N	50° 5' N	50° 7' 30" N

TABLE 2-14
Longitudes (Greenwich meridian)

	Whiston	Heath	Modern
Lizard	5° 42' 00" W	5° 23' 40" W	5° 12' 15" W
Cape Cornwall	6° 32' 30" W	6° 00' 00" W	5° 43' 00" W

V

HEATH: MILITARY ENGINEER

The Isles of Scilly occupy a strategic position at the entrance to the English Channel and were under constant threat in the 16th, 17th, 18th centuries from the Spanish, Dutch, French fleets and attacks by pirates, the latter were frequent and often brutal. An excellent account of these events is in Adams 1984. Fortifications were built on several islands, the most important being Star Castle on Hugh Hill, St Mary's, built in 1593. A strong circular tower was built in 1651 to guard the channel between New Grimsby and Bryher.

Heath never refers to his army duties but he has often been credited with being a 'military engineer' (Taylor 1960, p 180) or 'engineer' (Mumford 1972, p 23.). This is an obvious Army career for a mathematician with a knowledge of surveying who could plan and supervise the construction of fortifications etc. but is hardly consistent with Heath's well documented continuous service with various army Invalid Companies until his death.

There appear to be three possible explanations for the description 'military engineer'.

First, Heath may have had a formal link with what was then the Corps (now the Royal) Engineers but there is no record of a Robert Heath in the '**Roll of Officers in the Corps of Engineers, 1660-1898**' (Conolly, 1898).

Secondly, there may have been an informal link with Corps' parent, the now defunct but once powerful Board of Ordnance (to which Heath makes several references in the Isles of Scilly part his book[11]). The Board, separate from the Army, was responsible for fortifications, arms and ammunition. [12]. The Military branch included the gunners and the Civilian branch the engineers working on fortifications etc. At both of Heath's postings (Scilly and Upnor) work was in progress on fortifications. In 1742 The Hugh on St Mary's was being completely surrounded with immensely strong fortifications and bastions by the Board of Ordnance (Bowley 1968, p.64). Heath had arrived in January 1743 and work was still in progress in September.[13]

The third possible explanation is essentially a circular argument. Some military engineers at this time made hydrographic charts; Heath, a military man, made a chart; *ergo* Heath was a military engineer.

Robinson (1962 Ch.5 and Appendix H) has given a concise account of '**The Hydrographic Contribution of the Military Engineer**' in the 17th and 18th centuries. In 1661 Sir Bernard de Gomme was made Chief Engineer of the Kingdom and Charles II re-established the posts of 2nd. and 3rd. Engineers. They were charged with being '*... well skilled in ... Stereometry, Altimetry and Geodaesia, to take Distances, Heights, Depths...*'. Robinson records that '*The rather unusual arrangement whereby military engineers carried out marine surveys in conjunction with their land surveys worked quite satisfactorily during the sixteenth and seventeenth centuries...*'. In 1714 the corps of engineers was reorganized and senior engineers were made responsible for parts of the coast; they were appointed by the Board of Ordnance. Significantly, in the present context, in 1715 Colonel Christian Lilly (fl 1700-1717), the Third Engineer of England, was made responsible for the Plymouth division, extending from Portland to the Isles of Scilly. He was instructed to repair and strengthen the south coast defences, including Scilly, as France and Spain seemed likely future foes and immediately began a series of harbour surveys. '*The military engineers were among the earliest official mathematical practitioners*' (Taylor 1966, p 133).

What is significant in the present context is that the Master Gunner of Scilly, Abraham Tovey (whose possible involvement in N Gincer's MS 1731 chart is examined in Chapter Three), was the man who actually carried out Lilly's directives and plans. He '*...was intensely interested in military engineering...and a map maker of distinction*' (Adams and Adams, p 55 and p 57).

These Military Engineers far out-ranked Heath and, as emphasised above, were engaged on official topographic and hydrographic surveys. There is no direct evidence that Heath was ever employed officially as a military engineer.

Heath's main responsibilities would have been as second in command of the garrison of Invalids, the first line of defence before the mainland troops could arrive. It seems logical to assume that the renowned Abraham Tovey would have welcomed Heath's undoubted mathematical and surveying talents in the maintenance of the Islands' fortifications. Heath makes many references to Tovey in his 1750 book and it may be concluded that they had a close working relationship. His 'title' as a 'military engineer' may well stem from his association with Tovey, which would have been invaluable in the compilation of his chart of Scilly. **BEE**

Heath makes it clear that his 1744 chart of Scilly was undertaken on his own initiative. The dedication to the 'Captain General of all His Majesty's Forces' was purely formal. Heath made a significant survey of the Isles of Scilly in his book and the accompanying charts. This, with his presumed work with Tovey, may have led to the assumption that he was a recognised 'military engineer' rather than a very junior officer in the Company of Invalids.

END NOTES

1). Heath is credited with inventing 'Scillonian' to describe the inhabitants of the Islands (Thomas 1985, p63). Half the book is a less original account of Cornwall. It was reprinted in 1808 in Pinkerton's 'Voyages and Travels' (v.II, p 729-84).

2). An astronomer who, unlike Heath, enjoyed some recognition by the scientific establishment for his work on determining longitude, was William Whiston. In 1738 he published tables for the determination of longitude from Greenwich and he does give details of the instruments he used for his observations. **The Longitude discovered by Eclipses, Occultations etc with An Ephemeris of the Configurations of Jupiter's Planets and Conjunctions of Jupiter's Satellites.** The ephemeris was based on the longitude of Greenwich. It is unlikely that Heath would have even considered using this book! He used a quadrant by Barston, which was patented in 1738 (Taylor 1966, p 169) for his revision (in fact by Renshaw) of Halley's chart of the English Channel, which he supervised in 1740-1.

W Whiston (1667-1752) was for a time Professor of mathematics at Cambridge. It is not explained how the Trigonometrical Survey was extended to the Isles of Scilly, but Whiston was measuring longitudes (Cassini method) as early as 1715 but there is no evidence that he visited the Isles of Scilly. He had been granted £500 in 1740 by the Board of Longitude 'For the Surveying the chief Ports and Headlands of Great Britain and Ireland ... in order to the more exact determination of the Longitude & Latitude thereof'. Even if publication was as late as 1745, Heath would have had ample time to consult Whiston's chart, as his own was still in preparation as late as 1749. Whiston played an important part in the passing by Parliament of the Longitude Act in July 1714 (Aked 1974, pp 732-44). His books on longitude were published in 1715, 1720, 1724, 1738. (Taylor 1966, pp. 146-8).

Heath was not alone in exaggerating his achievements; a note on Whiston's chart states that it is a 'Corrected and Improvement of Dr Halley's chart of the Channel 1741- 42'. Whiston's chart in fact **ON** relies heavily on Halley's. It is highly improbable that Renshaw (under Whiston's direction) made a complete trigonometrical survey of such a large area (hence the acknowledgement to Halley)

3). For guidance on information concerning Heath's military career the writer is indebted to Dr P B Boyden, Hon Sec to The Society for Army Historical Research and Mr B Owen, Curator, The Welch Regiment Museum, Cardiff. Mr B Owen makes the point that officers in the Independent Companies of Invalids were generally, like the men, old and veterans of earlier campaigns. Heath's appointment at the age of 25 appears to be unusual, but there are other examples of very junior officers being in command of the Invalids garrison on Scilly and it appears to have been the norm there at this time.

4). Heath's knowledge of and commitment to safe navigation is shown by his emphasis on the importance of the little known annual variation in the magnetic compass (1750, p16; Whiston's 1741-2 chart), which Halley had shown altered in the Channel about a Degree Westerly every 6 years. This variation had not mattered too much prior to 1657 (see Note 4 on Heath's chart), as the then easterly variation of the compass meant that ships going east towards the Scilly tended to sail south of their intended latitude. After that year, however, the variation became westerly and so vessels going east tended to be north of the presumed latitude. During a half day of sailing by

compass alone, if not checked by astronomical means, they would *'...sail greatly to the north of their expected reckoning...'* and would be in danger of running onto Scilly, especially if they assumed that its latitude was 50° N as many charts showed.

5). Richard Norwood (?1590-1675) was a mathematical teacher and surveyor and was the author of six books on land surveying and navigation. Between 1630 and 1640 he was resident in London and Heath may well have come to know him and his scientific works at that time. In 1635 he measured the length of a degree of the meridian by observing the sun's noon altitude between two points near the Tower of London and York Minster, respectively, with a five foot quadrant and calculated the length to be 69.5454 statute miles (modern 69.045 miles). This was the most accurate measurement of a degree of latitude in England at that date (Williams 1992, p 81). This, presumably, is the 'Norwood Experiment' referred to by Heath. Heath's claim to have corrected the errors on all former charts was presumably based in part on Norwood's data.

6). Heath expected either to stay longer in the southwest than he did or to return at a later date, for he wrote in 1750 of his intention to make a [new] survey of Cornwall *'...being an Improvement and Correction of all the Latest Actual Surveys, from Latitudes observed by the Author.'* (p 451). This was never carried out.

7). The Benjamin Coles.

Taylor (1966) notes three Benjamin Coles. The first fl 1709. Taylor refers to his son as 'Benjamin Cole, Snr' (1695-1755) and to his son as 'Benjamin Cole, Jnr' (1727-1813). Both the latter were Mathematical Instrument makers. The Coles made and sold quadrants and Heath may well have purchased one (p—). As the two Coles worked together, they often cannot be separately distinguished. In 1760 Heath said that 'Mr Cole of Fleet Str., successor to Wright' sold his book, presumably 'Astronomia Accurata'. This must have been Cole jnr. Taylor names 4 London addresses for Cole Snr, 3 of them in Fleet St, but only 'The Orrery, next the Globe Tavern, 136 Fleet St. London' for Cole Jnr.

8). In 1715 Colonel Christian Lilly (fl 1700-1717), the Third Engineer of England, was made responsible for the Plymouth division, extending from Portland to the Isles of Scilly. His MS maps and text (BL MS King's 45 4; text pp 7-16) are entitled **'SURVEY / OF THE / FORTIFICATIONS / IN / PLYMOUTH DIVISION / BY / COL. CHR. LILLY / 1714-1717'**. [12] It has scales for 'English Sea Miles' and 'English Statute Miles'. Included is:-

'A Mapp of the ISLANDS of SCILLY / with the FORTIFICATIONS ETC. / Col. Christian Lilly one of his / Majesties Ingeniers / 1715' (no latitude or longitude)

9). *'Astronomia Accurata...'* re the 'Lunar Distance' method, (1760, pp197-8) lists a catalogue of 140 fixed stars, from Halley, 1720, and *Connaissance des Temps*, 1756. On p 406 Heath first considers Halley's method, relating longitude to the Greenwich prime, using Halley's tables, then secondly De la Caille's method using the latter's Ephemeris of 1755-65 for which Heath claims that the error cannot be less than 2° and thirdly (p 407), his own method using his own tables of lunar distances. It appears also in the title (1760 p 1) *'... how to determine the Difference of Longitude, from the Royal Observatory, at Greenwich, by observing the Moon's Plane, under any distant Meridian.'*

10). In 1770, three years after publication of the first edition of the official British Nautical Almanac, Heath developed his alternative solution to longitude in *'The Seaman's Guide to the Longitude, or Key to the Nautical Almanac'*, published by Order of the Board of Longitude, surely an official recognition of the quality of Heath's work. It was probably written at Portsmouth as some of the examples refer to Portsmouth Academy.

11). It was constituted in 1597 (PRO, 1987, no 67) and headed by the Master of the Ordnance.

12). In the Board's Commission Books 1740-72 (PRO WO 54/239) and 1743-47 (PRO WO 54/237) there is no reference to a Robert Heath. The Board's Establishment Books are the next source. Those for 1743 (PRO WO 54/208, p 35.) and 1745 (PRO WO 54/209, p 39) make no reference to a Robert Heath; 1744 is missing.

Heath's name is not listed in either book under any of the following ranks:-

Engineer in Ordinary, Engineer Extra, Sub Engineer, Practitioner, Engineer and so it is puzzling that he acquired the title 'Engineer' in the literature.

Similarly the Board's quarter book for 1755-67 (PRO WO 54/212) makes no mention of a Robert Heath under the Civil or Military Branches nor under superannuated officers.

13). John Wesley is recorded as preaching to those working on the fortifications in 1743 (Matthews 1960, p 78). A search of the relevant Board of Ordnance files at the Public Record Office failed, however, to reveal any reference to a Robert Heath on Scilly at this time.

CHAPTER THREE

CHARTS OF THE ISLES OF SCILLY: 1731 by Nich.^{os} GINVER and 1779 by A TOVEY and N GINVER

THE NICHOLAS GINVER MS CHART, 1731

This chart is entitled:- 'A MAP of SCILLY / ISLANDS / in Latitude $49^{\circ} 56'$ N / Longitude $06^{\circ} 44'$ W / With the True Soundings / Setting of the Tides, and time / of High Water at Full / and Change / By Nich.^{os} Ginver 1731.' BL ADD. MSS 60393 D (This chart is Fig 2-3 in Chapter 2 and Fig 3-2 in this Chapter) *and Chart 2-1, with the folded chart.*

The text accompanying the chart states:-

'THE Islands of SCILLY are a great Number of Isles / and Rocks of all sorts, lying on the West, and West-South-West parts / of Cape-Cornwall (distance about Eight Leagues) Situated between the / $49^{\circ} 52'$ and $50^{\circ} 00'$ of Latitude, and between the $6^{\circ} 39'$ and $6^{\circ} 49'$ of Longitude. / being in length from the East part thereof to the West Ten Miles and / from North to South Eight Miles...'

The chart is neither official nor published but deserves examination here as a unique MS chart which may be the earliest large scale chart of Scilly with a latitude and longitude 'frame'.

The provenance of Ginver's chart was described and discussed in the previous Chapter, where it was concluded, as a working hypothesis, that Ginver's 1731 MS chart is an updated version of Collins' 1689 and 1723 editions and that its bar-scale 'Scale of one English Mile' is, as on Collins, one statute mile.

The latitudes and Longitudes on Nicholas Ginver's chart

The title of Ginver's chart refers to the Islands being '... in Latitude $49^{\circ} 56'$ N. / Longitude $06^{\circ} 44'$ W. ...'. This single point is not identified on the chart or in the text, but was presumably meant to define a place of some importance. When plotted on a modern chart the latitude passes through the extreme north of the Island of St Mary's, the longitude lies in the Atlantic, west of Scilly (Fig 3-2). It is, therefore, not possible to identify the place in the archipelago which Ginver intended to locate. He may have been attempting to define a 'central point' to represent the archipelago, as had Captain John Davis many years previously *The Seaman's Secrets, 1595* (Fig I-6b). On *Natter's chart* (c 1550 / 85) *THE* 'Latitudo 51 degrees, Longitudo 14 degrees' is written just south of Tresco,

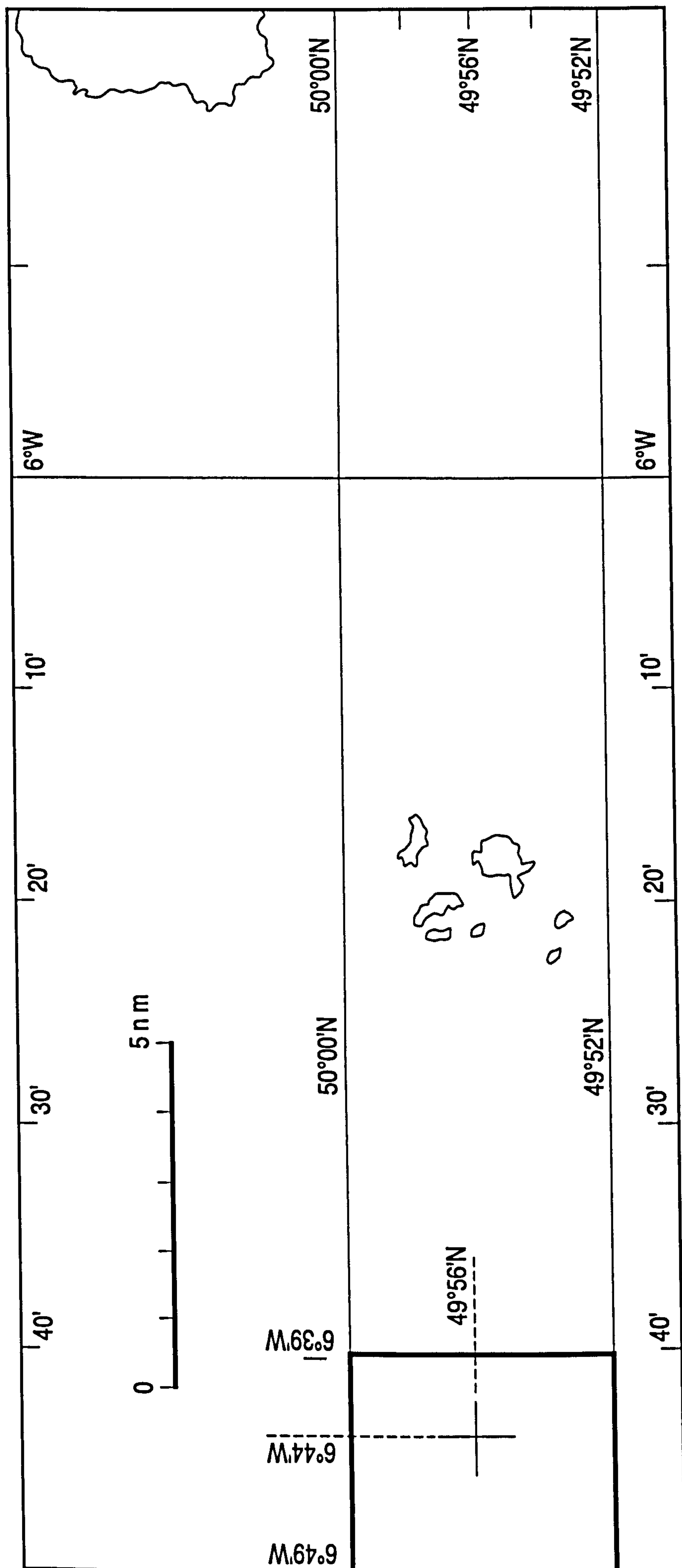


Fig 3-1. N. Gincer 1731. The Isles of Scilly: Latitude and Longitude according to text.

approximately a central point in the archipelago. The longitude would have been based on the Isle of Ferro prime meridian. There is no evidence, however, that Ginver knew of Davis's chart.

The importance of the above latitude measurement to the problem of latitudes on Greenville Collins' 1689 chart has possibly been overlooked. Ginver's parallel of latitude $49^{\circ} 56'$ N lies just north of the Island of St Mary's; one of Collins' assumed' parallels lies just to the south arbitrary numbered 05' from the south margin of the chart (Chapter Two, Table 1-4). If Ginver's parallel of 57' equates with Collins' nominal 05', then one problem may be resolved; Collins' latitudes lie in the zone 49° - 50° N. Other latitudes do not coincide.

The text accompanying Ginver's chart states that the Isles of Scilly are '*...Situated between the $49^{\circ} 52'$ and $50^{\circ} 00'$ of Latitude, and between the $6^{\circ} 39'$ and $6^{\circ} 49'$ of longitude,...*' Ginver does not identify the geographical sites through which the latitude and longitude 'frame' passes. Either they are the NS and EW margins of the chart or they pass through geographical features *i.e.* Lion Rock, the northern extremity, Hanjague Rk. the eastern, Pednathise Head, the southern, and Crim Rock the western. Ginver, being a local man (*infra*) would be very familiar with the most distant parts of the archipelago. As the margins of the 'frame' are uncertain, it complicates comparisons with other charts. As geographical features are permanent, and the drawn margins are arbitrary, the former are used where possible. In addition, although the bar-scale is an English [statute] Mile, the 'frame' is in minutes of latitude and longitude *i.e.* nautical miles.

Latitudes of the archipelago

'...Situated between the / $49^{\circ} 52'$ and $50^{\circ} 00'$ of Latitude... from North to South Eight Miles'. Ginver's latitudes are remarkably accurate.

On a modern chart $49^{\circ} 52' = 49^{\circ} 51'$ and $50^{\circ} 00' = 49^{\circ} 59' 30''$

The measurement of the latitudes on Ginver's chart present no problem; latitudes were regularly observed by navigators. The eight N-S divisions are each of one minute of latitude or one nautical mile, the N-S distance (Lion Rock- Pednathise Head,) is therefore is 8 nm or, using the bar-scale, $8 \times 1.15 = 9.2$ statute miles. A comparable distance on Collins' chart is 8.3nm and on a modern chart 9.6 statute miles or 8.3 nm. Ginver's distances are close to the modern.

Longitudes of the archipelago

'...and between the $6^{\circ} 39'$ and $6^{\circ} 49'$ of Longitude. / being in length from the East part thereof to the West Ten Miles...'

The text firmly states that the archipelago spans 10 miles, between the meridians of $6^{\circ} 39'$ (c Hanjague Rk.) and $6^{\circ} 49'$ (Crim Rk), similar to the distance on Collins' chart. There is little doubt that the observer regarded these minutes of longitude as the same length as latitude minutes *i.e.* one nautical mile; hence the distance of 10 'miles'. (9.6 modern statute miles).

The observer was clearly unaware of northward convergence of meridians. Each longitude minute at the latitude of Scilly is 0.64 nautical miles, so Ginver's 10 minutes = 6.4 nautical miles. The modern distance between the longitudes of Crim Rock and Hanjague is 8.3nm. (9.6 statute miles). Heath was aware of the convergence of meridians and on his chart there are 14 minutes of longitude between Crim Rock and Hanjague.

The measurement of the latitudes on Ginver's chart presents no problem; latitudes were regularly observed by navigators. Measurement of longitude was quite another matter. No obvious astronomer / navigator qualified to measure the longitudes on the Ginver chart has yet been identified. Heath was only 14 in 1731 but by the time he was on Scilly, in the 1740s, Ginver's chart would have been invaluable to him, especially as its existence was probably not widely known. Whiston had published astronomical tables in 1738 and is a possible contender but he only made single astronomical measurements on Scilly, unlike Heath. There were two main methods of measuring longitude on land at this time, the 'Lunar Distance' or 'Lunars' and the 'Eclipses of the Satellites of Jupiter'. Both were described in the previous Chapter and it was shown that considerable mathematical skill and access to the relevant astronomical tables were essential. Heath was a competent astronomer but he would have been too young in 1731.

The following first examines the possibility that a local man, with knowledge of the outer islands and the necessary instruments and mathematical skills constructed the chart's 'frame' and secondly that Robert Heath used, with or without permission, the Ginver data for his own use, plus considerable help from Abraham Tovey (*infra*).

THE OBSERVER OF THE LATITUDE AND LONGITUDE 'FRAME'

a). An unrecorded visit to Scilly in the 1720s^{He} by a competent astronomer, ~~who~~ ^{he} observed the ~~was made~~ longitudes and made them available to Ginver to be added to his chart. This improbable event is noted here as it will be shown in a later chapter (Chapter Five) that a longitude observation was made on St Mary's in 1795, which passed almost unnoticed.

A LOCAL ISLANDER

b). In the early decades of the 18th century there were Islanders who could draw and revise existing charts, measure latitude, and who could navigate within the archipelago and to and from the mainland. Whether they could calculate longitude is an open question. Possibly the most educated people on the Islands were members of two well-known Scillonian families, surnamed Ginver and Tovey.

The Ginver family

It is uncertain which member of the family was the Nich.^{os} Ginver, compiler the 1731 MS chart. The Isles of Scilly Parish Register [1] list the following three burials of persons with the surname Ginver (the absence of records of baptisms or marriages suggests that the Ginvers were 'incomers'.) [2]

Nicholas GINVER, snr., of St Mary's, buried October 20 1736.

Lucretia, wife of Mr. Nicholas Ginver, buried June 3 1752.

Mr. Nicholas GINVER, jnr. Comptroller and Surveyor of Customs, buried October 13 1754.

The Public Record Office (PROB 12) does not list a Will or Letters of Administration for a Nicholas Ginver for either of the above burial dates.

Two Nicholas Ginvors, father and son, were alive in 1731 and it is reasonable to assume that both contributed to the compilation of the MS chart of that date. The occupation of Ginver snr is not known but all males on Scilly would have inevitably had some knowledge of the seas between the islands. He may well have been one of the pilots so essential to shipping entering and leaving the various 'Sounds'.

Mr. Ginver jnr held an important post in the Islands. As Comptroller, or Collector, of Customs he would have been responsible for collecting duties and as Surveyor, responsible for searching ships for dutiable cargoes (Smith 1980, p 3). Collectors usually had the additional task of collecting light dues from ships entering and leaving Scilly to pass on ~~the~~ Trinity ^{To} House who managed the Agnes lighthouse. The Ginvors were 'incomers' and the younger Nicholas Ginver may well have been educated on the mainland [3]. He would have become very familiar with navigation within the archipelago, its tides, currents and anchorages, as well as the topography of the many islands. Robinson (1952, p 365) equates Customs House Officers with Trinity House Pilots in the production of local charts (~~Robinson 1952, p 365~~). He notes that Lewis Morris, waiter and searcher of His Majesty's Customs at Holyhead 1729, was a private hydrographic surveyor (Robinson 1957, p.453; 1962, 75-84).

The 1731 chart was never used at sea, but presumably remained a 'family' chart, possibly known only to a select few. There seems little doubt that both Ginvors would have known how to observe latitudes with a quadrant, as it was a well established technique, but longitude measurements demanded mathematical skills, access to tables of eclipses etc as well as suitable telescopes and were beyond the abilities of Ginver snr and jnr. Heath never mentions this family in his 1750 book, in contrast to many references to Abraham Tovey.

The Tovey Family

Another local contender for the astronomical measurements on the 1731 chart is a person of great experience and authority on the Isles of Scilly, namely Abraham Tovey, the Master Gunner of the Islands. It is not generally recognised ~~this~~ Abraham Tovey, first recorded on ^{THAT} Scilly in 1714, died in 1759 leaving several sons (Baxter 19734, p 4), [4] one of whom was also named Abraham. It was Abraham Tovey snr (fl. 1717-1759) who was the contemporary and possibly mentor of the two Nicholas Ginvors (and also of Robert Heath, Chapter Two) and who might have had some input into the 1731 chart.

Abraham Tovey snr is mentioned frequently with reference to the Isles of Scilly in the early and mid 18th century. Heath (1750) notes that he had been resident in Scilly for many years. Unfortunately, no Will or Letters of Administration are listed in PRO PROB 12 for an Abraham Tovey who died in 1759. Abraham Tovey snr 's talents were legion. He was mentioned by Col. C. Lilly [5] in his report on the '**Fortifications of the Plymouth Division**' (1714-17, p156), where he is described as the 'Master Gunner of Scilly'. He was a veteran of recent wars, who had served in the Navy and had been with the [Board of Ordnance] Train of Artillery in Spain. and was intensely interested in military engineering. He held the substantial titles of **Store-Keeper, Barrack Master and Collector of the Lights** and was given a 'robust' house. Adams and Adams (1984, pp 57-9) comment that Tovey snr was '*...a map-maker of distinction.*' He had made an MS plan of the Garrison on the Hugh in 1752 for Lord Godolphin, which was sent to him in London (Baxter 1974, p 4). His task as resident officer was to carry out Lilly's many directives to improve the fortifications and roads of Scilly.

His '*... detailed knowledge of the islands, and the channels and sailing marks used for making a safe passage amongst them, made him a recognised authority on the navigation of the area. In 1738 he composed a text on the tides and channels of the Isles...*' (Quixley 1966, p.44), being 'A true Description of the Setting of the Tides... in and about the Islands of Scilly, taken by Abraham Tovey'.^[6] This impressive compilation was added to the 1738 and later editions of Greenville Collins' chart. 1738 would have been the last before Heath made his survey in 1744.

The Ginver and Tovey families must have had close ties, although Abraham Tovey snr was far more knowledgeable than Ginver snr and jnr. Military affairs would have brought Heath and Tovey together and Heath no doubt used Tovey's immense local knowledge in the compilation of his charts, especially the hydrographic details. Abraham Tovey was more experienced than the Ginver family and may have assisted Ginver, father and son, in the compilation of the 1731 chart.

The very experienced Abraham Tovey *may* have been skilled enough to have at least contributed to the observations and plotting of the positional 'frame' of the archipelago, given his distinguished and varied military career. Heath makes a number of references in his book to Abraham Tovey,

The Ginver and Tovey families would have contributed greatly to the accumulated knowledge of the geography and hydrography of Scilly, the 'pilots' knowing every nuance of the tides and currents but the measurement of longitude was beyond their skills . Who, then added it to the family chart, which may well have been a jealously guarded secret?

ROBERT HEATH

Robert Heath's arrival on Scilly would not have passed unnoticed. His pre Scilly behaviour in London showed him to have been an active, outgoing, questioning person and as a member of the Islands' defence force he would have made it his business to seek out all the important residents. He had no inhibitions and in spite of his well-known temper (which

he apparently controlled on Scilly, in contrast to his behaviour at Upnor Castle) seems rapidly to have been accepted by the Tovey family (to whom he makes many references) and it may safely be assumed, the Ginvers and therefore, the Ginver chart.

Ginver's latitude and longitude 'frame' of the Isles of Scilly would have appealed to Heath. He may well have seized the opportunity to check it and compile a chart that was of genuine use to seamen, plotting the marginal gradations. By 1738, Tovey's *'True Description of the Setting of the Tides...'* had been added to copies of Collins' chart and Heath's references to tides are probably derived from these and those on the Ginver chart. Abraham Tovey had a very close relationship with Heath, probably closer than that with the Ginver family and probably ^{was} an important contributor to Heath's chart and astronomical observations.

Latitudes

Heath would have had no problems in measuring latitude. He had wandered widely over the Islands '... in his leisure hours ...' and ample opportunities to measure the latitudes of the remotest islets. had

TABLE 3-1
Latitudinal limits of the Isles of Scilly: Ginver and Heath compared,
(+ = northerly difference)

	Ginver	Heath	Difference
(north)	50° 00' [LION ROCK]	49° 59' 00" N	+01' / 6nm
(south)	49° 52' [PEDNATHISE HEAD]	49° 51' 30" N	+0' 30" / 3nm

That the differences are so small it not surprising, given that latitudes had been measured for many years, with steady improvement in the construction of quadrants. Masters of visiting ships would have observed the latitudes of such places as St Mary's harbour, Star Castle and the Agnes lighthouse but it is more likely that these latitude measurements were by a person with knowledge of, and time to, visit distant islands and rocks. ~~That~~ The latitudes are so similar that they suggest that Heath was using the Ginver chart to check his own measurements.

Longitudes

By 1731 tables and instruments were available for the measurement of the longitudes of the Isles of Scilly from the meridians of Paris and London. As the prime meridian is not identified, it is difficult to compare Ginver's and Heath's longitudes. It is assumed here that it was Greenwich but if Ginver's prime was London, then 5' has to be deducted from Heath's longitudes in Table 3-2. The longitudes on Ginver's 1731 chart may well be the earliest longitudes for Scilly based upon a prime meridian in England (Whiston's observation was 1741-2).

TABLE 3-2

Longitudinal limits of the Isles of Scilly: Ginver and Heath compared, Greenwich the prime

Distances in nautical miles are based on 1° long. at 50° N = 38.69nm.
(+ westerly difference)

Ginver	Site	Heath	Difference
6° 39' W	HANJAGUE	6° 37' W	+02' / 1.7 nm
6° 49' W	CRIM ROCKS	6° 50' W	-01' / 0.9 nm

At least 13 years separate these two almost identical measurements. Given that Heath, with his expertise in matters astronomical and navigational, had probably equipped himself with some of the best instruments available (*c.f.* Coles, Chapter Two), and that scientific progress was rapid at this time, it is hard to accept that an observer at least 13 years previously to Heath, would have had the instruments or tables to calculate longitudes that match Heath's.

Ginver 1731: The Isles of Scilly in relation to the mainland prime meridians

'THE Islands of SCILLY are a great Number of Isles / and Rocks of all sorts, lying on the West, and West-South-West parts / of Cape-Cornwall (distance about Eight Leagues).' (text accompanying Ginver's 1731 chart).

A league is usually assumed to be three nautical miles, so Ginver's chart places the Isles of Scilly (location not specified) about 24nm from Cape Cornwall. The latter was often preferred to Land's End, whose location was uncertain on the available charts. Greenville Collins (1689) estimated that Agnes lighthouse lay 32nm from the mainland. Table 3-3 shows the distances of Ginver's chart 'frame' longitudes from Land's End, which lies slightly west of Cape Cornwall,

The distance between the Land's End and St Mary's Castle, according to the bar-scale, is c 31 statute miles (27nm). In comparison, Collins' distance is c 36 statute miles c (31nm) and the modern distance c29 statute miles (c 25nm).

TABLE 3-3

Ginver 1731: Longitudes of the Isles of Scilly from Land's End (Greenwich meridian).

(+ = westerly error by Ginver)

Ginver	Site	Land's End	Error
6° 39' W	HANJAGUE	5 ° 43' W	+56' / 35.8nm
6° 49' W	CRIM ROCKS	5 ° 43' W	+66' / 42.2nm

Interest in finding the longitude at sea had, of course, been greatly stimulated by the disaster to Sir Cloudsely Shovell's fleet on the western Isles of Scilly in 1707 (Cooke *et al*, 1883; Graham 1980; Howse 1997, pp 53-4) and the subsequent founding of the Board of Longitude in 1714.

In the early 18th century the English prime meridian was usually that of the dome of St Paul's Cathedral, London and this may well have been the prime for Gincer's longitudes but the chart does not mention a prime meridian. The meridian of the Royal Observatory Greenwich (founded in 1675) seems to have been first used for longitudes of Scilly either by Renshaw / Whiston (1741-2, published ?1745) or Robert Heath (1744, published 1750). Greenwich lay 5' east of St Paul's. The longitudes on Gincer's chart are seriously in error, placing the Islands over 35nm west of their true positions. This is not surprising, given the complexity of the instruments and tables.

Source of the latitudes and longitudes on the 1731 MS chart of the Isles of Scilly by N Gincer

TABLE 3-4

Summary: Latitudinal and Longitudinal limits of the Isles of Scilly: Gincer (presumed locations) and Heath compared (Greenwich Prime)

(+/- - northerly or westerly error)

Gincer	Site	Heath	Difference
(north) 50° 00' N	LION ROCK	49° 59' 00"N	+01'
(south) 49° 52' N	PEDNATHISE HEAD	49° 51' 30 N	+30"
(east) 6° 39' W	HANJAGUE	6° 37' W	+02'
(west) 6° 49' W	CRIM ROCKS	6° 50' W	-01'

The 'frames' by Gincer and Heath are so similar that either there was an unknown navigator in the 1720s whose skills matched those of Heath or the latitudes and longitudes defining the 'frame' were added to the text of the Gincer chart after 1731. *i.e* the chart and text are not contemporaneous. There is no direct proof of this but it does provide a working hypothesis, namely that the 'frame' is based on the latitudes and longitudes on Heath's 1744/50 chart. In the writer's opinion, this is more acceptable than trying to justify the existence of a navigator or astronomer observing on the Isles of Scilly/c1731. *before*

Not until the mid 18th century were astronomers such as William Whiston (1667-1752) and Robert Heath (1718-78) busy measuring longitudes in western Britain. Their charts with latitudes and longitudes of Scilly post-date Gincer's chart by several years. As it seems that the chart was for the sole use of the Gincer family (it was never published), it is not impossible that Nicholas Gincer, jnr. (buried October 13th 1754) compiled the 'frame' from Heath's chart sometime between 1750 and his death in 1754. The question then arises, what would be the advantage of adding 1744/50 data to a 1731 base map?

Ginver's 1731 chart: The Isles of Scilly in relation to the mainland prime meridians

'THE Islands of SCILLY are a great Number of Isles / and Rocks of all sorts, lying on the West, and West-South-West parts / of Cape-Cornwall (distance about Eight Leagues).' (text accompanying Ginver's 1731 chart).

A league is usually assumed to be three nautical miles, so Ginver's chart places the Isles of Scilly (location not specified) about 24nm from Cape Cornwall. The latter was often preferred to Land's End, whose location was uncertain on the available charts. Greenville Collins (1689) estimated that Agnes lighthouse lay 32nm from the mainland. Table 3-3 shows the distances of Ginver's chart 'frame' longitudes from Land's End, which lies slightly west of Cape Cornwall,

The distance between the Land's End and St Mary's Castle, according to the bar-scale, is c 31 statute miles (27nm). In comparison, Collins' distance is c 36 statute miles c (31nm) and the modern distance c29 statute miles (c 25nm).

TABLE 3-5

Ginver 1731: Longitudes of the Isles of Scilly from Land's End (Greenwich meridian).

(+ = westerly error by Ginver)

Ginver	Site	Land's End	Error
6° 39' W	HANJAGUE	5° 43' W	+56' / 35.8nm
6° 49' W	CRIM ROCKS	5° 43' W	+66' / 42.2nm

Interest in finding the longitude at sea had, of course, been greatly stimulated by the disaster to Sir Cloudsely Shovell's fleet on the western Isles of Scilly in 1707 (Cooke *et al*, 1883; Graham 1980; Howse 1997, pp 53-4) and the subsequent founding of the Board of Longitude in 1714.

In the early 18th century the English prime meridian was usually that of the dome of St Paul's Cathedral, London and this may well have been the prime for Ginver's longitudes but the chart does not mention a prime meridian. The meridian of the Royal Observatory Greenwich (founded in 1675) seems to have been first used for longitudes of Scilly either by Renshaw / Whiston (1741-2, published ?1745) or Robert Heath (1744, published 1750). Greenwich lay 5' east of St Paul's. The longitudes on Ginver's chart are seriously in error, placing the Islands over 35nm west of their true positions. This is not surprising, given the complexity of the instruments and tables.

THE 1779 CHART by A TOVEY and N GINVER

(STET)

'A New Chart / of the / Islands of Scilly / with their Soundings, Channels and Sailing Marks; / By A.Tovey and N.Ginver. / London. / Printed for Rob^t Sayer and J^o Bennett Chart Sellers No.53 Fleet Street. / as the Act Directs 1st. July 1779.' (Fig 3-3)

This chart is briefly referred to here as an A Tovey and an N Ginver are named as its authors. In spite of its publication late in the 18th century, it makes no reference to latitude or longitude, apart from the latitude of ~~St~~ Agnes lighthouse (49° 55').

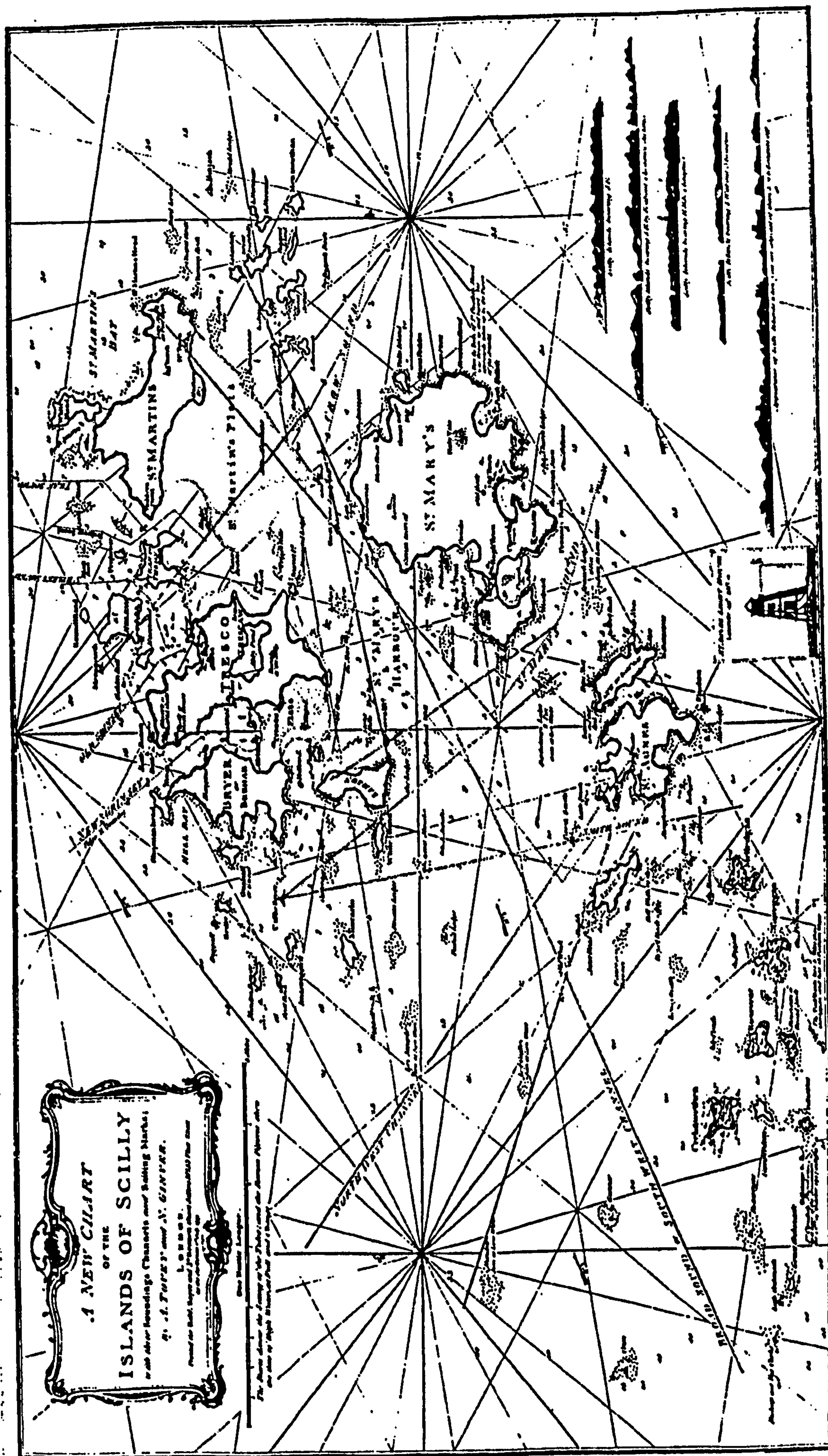


Fig 3-3 A Tovey and N. Gincer.
 A NEW CHART of the ISLANDS OF SCILLY 1779.

A review by Campbell (1978, pp 40-1) states that '*No other manuscript by Ginver has been traced, but a printed map published by Sayer & Bennet in 1779... acknowledged him as co-author with Abraham Tovey, the man who had added a note about the 'Setting of the Tides' to the 1736 edition of Collins' chart.*'

Campbell is certainly correct in attributing to an Abraham Tovey the Tide Tables added to Collins' 1736 chart but unfortunately that Abraham Tovey could not have co-authored the 1779 chart with the Nicholas Ginver (s) who compiled the 1731 MS chart of Scilly. The Abraham Tovey of the Tide Tables died in 1759 (Baxter, 1794, p 4); he had two sons, one also named Abraham, and it was Abraham Tovey jnr who co-authored the 1779 chart. Quixley (1966, p.26.) also attributes this chart to the wrong Abraham Tovey.

The confusion continues, however, as it has been shown above that the two Nicholas Ginvors, father and son, who made the 1731 MS chart, died in 1736 and 1754 respectively, and so neither could have co-authored the 1779 chart. Although it is possible that a third generation Nicholas Ginver, a son of the Comptroller and Surveyor of Customs who died in 1754, may have been given the 1731 MS chart by his father or even grandfather and used it in the preparation of the 1779 chart. There is, however, is no record of such a person in the St. Mary's registers for the last half of the 18th century. (Ottery, pers comm).

Abraham Tovey jnr is believed to have moved from the Isles of Scilly about 1772 and to have purchased a large part of Penzance (Ottery, pers. Comm.). This says much about the prospering of the Tovey family on Scilly, its business acumen and possibly the general standard of education of the family. The 1779 chart was therefore prepared after Abraham Tovey jnr had left Scilly for Penzance and his acknowledgement of the (posthumous) contribution of the Ginver family's MS chart is to his credit. [7] In the years that had elapsed since 1731, Abraham Tovey jnr may have become aware of some of the positional inaccuracies of the 1731 chart and he may have lacked the expertise to correct them. Hence the absence of latitudes and longitudes on the 1779 chart, apart from the generally known latitude of Agnes lighthouse. [8]

END NOTES

1). The writer is indebted to the Secretary and Curator of the Isles of Scilly Museum Association for extracting and supplying the information from the Parish Registers and the Custom House book (pers comm). The Public Record Office (PROB 12) does not list a Will or Letters of Administration for a Nicholas Ginver for either of the burial dates.

2). Baxter had described them as farmers, but Ottery (op. cit.) points out that '*...almost everyone of influence on the island, in the eighteenth century, obtained a piece of land on which to keep a cow and produce fruit and vegetables.*'

3). There is an intriguing twist in the history of the Ginver family. The International Genealogical Index (IGI) for Cornwall (March 1992 edition, p 13,239) lists about 32 entries under Genver/ Genvar/ Ginver/ Gynver, from a christening on 16 March 1602, to a marriage on 29 April 1710. All are recorded in Lanisly, a small agricultural village 1.6 km N E of Penzance and most all of whom from Gulval parish home of the Ginver family, one branch of whom moved to Scilly well before 1736 and therefore merited the description 'incomers'. The first name Nicholas (or Nicholai) appears at least nine times at Gulval between 1602 and 1693, so the Scilly branch was continuing an old tradition.

Many male first names are Johannes, Johannis, Henricus, Nicholai, Richardus, Gulierlim. This may have been no more than a family tradition or Latinised versions in which names were entered in the Parish register. There is just the possibility, however, that the family was originally Flemish and that a Ginver had settled in Gulval sometime before 1602. Matthews (1966), Reany (1967) and Hanks and Hodges (1988) do not include Ginver in their lists of English surnames. However, Ginner, Genower, Genner, Jennifer (cf IGI) is derived from OF and OL = maker of military machines; military engineer (Reany op cit, p 8). Nicholas Ginver may therefore have inherited a talent for map and chart making, a task often undertaken by military engineers.

4). Lilly prepared a map of Scilly but there are no references to latitude or longitude "A MAP of the ISLANDS of SCILLY with the FORTIFICATIONS etc. Coll. Christian Lilly one of his Majesties Ingeniers. 1715" (BL MS King's 45;4). Lilly was the 3rd. Engineer of the Kingdom, responsible for the Plymouth Division.

5). In a minute of August 1808 Mudge refers to '...Mr W Tovey, who had faithfully discharged his Duty during the time his was a Minor Engraver.' There is also a reference to a Richard Tovey at the Ordnance Survey in 1820. (Margary 1977, p xxvi).

6). Thomas (1985, p 36) notes that Scottish and Irish master gunners and garrison sergeants married, stayed on Scilly and 'put down roots'. Tovey may have done the same.

7). Two important facts, therefore, appear to have gone unrecognised. First, that the A.[braham] Tovey named on the 1779 chart was a son of the more famous Abraham Tovey snr. (fl. 1717 -1759) and secondly, that in 1779 no Nicholas Ginver was alive.

8). It would appear that the well-known chart of 1779 has a much more complicated history than is generally thought.

Transcript of Text accompanying the 1731 MS chart of the Isles of Scilly by Nicholas Ginver. The reference to the position of the Islands is here printed in bold.

'THE Islands of SCILLY are a great Number of Isles / and Rocks of all sorts, lying on the West, and West-South-West parts / of Cape-Cornwall (distance about Eight Leagues) **Situated between the / 49° 52' and 50° 00' of Latitude, and between the 6° 39' and 6° 49' of Longitude, / being in length from the East part thereof to the West Ten Miles and / from North to South Eight Miles:** The Inhabitants are for the most / part of the Reformed Religion, and the Language much beter [sic] spoken / than in Cornwall or any of the Adjacent County's [sic]. I shall proceed / to give a short Description of those Islands Inhabited, beginning with / the largest. Vizr. The First and Chief of them being St. Maries which / is about Three Miles from East to West, and almost of a Round form / except the South-West and West part, the latter of w^{ch} is a Peninsula / and is fortified all round with Batteries and Bastions, whereon are / Mounted a considerable proportion of Iron Ordnance, and a Train / of Artillery consisting of Eleven pieces of Cannon: There is a Castle / Erected (on a pleasant Plane) on the North part of said Peninsula, / built in the Reign of Queen Eliz^a in the form of a Star, and is properly / called Star Castle; There is a Church and Two small Towns on this / Island besides several small Villages not worthy of Note; the Chief / Town is the Hugh the other Old Town, the former standing on y^e Isthmus / joining the Peninsula and the said Island, whose shore is a Large Mould, / for the preservation of Shipping: This Island does abound with / all manner of Grain, Cattle etc., and fish, Fowl and Conies in abundance /

THE Second Island of Note is TRESKO which hath / a Strong Castle to command the Harbour called New-Grimsby & / a small piece of Fortification or Blockhouse to command Old Grimsby, / there is [sic] the ruins of / another Castle on said Island and a large old Abby [sic] / which is all worth mentioning on this Island.

THE Third Island is St. MARTIN'S which hath / on the East part a Land-Mark, it being the highest Land about / these Islands, and first seen coming from the East or N.E. / Note, The Seven Stones (where as Ancient History reports stood / the City of Lions lies due North East from St. Martin's Head / distance Three leagues.

THE Fourth Island of St. Agnes, on which stands / a Lighthouse to prevent Ships from falling in with those Dangerous / Islands and Rocks lying on the West and South West part of / this Island.

THE Fifth Island is Bryer, the Sixth Samson / and the Seventh Tean, but there is nothing on those three worth / mentioning; the two last having only a Family on Each Island.

DIRECTIONS to Sail into the Chief Sounds, and / principal Harbours belonging to Scilly, if you come into St. Maries / Sound (which is the best as having the fairest opening and lies in / W.N.W. nearest) stand in close with that Promontory [sic] of Land / called Penninis, and so Steer in for the Sound, keeping y^e Starboard / Shore aboard, for in the Middle of the Sound lyeth two large Sholes / or Sunken Rocks. Vizr. the Spanish Ledge & Bartholemaw [sic]; and you / are to take notice, that just before you come opposite the Southernmost / part of the Garrison or said Peninsula, you keep off your Starboard / Shore for about a Cable and halves [sic] length, to avoid runing [sic] on a Rock / called the Wooll-pack which shows before low-water, and for your / farther knowledge of this Wooll-pack, it lies off of that Battery / on which stands a large White Rock, after you are past, keep your / Starboard side close aboard and when you come to the Westernmost / Rock in the said Garrison called the Stoval Steer away for the Road / which lies up North, and Anchor two Cables length from Ned-Rock / leaving it lie W.N.W. from you: And whereas most Ship-masters / coming in through the said Sound without a Pilot, did observe to keep / on Third part of the Fanes [sic] of the Mill in the Garrison above / the Land, which was a mark to bring them clear of the Two / aforesaid Ledges and the Wooll-pack, you are to observe that the / Fanes of said Mill is blown down, therefore is no more to be taken / notice of as a mark, notwithstanding the Two houses or Mills are / yet remaining much resembling Dove-houses; and you are farther / to observe that there is a Wind mill built on that Promontory of Land called Penninis, before spoken of, but is no mark for the Sound, therefore might if not spoken of occasion a mistake in coming in

through said Sound, and bearing away / to the Road. To sail into CROW-SOUND, steer in about W.N.W. nearest, till you come almost to a Sandy point called Sandy-bar, then keep Nut-rock in the South part of Samson Island, so you will come in close by a Rock called / the Crow, which you little past it Steer over a small matter to the Southward to avoid running on a Shole called the Potts, and when you have so done, come to an Anchor in the Road near / Nut-rock as aforesaid. To sail into NEW GRIMSBY, keep your Starboard side close aboard, for there are Rocks on your Larboard side called the Kettle, so when you are within the Castle, Anchor near the round picked Island called / Hangman's Island. To come in through the N.W. Channel of Broad-Sound, keep the Light house on St. Agnis [sic], a Sails breadth open to the Westward of the Great-smith, run in on that mark till you are come within a half mile of it, after / which you steer away directly for the Road. To sail into the S.W. Channel of Broad-Sound, keep an Island called Little Ganhilly open of Bantscaran on the North part of St. Maries, which said mark will run you directly to the Road. To come / in through Smith Sound, which is a very good one and hath deep watter [sic], but doth not Show itself, you must keep the Castle of Bryer, opposite the Great Smith, run in on that mark till you are near the said Great Smith, then Steer / over a small matter to the Westward, to give said Rock a birth, and when you have so done, steer away about N.E. which will bring you to the Road near Nut-rock, where you may come to an Anchor in Five or Six Fathoms, as aforesaid.'

CHAPTER FOUR

Mr GRAEME SPENCE 1756/8-1822

CIVILIAN ADMIRALTY SURVEYOR 1788 -1803

INTRODUCTION

Biography and background to Appendix E
Charts' descriptions to Appendix F

Mr Graeme Spence, Maritime Surveyor to the Admiralty, was the first trained surveyor, marine or terrestrial, to chart or map the Isles of Scilly in detail (1789-93) and the first to plot them accurately, by triangulation, in relation to the mainland and the Greenwich meridian.

[1] Spence remained a civilian, conducting his surveys in a vessel commanded by a naval officer, directed to comply with his wishes (Dawson 1885,p 15). Spence's professional career is briefly discussed below and in Appendix E [2]. Spence's first major task as Admiralty Surveyor was the charting of and fixing the position of the Isles of Scilly in the years 1789 – 1793, so making the second official chart of the Islands, 100 years after that of Greenville Collins.

Spence assessed the problems he faced thus:-

'From the knowledge that I have acquired of Scilly in the Course of the Maritime Survey, I have every reason to believe, that the late Increase in [magnetic] variation, not properly allowed for, the prevailing Northerly Direction of the Stream of Tide to the S.Ward of Scilly, not hitherto Known, with any Certainty; Scilly being laid down in most Charts and Books I have seen, farther to the Northward and westward than it ought to be, and above all, Vessels losing their latitude in thick and foggy weather, in the mouth of the British Channel, are the Principal causes of Shipwreck on Scilly... most [charts] ...have laid down Scilly between 3 and 7 Minutes [3-7 nm] more northerly than it ought to be ...and also 12 or 14 [English or Statute] Miles [c 10.4 or 12.2 nm] farther from the Lizard, than it ought to be.' Spence (1812, p 56-7). Spence used statute rather than nautical miles in his early surveys (as did Collins and Heath, Chapters One and two respectively).

In this chapter, as in others, the latitude and longitude of the Old Lighthouse (built 1680) on the Island of Agnes are used to represent the Scilly archipelago.

In the following,

Part One discusses projections, scales, instruments, survey methods etc.

Part Two examines Spence's basic six inch chart of the Isles of Scilly and its derivatives.

Part Three reviews Spence's triangulation links first, with the 'Westernmost' part of Cornwall and secondly, their extension to the Lizard Lighthouses. The combination of these enabled Spence to be the first to determine the longitude of the Old Agnes Lighthouse and so the Scilly archipelago.

Spence's initial survey of the archipelago occupied the years 1789-93, with additions in 1795 and 1807; his first 'fair copies' of the charts and tide tables were made in 1797 but the first printed chart from which the latitudes and longitudes of Scilly could be measured was not published until 1808 (OCB Chart 33, Series A.1.1808 c 1:93 000) and his impressive summary, 'A Geographical and Nautical Description of Scilly, with...sailing Directions...tide tables... [with] two charts taken...in the years 1790, 1791, 1792 by Graeme Spence, Maritime Surveyor to the Lordships.' (GL Ms TH MS, 1812) did not appear until 1811/12, here referred to as 'Spence 1812'. [3]. Thomas (1979) has reproduced the Preface of this work.

Spence had the good fortune to be related to the Orcadian Mackenzie family of innovative professional maritime surveyors. He was a cousin of Murdoch Mackenzie junior R N Head Maritime Surveyor in the service of the Admiralty, 1771-1788, himself a nephew of, and the professional successor to, the distinguished Maritime Surveyor Mr Murdoch Mackenzie senior (Robinson 1975, p 454). It is the convention that 'senior' and 'junior' refer to the uncle and nephew rather than to father and son. In April 1773, at the age of 15, Spence was apprenticed for seven years to Mackenzie jnr to learn Maritime Surveying. Either he showed exceptional talent or a touch of family nepotism proved intuitive. He, of course, benefited from the great improvements in the techniques of maritime surveying made in the late 18th century e.g. the senior Murdoch Mackenzie's '*Treatise on Maritim Surveying*' (1774) [4] [5] and from being trained by Mackenzie jnr.[6] Spence had to use portable instruments, such as a 12" theodolite, but proved skilled enough to produce results comparable to those of the 18" and 36" theodolites used by the Trigonometrical Survey/Ordnance Survey.

Mackenzie jnr was commissioned Lieutenant in 1779, eight years after he was appointed Maritime Surveyor. He undoubtedly drew upon his uncle's experience and sought to maintain and improve upon the latter's high standards, which in turn were passed on to Graeme Spence. Spence (only two years into his apprenticeship and presumably in recognition of his ability), was appointed Surveyor's Assistant to Mackenzie jnr in 1775 and Dawson (1885, p 13) claims, giving no source, that '*...it was held out to Mr. Spence...*' that he would in turn succeed Mackenzie jnr, as the latter had succeeded his uncle. There is no doubt that Spence had absorbed all the surveying principles and techniques of the two Mackenzies and continued their high standards. He continued to assist Mackenzie jnr until 1788. Accounts of the latter's retirement are in Appendix E. Spence's Will shows that he died in 1822, not 1812 as is generally stated, aged about 66.

Any discussion about Spence and his surveys has to be considered against the background of major developments of the late 18th and early 19th centuries (Day 1967; Ritchie 1995). By the 1790's the Admiralty had accumulated a very large number of MS charts but had no means of disseminating this valuable resource. In August 1795 a 'Hydrographical' Department was established (6 years after Spence's survey of Scilly began) and Alexander Dalrymple, the distinguished East India Company's hydrographer, chart

maker and FRS [7], was appointed the first Hydrographer. He was to arrange and catalogue the MS charts and documents, rather than to initiate new surveys. Hence the first chart was not published until 1800. Spence retired in 1803 as Maritime Surveyor and from 1804 to 1811 worked at the Admiralty assisting Dalrymple, such as correcting Mackenzie jnr's charts to true north. In retirement Spence also worked for Trinity House, (Minutes dated 2nd May 1811, 6th June 1814 and 3rd December 1818). The latter was his last contribution to hydrography.

It is important, when placing Spence's surveys of Scilly in the chronology of the late 18th/19th surveys, to distinguish between the dates of his unpublished MS surveys and those of his published surveys. The former remained largely unknown and unavailable to navigators in the Admiralty archives until the first (of Scilly and the mainland with latitudes and longitudes) was published in 1808 (*supra*). Spence's best known and most reproduced printed chart, that of the Isles of Scilly 1810, (OCB Chart 34 Series A.1.), makes no reference to the latitudes or longitudes of the Isles and therefore has only a minor role in this study.

Spence's surveys of Scilly were ignored by contemporary surveyors such as Capt Joseph Huddart (1795) and the officers of the Trigonometrical/Ordnance Survey (1796). It is almost inconceivable that both were unaware of Spence's work. Huddart was present at some of the Trinity House Meetings at which Spence's letters about Scilly were recorded and they worked together on a survey of the Sandbanks of the Narrows (GL Ms: TH GCM 5th September 1799). Spence admittedly did not refer to Huddart in the 1795 and 1807 notes added to his 1792 MS chart but he did make frequent requests to the Hydrographer (Dalrymple) for his observations on that chart to be compared with those of the Trigonometrical / Ordnance Survey. In his additional notes of 1807 on chart UKHO 702 Dc (1791-1807) he concluded that his triangulation compared favourably with that of the Survey.

Details of the Trigonometrical / Ordnance Survey's 1796 triangulation to Scilly from the mainland (Chapter Six) were published in 1800, admittedly rather obscurely for mariners, in the Philosophical Transactions of the Royal Society. The tables provide, nevertheless, the first published latitudes and longitudes of the Islands and became available to navigators when quoted in the 1802 (3rd) edition of the British Nautical Almanac, which acknowledges the Trigonometrical Survey as the source. Strangely, the Trigonometrical / Ordnance Survey made no attempt to map the Scilly archipelago using the 1796 data, although topography was being mapped on the mainland (Margary 1977, v II pp xiv-xix) so, although its position was now known, officially its topography was not. Spence's excellent very detailed six inch chart of the hydrography and topography (1792; UKHO 637 1g) remained in the Admiralty archives and has never been published. (*extract:-CHART 4-1*). Most of Spence's charts, MSS and Printed are too large to be copied here, but a number have been reduced to 1/2 scale and are numbered **CHARTS 4-1 to 4-6**. They are in a pocket at the end of volume 2 and should be consulted throughout this study.

PART ONE

Scales, Projection, Instrumentation, Survey Methods

SCALES

In the Chapters on Collins and Heath (Chapters One and Two respectively) the difficulty of establishing the scales of the their charts has been discussed. For Graeme Spence's charts there is no such problem. Spence followed Mackenzie jnr, his mentor, in using English or Statute miles for distances, rather than nautical miles. Referring to some of Mackenzie's work Spence (1812, p 34) records:- *'The Distances in the following Description are given in English Miles, of which there are $69\frac{1}{2}$ to a Degree: note signed Murdoch Mackenzie.'* In 1797, when Spence was at Shoreham writing his *'... Description of Scilly...'* he states:- *'When the particular Distance between any Two Objects or Places, is given in Miles; it always means English miles: the Scale of the large [scale] Chart, (UKHO 637 Ig: 1792) is 6 Inches to an English Mile, and that of the small [scale] Chart, (UKHO 702 Dc, 1892-1807) 1 Inch.'* (Spence 1812, p 161). He was not, however, adverse to nautical miles. Referring to his small 'Plain Chart' [UKHO 702 Dc; 1792 - 1807] Spence states:-

'There are two linear scales:-

Scale of 4 English Miles, 1 inch to a mile, of 1760 yds.

Scale of 4 Geometrical [Nautical] Miles, 1.15278 inches to a mile of 2028.91 yds.'

Surprisingly, but perhaps to accept contemporary convention, the bar-scale on the first printed chart of Scilly is in Nautical Miles only (OCB Chart 34. Series A.1. 1810).

PROJECTION

Spence makes several references to his charts being 'plain' charts, *i.e.* not based upon a projection. For example:- **'A Trigonometrical PLAIN Chart, showing the relative situation of SCILLY, the LANDSEND and the LIZARD; 1791 and 1792: by Graeme Spence,.** (UKHO 702 Dc; 1791/1807). This chart has a number of Notes added at different times. To aid identification these are lettered on the chart clockwise from (A) to (I)

He was well aware of the poleward convergence of meridians and sought to justify his use of a Plain chart in Note B (text on his ' Plain chart' *supra*) *'...the length of a degree of the Meridian at that latitude [50°N] as 365204.64 feet and a geometrical [nautical] mile as 6086.74 feet or 2028.91 yards ... and although a plain Chart, it is sufficiently exact for any purpose in navigation, it being so small extent.'* The 'plain chart' spans c20' (20nm) of latitude and c79' (51nm) of longitude. *'The length of a Degree of Longitude in the Parallel of 50°, contains about 38.8179 geometrical miles; or about 44.7489 English miles: the length of a Degree of the Meridian there, contains about 365204.64 feet; and of a geometrical mile 6086.74 feet; the Scales around the margin of this Chart, are adapted to the above measure; and although a plain Chart, it is sufficiently exact for any purpose in navigation, it being of so small extent.*

Note C). [added to Note B] *'In the year 1807 I find the length of a degree of the Meridian in 49° is laid down at 365106 feet and the geometrical mile is there laid down at 2028.36666 yards, which is*

about 19.56024 inches less than I call it; which is not worth notice here.' This claim cannot be checked as he refers to 50° N in his earlier comments. Spence appears to be unaware that some of the Trigonometrical Survey's calculations assumed that the Earth's surface was a plane (Margary 1981, v 3 p xiii). Airey's figure of the Earth was not adopted by the Ordnance Survey until c1830 (Close 1969, p 148). At the parallel of 50° N the modern length of a degree of longitude is 38.69 geometrical or nautical miles and 44.5 statute or English miles.

The initiation of Spence's survey and the progress reports to the Admiralty and Trinity House provide valuable background information. The give them the full descriptions they deserve, they have been transferred to Appendices E and F.

SPENCE'S INSTRUMENTS AND METHODS OF SURVEY

As Andrew David (2003) has pointed out [6] hydrographic surveyors seem very reluctant to record how they carried out their surveys.

Spence (1812, p 161) only specifically names two surveying instruments; the quadrant and sextant:- *'Bird's 12 inch Quadrant and a 12 inch Sextant by Nain and Blunt'* [8]. It is an indication of Spence's approach to his work that he made sure that his instruments were handled with great care and between surveys were deposited onshore, often with the local Customs Officer, rather than risk transporting them to Portsmouth or London.

However, there are clues as to how the survey of Scilly was carried out. In the detailed *'...Description of Scilly...'* Spence (1812) sets out the broad principles followed. *'The Land Work [of Scilly] was trigonometrically Surveyed from a sufficient Base [not identified], with a good Chain and Theodolet [sic]; the water Work, and the Soundings, were fixed by Sextant Angles: and no Compass Bearings were ever used, to fix even the most insignificant Part of the Work: and the Latitudes were observed with a double framed astronomical Quadrant of Troughton's make since the Year 1789'* [the beginning of the survey] (Spence 1812, p161).

Andrew David (*op. cit.*) has extracted similar but more detailed accounts of the survey of the Thames Estuary (Spence, *Nautical description of the Banks and Channels in the Thames Estuary*, p.2) and the approaches to Portsmouth (Murdoch Mackenzie, *A Nautical Description of the East Part of the Channel between the Isle of Wight and Hampshire...*(Guildhall Library, MS 30,152, Vol.2, Book 1).

In the joint survey by Mackenzie jnr and Spence of Margate Roads, Spence (1804) noted that *'...the water work was surveyed by sextant angles between the several fixed objects on land and no compass bearings were used to fix or protract the work.'* As Robinson (1962, p 69) has observed *'... in 1775 Mackenzie jnr and Spence were already applying the principles of resection laid down by the elder Mackenzie in his book issued the previous*



Fig 4-1a St Buryan Church. 410258. Tower c29m. © acknowledged.

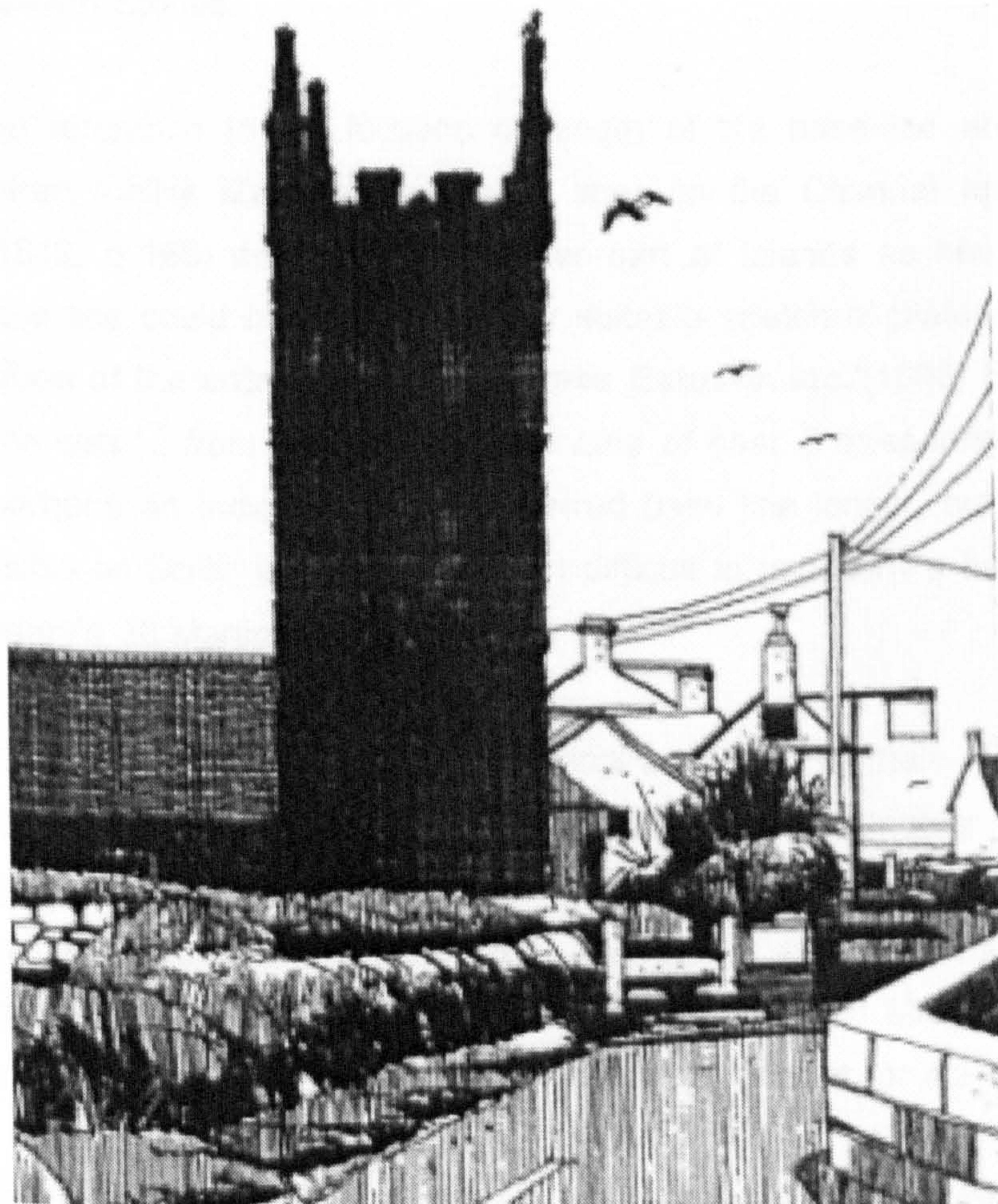


Fig 4-1b Sennen Church. 356255. Tower c18m. © acknowledged.

year.' (**Treatise on Maritim [sic] Surveying, 1774**). Mackenzie snr proposed an instrumental solution to the resection problem of fixing position at sea but it is uncertain whether he actually invented what he named the 'Station Pointer' which came to be used for the purpose. He certainly had never used such an instrument in his career, so it must have been of very recent invention when ~~the~~ book was published in 1774 (Robinson 1957, p 455; *THE* 1962 p 64-5). Mackenzie jnr '*... plotted his soundings...probably by an early form of station pointer.*' Mackenzie plotted soundings by the tracing paper method or by an early form of the station pointer (David 2003). Spence presumably did the same..

Spence was well aware of the need to link geodetically his survey of Scilly with the mainland: '*It is necessary to mention that in the course of this Maritime Survey, some Pains have been taken to determine trigonometrically, the relative Situation of St. Agnes Light, the Lizard Lights, and the Longships Light: the Westernmost Landsend [sic] of England, the Wolf Rock, and the Pollard Rock of the Seven Stones; as being objects of greatest Importance to the Navigation of these Seas; and without which this Description would have been incomplete.*' (Spence 1812, p 171). He might have added that the triangulations to the Longships Lighthouse and The Wolf Rock were made in 1795, three years after the main triangulation (Fig 4-2). Surprisingly, Spence does not emphasise that the trigonometrical link with the mainland (Figs 4-2) would enable him to determine the longitude of the Isles of Scilly. As noted earlier, there is no reference to any triangulation, within Scilly or to the mainland, in any of Spence's letters to the Admiralty or Trinity House, apart to one reference to the Seven Stones.

Spence makes no reference to the location or length of the base-line and it does not appear on any chart (unlike Martin White's base lines on the Channel Islands (Chapter Eight). Spence (1812, p 166) describes the greater part of Islands as heathy, rocky and barren, so the base line could have been on any suitable stretch of plateau. In the 1808 '**Nautical Description of the entrance to the Thames Estuary..etc.**'(1808) Spence records that its triangulation was '*... from a measured Base Line of near 3 miles long,...*' (PRO ADM 7/ 846). This is perhaps an indication of his preferred base line length, but 3 miles would have been impossible on Scilly; it would have been difficult to lay down a base-line as long as 2 miles on St Mary's, St Martin's or Tresco.

Further information can be found in the Master's log books or 'journals. These convey a more intimate account of Spence's day to day activities. Unfortunately the log of the *Sorlings* for the years of Spence's surveys of Scilly (1789-1793) has apparently been lost but the log for the years following has survived. The survey methods would hardly have changed. By warrant on 21st March 1795 Mr Jerom Seater replaced Mr Richard Burlace as Master of the *Sorlings* and Burlace may therefore have been Master for the survey of Scilly.

Spence continued to use the *Sorlings* for subsequent surveys and fortunately the two 'journals' covering March 1795 [9] to September 1798 have survived (Masters' Logs: PRO ADM 52/4333; see also Captains' Logs: PRO ADM 51/1659):-

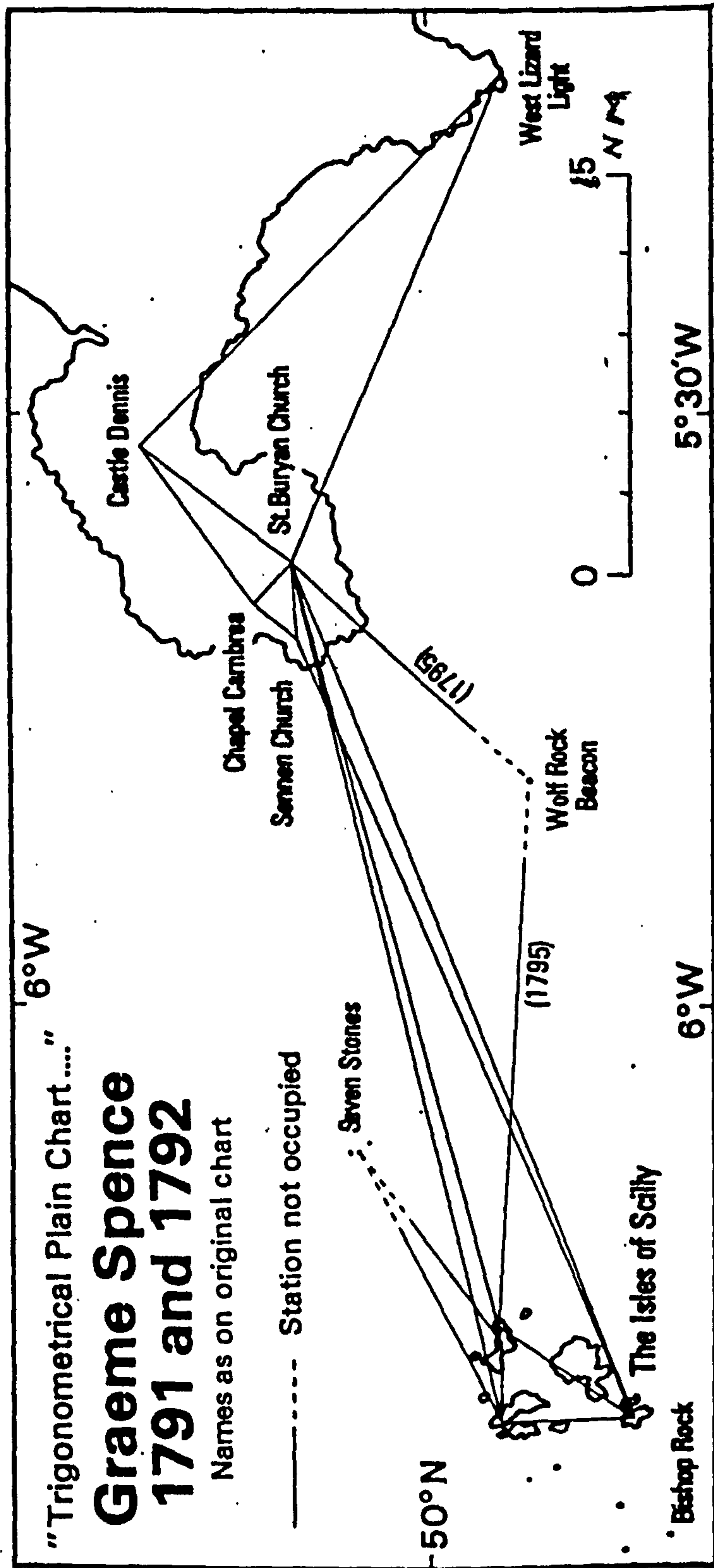


Fig 4-2 Spence's 1791, 1792 and 1795 Triangulations (Isles of Scilly outlines added)

- i). 'A Journal of the proceedings of His Majesty's Surveying Sloop Sorlings Mr. Jerom Seater, MASTER. From the 26th. day of March 1795, till the 31st. day of March 1797.'
- ii). 'A Journal of the proceedings of His Majesty's Surveying Sloop Sorlings. Mr. Jerom Seater - Master.' [1st April 1787 - 30th September 1798.]

The Master's daily log (or 'journal') of the surveying sloop Sorlings 1795-98. (PRO ADM 51/1971).

- 1.5.1795 Used the Survey Cutter getting the Instruments from the shore that were left [at end of previous survey] in Mr. Culls care at Ramsgate.
- 20.5.1795 (Ramsgate): Surveyor observed the Sun's Altitude at Noon with the Astronomical Quadrant.
- 21.5.1795 Surveyor observed the Sun's Altitude at Noon with the Sextant by Reflection from mercury near Jacob's Ladder.
- 30.6.1795 (Dover) Surveyor went to Town [London] with some instruments to get them repaired; returned on 3.7.1975.
- 23.9.1795 (Rye): Surveyor onshore on the Survey. Pitched the Markee [sic] and Tent at the end of the Base Line to Observe from with the Astronomical Quadrant.
- 16.3.1796 Surveyor employed in getting the Instruments packed up in order to leave them with the Collector of Customs at Rye, '*...till we return again on the survey...*'
- 13.6.1796 (Rye) Instruments collected as surveying resumed.
- 30.3.1797 Mathematical Instruments lodged in the Collector's Care '*..by Mr. Spence...*' [the only time he is named] at the Customs House, Shoreham, till the arrival of the *Sorlings* from Portsmouth [where she had been refitting].
- 19.5.1797 Instruments collected as surveying resumed.
- 12.10.1797 People employed carrying the Instruments to the Naze Tower.

The areas covered include Ramsgate, the Downs, Sheerness, Shoreham, etc. Graeme Spence is only named once in these journals; he is normally referred to as '*...the Surveyor...*'. It will be recalled that Spence was a civilian and that for any surveying work the Master took orders from him. These logs are so close in time to the survey of Scilly that the surveying methods described in them must have been used also on Scilly, so partially at least, they can be used to fill the gap left by the lost logs. They are so revealing of the daily work on a surveying sloop that it is tempting but impracticable to quote them in full. Instead, in the following, all references to the working of the ship (victualling, weather, refits etc.) are omitted and the daily entries are summarised and restricted to surveying topics. The selected extracts are not set out chronologically but by topic, e.g. sea surveys, land surveys, preparing the 'Draught' or chart (provisional and 'clean' plotting), tidal observations, preparing sailing directions. It is impossible to apportion the 'Surveyor's' time to these various duties but over several years he was probably engaged equally on all five. It will be seen that Spence devoted much time to land surveys, in the Mackenzie tradition, and that his regular tasks at sea were the 'rough' draughting of charts, writing sailing directions and tide tables but he tried to be on land for the final drafting of his work. Spence must have had professional help at times as there is an entry for 31.3.1796 (when the *Sorlings* was refitting at Portsmouth):- 'Discharged Robert Atkins, Surveyor's Assistant.'

BEGINNING OF A VOYAGE

22.4.1795 Master informed Admiralty that the *Sorlings* was ready to proceed on a survey and also informed the Surveyor 'in Town' [London].

27.4.1795 The Surveyor arrived and on the 28th the vessel set sail.

SEA SURVEYS

Surprisingly, there are very few specific references to soundings and other aspects of the surveys carried out at sea. Perhaps these were regarded by the Master as so routine as not being worthy of mention. There are, however, references to the Cutter being sent '...on the business...' possibly to sea surveys.

20.5.1795 Measured depth of water across Ramsgate Harbour every 20' asunder.

26.6.1797 Surveyor went in the Cutter with the Midshipman and 5 men on the survey.

In contrast there are numerous entries about the land surveys.

LAND SURVEYS

A little information about triangulation on the Isles of Scilly can be obtained from Spence's chart of his triangulation to the mainland and is discussed later. The following refers to post-Scilly land surveys.

23. 1.1795 (Downs): Hauled vessel near the shore for purpose of carrying out a Land Survey.

20.5.1795 (Ramsgate): Surveyor observed the Sun's Altitude at Noon with the Astronomical Quadrant.

21.5.1795 Surveyor observed the Sun's Altitude at Noon with the Sextant, by Reflection from mercury near Jacob's Ladder.

2. 9.1795 (Ramsgate): People employed getting the Surveying Flags in readiness for the survey of the Coast.

23.9.1795 (Rye): Surveyor onshore on the Survey. Pitched the Markee [*sic*] and Tent at the end of the Base Line to Observe from with the Astronomical Quadrant.

5.10.1795 and 4.8.1798: People employed mending Surveying Flags.

18.7.1796 (Rye): Warped up the Harbour in Order to get a more convenient place for carrying out the Land Survey.

6.8.1796 Surveyor employed getting ready to go away with Tent on the Land Survey.

8.8.1796 The Midshipman and four men with the Marker went away to meet the Surveyor [near] Bexhill in Order to carry out the Land Survey (continued to 21st)

26.11.1796 (Shoreham): Surveyor went in Post Chaise to New Shoreham with his Chart and Papers and on shore on survey; returned 10.12.1796.

14.12.1796 (Shoreham): Flag guys cut (probably stolen).

3. 6. 1797 (Crouch): Surveyor onshore placing Flags in readiness to begin the Measurement of the Base Line. Land survey continued to 15th .

DRAUGHTING.

[there are numerous references to 'Surveyor employed on the Draught.'].]

21.12.1795 (Rye): 'Surveyor engaged a Room onshore in Order to Draw the clean Draught of the Downs, the *Sorlings* cabin not having Light Sufficient.' [log refers to gales].

15.3.1796 Surveyor informed me [the Master] that he had finished the Clean Draught of the Downs for the Admiralty and intended going to London with it by Land.

- 6.4.1796 Surveyor returned from London to make Clean Copy of the Downs for the Corporation of Trinity House.
- 17/18.6.1796 Surveyor employed in preparing paper for drawing on.
15. 6. 1797 Surveyor employed on preparing paper for a chart.

TIDES

- 20.7.1795 (Downs): Surveyor went out with Cutter to observe tides.
[numerous similar entries].
- 10/13.12.1796 (Shoreham) Surveyor engaged on making Tide Tables.
- 2.5.1797 (Ramsgate) Put Pole up to observe the rise and fall of the Tide; observations recorded.
- 18.12.1797 (Dovercourt) Put up Pole to observe rise and fall of tide.

The Tide Tables for the Isles of Scilly (UKHO 671 13K; dated 1792 but not finally compiled until 1797) are extremely detailed and in the above version cover a large sheet; they were redesigned to fit the pages of the published '**... Description of Scilly...**' Spence gives no indication of where he placed his tidal datum or what it was, beyond saying that he '*...contrived...*' the Tide Tables so that there was no danger of having less water over shoals than the Tables indicated. As an indication of his method, in the '**Nautical Description of the Entrance to the Thames Estuary... (1808)**, Spence records that '*All soundings were reduced to LW Spring Tide. The lead lines used were marked in feet and fathoms...*' (PRO ADM 7/846).

Spence (1812, p 155) was the first to plot and record in detail the pattern of tidal streams around Scilly and the dangers they presented to shipping. (Abraham Tovey had prepared an earlier version, Chapter Three). He advised ships to sail E¹/₂ S of the proper latitude, to make sure they kept south of Scilly when coming from the west. Others had offered similar advice but on an *ad hoc* basis. Spence was the first to gather systematically the evidence and he makes much of the northward 'push' of the tides towards Scilly; but for this northward push, he claimed, ships on the correct latitude would clear Scilly by 4/5 leagues. In 1812 Spence seems to have been unaware of the Rennel Current, identified some years earlier (Rennel 1793), which has the same effect (INTRODUCTION).

SAILING DIRECTIONS

- 25-29.8.1795 Surveyor employed on making out the Sailing Directions for the Goodwin Light.
- 21.8.1795 Occasionally surveying was interrupted, as when '*...Surveyor got directions from Trinity Corporation to proceed to Ramsgate in order to assist them in laying the Light on the Goodwin Sands.*'
- 3.1.1797-31.3.1797 Shoreham. As already noted, Spence spent these months working on the '**Geographical and Nautical Description and Tide Tables**' of Scilly.
- 18.12.1797 Surveyor employed on making out a Nautical Description of the Downs.
- 20.3.1798 Clean Copy of Nautical Description of the Downs sent by coach to the Admiralty.

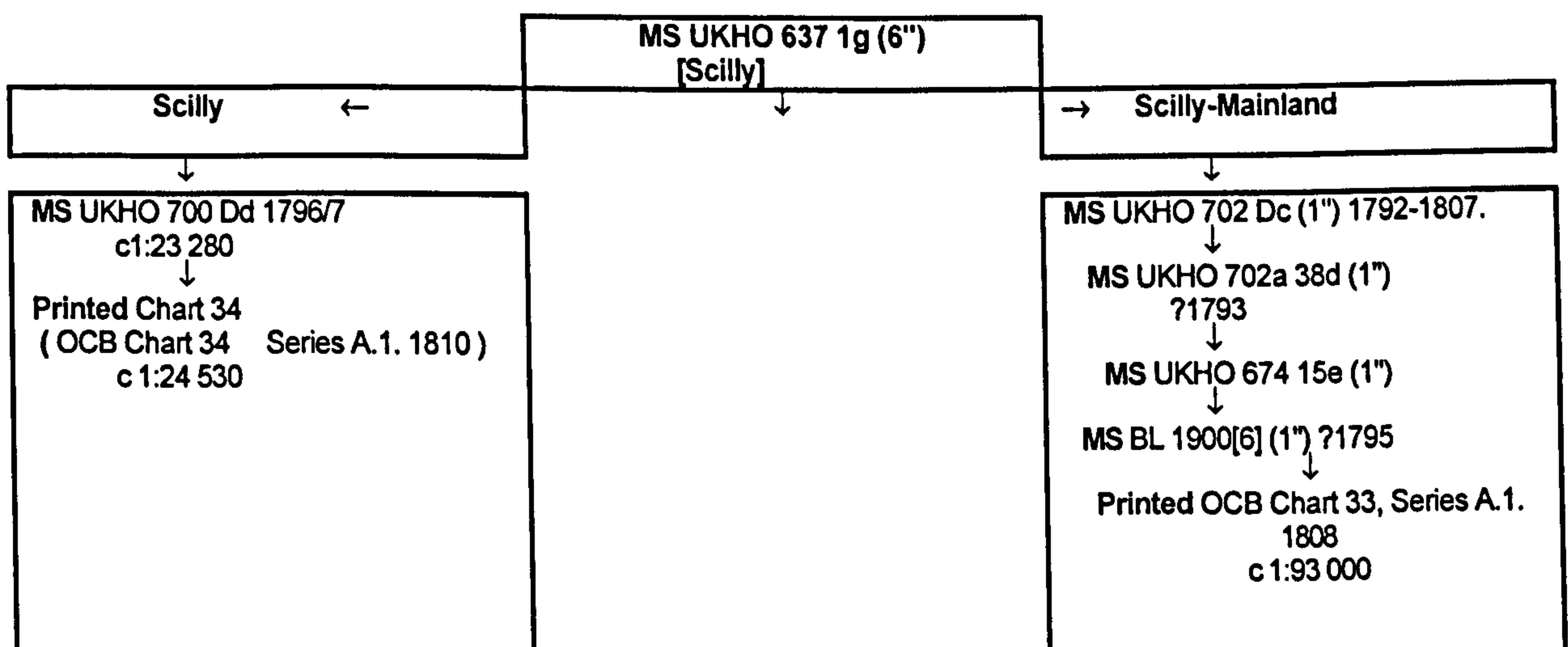
PART TWO

The UK Hydrographic Office holds five MS charts of Scilly or Scilly and the mainland and has complete sets of the printed charts by Spence or Spence and Mackenzie jnr. There are additional MS charts in the British Library and the Royal Navy Museum Library. It is difficult to establish a definitive chronology of Spence's MS charts of Scilly with the mainland, as four have the same or very similar titles and are all dated 1792. First and subsequent editions of printed charts based on the MS charts present no such problems. The basic chart of the Isles of Scilly is Spence's six inches to the statute mile, his 'large [scale] chart' (MS UKHO 637 1g), and from it he developed two sets of MS charts (TABLE 4-1). First, a smaller scale version of the six inch, leading to a printed chart (No 34), dedicated to the Isles of Scilly and dated 1810. Secondly, a collection of MS charts, all dated 1792, plotting the Isles of Scilly in relation to the mainland (west Cornwall), and eventually published as chart 33 in 1808 (further details are in Appendix F)

Mackenzie jnr. Began his survey of Avonmouth in 1772 and by March 1773 the north coasts of Somerset and Devon were completed. The surviving part of the 1773 log shows Mackenzie was employed west of the Lizard and round Land's End. The title of the printed chart OCB 33 states that the coast of Cornwall from the Lizard Point to St Agnes Head was surveyed by Lieut. Mackenzie in 1772.

TABLE 4-1

Suggested Relationships between Spence's MS and Printed charts of Scilly and Scilly -mainland



Spence's Survey of the Isles of Scilly

MS: (UKHO 637 1g). 'A Maritime Survey of / Scilly / taken by Order of / the Right Hon. Lords Commissioners of the / Admiralty; / at the Request of the Corporation of the / Trinity House. / By Graeme Spence 1792.' Scale: Six inches to one English [Statute] Mile. c163cm x 190cm.

(The Document is mounted on linen. The watermark 'J WHATMAN' is just visible but unfortunately no date or pattern make can be seen).

The six inches to one mile chart is Spence's definitive chart of the archipelago; upon its accuracy depended his triangulation to the mainland and his 1810 published chart of Scilly (OCB Chart 34, Series A.1. 1810.) The detail and beauty of the full coloured chart is astonishing. The monochrome extract (*CHART 4-1*) cannot convey the effort Spence put into the 'land work' upon which he based his survey. A portion showing the island of St Mary's reveals the detail of landuse, field boundaries, hachures, coastal detail etc. Spence was accumulating the data which would be the basis for his most important MS charts from the date of his arrival on Scilly on 31st August 1789. In his '*... Description of Scilly...*' Spence refers to '*... two [MS] charts taken...in the years 1790, 1791, 1792 by Graeme Spence,...*' and '*... the Scale of the large Chart, is 6 Inches to an English Mile, and that of the small Chart, 1 Inch.*' (Spence 1812, p 161).

Unfortunately and unexpectedly, the chart lacks any evidence of the triangulation upon which it was based. There are no triangulation stations marked and no sight-lines. That there was a triangulation is to be found on the Scilly-mainland one inch chart MS UKHO 702 Dc (1792-1807). The coastlines of the Islands are not plotted (*cf CHART 4-4a*, the west half of UKHO 702 Dc), but four trigonometrical stations are, namely St Agnes Lighthouse, station M on Trescow Isle, station K on St Martin's Isle and St Martin's Beacon, plus the sight lines to the main land. These are the stations used for the triangulation to the mainland and must have been especially chosen from the larger number used to plot the archipelago.

There is, however, a problem. The Scilly-mainland one inch charts MS UKHO 702a 38d and MS UKHO 674 15e plot the islands in as much detail as the scale allows. When a tracing of the four triangulation stations on MS UKHO 702 Dc is placed over the maps of the islands plotted on MS UHHO 702a 338d and MS UKHO 674 15e, they do not fit. St Martin's Beacon is about 600 ft SSW of its true position. The problem is discussed further when the Scilly-mainland links are examined. In spite of its detail the chart lacks latitudes and longitudes and therefore contributes little to determining the true position of Scilly. The MS six inch chart (UKHO 637 1g) and the printed chart 34 (OCB 34 Series A.1.) derived from it, lack any reference to latitude and longitude and therefore receive only the brief mention here

MS. (UKHO 700 Dd). 'A Maritime Survey of / SCILLY / taken by Order of / the Right Hon. Lords Commissioners of the / ADMIRALTY / at the Request of the Corporation of the / the / TRINITY HOUSE. / By Graeme Spence 1792.'

(The Document is mounted on linen. No watermark, date or pattern make can be seen).

1792 is the date of the survey of the six inch chart (MS UKHO 637 1g) which was obviously too unwieldy for normal use. Hence is the note: *Reduced 137/ 64 by J Walker 1796/7'* This was a faithful version of the six inch and produced a chart (MS UKHO 700 Dd) 76.5cm x 827cm, (*CHART 4-2* is a half scale copy.). The RF is c 1:23 280, close to the modern 1:25 000 chart. Pressure of work may account for the four year delay. The chart lacks any triangulation details, reference to latitude and longitude, and no linear scale. It remained unpublished.

PRINTED CHART: (OCB Chart No 34. Series A.1.). (*CHART 4-3* 1/2scale). The first printed version of Spence's Isles of Scilly survey was not published until 1810, entitled:- "A / SURVEY / of the / SCILLY ISLES, / by / Graeme Spence / 1792 / Variation 24° 45' W." In the south margin is printed:- 'Hydrographic Office Published according to Act of Parliament June 27th. 1810 by Capt. Hurd R.N. Hydrographer to the Admiralty.' 63cm x 94.7cm. RF 1:25 370. The bar-scale is one nautical mile. There are no latitudes or longitudes. An important addition is the 23 coastal views.

Although Spence's 1810 chart had 'additions and corrections' four times up to 1862 (Series A.2.- A.5.), latitude and longitude were never added. A description of this chart and the succeeding B,C and D Series are in Appendix F. Suffice to note here that not until 1866 was the position of Agnes Lighthouse added to the chart (OCB Chart No 34. Series B.1.)* and not until 1916 were latitudes and longitudes added in the chart margins (OCB Chart No 34. Series C.5.). These overlap chronologically with Ordnance Survey measurements and are discussed later.

* 'St. Agnes Lighthouse Lat. 49° 53' 32".9 N. Long. 6° 20' 38".1 W of Greenwich'

PART THREE

Spence's Triangulation between the Isles of Scilly and Western Cornwall

THE 1791-2 TRIANGULATION ((UKHO 702 shelf Dc)

The 'small Chart' is, in fact, very large and the reduced scale version reproduced here is in two halves:- *CHART 4-4a* (the Isles of Scilly) and *CHART 4-4b* (Lands End to the Lizard)

- a). Isles of Scilly / 'Westmost Cornwall' (*west half:CHART 4-4a*)
- b). 'Westmost Cornwall' / The Lizard Lighthouses (*east half CHART4-b*)

a). Isles of Scilly / 'Westmost Cornwall' (west half: *CHART 4-4a*).

[The explanatory Note A below the chart title was probably added c 1795, as it refers to the Wolf Rock survey of that date, and is therefore discussed later].

Thus far attention has been directed to the background of Spence's surveys of Scilly and Scilly / West Cornwall. Details on the origin of the Survey and Progress reports to the Admiralty and Trinity House have been transferred to Appendix E. The MS and printed charts were listed on an earlier page and are briefly described in Appendix F. The determination of the true position of the Isles of Scilly is, of course, the main purpose of this study and the rest of this Chapter is devoted to that. Spence compiled at least four very large MS charts, scale one inch to one (statute) mile, with longitudes and latitudes, which plot the Isles of Scilly in relation to west Cornwall. All have similar titles and are all dated c1791-2. They were the basis of the modern chart 33.

In all his writings Spence comes across as a very modest man, conscious of his limitations and those of his necessarily small, portable survey instruments. He was clearly anxious in 1791-2 to fix the position of Scilly (as represented by Agnes Lighthouse) as accurately as possible. The bulk of Spence's triangulation to the mainland was completed by 1792; small additions were made in 1795; the Trigonometrical Survey made its observations in this area in 1796 (Williams *et al*, 1797) and Spence compared it with his measurements in notes added to his chart in 1807. He must have been aware of the impending arrival of the Trigonometrical Survey with its superior instruments and larger staffing, against which his survey would inevitably be judged. His comments written before and after the publication of the Survey's findings are therefore very revealing. The same cannot be said of the Trigonometrical Survey, which totally ignores Spence's survey.

The most important chart is MS. (UKHO 702 Dc):

'A / Trigonometrical PLAIN Chart, / showing the relative situation of SCILLY, the / LANDSEND and the LIZARD; deduced from / a Base Line measured in SCILLY, and a scheme / of triangles carried on therefrom, in the years / 1791 and 1792: by / Graeme Spence, / late Maritime Surveyor to the Admiralty.' [with MS additions in 1795 and 1807]. 56.5cm x 148.5cm. RF 1:63 360. [*CHARTS 4-4a and 4-4b.*] East and west margins: latitudes in degrees, minutes and 10 secs. North margin: longitudes in degrees and minutes from Greenwich; South margin time in minutes and 10 secs. W of Greenwich. MS chart UKHO 702 Dc is believed to be the earliest 1" chart, upon which the other three were based. (The chart is mounted on linen. No watermark, date or pattern make can be seen).

Including the Title, there are five MS notes (of varying length) written by Spence on the face of the chart in 1791/2, 1795 and five added in 1807 (identified here as Notes A to J clockwise round UKHO 702 Dc and therefore on *CHARTS 4-4a and 4-4b*. These tell us a great deal about its construction and Spence's evaluation of his own work. The MS Notes, summarised in the following, are quoted in full at the end of the Chapter.

This large chart is obviously a working plot to illustrate the triangulation and was not intended for publication. Part has been reproduced at a reduced scale in Blewitt (1958). Here it has been reproduced in two parts at half scale and the western, **CHART 4-4a**, is that discussed here.

The chart details the triangulation Spence laid down (using only four triangulation Stations in Scilly) to fix the latitude and longitude of the Isles of Scilly (*i.e.* Agnes Lighthouse) in relation to the mainland (*i.e.* the West Lizard Lighthouse). The latitudes were based upon Spence's own observations at the Lizard and Agnes Lighthouses (the Longships Lighthouse was under construction Fig 4-3). The longitudes were measured by triangulation from Scilly to the Lizard, but as the longitude of the ~~later~~ **LATTER** had been erroneously measured by others, Spence's calculations were subject to these errors.

A minor point of dating arises, as Spence describes himself in the chart Title as '*...late Maritime Surveyor to the Admiralty*'. He did not resign as Admiralty Surveyor until 1803. Spence's supplementary notes on the chart are dated 1795 and 1807 (the latter in a less firm hand than earlier ones) so he probably added the 'late' to the title in 1807.

Spence's measured the distances between selected triangulation stations on Scilly (including the Agnes lighthouse) and those on the mainland close to what Spence called the 'Landsend'. These depended solely upon the accuracy of his measured baseline and his angular observations. Triangulation was the basis of the six inch MS chart completed in 1792. Three of the triangulation stations used in that survey provided carefully selected stations from which the triangulation to the mainland of west Cornwall could be observed and the distances to selected stations on the mainland calculated with great accuracy. The mainland coast is plotted in detail but the Isles of Scilly are represented simply by a small number of outlying rocks and four trigonometrical stations. Spence used Mackenzie jnr's surveys of west Cornwall for the mainland. Mackenzie notes:- "*LATITUDE of PLACES on the COASTS of CORNWALL. The Altitude of Sun...was taken with Bird's 12 Inch Quadrant; and with a 12 Inch Sextant made by Nain and Blunt.*" (Spence 1812, p 58).

Along the east and west margins is the latitude in degrees, minutes and 10 second intervals. The north margin shows 'Longitude in Degrees West from Greenwich', divided into 5 minute and 12 second intervals. The south margin shows Longitude in Time West from Greenwich', divided into hours, minutes and 10 second intervals. The parallels and meridians for the Agnes and the West Lizard Lighthouses are drawn across the face of the chart but are not numbered (compare charts UKHO 702a 38d and UKHO 674 14e *infra*).

The compass rose is 'True North, Variation 24° 50' W. 1792'. Elsewhere Spence quotes the 1792 variation as 24° 45' W.

There are two bar-scales:-



Fig 4-3 Longships Lighthouse. 320253

"Scale of 4 English Miles, 1 inch to a mile, of 1760 yds." [*i.e.* Statute Miles]

"Scale of 4 Geometrical [Nautical] Miles, 1,15278 inches to a mile, of 2028.91 yds."

The R F is 1:63,360. This scale, of course, explains the large size of the chart, which extends W-E from $\frac{1}{4}$ mile west of Crim Rock, Isles of Scilly to Kinnock [Kinnack] Cove on the Lizard peninsula., a distance of approximately 58 statute miles.

The title of the chart makes it clear that the triangulation is founded upon a '*...base Line measured in Scilly*' (the location and length are not given) and on a '*...scheme of triangles carried on therefrom*'. It was the only Scilly / mainland triangulation of the four that ~~have~~ ^{HAS} been recorded between 1791 and 1967 [11] that was observed solely from the Islands to the mainland. On this chart, the yard was Spence's preferred unit of measurement.

The Isles of Scilly are not plotted on the chart but are represented only by i) a few named rocks defining the commonly used outer limits of the archipelago, namely Lion Rock, Hanjaque Rocks, Prednathias Rock and Crim Rock; ii) three triangulation stations used by Spence to observe the mainland, viz Agnes Lighthouse, St Martin's Beacon and **Station M** on Trescow [*sic*] Isle. The Beacon had been erected in 1693 by Thomas Ekins, steward to the Godolphin Lord Proprietors. Spence's triangulation stations do not exactly match their named positions on his other one inch charts the most serious is the Beacon which, as plotted on chart UKHO 702 Shelf Dc, is about 600 ft SSW of its location on the

other three 1" charts, e.g. UKHO 702a 38d. There is no reason to doubt that Spence used the Beacon and that his observations were as accurate as he claimed. In the Napoleonic wars, a now ruined semaphore station lay just south of the Beacon and possibly the draftsman confused the two sites. It must be remembered that this is a working plot and that the angles Spence has inserted were based upon his original calculations, not those measured on the chart. The triangulation angles are plotted on the chart in degrees and minutes.

Baseline and Triangulation stations.

The chart does not identify Spence's baseline which must have been used initially to plot his six inch chart (UKHO 637 1g). From it, of course, all his distances were calculated. St Mary's and St Martin's are the longest Islands but no Station is plotted on the former. **Station K** and St Martin's Beacon are on St Martin's Isle but they are only c 998 yards (c 913m) apart, which is very short for a baseline. Spence may have used one of several intertidal sand flats to set out a longer temporary baseline (c.f. Admiral Martin White in his surveys of the Channel Islands; Chapter Eight). Wherever located the baseline must have been of limited length and it is to Spence's credit that his calculated distances to the mainland were so accurate.

All the triangulation sight lines on the chart are in red, as are i) the flags marking **Stations A, M and K**; ii) Agnes lighthouse; iii) the profiles of the churches at Sennen and St Buryan (Figs 4-4a and 4-4b); iv) the two Lizard Lighthouses or towers; v) the Wolf Rock beacon. Leading lines are in black, as is all other detail, such as the crudely drawn hill profiles on the mainland. All the angles inserted on his chart are in degrees and minutes; it is not known whether the original observations were more precise. The angles measured from the Isles of Scilly to a point on the mainland are inevitably very acute because of the limited N-S span of the Islands and their distance from the mainland.

Two stations, St Martin's Beacon and Agnes Lighthouse were well-known navigation marks. Spence was able to observe from the top of the cone-topped St Martin's Beacon (Spence 1812, p 165), built on St Martin's Head (47m OD [local]). It was hollow and 12.2 m high, which places the apex at 59m (Spence claimed the top to be 207ft / 63m asl.). The gallery of the Agnes Lighthouse had the advantage of being c 160 ft / 49m above low water. The third station used for the mainland observations was flag '**Station M**' on Trescow [*sic*] Isle, one of the network of temporary sites marked by flags used for the survey. A fourth station, flag '**Station K**', east of the Beacon on St Martin's Isle, was used only for observations to the Pollard Rock, one of the Seven Stones.

Spence does not describe the locations of flag **Stations K** (St Martin's) and **M** (Tresco); they are not plotted on Spence's six inch MS chart. Their positions can be located by placing a tracing of them over one of the one inch charts of Scilly on UKHO 702a 38d or UKHO 674 15e, or by using measurements taken from chart UKHO 702a Dc. In either case, flag **Station M** (Tresco) appears to lie on Gimble Point (880164). This is obviously too

low and allowing for the inaccuracies of the charts, **Station B** must have been the ruined Cromwell's Old Castle or King Charles' Castle (882161) originally built in 1550-54 and rebuilt as '*a strong circular tower*' in 1651 and repaired in 1740. Originally it was 150ft (45.7m) in circumference and 60ft(18.3m) high, surmounted by a flagstaff. It is clearly shown on the 1792 six inch chart (but not as a triangulation station), on Spence's 1810 chart 34, Series A.1.; scale 1:25,159), and on the modern Ordnance Survey 1:25,000 map as '*Castle, rem. of*'. Ground level is 43m OD [local], only 1m below the island's highest point.

Flag **Station K** (St Martin's) can be shown to lie north of Higher Town, on an unnamed local summit (932158) 42m asl. It is named the 'Guardhouse carn' on Spence's six inch chart of 1792, (which his hachures show it to be on higher ground than the surrounding plateau) and the 'Guardhouse carn' on Spence's 1810 chart of Scilly. Fortunately flag **Station K** was not used for the mainland observations so the uncertainty about its position is not too serious. Several writers (e.g. Courtney 1897, p 419) point out that the highest part of Samson (42m; 878124) commands a view of all the islands; it may well have been used as a trigonometrical station in the six inch survey but it would not be suitable for observing the mainland.

It might seem obvious that ~~of~~ **Stations K** and **M** could be located simply by using the latitude and longitude scales in the chart margins. Spence, however, derived his longitudes from that of the Lizard lighthouse and at the time of the 1791-2 survey, it was incorrectly measured. Using the contemporary longitude of the Lizard Lighthouse, **Station M** lies 2nm WSW to the islet of Maiden Bower!

The chief mainland station was the 27m high tower of St Burryan [*sic*] Church (410258), the top of which is 152m OD (1999; 50° 04' N; 05° 37' W; Fig 4-1a). It was observed from St Agnes Lighthouse and Tresco (**Station M**) to form one triangle, and from Agnes Lighthouse and St Martin's Beacon to form a second. They were observed in 1791-92 and there were no back-sights. The top of the 18 m high tower of Sennen Church (357255), is 119m OD, (1999; 50° 04' N; 05° 42' W; Fig 4-1b) and is included here as it was one of the apices of a third triangle:- Agnes Lighthouse, Sennen Church and St Buryan Church. It had one very acute angle (1° 38') and although the lengths of its sides are written on the chart, Spence obviously decided not to use them. '*St. Buryan [church tower] can be easily distinguished from Sennan [sic] because the former is the largest and highest of the 2 towers.*' (Spence 1812, p 173). At the distances quoted the fact that a tower has width (unlike a spire) would not be significant when measuring angles with a 12" theodolite. Both these towers are prominent on the sky-line from many places on the Penwith peninsula, as well as the Isles of Scilly.

Spence added the following note on the chart alongside the Agnes-St Buryan sightline:-

Note I:- '60810 yards, by the Triangle St Agnes Lighthouse, St Martin's Beacon, and St Burryan Church.

60800 yards, by the Triangle St. Agnes Lighthouse, M Station on Trescow Isle, and St Burryan Church.

The distance from St Agnes Lighthouse, to St Burryan Church, found by two different Triangles, only differing 10 yards, is a tacit proof that, although the Triangles are acute, [6° 41' and 8° 12' respectively] they are pretty correct; and that the mean distance 60805 yards [30.020nm] is nearly the true distance: however I have preferred the number 60800 [30.018nm] in [extending] this scheme of triangles to the Lizard.'

Note J). [*? An 1807 addition*] ' *N:B: This distance is only about 222 yards more than that of the Grand Trigonometrical Survey; which is a much nearer agreement than could be expected considering Mr Spence's imperfect Instruments* '.

Spence's calculated distances from St Martin's Beacon and Station M to St Buryan Church are 52060 [25.702nm] and 58480 yards [28.872nm] respectively. The exact position of Station M would have been known to Spence.

The only other 1791-2 triangulation was to the Pollard Rock, which was never landed on (Spence 1812, p 172). It was one of the dangerous Seven Stones group lying in the channel between Scilly and Cornwall. Many of the rocks dry and are mainly steep-to with depths of more than 50m outside a distance of 1 mile, giving little warning of their presence (Channel Pilot, 1999). The Pollard Rock dries 2.4m. It was observed from flag Station M on Trescow and flag Station K on St Martin's. As noted above, Stations K and M were temporary flag stations. Spence offers no reason why the well established St Martin's Beacon was not used instead of Station K.

TABLE 4-2

Pollard Rock (Seven Stones)

Spence	50° 02' 42" N	06° 10' 21"W
Modern	50° 03' N	06° 08' W

Channel Pilot 1999.

Reproduced from Admiralty Publications/Charts by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office.

b) 'Westmost Cornwall' / The Lizard Lighthouses

This was the extension of the above triangulation to the lighthouses on the Lizard peninsula (**CHART 4-4b**). At the time of the 1791-2 survey, the Lizard lighthouses were the nearest place to Scilly whose latitude and longitude were believed to be known accurately [12] (British Nautical Almanac 2nd Edition 1781. Tables requisite...Table XX, p 153: 49° 57' 30" N and 05° 15' 00" W).

The extension of Spence's triangulation made it possible for him to compare his measurements and calculations of the latitude and longitude of the Agnes Lighthouse in relation to those of the Lizard lighthouses. Errors, especially in the longitude of the Lizard lighthouses, would be transferred to the Agnes Lighthouse, however carefully Spence



Fig 4-4 East Lizard Lighthouse. 704115. © Judges Post Cards, Hastings

observed his triangulation between Agnes and the Lizard. Ravenhill (1987;1989) has discussed the many estimates / measurements of the position of the Lizard at length and his work is referred to later. Spence was aware that the Trigonometrical Survey had measured the position of the Lizard and had observed Scilly from the mainland in 1796 (Williams *et al* 1797; Chapter Six). He is at pains to show that his results as regards distance from the mainland compared favourably with those of the Survey (notes added to his original 1791-2 chart).

Note A). *'N.B. The Coast Line Soundings, Shoals, etc. from Cape Cornwall to the Lizard; are all copied from Mr. Mackenzie Jnr's.. survey of Mounts Bay taken in 1773. The Scilly Islands, the Seven Stones, the Wolf Rock and the Longships Lighthouse were surveyed by Mr. Spence; so that the junction of these two Surveys, depends on the accuracy of Mr. Spence's Triangles; the first of which is unavoidably Acute [6° 41']; and therefore, he wishes, that Mr. Dalrymple [the Admiralty Hydrographer] would compare the whole, with the Grand Trigonometrical Survey [1797] and correct them where necessary, as that has been taken since the year 1792: all that Mr. Spence presumes to say is, that he believes his to be the most accurate of any prior to that year; nothing further can be expected from such a maritime survey carried on with necessarily small portable Instruments.'*

A second group of triangulation stations was used to carry Spence's triangulation network across Mounts Bay to the Lizard. Using the already established stations at St Buryan and Sennen Churches, he skillfully had to add only two new stations, at Chapel Carnbrea (now Carn Brea 386281) 203m OD, and Castle Dennis (now Castle-an-Dinas 484350) 233m OD to determine the Lizard's position (represented by the Western Lighthouse, as drawn on UKHO 702 Shelf Dc). This was done using one large well formed triangle, based on St Buryan Church and Castle Dennis. Chapel Carnbrea's position was fixed from Sennen Church and St Buryan Church and Castle Dennis's from Chapel Carnbrea and St Buryan Church. The distances on the chart are in yards.

TABLE 4-3

St Buryan Church – Castle Dennis	13 090 yds / 7.438 st mls / c11.97km
St Buryan Church – West Lizard light	35 040 yds / 19.909st mls / c32.00km
Castle Dennis - West Lizard light	35 770 yds / 20.323 st mls / 32.7km

The Lizard

The accurate position of 'The Lizard' was crucial to Spence's determination of the position of the Isles of Scilly, as represented by the Agnes Lighthouse, but what is meant by 'The Lizard', the southernmost part of England, requires clarification (Figs 4-5 and 4-6). Tarrant (1993) and Boyle (1999) give detailed accounts of the history of the Lizard lights and Lighthouses. The present building, which once had lights on both the west and east towers, was completed in 1751. A row of cottages (450ft long) links the two towers. The western tower had its light removed in 1903 and has been reduced in height. The present Lighthouse (east tower Fig 4-4) rises 18.6m above ground level and 70m above MHW [13].

Lizard village (703125) lies close to the southern end of the large peninsula generally referred to as 'The Lizard' [14]. South of the village are three sites which have at various times have been used to measure the latitude and longitude of 'The Lizard', so that unfortunately, published latitudes and longitudes, then and now, are not necessarily comparable (Ravenhill in Starkey ND, p17). To the west lies **Lizard Point or Cape Lizard** (695115) the most southwesterly tip ;about a kilometre to the east is the westerly of two white painted octagonal towers (**originally the West and East Lighthouses**), which are c 137m / 450ft apart, (Williams *et al* 1797, p 502) joined by a row of cottages and c1.2 km further east is **Bass Point** (717119), which was the site of the **Lloyds signal station** (now a private residence), where the coast turns northward. Even the Channel Pilot (HD 1971, p 83) is confused '*...Lizard point is a bold and precipitous promontory ...it is easily identified by its two white octagonal towers, the eastern of which is the lighthouse'* and even Boyle (1999) in his detailed account of the Lizard Lighthouses, entitles a photograph of the eastern lighthouse '**Lizard Point**'.

Latitudes

Ravenhill (1989; see also 1975 and Exeter Maritime Studies 3) has compiled a masterly review of '**Mapping the Lizard**' to which no summary here could do justice. Suffice to say that Ravenhill traces the recognition of the Lizard as the most southerly point of the English mainland and analyses the attempts to fix its position from Ptolemy to the Ordnance Survey (late 20th century). It concentrates on latitudes for the Lizard Point but fortunately the latitudes of Lizard Point and the west and east light towers are almost identical. Measurements that may have been useful to Spence include Maskelyne 1763 and Bradley 1769. Sadly, the measurements by Mackenzie jnr and Graeme Spence have been omitted. Ravenhill's graphical demonstration (1989, p 35) is based on a modern latitude of **49° 57' 32" N**. According to the Trinity House Lighthouse Service, the most recent measurement of the latitude of the east Lighthouse is **49° 57.58' N [49° 57' 35" N]**.

The Scilly Isles / Mainland triangulation really begins at the Agnes Lighthouse:-

Note G). *St Agnes Lighthouse. Latitude 49° 53' 47" Observed in 1791 with Troughton's double framed Astronomical Quadrant, by G. Spence. This is taken here as Spence's definitive latitude of the Lighthouse as measured in his initial 1791-2 survey.*

N.B. The Requisite Tables was [sic] altered agreeably to this Chart, at least Dr. Maskelyne told me they should be altered, as it was wrong laid down in all former Charts and Navigation Books.'

Maskelyne was the Astronomer Royal and responsible for the Nautical Almanac. The positions of significant places were listed in the '**Requisite Tables...**'. In the 2nd edition (1781) the latitude of the Agnes Light was listed as 49° 56' 0" N but Spence's 1791 comment was obviously noted and in the 3rd edition (1802) the latitude of the Agnes Light was amended to 49° 53' 47" N.

Spence (**Note D**) spent eight days in early June 1792 observing the latitude of the western Lizard Light in 1792 with a TROUGHTON'S double framed Astronomical Quadrant, and concluded that its latitude was 49° 57' 55" N. No explanation has been given for an eight day stay but the weather may have played a part. Using his triangulation from the Scilly base [unlocated] he made the latitude of the Lizard (presumably the west Lighthouse - this was used for his longitude measurements) as 49° 57' 52" N. He admits that such a small difference of 3" of arc was unexpected, considering the acuteness of the Scilly-mainland triangles and the small portable instruments he used. (elaborated in **Note D**). These latitudes are here regarded as Spence's definitive values based on his 1791-92 survey. He asked the Admiralty's permission to communicate to Trinity House the Latitude of the Lizard ' (GL Ms: THGCM 14th June 1792).

For comparative purposes, Spence would only have been interested in contemporary measurements of the Lizard's latitude (and longitude) :-

i). Bradley observed the transit of Venus at the Lizard in June 1769 and calculated the latitude as 49° 57' 30" N., using a point just north of a line joining the centres of the two towers (he had to avoid the row of buildings linking them).

ii). Mackenzie jnr had surveyed west Cornwall in 1773 and Spence records some of his results in Spence 1812:- *'The Altitude of Sun, from which the following Latitudes were deduced, were taken with Bird's 12 Inch Quadrant; and with a 12 Inch Sextant made by Nain and Blunt.'* He recorded the Lizard Lighthouses as 49° 57' 30" N.

iii). The 2nd and 3rd editions (1781 and 1802) of the Nautical Almanac (Nevil Maskelyne) both list the latitude of the 'Lizard' as 49° 57' 30" N. (Tables XX and XX1X respectively), a latitude recorded both by Bradley and Mackenzie jnr and presumably made at the Lizard Lighthouses.

iv). Spence's 1791-2 latitudes (49° 57' 55" N. / 49° 57' 52" N) were 22" / 25" north of north of contemporary published values.

v). The Trigonometrical Survey's 1796 (Chapter Six) re-measurement of Bradley's site placed the latitude as 49° 57' 44" N. It was 14" north of Bradley/Mackenzie and 8" (810.6ft / 247m) or 11" (1114.7ft / 339.7m) south of Spence (1791-2).

vi).Channel Pilot 1999 (to nearest minute):- East Lighthouse : 49° 58' N;

vii).Trinity House Lighthouse Service (2001) :-East LH: 49° 57'.58 N [49° 57' 35" N]

TABLE 4-4

Examples of 'Lizard' Latitudes

Bradley 1767 (just north of twin towers)	49° 57' 30" N
Lt Mackenzie 1773 ('lighthouses')	49° 57' 30" N
Nautical Almanac 1781 (2 nd ed)	49° 57' 30" N
Spence (1) 1791-2 (west tower). Observed	49° 57' 55" N
Spence (2) 1791-2 (west tower). Triangulation.	49° 57' 52" N
Trigonometrical Survey 1797 (west tower)	49° 57' 44" N
Nautical Almanac 1802 3 rd ed (repeating Bradley)	49° 57' 30" N

The persistence of the 49° 57' 30" N latitude from 1769 to 1802 is surprising.

Longitudes

Spence sought the Admiralty's permission to communicate to Trinity House the Longitude of Scilly, '*...as he thinks the Longitude of Scilly should be corrected as well as its latitude has been.*' (GL Ms: THGCM 14th June 1792). Determining the longitude of Scilly was, of course, the *raison d'être* for the triangulation described above. As the east and west towers of the Lizard Lighthouses are in the same latitude, distinguishing between them is not important, but when longitudes are being measured, the c 450ft difference is significant.

As the Trigonometrical Survey did not reach the Lizard until 1796, Spence's 1791-2 survey had to rely on existing data. Spence did not measure the longitudes of the Lizard Lights astronomically. He may have lacked a suitable telescope, time piece and lunar tables or tables of the eclipses of the moons of Jupiter. 'Lizard Lights' is too vague for a longitude measurement, as the two towers are 450ft(137.2m) apart. Spence's 1791-2 'Plain Chart' (UKHO 702 Dc) clearly shows in profile two towers east of Lizard Point, and his meridian passes through the western. Spence's observations refer to the western lighthouse/tower, whose longitude is west of the modern lighthouse by some 6.9" of arc. Fortunately, most observations contemporary with Spence's are based on the western lighthouse / tower.

He was obliged to use information from Dr Maskelyne, the Astronomer Royal, in the Nautical Almanac for 1781, which was probably based on Bradley 1767. Note d). *....the Longitude of the Lizard Lights is here put down at 5°, 15'W. or 0^h, 21^m, 0^s of time; from the information of Dr.Maskelyne the Astronomer Royal. [c.f. Nautical Almanac 1781.*

Ravenhill (ND. Exeter Maritime Studies 3, pp 5-23) reviews the attempts to measure the longitude of the Lizard Point, as he had the latitudes in 1989. The Point is, however, c 40" of arc west of the west Lighthouse used by Spence. Ravenhill's diagram (p 17) shows how inaccurate were the longitudes of Halley 1701 (c 04° 36' W), Renshaw 1741(c 05° 44' W), Heath 1749/50 (c 05° 34' W) , Maskelyne 1763 (05° 43' W), Bradley 1769 (05° 15' W), Maskelyne 1781 (05° 15' W). c 45" of arc should be subtracted from the above longitudes of the Lizard Point to compare them with the modern east Lighthouse.

MODERN LONGITUDES

Channel Pilot 1999 (to nearest minute):- East LH : 05° 12' W.

Trinity House Lighthouse Service (2001):- Easy LH: . 05° 12.' 07 W. [05° 12' 4" W]

If it is assumed that Bradley observed the longitude at the same site as his latitude (from a point midway between and just north of the twin lighthouse towers) and that Maskelyne repeated this figure in the 1781 Nautical Almanac, then Spence was wrong to draw on his 'Plain Chart' (UKHO 702 Dc) the meridian of 5° 15' 0" W through the west tower. This was 225ft (68.6m) west of Bradley's measured meridian of 5° 15' 0" W, a figure which Spence had obtained from Maskelyne. The difference is only 3.4" of arc but still significant and Spence should have been aware of it, as he was so anxious to have his measurements compared with those of other surveyors.

Agnes Lighthouse

At the end of his 1791-2 triangulation from Agnes Lighthouse to the mainland and the Lizard Lighthouses, Spence had largely completed his first attempt to fix the position of the most recognised navigation mark on Scilly, the Agnes Lighthouse. He may have been referring to this in 1812 (p 156-7) when he stated that Scilly (? Agnes Lighthouse) was ... *laid down ... between 3 and 7 Minutes [3-7 nm] more northerly than it ought to be...* [and] *'... 12 or 14 [English or Statute] Miles [c 10.4 or 12.2 nm] farther from the Lizard, than it ought to be.'*

Latitude

As noted above, on chart UKHO 702 Dc ('the plain chart').is written:- *'St. Agnes Lighthouse / Latitude 49° 53' 47."N. / Observed in 1791 with Troughton's double framed Astronomical Quadrant, by G: Spence'. N.B. The Requisite Tables was [sic] altered agreeably to this Chart, at least Dr. Maskelyne told me they should be altered, as it was wrong laid down in all former Charts and Navigation Books.'* (Note G). The 1802 Nautical Almanac Requisite Tables (3rd ed) do list the latitude of the Agnes Lighthouse as 49° 53' 47" N. (N A Table 19, p 169).

The parallels of Agnes Lighthouse drawn across the one inch charts UKHO 674 15e, UKHO 702a 38d (all c 1792) are numbered 49° 53' 47 "N. The 1781 'Requisite Tables' give the latitude as 49° 56' 00", 02' 13" (or 2.8nm) north of Spence, who knew that the published Agnes lighthouse latitudes were too far north. Spence's measurement compared with the modern latitude (49° 53' 30" N) reveals a remarkably small error of 17" of arc or 0.28nm.

Longitude

As measured from the 'Plain Chart' (UKHO 702 Dc) and as numbered on the meridians of Agnes Lighthouse drawn across the one inch charts UKHO 674 15e, UKHO 702a 38d, the 1792 longitude of Agnes Lighthouse is 06° 23' 15" W. This longitude is, of course, based (Note d) on *'the Longitude of the Lizard Lights is here put down at 5°, 15'W. or 0^h, 21^m, 0^s*

of time; from the information of Dr. Maskelyne the Astronomer Royal. Spence later attempted to correct this longitude, using more accurate data for the Lizard. (06° 23' 15"). The modern longitude of the east lighthouse is 06° 20' 42" W, 22' 33" east of Spence's calculation. Spence was aware that the published longitude of Scilly was too far east, but the 1791-2 triangulation only partly corrected the error.

The charts of Scilly - mainland are generally attributed to the years 1791-2 but in fact Spence was still working on them as late as 18th December 1793. In fact he complained that he could not finish the chart of Scilly for Trinity House (GL Ms:THBBM 12th March 1795) without an assistant. It is no surprise, therefore, that Spence, aware of the limitations of his 1791-2 survey, sought to improve it in later years.

THE 1795 TRIANGULATION

In 1795 Spence was engaged on surveys on the coasts of east Kent (e.g. Ramsgate; the South Foreland etc. (Robinson 1962, p179) but he found time in the year to revisit west Cornwall and Scilly to make additional observations. '1795' is written alongside three minor but navigationally important features: the Longships Lighthouse (Fig 4-3), the Wolf Rock Beacon and the Runnelstone Beacon (Chapter Six). These triangulations were unique in that they were observed from the mainland.

With the new 1795 observations, Spence obviously thought that important, clarifying details should be added in a prominent place below the chart's title (Note A). In them he makes clear that the coast line Cape Cornwall to the Lizard was copied from Lieut Mackenzie's survey of Mounts Bay in 1773. The Scilly Islands, the Seven Stones, the Wolf Rock and the Longships Rock were surveyed by Spence himself. Joining the two surveys therefore depended on the accuracy of Spence's triangles, observed in 1791-2, the first of which was unavoidably acute [6° 41']. Spence asked that Mr Dalrymple [the Admiralty Hydrographer] should compare the whole survey with the Trigonometrical Survey [1796], correcting where necessary. 'all that Mr. Spence presumes to say is, that he believes his to be the most accurate of any prior to that year; nothing further can be expected from such a maritime survey carried on with necessarily small portable instruments.' [our emphasis].

The largest new triangle was to the Wolf Rock (against which is written on the 'Plain Chart':- 'Wolf Rock Beacon in 1795') observed from the established Stations at St Martin's Beacon and St Buryan Church (presumably from the tower).

St Martin's Beacon-St Buryan Church 52 060 yds;

St Martin's Beacon- Wolf 35 910yds;

St Buryan's Church- Wolf 21 470 yds

This was the first time that the position of the Wolf Rock had been plotted. Its latitude and longitude are plotted and numbered on charts UKHO 674 15e and UKHO 702a 48d (49° 56' 56" N; 5° 51' 12"W). The longitude is, of course, based on that of the incorrect west Lizard Lighthouse (5° 15' W). Trinity House had rejected a plan for a bell buoy for the Wolf Rock in 1742 and 1750 (GL Ms TH 30,117/1). Lieut Henry Smith (Appendix B) had proposed in 1791 the erection of a 20ft iron mast or pole, but it was built in fact by Capt Joseph Huddart (Chapter Five) who successfully put a 4" diameter pole of wrought iron set in lead on the rock in 1795. Although soon washed away, it was replaced more than once. It was, therefore, fortunate that at the time of Spence's survey there was a 'Wolf Rock Beacon' in place and on chart UKHO 702 Dc (only) is drawn a typical pole with basket at the top. When describing St Martin's Isle, Spence (1812, p 165) says that from ^{THE} top of its Beacon he once or twice saw the Wolf Rock, which he believed was not possible from any other part of the Islands. He was, therefore, fortunate to make the observations recorded on his chart. The first lighthouse was built 1862-69 and lit January 1870. Excellent summaries are in Tarrent 1993; Boyle 1997b. On a clear day it is easily visible from Land's End.

TABLE 4-5

Position of the WOLF ROCK (*CHARTt 4-4b*)

Spence 1795: (charts UKHO 674 15e, 702 Dc and 702a 38d)	49° 56' 56" N	05° 51' 12" W
Modern Chart	49° 56' 07" N	05° 48' 02" W*

*Channel Pilot 1999:- 05° 48' W.

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The second 1795 triangle plotted on the chart using two observations from the mainland was to the Longships Lighthouse (1794) c 1.4nm west of Land's End. Detailed accounts of the Lighthouse are in Tarrant (1993) and Boyle (1997c). It was observed from Sennen Church (presumably from the tower) and flag Station A. No further details of the latter temporary Station are given by Spence but it must have been south of White Sand Bay on Mayon Cliff (350261) above Sennen Cove, c 78m OD. The latitude and longitude of the Longship Lighthouse (now complete: Fig 4-3) are drawn right across the face of chart UKHO 702 Dc to the margins but are unnumbered. The latitude and longitude are, however, plotted and numbered on charts UKHO 674 15e and UKHO 702a 48d (50° 04' 20" N ; 5° 47' 30" W). The longitude is, of course, based on that of the west Lizard Lighthouse (5° 15' W).

TABLE 4-6

Position of the LONGSHIPS LIGHTHOUSE (Fig 4-3)

Spence 1795:		
charts UKHO 674 15e &	50° 04' 13" N	05° 47' 18" W
UKHO 702a 38d	"	"
UKHO 702 Dc	50° 04' 13" N	05° 47' 28" W
Modern Chart	50° 04' 00" N	05° 44' 07" W*

*Channel Pilot 1999:- 05° 45'.

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There is a third entry on chart UKHO 702 Dc: 'Runnelstone / Beacon 1795' (c 0.5nm south of Pol Pedn Penwith: 365217). It is awash at high water, but no triangulation to it is plotted on the chart. It is a serious navigational hazard and its position was probably taken from Mackenzie jnr's 1773 chart.

TABLE 4-7

Position of RUNNELSTONE SOUTH BEACON

Spence 1795	50° 01' 14" N	05° 43' 00" W
Modern Chart	50° 02' 01" N	05° 40' 30" W*

*Channel Pilot 1999:- 50° 02'.2 [12"] N; 05° 40'. 5[30"] W

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THE 1807 CORRECTIONS AND COMPARISONS

In 1803 Spence retired as Maritime Surveyor and moved to the Hydrographic Office in 1804 to work on the backlog of MS charts but was still adding notes to his 'Plain Chart' at least until 1807 (he finally retired in 1811). He took pleasure in demonstrating that his 1791-2 survey results compared favourably with those of the Grand Trigonometrical Survey of 1796. Spence's handwriting is less firm in these later additions to his 'Plain chart'.

He also converted ~~of~~ all bearings from magnetic or compass to true. A footnote (Spence 1812, p 19), signed by Spence, records that in 1808 he had corrected Mackenzie jnr's charting from Barnstaple Bay to Land's End, so that all Compass Bearings were True Bearings, so that annual compass variation could be allowed for. He had similarly corrected Mackenzie's Mounts Bay chart, covering Land's End to Lizard, and '*...laid it down upon the True Meridian, by his own surveys of Scilly; (which agrees with the Grand Trigonometrical Survey).*

Spence did not re-plot his 'Plain Chart' to take into account the 1807 adjustments; they were simply noted on the chart.

Agnes Lighthouse-St. Buryan.

Below the 1791-2 comments (Note I) on the Agnes-St Buryan sightline:- . ' 60800 yards, by the Triangle $\text{\textcircled{S}}$. Agnes Lighthouse, St. Martin's Beacon, and St. Burryan Church. 60810 yards, by the Triangle St. Agnes Lighthouse, M Station on Trescow Isle, and St. Burryan Church.

The distance from $\text{\textcircled{S}}$. Agnes Lighthouse, to St. Burryan Church, is found by two different Triangles, only differing 10 yards; is a proof that, although the triangles are acute, they are pretty correct; and that the mean distance 60805 yards, is nearly a true distance: however I have preferred the number 60800 yards in this scheme of triangles to the Lizard.' Spence added Note J c1807:- 'N.B: This distance is only about 222 yards more than that in the Grand Trigonometrical Survey; which is a much nearer agreement than could be expected considering Mr. Spence's imperfect instruments.' The Trigonometrical Survey distance is 18,3096ft = 61,032 yds. Spence quotes two distances, derived from different triangles (see above); one is 222 yds and the other 232 yds longer than the Survey. Alongside the St Buryan-Lizard sightline Spence noted: 'N.B. This is only 10 yds. less than the Gr. Tr. Survey.'

Lizard latitude.

Note E). 'In the year 1807, Mr. Spence compared the above Latitude [i.e. Note D; his 1791-2 latitude of the Lizard Lighthouses; $49^{\circ} 57' 52''$ N or $49^{\circ} 57' 55''$ N] with that laid down in the Grand Trigonometrical Survey [West Lighthouse $49^{\circ} 57' 44''$; Williams et al 1800, p 671], and found his only between 8 and 11 seconds (810.6ft / 247m or 1114.7 / 339.7m) more than it; which is a much nearer agreement than could well be expected from him and his Imperfect Instruments.' In 1812 Spence confirmed his latitude of the West Lizard Lighthouse as $49^{\circ} 57' 52''$ N [Spence 1812, V.4 Book 2]. The modern latitude of the West Lizard Lighthouse is $49^{\circ} 57' 35''$ N.

Longitudes: Agnes and Lizard Lighthouses

In 1792 Spence accepted Maskelyne's longitude of the Lizard lighthouses as $05^{\circ} 15' 00''$ W. and based the longitude of the Agnes Lighthouse on it ($06^{\circ} 23' 15''$). Later, in 1807, he explained the corrections necessitated by the measurements of the Trigonometrical Survey, although his reasoning in Notes E and F has to be followed with care. *BE*

Note E). [1807] *The Longitude of the Western Lizard Lighthouse, is laid down in the grand trigonometrical Survey, at $5^{\circ} 11' 4''.8$; which is $0^{\circ} 3' 55''.2$ less than the above by Dr. Maskelyne [Note D; $05^{\circ} 15' 00''$]: and which consequently makes Mr Spence's Longitude of St. Agnes Lighthouse only 1 second of a degree less than the g: tri: Survey' [sic].*

Note F). ' This longitude [Note E; Agnes light] is only about $3' 53.6''$ of a degree more than the grand trigonometrical Survey; but as this depends upon the Longitude of the Lizard in the Nautical Almanac before the year 1791, and from Dr. Maskelyne's then

information to Mr. Spence, which is 5° 15' 0"; it must be now in 1807 corrected by the grand trigonometrical Survey, in which the Longitude of the Lizard Lights is 5° 11' 4.8" or 0°3' 55.2" less; and then the Longitude of St. Agnes Lighthouse will be 6° 19' 21. 8", which is only 0° 0' 1.6" of a degree less than the Grand Trigonometrical Survey.'

Unfortunately, Spence's revisions of the longitude of the Agnes Lighthouse [numbered [1], [2] etc.in the following discussion of Notes E and F] do not give wholly consistent results.

i). As plotted on Spence's 1 inch charts (c1791-2: UKHO 702 Dc, 702a 38d, 674 15e) the longitude of Agnes Lighthouse is 06° 23' 15" W [1], based on the west Lizard light being 05° 15' 00" W [2]. (There are very small variations from chart to chart: 06 23' 15" is most quoted value).

ii). In 1796 the Trigonometrical Survey calculated the longitude of West Lizard Lighthouse as 05° 11' 4.8" W [3].

iii). This meant that longitudes measured from the scale in the north margin of his three 1 inch charts were 00° 03' 55.2" too far west. This would make the longitude of the Agnes lighthouse 06° 19' 24.8" W [4].

iv) In 1796 the Trigonometrical Survey measured the longitude of Agnes Lighthouse as 06° 19' 23.4" W. [5].

v). In 1807 Spence recalculated the Agnes Lighthouse position, using the new longitude of the west Lizard tower measured by the Trigonometrical Survey (05° 11' 4.8" W) [3] and made the longitude of the Agnes light 06° 19' 21.8" W, [6] '*... which is only 0° 0' 1.6" of a degree less than [east of] the grand trigonometrical survey.*' (this is correct: 5-6). [Note F]. There is a very slight discrepancy here. [Note E]: '*... Mr Spence's Longitude of St. Agnes Lighthouse [is] only 1 second of a degree less than the g: tri: Survey'* [sic]. Which would make Spence's longitude of the Agnes light 06° 19' 22.4" [7].

In years 1791-1807 there were, therefore five published longitudes for the Agnes Lighthouse; [1], [4], [5], [6] and [7]. The modern longitude is 06° 20'.7 W (06° 20' 42" W). HO Channel Pilot 1999, p 63.

The error of 00° 03' 55.2" in longitudes was the reason why Stations K and M could not be located using the longitude scales on Spence's 1791-2 charts UKHO 702 Dc, 702a 38d, 674 15e.

It should be noted that nowhere does Spence give the longitude of the Agnes light as 06° 25' 33" W, as is stated by Blewitt (1958, p 108), an error apparently introduced by misreading the longitude in time on the southern margin of Spence's MS chart as longitude in degrees etc. of arc. This wrongly attributes to him a longitude several minutes of arc west of both his 1791 and 1807 longitudes.

The prime object of Spence's 1791-2 'Plain Chart' survey was to fix the position, especially the longitude, of the Isles of Scilly (as represented by the Agnes Lighthouse) in relation to the west Lizard Lighthouse. Any later revision of the latter's longitude of course immediately altered that of the Agnes Lighthouse and in turn that of the whole archipelago.

TABLE 4-8

	1791-2 / 1807		1808		Modern (charts)	
Pollard Rk	50° 03' 00"	06° 10' 00"	50° 02' 30"	06° 07' 00"	50° 03' 00"	06°08' 00"
Wolf Rk	49° 51' 30"	05° 56' 55"	49° 56' 40"	05° 47' 25"	49°56' 07"	05° 48' 02"
Longships	50° 04' 12"	05° 47' 25"	50° 04' 25"	05° 43' 30"	50°04' 00"	05° 44' 07"
Agnes Lt	49° 53' 47"	06° 23' 30"	49° 53' 40"	06° 20' 10"	49° 53' 30"	06° 20' 42"
St Martin B	49° 58' 10"	06° 18' 35"	49° 58' 00"	06° 18' 20"	49° 57' 58"	06°15' 56"

*Channel Pilot 1999:- 5° 48'

**Channel Pilot 1999:- 05° 45'

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Post 1791 surveys have revised the longitude of the Lizard [variously defined] several times. In fairness to Spence, therefore, the best test of the accuracy of his triangulation is to compare his final revised longitude difference between Agnes Lighthouse and West Lizard Lighthouse, with that determined by others:-

TABLE 4-9

Agnes lighthouse to West Lizard lighthouse: longitude difference
(distance based on 1° long. at 50° N = 38.69nm)

Spence	1791-2	1° 8' 15"
Spence	1791-2	1° 8' 20"
Trigonometrical Survey	1796/1800	1° 8' 18".6
Spence	1807	1° 8' 17"
Spence	1807	1° 8' 17".6
Clarke (OS)	1858	1° 7' 16".1
Modern Chart		1° 8' 28".2

The tendency to place the Isles of Scilly too far north and west persisted even in Spence's measurements, although he was closer to the true positions than were his predecessors.

Spence's MS notes on the 'Plain Chart' MS UKHO 702 Shelf Dc

The notes¹ are lettered A). to J). clockwise round **CHARTS 4-4a and 4-4b**.

These Notes are an invaluable guide to Spence's assessments of his own measurements and his comparisons with those of the Grand Trigonometrical Survey, of which he seems to have had great respect. They also make it possible to date and assess the original 1791-92 triangulation and the corrections and revisions to the data made by Spence in 1807. The triangulation itself was unaltered. The 1791-92 Notes are :- A). B). D). G). I). Those dated 1807 are :- C). E). F). Notes H). and J). were also probably added in 1807.

Note A). 'N.B. The Coast Line Soundings, Shoals, etc. from Cape Cornwall to the Lizard; are all copied from Mr. Mackenzie Jnr's.. survey of Mounts Bay taken in 1773. The Scilly Islands, the Seven Stones, the Wolf Rock and the Longships Lighthouse were surveyed by Mr. Spence; so that the junction of these two Surveys, depends on the accuracy of Mr. Spence's Triangles; the first of which is unavoidably Acute [6° 41']; and therefore, he wishes, that Mr. Dalrymple [the Admiralty

Hydrographer] would compare the whole, with the Grand Trigonometrical Survey [1796] and correct them where necessary, as that has been taken since the year 1792: all that Mr. Spence presumes to say is, that he believes his to be the most accurate of any prior to that year; nothing further can be expected from such a maritime survey carried on with necessarily small portable Instruments.'

Note B). 'The length of a Degree of Longitude in the Parallel of 50° , contains about 38.8179 geometrical miles; or about 44.7489 English miles [statute]: the length of a Degree of the Meridian there, contains about 365204.64 feet; and of a geometrical mile 6086.74 feet; the Scales around the margin of this Chart, are adapted to the above measure; and although a plain Chart, it is sufficiently exact for any purpose in navigation, it being of so small extent.

The length of a geometrical Mile, in these Latitudes, has been formerly supposed by some, to contain about 2017 yards, by others about 2028 yards, and by others about 2038 yards; all therefore that can be said with certainty upon a Matter that depends upon so abstruse a thing as the true Figure of the Earth, (and which I for one, have long supposed to be a little indented in some Latitudes, and elevated in others, though imperceptible to our Senses or to Observation) is that the length of a geometrical Mile, is something between 2010 yards and 2048 yards; and that I take about the mean of these, or 2028.91 yards, to be pretty near the truth: others who think they know more of the Matter than I do, may correct me if they please, as nothing is so easy as to be mistaken; indeed experience teaches us, that former observations though made with very imperfect Instruments, have, in some instances, turned out to be as accurate or to agree nearly with some late ones, though taken with the best Instruments, such is the fallibility of all Human Wisdom.'

Note C). 'In the year 1807 I find the length of a degree of the Meridian in 49° is laid down at 365106 feet and the geometrical mile is there laid down at 2028.36666 yards, which is about 19.56024 inches less than I call it; which is not worth notice here.'

Note D). 'Latitude of the Lizard Lights, [the western lighthouse] observed by G. Spence in the year 1792 with TROUGHTON'S double framed Astronomical Quadrant, is $49^{\circ}, 57', 55''$; and by Protraction in this Chart from the SCILLY Base and triangles is $49^{\circ}, 57', 52''$; so near an agreement between the Chart, and Observation, was hardly to be expected, considering the acuteness of the several Triangles, and also the necessary smallness of the portable Instruments used: the Longitude of the Lizard Lights is here put down at $5^{\circ}, 15'W.$ or $0^h, 21^m, 0^s$ of time; from the information of Dr.Maskelyne the Astronomer Royal. [cf Nautical Almanac 1781: Spence made no astronomical longitude measurement himself; he lacked the instruments.]

N.B. Mr. Spence wishes much, to have the above Latitude and Longitude compared with the grand Trigonometrical Survey of Britain; as both will, most likely, require to be corrected by so Accurate a Work as that no doubt must be.'

Note E). 'In the year 1807, Mr Spence compared the above Latitude [Note d; Lizard Lights] with that laid down in the grand trigonometrical Survey, and found his only between 8 and 11 seconds more than it; which is a much nearer agreement than could well be expected from him [Spence] and his imperfect Instruments.

The Longitude of the Western Lizard Lighthouse, is laid down in the grand trigonometrical Survey, at $5^{\circ} 11' 4''.8$; which is $0^{\circ} 3' 55''.2$ less than the above by Dr. Maskelyne [Note d]: and which consequently makes Mr Spence's Longitude of St. Agnes Lighthouse only 1 second of a degree ??? than the g: tri: Survey' [sic].

Note F). ' *This longitude [Note e). 6° 23' 16", ?Agnes LH derived by triangulation from Maskelyne's 1791 longitude for the Lizard] is only about 3' 53".5 of a degree more than the grand trigonometrical Survey; but as this depends upon the Longitude of the Lizard in the Nautical Almanac before the year 1791, and from Dr. Maskelyne's then information to Mr. Spence, which is 5° 15' 0"; it must be now in 1807 corrected by the grand trigonometrical Survey, in which the Longitude of the Lizard Lights is 5° 11' 4.8" or 0° 3' 55.2" less; and then the Longitude of St. Agnes Lighthouse will be 6° 19' 21' 8", which is only 0° 0' 1.6" of a degree less than the grand trigonometrical survey.'*

Note G). ' *St Agnes Lighthouse. Latitude 49 ° 53' 47" Observed in 1791 with Troughton's double framed Astronomical Quadrant, by G. Spence.*

N.B. The Requisite Tables was [sic] altered agreeably to this Chart, at least Dr. Maskelyne told me they should be altered, as it was wrong laid down in all former Charts and Navigation Books.'

Note H). [? an 1807 addition] ' *This latitude, is only about 10 seconds of a degree more [west] than the grand trigonometrical Survey.'*

Note I). ' *60800 yards, by the Triangle St. Agnes Lighthouse, St. Martin's Beacon, and St. Burryan Church.*

60810 yards, by the Triangle St. Agnes Lighthouse, M Station on Trescow Isle, and St. Burryan Church.

The distance from St. Agnes Lighthouse, to St. Burryan Church, is found by two different Triangles, only differing 10 yards; is a proof that, although the triangles are acute, they are pretty correct; and that the mean distance 60805 yards, is nearly a true distance: however I have preferred the number 60800 yards in this scheme of triangles to the Lizard.'

Note J). [? An 1807 addition] ' *N:B: This distance is only about 222 yards more than that of the Grand Trigonometrical Survey; which is a much nearer agreement than could be expected considering Mr Spence's imperfect Instruments '.*

Spence's other MS one inch charts of Scilly / Mainland

In addition to the MS 1791-2 'Plain Chart' (UKHO 702 Dc, which was under revision from 1792 to 1807), the UK Hydrographic Office holds two further MS charts of Scilly and the mainland at the 1: 63 360 scale:-. UKHO 702a 38d; UKHO 674 15e (west half **CHART 4-5**) and there is a third at the same scale in the British Library BL. 1900 (6). All are dated 1792 and it is at present impossible to establish a chronology. The triangulation on MS chart UKHO 702 Dc is clearly their basis, and the sight lines are not reproduced. They are working plots not intended for publication and were probably all made in 1792 for various specific tasks..

The latitudes and longitudes of these three charts are the same as on MS chart UKHO 702 Dc and, therefore, repeat its errors. Perhaps their most significant contribution is that, unlike chart 702 Dc), they portray the Isles of Scilly in some detail at the one inch scale the best being UKHO 674 15e (west half **CHART 4-5**) so that the position of any place on them

can be plotted but, of course, using the incorrectly measured latitudes and particularly longitudes of chart UKHO 702 Dc. Paradoxically the mainland, so carefully plotted on UKHO 702 Dc, is reduced to a mile of coast about Lands End and isolated sites, such as the Sennen and St Buryan churches.

MS. (UKHO 674 15e). 'A Maritime Survey of / SCILLY / taken by Order of / the Right Hon. Lords Commissioners of the / ADMIRALTY / at the Request of the Corporation of the / the / TRINITY HOUSE. / By Graeme Spence 1792.' (In a simple but professional cartouche). 66.1cm x 160.7cm. RF 1:63 360. The latitudes and longitudes are derived from chart UKHO 702 Dc and are therefore incorrect.

(Document not mounted on linen. The watermark 'J Whatman' is clearly visible but no date can be seen. A copy of the watermark is Fig 4-7(*Reproduced from Admiralty Publications / Charts by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office*:. unfortunately the writer was unable to investigate this further).



Fig 4-7 UKHO 674 15e. Watermark: J Whatman and design (Fig4-7) clearly visible.

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Scilly is plotted in detail but leading lines are limited (see UKHO 702a 38d). The 'mainland' is represented by the Lands End and the Lizard, from which some 16 lines radiate (? Rhumb lines. Kemp 1990 p 700-1).The Long Ships Light was building, so this chart probably pre-dates UKHO 702a 38d.

In the north margin is a longitude scale of degrees, minutes and 10 secs. from Greenwich; the south margin scale is of minutes and 20 secs. of time from Greenwich. The latitude scale in the east margin is in degrees, minutes and 10 secs. The west margin is damaged. Drawn across the face of the chart are numbered parallels and/or meridians of important places, almost identical to those on above chart, UKHO 702a 38d.

MS. (UKHO 702a 38d). 'A Maritime Survey of / SCILLY / taken by Order of / the Right Hon. Lords Commissioners of the / ADMIRALTY / at the Request of the Corporation of the / the / TRINITY HOUSE. / By Graeme Spence 1792.' There is no formal title or cartouche: the title is neat but not professionally drawn.. 72cm x 179.3cm. RF 1: 63 360. (The document mounted on linen. The watermark 'J Whatman' is just visible but no date or pattern make can be seen).

Below the title is:- '*N.B. The Explanation with the large Chart [ie the six inch chart UKHO 637 1g] does also for this Chart with this addition... [references to tides].* A very similar Note is on MS chart BL 1900[6]. The latitudes and longitudes are derived from chart UKHO 702 Dc and are therefore incorrect. Scilly is plotted in detail and the very large number of leading lines are mainly focussed on the Islands. There is a reference to the Longships Lighthouse not yet in use in January 1793, dating it after Spence's original 1792 triangulation.

In the north margin is a longitude scale of degrees and minutes from Greenwich and minutes and seconds of time. The east and west margin latitude scales are in degrees, minutes and 10 secs. Drawn across the face of the chart are numbered parallels and/or meridians of about 12 important places, such as the Agnes Light, Seven Stones, Longships Light, Wolf Rock, West Lizard Light. In some cases e.g. Lion Rock and Pednathias Head, only latitude is shown and in others only longitude e.g. Crim Rock and Hanjague Rock. The Crim, Lion and Hanjague Rocks, with Pednathias Head define the boundaries of the archipelago. There is a large number of leading lines and several surface current courses.

MS. (BL 1900 [6]). 'A Maritime Survey of / SCILLY / taken by Order of / the Right Honourable Lords Commissioners of the / ADMIRALTY / at the Request of the Corporation of the / the / TRINITY HOUSE. / By Graeme Spence 1792.' 70.3cm x 166.5cm. RF 1: 63 360.

This is a second MS 'small chart' . Below its title is:- '*N.B. The Explanation in the large Chart [ie the six inch chart] will do also for this:...'.* Coloured and Scilly based on the six inch chart. The latitude and longitude scales are as on the previous chart and numbered parallels and meridians are drawn across the chart to locate important sites such as Agnes Light, Pollard Rock, Wolf Rock, Longships Light and the West Lizard Light.

The only places on Scilly which are on all four one inch MS charts are Agnes Lighthouse and St Martin's Beacon:-

Latitude 49° 58' 15" Longitude 6° 18' 30"

These have been examined in the discussion of chart **UKHO 702 Dc**

PRINTED CHARTS

(Discussed in detail in Appendix F)

(OCB Chart 33; Series A.1.) "A Survey / of the / Coast of Cornwall / from the Lizard Point to St. Agnes Head / by / Lieut. Mackenzie 1772 / and the / Scilly Islands / by / Mr. Graeme Spence / 1792."

In the bottom margin is printed:-

'Hydrographic Office. Published according to Act of Parliament Sept. 19th. 1808 by Capt. Hurd R.N., Hydrographer to the Admiralty.'

Chart 4-6, reproduced by permission of the Royal Navy Museum Library ; Vf2 / 22)

This was the first printed chart based upon Spence's four MS 'small scale-1inch' charts to show the Isles of Scilly in relation to the mainland. The chart must have been prepared for publication by Spence. There is no linear scale but at 50° N, 10' of latitude measures 19.9cm, which converts to an RF of c1 : 93 000.

This chart has the distinction of being the first printed Admiralty chart:-

- a) to be based on Spence's triangulation from Scilly to the mainland; its derivation from UKHO 702 Shelf Dc is obvious. Although the sight-lines between Scilly and the mainland have been deleted, others to Poll Bank, the Wolf Rock and the Lizard (just) have been retained.
- b) to be graduated in latitude and longitude (degrees and minutes), making it possible for the first time to plot the positions of the Isles of Scilly on a printed Admiralty chart.

It was published only a year after Spence had made the final corrections to his MS 'Plain Chart'. The basic information however is that of 1792 and therefore 16 years out of date. The delay in engraving and printing the chart is shown by the magnetic variation being dated 1792.

The chart is 60cm by 95cm. It extends W-E from Poll Bank to the Lizard Point (and so inexplicably excludes the two Lizard lighthouses shown on the 'Plain Chart'). The chart would have been compiled from at least three MS charts : UKHO 702 Dc for the mainland (itself based on Mackenzie 1772), UKHO 674 and BL 1900 [6] for the Isles of Scilly. Although the chart was published in 1808, Spence's 1792 magnetic variation (24 deg 45min W.) is printed unchanged. There are three coastal profiles at the bottom showing *inter alia* St Mary's windmill and St Martin's Beacon.

The Isles of Scilly are shown in sharply drawn detail, including small clear hachures on the main islands and areas drying at low water in a fine stipple. There are no field boundaries or land use symbols. St Martin's Beacon, the ruins of the windmills on the Hugh and the mill on Penninis, Agnes lighthouse in profile, the SW rocks Gilstone and Shovel are among other details shown, all based on Spence's 1792 six inch chart. Minor details from the 'Plain Chart' are repeated:-

'Wolf Rock / Beacon in 1795' ; 'Long Ship / Rocks / Lighthouse 1795'; 'Runnelstone / Beacon 1795.'

The mainland detail is, of course, from Mackenzie jnr 1772 and is limited to the coastal outline and a few place names (Fig 4-6). Some of the rather crudely drawn hill profiles on the mainland are copies of those on the 'Plain Chart'. Unaccountably, several seemingly irrelevant details from the 'Plain Chart' have been retained on the mainland by the engraver. For example (*CHART 4-6*) the trigonometrical sight lines; St Buryan Church-Sennen Church; Chapel Carn Brea-Castle Dennis; Castle Dennis-Lizard and St Buryan-Lizard (truncated by chart margin but apparently aimed at the west Lizard light), and a single sight line St Buryan Church -Wolf Rock. The arbitrary omission of other sight lines, including those to Scilly, leaves the triangulation incomplete and meaningless. The flag symbol marking **Station A** south of Sennen Cove is preserved but not those marking **Stations K and M** on Scilly. On the 'Plain Chart' the most westerly point is named 'Landsend'; on this chart it is 'Westmost Lands End', an old fashioned designation. Numerous leading lines are plotted and there are many soundings, and arrows indicating tidal currents [15].

END NOTES

1). Many surveys, charts etc referred to in this Chapter are held in the United Kingdom Hydrographic Office (UKHO) and the modern catalogue references may differ from those used in earlier publications.

i). Material in the archives (manly MS charts and surveys) are referenced as UKHO+shelf reference eg UKHO 702 Dc.

ii). Unique copies of printed charts are found in the UKHO 'Old copy bundle sequence' are referenced as: OCB Chart 33 Series A.1. etc.

2). Taylor (1966, p. 232) writes remarkably little about Spence's life compared, say, with that of Robert Heath.

3). There are several MS versions of Spence's 'Geographical and Nautical Description' of Scilly in the PRO, NMM, Trinity House etc. the copyists of the original including Jacob Herbert and Maltby. The copies vary slightly; e.g. "...should not take it for granted that Scilly is accurately laid down in the several Charts and Tables hitherto published..." (NMM version, p.169.); "...should not take for granted that Scilly properly located on existing Charts and Tables..." (Trinity House version p.157). Thomas (1979), claims to have been the first to have published the 'Geographical Description' part of Spence's Ms.

It is part of "A / NAUTICAL DESCRIPTION / of the / LINE of COAST from the NORE to ORFORDNESS / also from the / NORE into the DOWNS / down the BRITISH CHANNEL, round the / LAND'S END and up the BRISTOL CHANNEL / to the / ENTRANCE of the RIVER SEVERN." In THREE Volumes. Vol. IIIrd. Compiled from the Original Surveys of Mr Murdoch Mackenzie Jnr.. and Mr Graeme Spence, / by Mr Spence, and transcribed from the Original Compilation, by Jacob Herbert. Trinity House 1812".

From the Trinity house copy ref.LGL TH Ms 30,152 but there are copies in other libraries. Thomas (1979, p.3) says that the copy in the NMM (NVP/78) was also prepared for Trinity House,

It is part of much larger work, of which it is Book IV of Volume Three. It fills pp 151 - 274 in the transcribed by one Brough George Maltby. The original version may have been at Trinity House as early as 1809. Trinity House version used here. (The full reference is: Spence 1812, GL Ms:TH MS 30,152; in the following it is abbreviated to Spence 1812, p-). It is not in Spence's hand, as copyists were usually employed, presumably using Spence's original MS prepared at Shoreham in 1797.

Book II includes the Land's End charting, based on surveys by Mackenzie jnr's charts of 1772 and 1773.

4). Trinity House ordered 21 copies of Mackenzie's "Treatise on Maritim[sic] Surveying" for use of its members. (LGL THGCM 4 February 1819).

5). Dawson (1885, p3 &8) is very confused about this volume. He ignores Mackenzie snr. 1774 'Treatis...' [p3] and under the younger Mackenzie [p8] writes 'The earliest work upon modern hydrography or nautical Surveying, is we believe, that of [Lieut] Murdock Mackenzie, published in

1819, with a supplement by James Horsburgh, the East India hydrographer.' Mackenzie jnr and Spence would have had little use for a book published in 1819.

6). Lieutenant Murdoch Mackenzie and his survey of the Bristol Channel and the south coast of England. (David, A C 2003 *Cartographic Journal* 40, 69-78) .The definitive study of the younger Mackenzie, forthcoming in *The Cartographic Journal*.

7). Dr Andrew Cook (pers comm, 23 1 03) has kindly given the writer permission to include some of his notes about Dalrymple and the Isles of Scilly (Chapter 5 and Notes 2 and 10). In May 1795 Dalrymple was compiling a portfolio of material on the Scilly Isles, including engraved charts and views and printed tide tables. Nothing has survived except a composite from impressions of three plates forming the chart (Naval Historical Library Vf. 2/21). On it is a pencil sketch of a mole or breakwater in St Mary's Passage. (David, A C 1981) discusses Dalrymple's career at length and seeks to restore his reputation as "the father of the Admiralty Chart"

The writer has seen in the UKHO two charts on which are plotted proposed moles protecting St Mary's Sound. One is UKHO 728, scale one inch to an English (statute) mile. It is a beautifully coloured chart, the proposed mole placed between the Peak and Great Smith. There is also a c1:23 000 chart of the archipelago, which appears to be a composite of sheets, printed and plain. There are two moles, one south from the Minator and the other NE from Gugh. A letter from Spence about a 'special project' (LGL TH GCM 6 June 1814) may date these charts.

8). Clifton (1995, p 30) lists 5 Birds. Of these the most likely is BIRD John (1709-1776), Mathematical instrument maker, involved in development of the marine sextant in co-operation with the Board of Longitude. Sold: astronomical, clock, barometer, quadrant, repeating circle, rule, thermometer, zenith sector. Although he died long before Spence's survey, Clifton gives the longest account of him and there is no reason why a good quadrant should not last, given Spence's care.

NAIRNE & BLUNT Edward & Thomas w 1774-1793. Sold barometer, level, microscope, sector, sextant, sundial, telescope, thermometer.

NAIRNE Edward w 1749 d 1806. Long account by Clifton (1995, p 196), which includes reference to the above partnership. Sold: barometer, dip circle, hygrometer, magnet, marine astrolabe, microscope, sector, telescope, thermometer, rule [no mention of sextant].

BLUNT Thomas(1). (Clifton 1995, p 313) Working 1794-died 1823. Mathematical instrument maker.

Clifton (1995, p 281-2) lists 4 Troughtons. Most likely are John & Edward T (w1788-1840) or John T II (w1769-1788).

9). It is ironic that this log should start in 1795, the year Spence completed his limited supplementary trigonometrical survey.

10). Robinson (1962, p 100) is incorrect in saying that it was a "...system of triangles projected from the mainland".

11). Spence 1791-2; Mudge 1796; Clark 1858; Ordnance Survey 1967). It is here assumed that the prominent Sennen and St Buryan church towers were used here as Stations; Spence had sighted them from Scilly. The Trigonometrical Survey (1796) did not use the towers and gave specific descriptions of nearby sites that were used (Chapter Six).

12). The peninsula was the last and first landfall, respectively, for shipping leaving or entering the English Channel, so its accurate position was vital and many attempts were made to determine it. As Ravenhill points out, the Lizard was seriously misplaced on many early maps and charts.

Stevenson (1959, pp. 100-2, 141.) concisely summarises the complex history of the Lizard lighthouses, the first was in 1570, the second 1619. It fell into disrepair after a few years and was demolished. In 1748 Trinity House supported a new plan for two Each light was c.210ft./55m. above HWM and in 1751/2 the lighthouses were opened. Spence plots and refers to two towers; Ravenhill (1989, pp.34-5), supported by a 1770 drawing, refers to two free-standing towers, c. 72 yards [c.66m.] apart.

A diagram in Williams (1797, p.502) shows the West Lizard light about 2700ft./823m. from the Lizard Head and the distance between the East and West lighthouses as c. 450ft./137m. They were re-built in 1812 and both were in use in 1861, but to-day only the East light is used. The light is 230ft./60m above HWM. The early Nautical Almanacs do not specify to which place on the Lizard the longitudes refer but Spence clearly thought it was the West light and this was used by the Trigonometrical Survey (1800). By 1851 Admiralty charts of the Lizard, although showing both lighthouses as lit, give only the longitude of the East Light, 05° 12' 06.3" W.

In 1992 another prominent building on the Lizard ceased operation. This was the Lloyd's Signal Station at Bass Point (712119) east of the lighthouses. Built in 1872 it passed on details of ships' cargoes and in 1900 a radio station was added and in the 1930's one of the early radar stations. It now belongs to the National Trust.

Ravenhill (1989) notes that in Collins' atlas '*...the shape of the Lizard is hardly recognisable. The latitude ...of 50°...is too far north by 2' 28'.* By 1699 Gascoyne had reduced the error to 1' 34" south of the modern position. Then for nearly half a century Halley's (1656-1742) value of 49° 55'N. held sway. Martyn in 1748 (see Chapter on Heath) reversed progress by publishing the position as 49° 48' 49"N. and 05° 37' 39"W. On 3 June 1769 Maskelyne and Bradley determined the latitude as 49° 57' 30" (based on a transit of Venus), at a point north of a line joining the two towers. This value was entered in the Nautical Almanac in 1781. Exactly the same figure was obtained by a different method by Murdoch Mackenzie jnr., in 1772: '*The Altitude of Sun, from which the following Latitudes were deduced, were taken with Bird's 12 Inch Quadrant; and with a 12 Inch Sextant made by Nain and Blunt:- Lizard Lighthouses 49° 57' 30" N.*' (Spence 1812, p 58). Ravenhill's comments on the measurements by the Grand Trigonometrical (Ordnance) Survey are discussed in the next Chapter.

The Nautical Almanac did not publish location tables until 1781, ten years before Spence's measurements and then not again until 1802. Cap Lezard or Lizard first appears in the 1779 (published 1777) edition. The nearest editions to Spence are 1792 (1790), 1793 (1791) and 1807 (1804). Spence initially only measured latitude and accepted Maskelyne's longitude, published in the Nautical Almanac. He later used the Trigonometrical Survey's figure.

There are several references to the Lizard lighthouses in the Trinity House Records. e.g. LGL TH Ms 30,072: Records of Deeds, 1765 to 1841./ LGL TH Ms 30,003 v.3. Charters etc. / LGL THGCM 11794/97 re. repairs and leases.

13). Phil. Trans. 1797 p 502 explains how Mudge located Lizard Point, taking bearings with a sextant from the Naval-Signal-staff and the Western Lighthouse. It was 2419 ft from the Signal-staff and 2700 ft from the W Lighthouse. The position of the Point could then be calculated, using the angle from the Principal station Karnbonellis to the two sites: 1° 53' 47". This tied the Point to the main triangulation. The position of Bradley's 1769 observatory is also shown on Mudge's diagram. It was 25 ft north of the line joining the centres of the lighthouses.

14). Spence's use of the towers of Sennen and St Buryan Churches as a trigonometrical stations is acceptable as the width of the towers would be insignificant when sighted from Scilly. Mudge observed from the mainland to Scilly and chose to ignore both church towers in favour of temporary stations at ground level (Chapter Six).

15). The well-known hydrographer Captain (later Admiral) Martin White made extensive surveys of the Western Channel and Approaches in *HMS Shamrock* in the years 1817-21. He makes several references to the position of the Isles of Scilly but omits the exact location of his observations. Thus in his 'General Remarks Book (UKHO OD 537) c 1821, he notes that on 26th 6 1817 he measured the Amplitude, Azimuth and Variation of Scilly, and states its position as 49° 56' 16".8 N and 06° 19' 20".40 W. The location is not recorded. It may have been the Agnes Lighthouse. On an undated chart (UKHO 826 Oix) he gives the position as 49° 53' 37" N and 06° 19' 45" W, but again not located. The modern position of the Lighthouse is:- 49° 53' 47" N ; 6° 20' 42" W. These figures suggest that White was observing from the Lighthouse.

CHAPTER FIVE

CAPTAIN JOSEPH HUDDART FRS (1741-1816)

INTRODUCTION

An excellent biography of Joseph Huddart has been published by a descendant (Huddart, W. 1989). He is assessed as '*... one of...many unsung heroes of eighteenth century England...*' Joseph Huddart was born into a farming and seafaring family at Allonby, Cumberland, on 11th January 1741 and died in London in 1816.

From his boyhood he showed great mathematical talent, studying astronomy and navigation. '*It was the basis by which he determined the longitude of many places on his charts: it was by astronomy that he calculated the true north and magnetic variation of his compass as it changed during his voyages: it was by lunar distances that he checked the accuracy of his chronometer at sea.*' (Huddart, W 1989, pp 8-9). He served in The Honourable East India Company (as a Captain from 1778). '*... making scientific observations and nautical surveys...*' *Inter alia* he measured the longitude of Bombay, using the eclipses of the satellites of Jupiter method (Huddart W. 1989, p 80) [1].

He retired from active seafaring in 1788 to be a marine surveyor. Notes on his chart of the west coast of Scotland (1790) state:- '*...the survey was carried on from observations made at Campbelltown... Barra, to determine the latitude and longitude by astronomical instruments and chronometers, from which a series of triangles, determined from the true meridian, was carried on, to find the situation of the intermediate places etc.*' Robinson (1962, p 84) points out, however, that the chart owed much to the elder Murdoch Mackenzie's earlier chart. Huddart was also a successful businessman, making ropes etc [2].

He was '*... admitted ... a Younger Brother of the Corporation of Trinity House.*' (GL Ms TH GCM 3 June 1790) and on 15 September 1791 elected as an Elder Brother, '*... directed to the improvement and security of coastal navigation, erection of lighthouses ...*' (Huddart, Sir J. 1821, p 29). Also in 1791 he was elected a Fellow of the Royal Society. It was his responsibility for lighthouses that took him to the Isles of Scilly and to the notorious Longships Rocks off Land's End. The last recorded presence of Huddart at a Trinity House General Court meeting was 5 October 1815. The Isles of Scilly longitude measurement was not, it must be emphasised, in the same league as Huddart's major surveys, which makes the Trigonometrical Survey's interest in it all the more intriguing.

Captain Joseph Huddart paid but one brief visit to the Isles of Scilly, in September 1795, during which he made a single measurement of longitude on the Island of St Mary's. Such a short acquaintance with, and limited observation on, the Islands may at first sight seem insufficient to merit a full chapter. Huddart was, however, no ordinary visitor. At the time he was in the Islands he was an experienced navigator and hydrographic surveyor, a Fellow of the Royal Society and an Elder Brother of Trinity House. His one observation on Scilly attracted attention from the Trigonometrical Survey, which discussed it in a lengthy footnote. It would seem that this is the first time that the conclusions reached in the footnote have been questioned. Reports on the progress of the Grand Trigonometrical Survey across southern England were published in volumes of the Philosophical Transactions of the Royal Society, beginning in 1795. In 1797 it reported *that '...the most important business of the year 1796 was the determination of the distance between Land's End and the Isles of Scilly.'* (Williams, W. Mudge and Dalby 1797, p 449). There was no mention of Huddart in this report. [3]

The work of the Survey for the years 1797-99 was published in the Philosophical Transactions of the Royal Society (W Mudge 1800, pp 539-728) and it is here, on p 673, that the footnote about Huddart first appears. Consolidated and partly revised versions of the Survey, originally published in the Philosophical Transactions, were republished, in three volumes by Faden between 1801 and 1811 edited by Mudge. The 'Huddart' footnote is repeated in Volume II (Mudge, 1801, p 135), where Huddart is ~~mispelt~~ *mispelt* Hubbart.

The following discussion is in two parts: the first examines critically the 'Huddart' footnote the second considers the background to Huddart's visit to the Isles of Scilly.

1

The presumed position of Sir Cloudesley Shovell's temporary grave is at Porth Hillick, St Mary's (Fig 5-1). Using his chronometer Huddart, measured the longitude of the grave as $0^h 0^m 10^s / 0^\circ 2' 30''$ / which is 1.9nm west of the modern position (Table 5-1). An error of ten seconds of time, given that Huddart had traveled from London by road and then sailed in stormy weather to St Mary's does not seem unreasonable. This is the only error in the footnote that can be attributed directly to Huddart. His longitude would have placed the grave near Star Castle, in the west of St Mary's Island, whereas it is on the south east coast.

TABLE 5-1
Huddart and the longitude of the Porth Hellick grave

	Time	Arc
Huddart (1795)	$0^h 25^m 18^s W$	$6^\circ 19' 30'' W$ (d)
Modern	$0^h 25^m 8^s W$	$6^\circ 17' 00'' W$ (i).

THE FOOTNOTE

Mudge primarily wanted to show that the 'official' longitude of Scilly in the Nautical Almanac's Requisite Tables (1781) was grossly in error compared with that measured by his

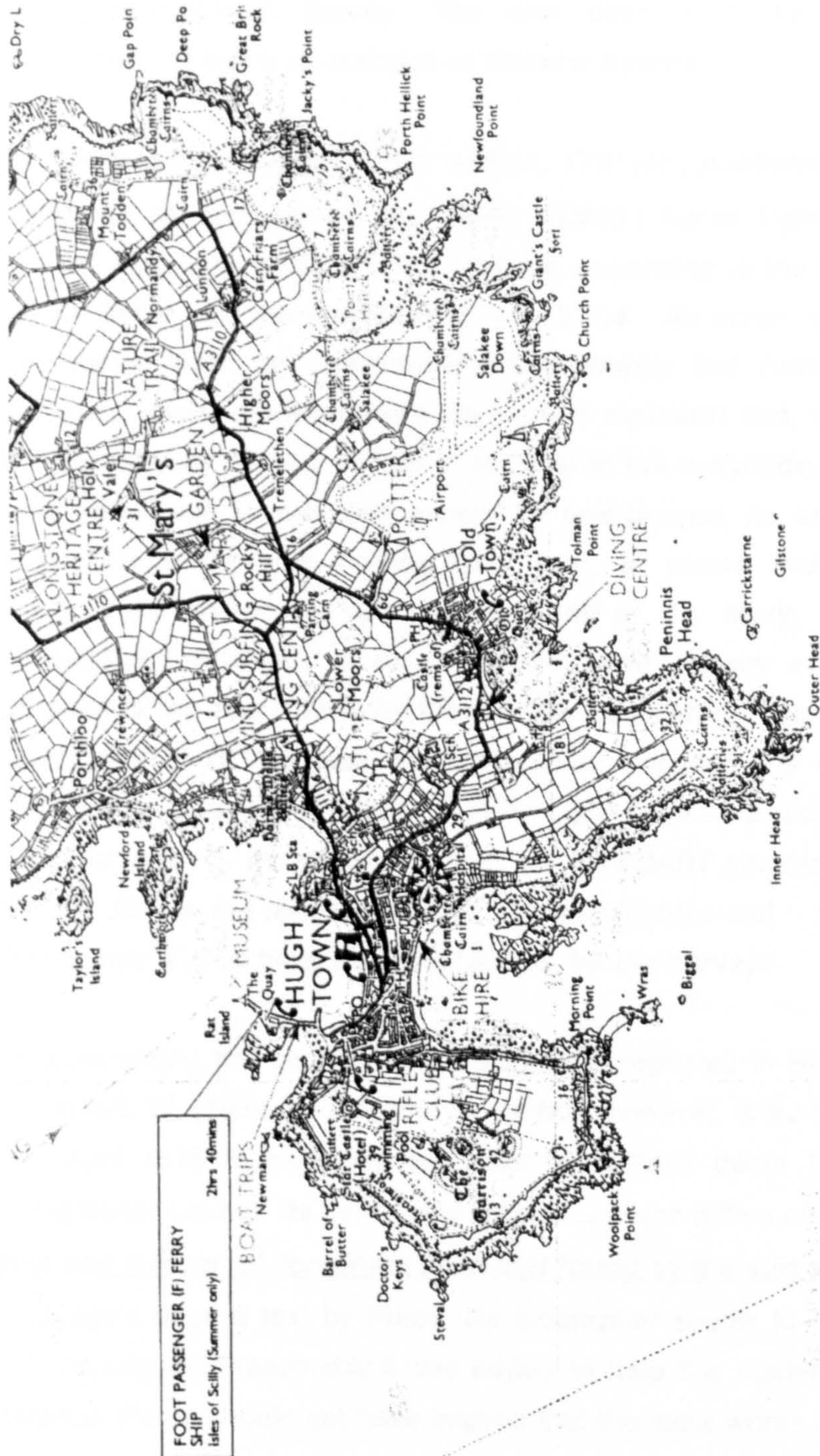


Fig 5-1. Porth Hellick, St Mary's : 926105.
 Reproduced from 1:25 000 Explorer sheet 20, 1996, Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office, © Crown Copyright NC/02/40390.

ISLES OF SCILLY



Ledges
 Southward
 Well

Halfide
 Ledges

Agnes

own Trigonometrical Survey. The one observation by Huddart was a convenient introduction. There is no mention of Graeme Spence.

'In the Requisite Tables, [2nd. edition, 1781[4]] published by order of the Board of Longitude, the latitude of the Scilly Lights [Agnes Lighthouse] is said to be $49^{\circ} 56' 0''$, and longitude $6^{\circ} 46' 0''$. The latitude, according to the [Trigonometrical] survey, is $49^{\circ} 53' 36''.8$ and the longitude $6^{\circ} 19' 23''.4$. An error of $[00^{\circ}] 2' 23''$ in the latitude, may not perhaps be considered extraordinary; but how, in a maritime country, like our own, where chronometers are in such constant use, so great an error as $[00^{\circ}] 26' 37''$ [actually $26' 36''.6$,] ($1^m 46\frac{1}{2}^s$ in time) In the longitude, [of Agnes Lighthouse] should have remained undetected, except by one person, is surprising. J.HUDDART, Esq. visited the Scilly Isles, having with him a watch made by [JOHN] ARNOLD, and obtained his time at that spot in the island of St. Mary, [5] where the body of Sir CLOUDSLEY SHOVEL is said to have been thrown ashore, by means of equal altitudes of the Sun's limb; he then found, comparing his time with that shown by the watch, that $0^h 25^m 18^s$ was the difference between the meridians of Greenwich and this spot in St. Mary's. Now St. Agnes Light-house [i.e. Scilly Lights above] is about 2' of a degree west of the place to which Mr. HUDDART alludes; therefore, $[0^h] 25' 18'' + 8'' = [0^h] 25' 26''$ is the longitude of St. Agnes [lighthouse], through these means; which differs only $4^s,5$ in time, from that found by the survey.'

Not surprisingly, this complimentary footnote is reprinted in Huddart, Sir J. (1821, p 54) and in Huddart, W. (1989, pp 80-1). Their version, however, is from a letter by John Purdy dated 14th April 1818 to Huddart's son after his father's death (Purdy was geographer to the cartographer Laurie). Its concluding words '*... which differs only $4^s,5$ in time, or a little more than one minute of longitude from that found by the survey.*' (our emphasis) were added to Mudge's original text by Purdy. No biographer seems to have checked Purdy's version with the original. Presumably it was added to help the reader visualise the error in terms of distance. Purdy should not have implied that the extra words were written by Mudge.

This seemingly simple, factual, footnote raises problems when subjected to detailed examination. Analysis of the data in the footnote is not helped by the mixture of arc and time measurements. It is possible that a garbled version of the original was printed. Nevertheless, Mudge was ultimately responsible for the published Report of the Trigonometrical Survey (1800) and in the following it is referred to as Mudge's footnote.

Mudge

1. Although Mudge praises Huddart's observation, ~~he~~ was primarily interested in the longitude of the Agnes Lighthouse.
2. The footnote is the only record of Huddart's measurement; he never refers to it himself and Mudge does not say how it came to his notice.
3. It is incorrectly quoted in the main biographies.
4. Its confused construction raises the possibility that it was not written by Mudge but there is no evidence to support this.

5. The footnote is undated and no biographer refers to a visit by Huddart to the Isles of Scilly .
6. The site of Huddart's observation, a small uninhabited bay in the SW of St Mary's (Fig 5-1) is scientifically indefensible. Huddart ignored well established navigational sea-marks such as Agnes Lighthouse, St Mary's Castle; St Martin's Day-mark.
7. Arnold made Huddart's chronometer but no details are given.
8. In the footnote Mudge uses a confusing mixture of arc and time measurements, which hide inaccuracies in his assessment of, and deductions from, Huddart's original observations. As a result, Mudge's fulsome praise of Huddart is unwarranted.
9. In contrast to Huddart's very minor contribution, Graeme Spence's major trigonometrical surveys (1789-92 and 1795) between Scilly and west Cornwall, which produced the first reliable longitudes for the former, languished on the shelves of the Admiralty, apparently unknown to the Trigonometrical Survey.

The errors in the footnote negate the claim, which Huddart never himself made, that he came close to fixing for the first time the true longitude of the Agnes Lighthouse. This might explain his silence about the whole affair.

Huddart's visit drew together several apparently disparate strands in the cartographic history of the Isles of Scilly. First, the site for his observation was linked with the infamous shipwreck of the fleet of Sir Cloudesley Shovell in 1707, which inspired the formation of the Board of Longitude. Secondly, he used a small chronometer or watch to measure the longitude by time, a relatively new technique, stemming from the work of the Board. Thirdly, his longitude for Agnes Lighthouse was quoted in the account of the first official triangulation from the mainland to the Isles of Scilly. Fourthly, there was the fertilising influence of west Country intellectual / scientific 'Society' (centered on Plymouth) in which the Mudge and Arnold families were closely involved.

2

LATITUDE OF THE SCILLY LIGHTS (AGNES LIGHTHOUSE)

Huddart did not measure the latitude of the Lighthouse when on Scilly. Mudge's footnote dismisses latitude in a few words (Table 5-2) '*An error of [00°] 2' 23" in the latitude, may not perhaps be considered extraordinary;...*' Spence's figure is added below for comparison.

TABLE 5-2

Requisite Tables 1781	49° 56' 0" N
Trigonometrical Survey 1797-99	49° 53' 36",8 N
<i>[Spence 1791-2]</i>	49° 53' 47" N

Modern 49° 53' 42" N

HUDDART'S ISLES of SCILLY LONGITUDE OBSERVATION, SEPTEMBER 1795.

According to Mudge, Huddart using a small watch or chronometer, measured the longitude of the presumed position of Sir Cloudesley Shovell's grave as 0^h 25^m 18^s W (6° 19' 30" W). [6]. Huddart himself never published it.



Fig 5-2. Site of Sir Choudesley Shovell's grave, Porth Hellick, St Mary's 925108
© Gibson of Scilly

MUDGE, HUDDART AND AGNES LIGHTHOUSE.

The grave site was, of course, navigationally insignificant and to make use of Huddart's measurement, Mudge had to extrapolate westwards to the important Agnes lighthouse, which was one of Trigonometrical Survey's stations in 1796. Mudge:- *'Now St. Agnes Lighthouse is about 2' of a degree west of the place [Porth Hellick] to which Mr. HUDDART alludes, therefore, [0^h] 25' 18" + 8" = [0^h] 25' 26" is the longitude of St. Agnes [lighthouse]...* [our emphasis].

First, Mudge does not explain the source of his *'...2' of a degree...'* and secondly, for some inexplicable reason, he has omitted the hours from the time measurements and it takes a moment to realise that there has been a switch from arc to time measurements in the second element of the equation. The *'...about 2' of a degree...'* at the beginning of the quotation has later become 8 seconds of time in the equation. Mudge's calculation of the longitude of Agnes lighthouse, based on Huddart's data, is therefore:-

TABLE 5-3
Agnes Lighthouse: Mudge's extrapolation

(Huddart)		(Mudge)	=	(Mudge's extrapolation)
0 ^h 25 ^m 18 ^s W	+	8 ^s	=	0 ^h 25 ^m 26 ^s W
		or		
6° 19' 30" W	+	2'	=	6° 21' 30" W

THE 1781 REQUISITE TABLES, MUDGE AND AGNES LIGHTHOUSE

The longitude of 'St Agnes (Light)' is listed in the Requisite Tables (2nd ed 1781, Table XX, p 154) as 6° 46' 0" W of Greenwich. In the Footnote the Trigonometrical Survey gives the longitude as 6° 19' 23".4 W (in the 1797 main published text it is 6° 19' 21".8). Mudge is forthright:- - *'... how, in a maritime country, like our own, where chronometers are in such constant use, so great an error as [00°] 26' 37" [actually 26' 36".6] (1^m 46^s½ in time) in the longitude, [of Agnes Lighthouse] should have remained undetected, except by one person, is surprising.'*

Mudge's extrapolation of Huddart's longitude put the lighthouse's longitude as 0^h 25^m 26° W. only 1' 11" east of Mudge's longitude and the latter had good reason to praise Huddart, to whom the event was obviously of no consequence. Given Huddart's short visit and his use of a small chronometer this is ~~is~~ creditable figure. Mudge rather confuses the story by complimenting Huddart for exposing the undetected 'error' in the officially published longitude of the Agnes lighthouse (Requisite Tables, 1781). Huddart made no published reference to the longitude of the lighthouse, although it is known that he had visited it. A

Mudge assumed that the Trigonometrical Survey's longitude for the Agnes Lighthouse was the most accurate then available and that the Requisite Tables' westward error of the longitude of the Agnes Light was:-

26' 37" of arc or 1^m 46^s½, equal to 17.2nm

(This is a slight generalisation: the correct error is 26' 36.6" or 1^m 46.47^s, but is not significant in the present context).

MUDGE, HUDDART AND AGNES LIGHTHOUSE

Mudge claimed that the Agnes Lighthouse's longitude based on his extrapolation of Huddart's grave measurement *'... differs only 4^s5 in time from that found by the [Trigonometrical] survey.'* This is wrong. The Trigonometrical Survey's longitude for Agnes lighthouse is 0^h 25^m 17.6° W and Huddart/ Mudge is 0^h 25^m 26° W. The difference is therefore 8° 4 (0.62nm). The source of this small arithmetical mistake has not been traced. It does suggest that the footnote may not have been reviewed by Mudge.

Purdy added *'... which differs only 4^s,5 in time, or a little more than one minute of longitude from that found by the survey.'* [our emphasis] At the latitude of the Isles of Scilly one (arc) minute of longitude is c. 0.64 nautical miles, because of the poleward convergence of the meridians. Purdy does not say that he was aware of this but it may be presumed that he was, if it is accepted that 4.5^s/ 0.73nm. (the original footnote error) is *'... is a little more than one minute of longitude..'* i.e. 0.64nm. The true error is 8.4 (1.35nm) and this shows that Purdy, in common with other commentators, had not checked the original data.

$$0^h 25^m 26^s W \text{ minus } 0^h 25^m 17.6^s W = 8.4^s$$

and so:-

Footnote error: $4.5^\circ \text{ W} = 1' 7, 5''$ of a degree = 0.73nm

Revised error: $8.4^\circ \text{ W} = 2' 6''$ of a degree = 1.35nm

Mudge, extrapolating from Huddart ($6^\circ 19' 30'' \text{ W}$), placed the Lighthouse at $6^\circ 21' 30'' \text{ W}$ or $2' 6''$ / 1.36nm west of the Trigonometrical Survey's longitude of $6^\circ 19' 32''$.⁴

Had Mudge used the correct distance between the grave and the Lighthouse ($3' 42''$) he would have made the latter's longitude $6^\circ 23' 12'' \text{ W}$, or $3' 48''$ / 2.44nm west of the Trigonometrical Survey's longitude. This compares very favourably with Spence (1791-2) $6^\circ 23' 15'' \text{ W}$, and it is regrettable that Spence's charts remained unpublished in the Admiralty archives.

The modern longitudes are :- Porth Hellick grave: $6^\circ 17' 00'' \text{ W}$

Agnes lighthouse: $6^\circ 20' 42'' \text{ W}$

2 3

THE DATE OF THE OBSERVATION

Neither Huddart nor his biographers mention a visit to the Isles of Scilly. It is important to establish the date of the visit, to place it in the context of contemporary surveys of the Islands by Graeme Spence and Trigonometrical Survey.

The footnote first appears in Mudge (1800, p.473), so Huddart's measurement must pre-date this. The triangulation from the mainland to the Isles of Scilly by the Trigonometrical Survey was observed four years earlier, in 1796 (Williams *et al.*, 1797).

Huddart's visit to the Isles of Scilly can be dated from the archives of Trinity House. It is linked with the efforts of one Lieut Henry Smith R N (Appendix B) to build a lighthouse and two sea marks or beacons [7] on dangerous rocks near Land's End. Smith needed a lease from Trinity House to pursue these works and to allow him to collect tolls from passing ships. Henry Smith was commissioned in the Royal Navy in 1781.

In October 1790 the General Court of Trinity House, granted Smith a Lease to build a lighthouse on the Longships off Land's End and two beacons. From the beginning of 1792 Smith met increasing problems (weather and money). In May 1795 Capt Huddart, Elder Brother responsible for lighthouses *etc.* and Mr Wyatt (Trinity House surveyor) visited the sites and '*... found that the Beacons on the Wolf Rock and Rundle Stone had been wash'd down before they had arrived...*' This was Huddart's first visit to the Land's End and the General Court of 4th June 1795 '*... thanks of the Court to Capt. Huddart for the trouble he has taken on the survey of the Light-House on the Long Ships, and the Wolf Rock and Rundle Stone, and the Direction he has given to that business...*' There was no mention of the Isles of Scilly.

In September 1795 Huddart was dispatched a second time to Cornwall to examine the three sites. Trinity House received a letter from Huddart on the 17th Sept 1795 (dated 12th instant):- *'...on the 1st instant he sailed to Scilly to inspect the [Agnes] Lighthouse' [8] which he found in good order...'* and *' that being detained at Scilly by bad weather [our emphasis] and there being on the 5th instant a strong Gale from the South West with a heavy sea, he intended on his Return to have survey'd the Beacon on the Wolf Rock which he saw on his passage over, but found it was gone ...'*

Huddart was therefore in the Isles of Scilly in September 1795 between the 1st and 8th, as bad weather forced him to shelter in the harbour of St Mary's. He would have had time to visit the remote spot on St Mary's where Sir Cloudsley Shovell's body had been washed ashore in 1707 and to observe the longitude at the site. Why he did not choose the Agnes Lighthouse or the Star Fort on St Mary's will never be known. The sun may have been briefly visible and observations possible at the grave site in an otherwise stormy week (Fig 5-4). Thanks were recorded from General Court of 8th October 1795 (GL Ms) for Huddart *'... proceeding twice this year from London to the Land's End...'* The Agnes lighthouse and the Isles of Scilly were ignored. Nowhere in his lengthy correspondence with Trinity House does Smith refer to, or acknowledge assistance from, Joseph Huddart or Spence.

THE SITE OF THE OBSERVATION

According to the footnote, Huddart measured the *longitude* *'...at that spot in the island of St. Mary, where the body of Sir Cloudesley Shovel is said to have been thrown ashore...'* Porth Hellick Bay is linked, of course, with the greatest of all Scilly shipwrecks, that of the fleet of Sir Cloudesley Shovell in 1707. The accounts of the corpse's discovery differ in detail. It *'... was buried 4 yards off ye sands; which place I myself view'd,'* c.f. a MS by E. Herbert, Deputy Paymaster General of the Marine Regiments [9] for many years; written at the site in 1709, when he was recovering property lost in the 1707 wreck: it is quoted in ISMP no.6, n.d., p 3. Troutbeck, (1795, p 86), is very precise: the temporary grave was near a fresh water pool called Upper Moors which emptied into the sea c 100 yards from a vast stone, Dick's Carn (Fig 5-2). This would place it in the NE of Porth Hellick Bay. The body was exhumed within a few days and eventually given a state funeral in Westminster Abbey.

THE SOURCE OF THE FOOTNOTE

Towards the end of the 18th century four distinguished men of science were involved in determining the position of the Isles of Scilly; Joseph Huddart (FRS, hydrographer), William Mudge (Colonel, of the Trigonometrical Survey), John Arnold snr (chronometer maker) and Graeme Spence (Admiralty Surveyor). The first three were acquainted, via a small group of intellectuals who met in the city of Plymouth, among them Dr. Samuel Johnson, Samuel and James Northcote, Sir Joshua Reynolds, Smeaton etc. Further details are in ~~in~~ Appendix B.

In this context, Spence was an outsider and was ignored. He was working for the Admiralty and Trinity House and his surveys of Scilly languished on the shelves of the 'Hydrographical Office'. Mudge's surveys were for the Board of Ordnance and the observations of his Trigonometrical Survey were published by the Royal Society. Huddart was deeply interested in the accuracy and use of chronometers.

It is disturbing to discover that Huddart must have been fully aware of the surveys by Spence, because the latter kept Trinity House regularly informed of his progress, as many of the General Court and By Board Minutes record (e.g. GL Ms TH BBM 27th August 1789; GL Ms TH GCM 14th June 1792; GL Ms TH GCM 7th May 1795) and Huddart was present at some of these meetings. Given the personal links between Huddart and William Mudge, outlined above, it is difficult to understand Mudge's apparent ignorance of Spence's charting.

Huddart's longitude observation was but a mere passing 'opportunist' measurement in his long career. It is, therefore, of some interest that Colonel William Mudge of the Trigonometrical Survey should even have heard of it, let alone draw attention to it. William Mudge was a member of a distinguished family that was part of a small group of intellectuals (*supra*) who met in the city of Plymouth. Huddart's visit to Scilly could have come to the attention of William Mudge, via his uncle Thomas Mudge snr, as he and Huddart were both on the Board of Longitude. Alternatively, Huddart may have told John Arnold, the expert chronometer maker (who had moved to Plymouth) about using one of his watches to measure the longitude of Sir Cloudesley Shovell's grave in Scilly and the information had passed from Arnold to Thomas Mudge snr, and so to his nephew, William Mudge.

HUDDART'S INSTRUMENTS

THE WATCH. [10].

The development of a reliable sea-going 'watch' or chronometer by the Harrison brothers has been well documented (Quill 1966; Sobel 1995; Sobel & Andrewes 1998 etc). Unlike the three previous attempts Harrison's H.4. resembled a large watch. John Harrison was reluctant to have the 'secrets' of H.4. revealed. Thomas Mudge (*infra*) knew about the details of H.4. as he was on the Board of Longitude and gave the details to Ferdinand Berthoud (1727-1807). This breach of trust was not investigated until 11th 3 1767. Mudge claimed that ~~he~~ was never told that the Board's Minutes were secret. A Rev Ludham had in fact disclosed details in 1765. In 1764 John Arnold claimed that he could make a time piece for 10 guineas, making it commercially available.

Mudge described Huddart using '*... a watch made by Arnold, [Figs 5-2 and 5-3] and obtained his time at that spot in the island of St. Mary, where the body of Sir Cloudesly Shovel is said to have been thrown ashore, by means of equal altitudes of the Sun's limb; he then found, comparing his [local noon] time with that shewn by the watch, that 0^h 25^m 18^s was the difference between the meridians of Greenwich and this spot in St. Mary's.*

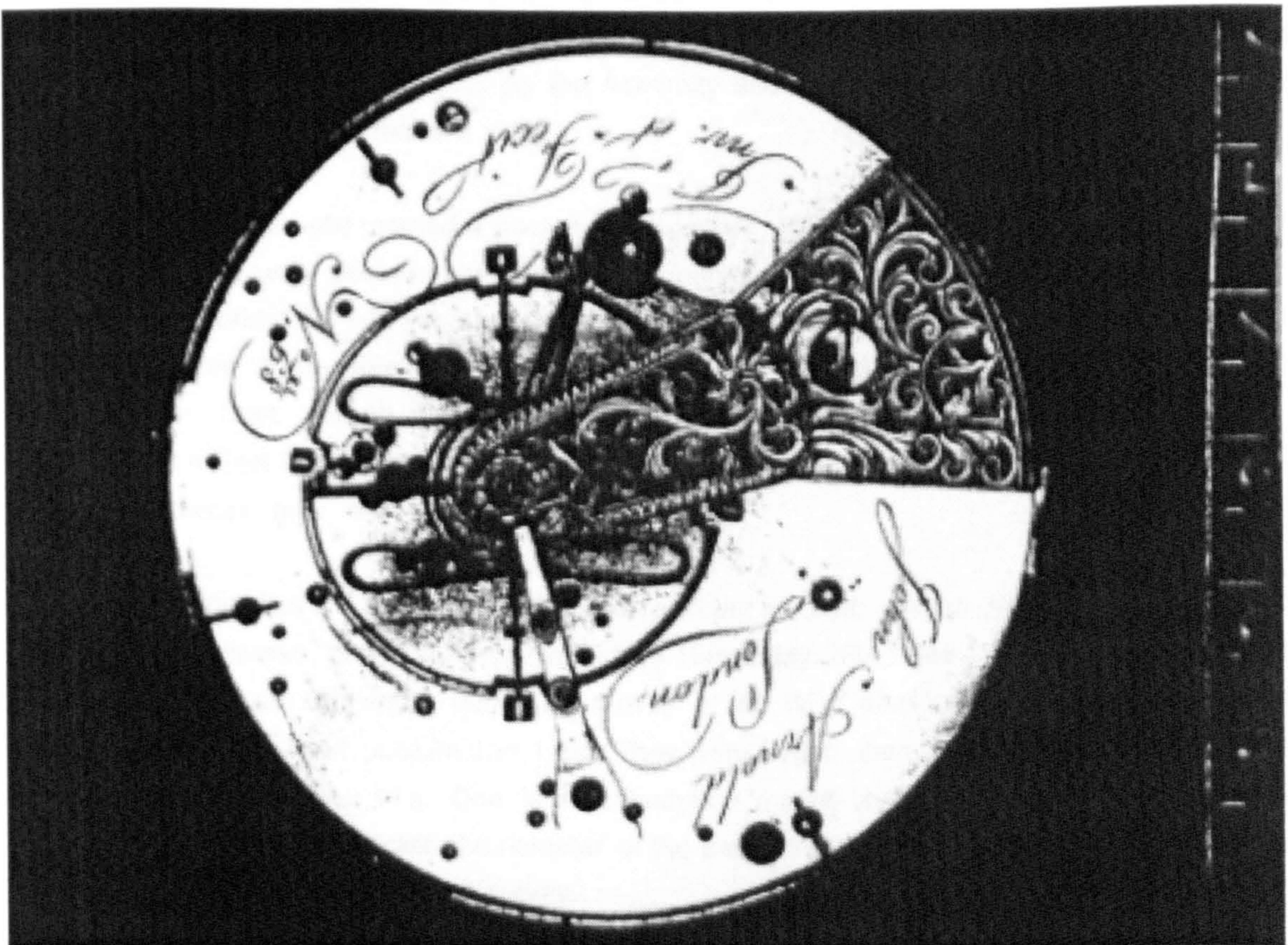
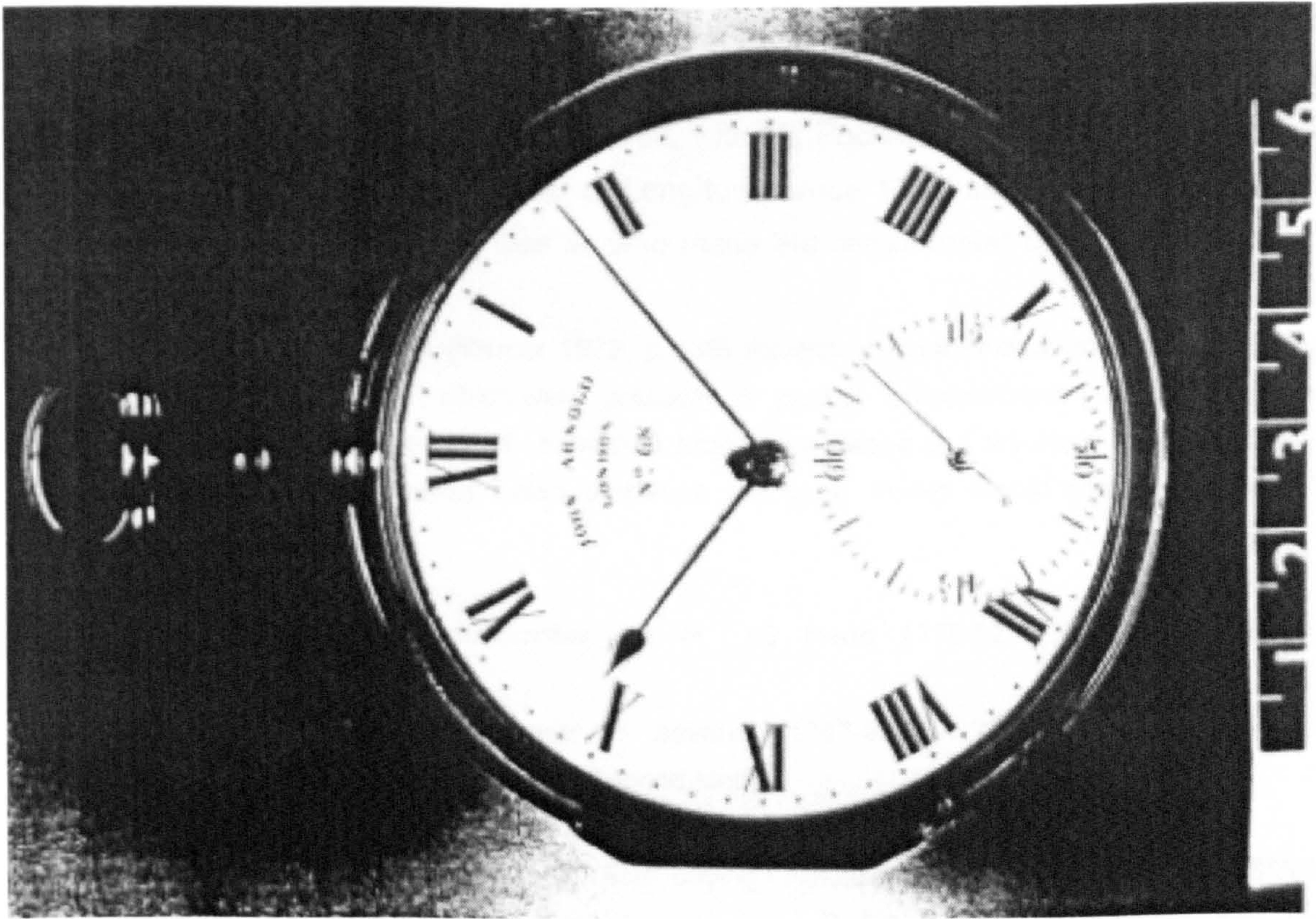


Fig 5-3. John Arnold's Watch No 21/68. Probably owned and used by Edward Everard of King's Lynn, 1785–1787 and later (see End Note 13).

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Arnold made his first chronometer in 1770 (May 1974-6, p 638) and by 1782 he (and Earnshaw in 1783) had devised and patented practical marine chronometers and pocket chronometer watches (Cutmore, 1985) and by the late eighteenth century very accurate, small, watch-sized chronometers were becoming available [11]. According to Mercer's definitive study of the Arnolds, father and son (1972), John Arnold snr achieved a major breakthrough in design and accuracy in 1780, with his Pocket Chronometer No 36. His time pieces had been tested by the Board of Longitude since 1770 and he had made over 60 pocket chronometers by 1796. It was he who made the chronometer used by Huddart. [12].

The Board of Longitude Records (Mercer 1972, p 136) mention a number of John Arnold time-pieces, among them Nos 36, 42, 68, 82, which were probably all pocket chronometers [13]. The authorities do not wholly agree on the history of individual Arnold timepieces and the topic cannot be followed further here. Mercer (1972) makes it clear that there are three known Arnold time-pieces called 'No. 68', from the following series :-

- i). 21/68. Large Pocket Chronometer, one of 40 made 1779-82 (?Everard's). Hallmarked 1780.
- ii). 68. Marine Chronometer, one of several 1787-99 (?Blair's)
- iii). 68/369 Small Pocket Chronometers (Second kind).

Dalrymple (1806, p 69) refers to a Captain Blair buying Arnold's 'Pocket Chronometer No.68/369' in Madras about the year 1786, but D. Thompson, of the British Museum Horological Dept. (pers. comm.) doubts its suitability for general marine use and favours a marine chronometer, e.g.. No 21/68. An Arnold No 68 turned up again in 1918 in the general shortage of chronometers caused by the Great War; it was purchased by the Admiralty and sold again in 1937 (May 1976, p 643), a remarkable testimony to its maker's skill.

Huddart probably habitually carried a pocket chronometer with him, as did Edward Everard (*end note 13*). The Admiralty was slow to appreciate the chronometer, whereas the East India Company (for which Huddart worked 1777-87) was quick to do so and at least a dozen East Indiamen carried these timepieces before 1790 (May 1976, p 638). May (*op cit* p 642) quotes Dalrymple (1806, p 68) to the effect that Capt Joseph Huddart carried chronometers in the '*Royal Admiral*' in 1784-86. All those used on East Indiamen were made by Arnold (May *op.cit.* p 643). Huddart's preference for Arnold's timepieces may stem from this. [14]

Arnold (1791) includes the following:- '1789 - *An account of Capt. Joseph Huddart, late of the 'Royal Admiral, East Indiaman', giving a comparison [June 10th - July 28th 1789] of two Box Chronometers, Nos 11 and 16, made by Arnold, during his survey of the West coast of Scotland.*' They must have been used for the chart published in 1790. They were larger than pocket chronometers. Mercer (1972 pp.46-7) lists two No. 11's. One is described as a 'marine chronometer', made 1778 and altered 1782, and the other as a 'pocket chronometer' of the best kind, made 1774. The former would have been the one used on the Scottish survey.

THE QUADRANT OR SEXTANT

In addition to his watch, Huddart would have needed a quadrant or sextant to measure the elevation of the sun, to obtain the local noon time. A 10 inch quadrant used by

169

AUG 1926

AUG 1927

3 AUG 1938

John Arnold CAI/301 ✓

No 68

One plain gold case 1780

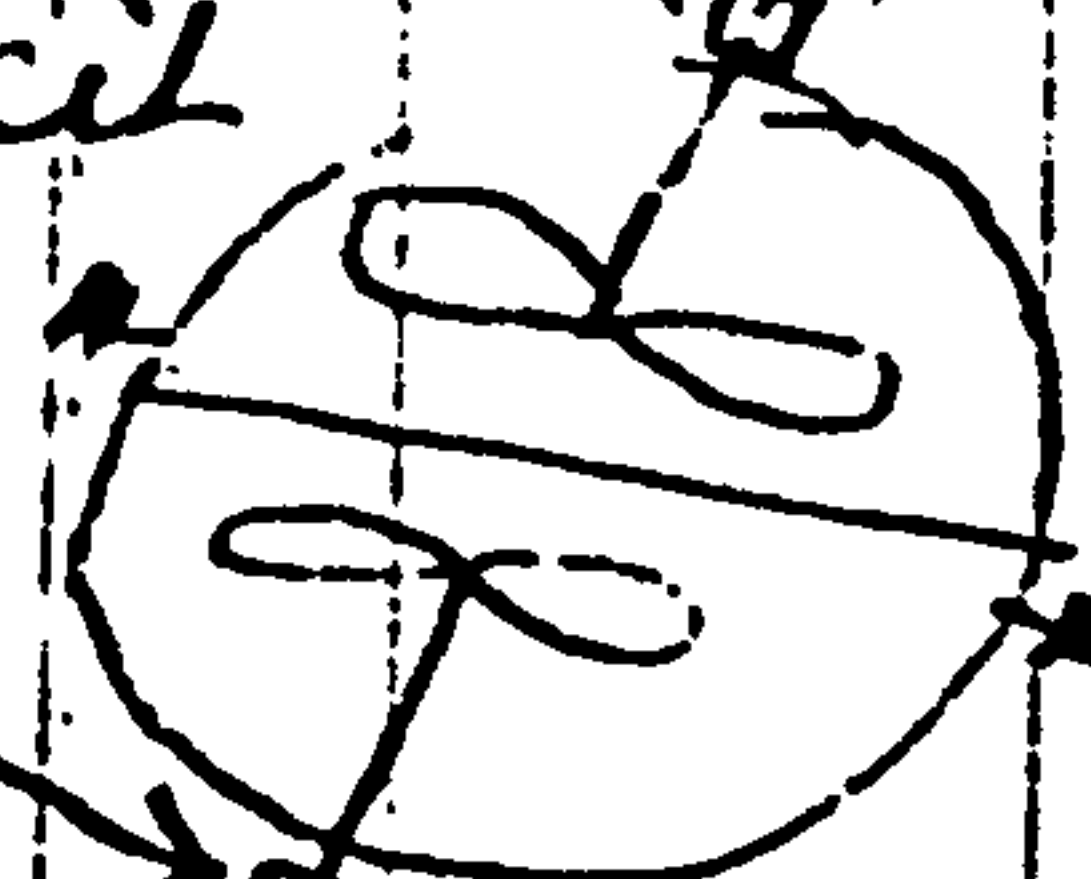
On net 21

68

John Arnold London

Inst of Tech

Balanced gold knobs



✓ Steel escape wheel

Perpetual work

1/4 Repeater. Dumb of pulse

White dial. 10 minutes

Gold hands. Sec: hand

Screwed on. also minute

Shot helical spring

jewelled to fit hole

This is famous watch mentioned

in Arnold's & Mudge's books

1780

AUG 1939

Elkington 52

✓ 5255

Fig 5-4. Watch No 21/68. Note: 'This is famous watch mentioned in Arnold's & [William] Mudge's books'.

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Huddart in 1784 is referred to below and he published a paper on refraction and the sextant in 1796.

Dalrymple (Philosophical Transactions of the Royal Society, 1785) quotes extracts from a letter by Huddart, dated St Helena, 7th July 1784, referring to a small quadrant which may

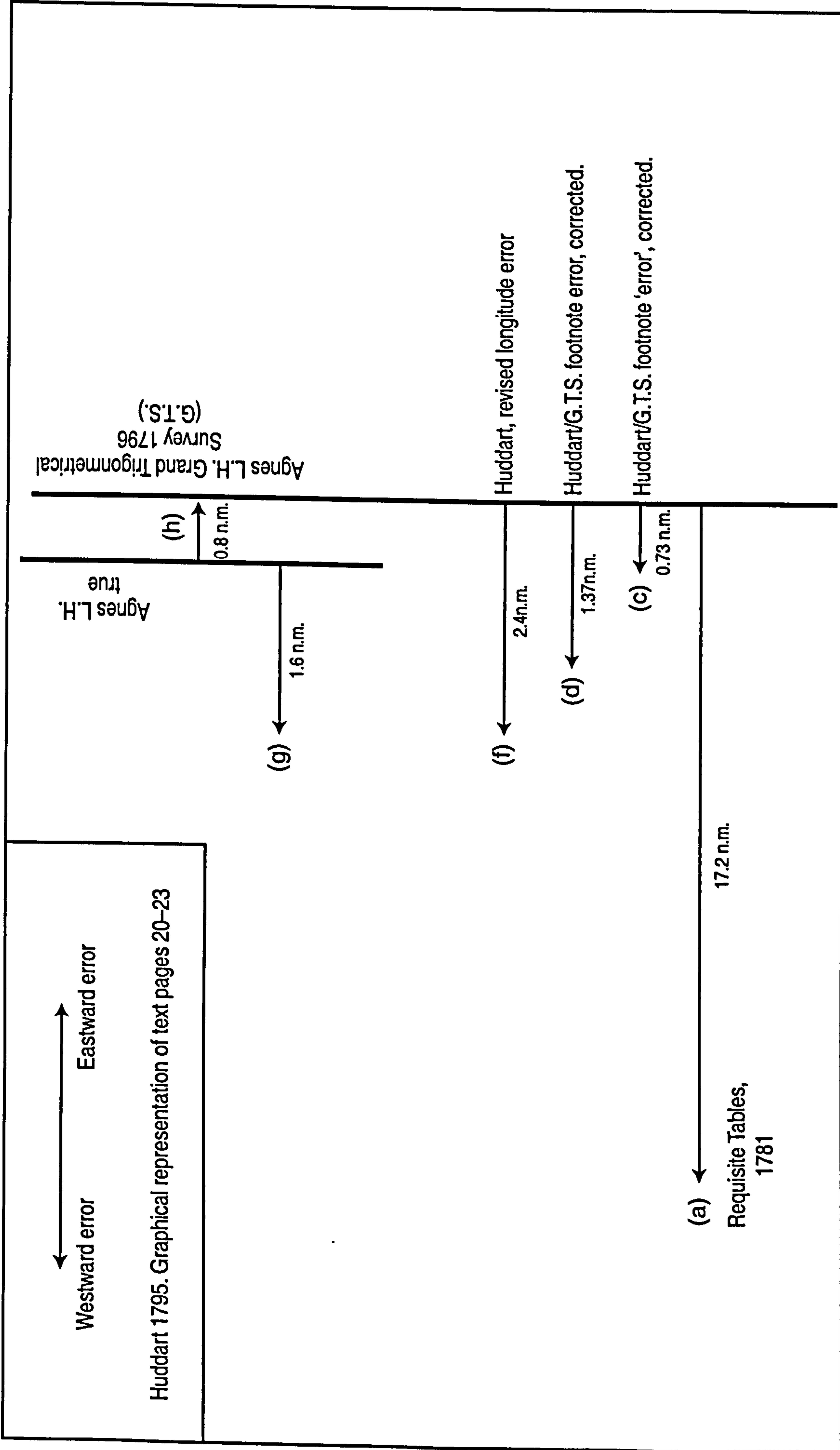


Fig 5-4. Agnes L.H.

well have been the type he used on Scilly. (Huddart was not then an FRS, hence the letter's presentation by Dalrymple; Huddart 1989, p 83-4). Very bad weather allowed Huddart only one observation of the Eclipses of Jupiter's Satellites. He was using a quadrant of 12 inch radius made by John Bird; this was rather small but '*... answers tollerably [sic] well...The Quadrant giving me the Time (as it adjusts well) to the nearest second by equal altitudes.*' The quadrant had been with the late Captain Cooke on his last voyage and had been lent to Huddart by the Board of Longitude.

END NOTES

1). Histories of the Honourable East India Company make little reference to Huddart e.g. Mead (n.d.); the '*Royal Admiral*' is mentioned by Cotton and Fawcett (1949) but not in Huddart's time. An East Indiaman was named '*Huddart*' in the early 1800s. For his Far East surveys, however, Huddart was thanked by the Court of Directors on 28th October 1786 (Chaplin, c1940).

2). Huddart and Co. of Limehouse supplied chains in 1809 for a lightship near Wells, Norfolk (Stevenson 1959, p 233) cf Huddart's Trinity House responsibilities.

3). Major Edward Williams was the first the first Director of the Trigonometrical Survey of the Board of Ordnance. He was succeeded in 1798 by Colonel William Mudge, with the title of Superintendent of the Trigonometrical Survey. Isaac Dalby, a mathematician had been with the Survey since 1787.

4). The French had used chronometers to measure the longitude of Scilly.

In the 1794/1795 edition of the *Connaissance des Temps* (p 258) the position of Agnes lighthouse is given as :-

Longitude (west of Paris)	Latitude
(a) 0 ^h 36 ^m 24 ^s / 9° 6' 0"	(b) 49° 56' 0"

(a) = longitude determined on land or sea by average of marine watches or by chronometers.

(b)= latitude observed at sea.

Allowing for the Paris-Greenwich longitude difference of 2° 19', the French fixed the longitude of Agnes lighthouse as 6° 47' west of Greenwich, a westward error of 26' 19"/c.17nm. This is almost identical to the '*Requisite Tables*' longitude of 1781. It is not stated who made the chronometer measurements.

5). Porth is Cornish for landing place (Thomas 1985, p 38). Folklore has placed the temporary grave as shown on Fig 5-1 (grid ref. c 926107). A monument of two granite stones on the east side of Porth Hellick bay now marks the presumed site of the original grave.

6). The British '*Nautical Almanac*' was first published in 1766 and appeared annually, accompanied by a second periodical, "*Tables requisite to be used with the nautical Ephemeris.*" The latter's first edition (1766) contained no position tables but a second edition (1781) entitled "*Tables requisite to be used with the Nautical Ephemeris for finding the Latitude and Longitude at Sea*" listed in Table XX, p.152, the latitude and longitude of a number of places, including Scilly. It is to this Table that Mudge refers.

7). Pengelly (Trans. Dev. Ass. 1884, pp 605-26), notes that in the 18th century beacons were often poles with pitch barrels near the coast, to be lit to warn of invasion but that Johnson, Dictionary, 1784, defined them as "*Marks erected, or lights made in the night, to direct navigators in their courses, and warn them from rocks, shallows and sandbanks.*"

8). Agnes lighthouse, one of the earliest English lighthouses, was built in 1680 but ceased to be used in 1911. It remains a prominent sea and land mark (Fig 2-4b) and for many years Admiralty charts of Scilly continued to print its precise position in the chart notes.

9). The Invalids Regiment formed the Garrison on Scilly; the Marine Regiments were a separate force, not stationed on Scilly.

10). A little care is necessary in the interpretation of 'watch'. In the past watch was a non-chiming timepiece, in contrast to a clock (cf cloche), which chimed. Size was not relevant. It is clear, however, from the background to the footnote that in this instance 'watch' means a pocket chronometer, specially designed to determine longitude at sea. 'Chronometer' was first used in 1735 (OED). The Admiralty Manual of Navigation helpfully defines a chronometer as "...simply an enlarged watch."!

11). According to May (1976 p 644) the first reference to the use of chronometers in a book of navigation appears to be "Navigation Made Easy and Familiar" (Malham, Rev. John, 1790).

12). In 1792 Arnold was selling his marine chronometers for 60-80 guineas and gold pocket watches for 41-120 guineas.

13). The following gives some idea of the serviceability of a comparable instrument. A certain Mr. Edward Everard (1761-1829) of Lynn Regis [King's Lynn], a member of a wealthy shipping dynasty of the town, (Bradfer-Lawrence 1930, Walter, 1913) owned an Arnold chronometer (Gould 1923 p 113). It was No.21/ 68, hall-marked 1780 (Mercer 1972, p 53-4). D. Thompson, of the British Museum (pers. comm.), states that it was not a 'sea-going' piece. In his Will of 1829 (PRO PROB. 11 1752) Edward Everard left a gold watch (possibly the above), valued at £31 10s., to his wife.

The following reference to the Everard watch (No.21/68) is inserted into an account by John Arnold (1790) of a trial of one of his chronometers at Greenwich Observatory in 1790 (British Library: 1391.i.10(1)):-

'The following comparisons were made with a Regulator, the going of which was examined by a transit instrument, and the Errors of the Regulator accounted for, in the Rate of the Chronometer. When I have not been at home to make Daily comparisons, the mean rate of the Chronometer for that Interval, is inserted in the Register. Having travelled with it some Thousands of Miles, on Horseback and in Carriages, I can with truth assert, that neither the motion of the one, nor the other, has ever, as far as I have been able to discover, altered the rate of THIS Chronometer. It is still going.'

*Edward Everard
Lynn-Regis, April 12 1787.*

Daily rate of the Chronometer, No. 68, made by Mr. John Arnold, and worn in the pocket of Mr. Everard of Lynn.'

Then follows the Register: it runs from 11th Nov 1785 to 21st April 1787, some 73 weeks. 'Some thousands of miles' sounds extravagant but at about 40 miles a week he could have covered 3000 miles during the time of his Register. Arnold (1791) includes 23 letters of testimony for his chronometers and on p 43 refers again to the daily rate of No. 68 '*...worn in the pocket by Mr. Everard of Lynn.*' Its 'Register' is now extended to March 1790. These chronometers, sometimes with silver or gold cases, could cost up to 120 guineas and were usually to be found in the hands of professional surveyors or, as in the case of Edward Everard, rich merchants with an interest in shipping. Everard's watch is now in the Ilbert collection at the British Museum. It is c 7cm in diameter, has a gold case, and is a half quarter repeater. It is in very good condition (Fig 53) and must be very like the one used on Scilly by Huddart.

14). The following entertaining letter is dated 12 9 1782 and was written by a Reuben Burrow '*...on day of sailing to Calcutta...*' It is quoted in Mercer (1972 p.103-): '*In the afternoon the Captain showed me a letter he had received from Arnold the watchmaker, wherein the Scoundrel had pretended that it was in consequence of an expression of mine that he did not send Capt. H— a watch; this exasperated me so highly, that I wrote him a most bloody letter, and shewed it to Capt. H—, and his wife took it with her on shore.*' It is tempting to see Capt. H— as Huddart, as he was in India at this time, sailing from Bombay on 12 10 1782 (Huddart W., 1989, p.184.) but it is not definitely recorded that his wife Elizabeth ever accompanied him at sea. She did not do so on his penultimate voyage, March 1783-April 1786, as she died after a long and painful illness in February 1786, before he reached England.

CHAPTER SIX

THE TRIGONOMETRICAL / ORDNANCE SURVEY

1796-1976

INTRODUCTION

The beginning of the last decade of the 18th century saw the establishment of the first official national organisation to survey and map the British Isles, originally for military purposes. It dates from the 21st June 1791 [1] and was initially named the **Trigonometrical Survey of the Board of Ordnance**. [2] Graeme Spence referred to it as the Grand Trigonometrical Survey. In the early days of the Survey, 'Ordnance Survey' was not used officially; for example, Mudge refers to the Trigonometrical Survey when surveying the Isles of Scilly in 1796. The first official use of 'Ordnance Survey' appears to be in a minute dated 1820 and from then on the Survey was regularly known as the Ordnance Survey, reflecting its origin. (Close 1926; Harley *in* Close 1968; Harley 1964, 1969; Hodson 1991; Oliver, 1991). In recent years the origins of the Ordnance Survey have been fully explored and documented and have been shown to be much more complex than was assumed even 30 years ago. [3].

With the establishment of an official national survey department with an increasingly large professional staff, the practice in earlier chapters of giving at least a brief biography of the principal surveyors of Scilly is progressively less necessary. In the first Trigonometrical Survey the staff was small and William Mudge took a leading part in the actual field work. This was not the case ~~when~~ when that survey had to be 'Re-cast' by Capt (later Col) Alex *in 1858* Ross Clarke (Harley, *in* Close 1969, pp 131,154) *who* was personally involved in the computations and compiled the resultant report. Although the influence of certain outstanding Superintendants/Directors is undoubted, as time passed they were naturally concerned with the administration of a large organisation and ceased to be involved in the detailed field work and reporting. By the time of the 'Re-triangulation', teams rather than individuals were responsible for the practical surveying and subsequent calculations.

Between the years 1796 and 1960 the Trigonometrical/Ordnance Survey made three triangulation connections between the Isles of Scilly and the mainland each in its turn being accepted as providing the definitive position of the Islands. [4].

1). THE TRIGONOMETRICAL SURVEY of the BOARD of ORDNANCE.
('MUDGE'S' TRIANGULATION)

Williams, Mudge and Dalby. Surveyed 1796. Published 1797, 1799, 1800, 1801.

2). THE PRINCIPAL or ' RE-CAST' TRIANGULATION.
Clarke. Re-calculated 1845-50. Limited field work. Published 1858.

3). THE RE-TRIANGULATION.
Surveyed 1959-60. Published 1967.

THE TRIGONOMETRICAL SURVEY of the BOARD of ORDNANCE.

('MUDGE'S' TRIANGULATION)

INTRODUCTION

Graeme Spence (Chapter Four) made frequent references to, and comparisons with, 'The Grand Trigonometrical Survey' his name for the Trigonometrical Survey of the Board of Ordnance. In this account the latter is often referred to as 'Mudge's Triangulation',

This Trigonometrical Survey was particularly associated with three men: Edward Williams, William Mudge and Isaac Dalby.[5], of whom Mudge was the driving force. The discussion which follows is highly selective and dependent upon the scholarly accounts of all aspects of the Survey's work in west Cornwall and the Isles of Scilly by Harley 1969 (Old Series 1" sheets 31 and 33; David and Charles facsimilies); Harley and O' Donoghue in Margary, 1977, vol. 11, Devon, Cornwall and Somerset pp vii-xliv; Messenger 1991; Owen and Pilbeam 1992).

The results of the Trigonometrical Survey were published twice: first in the Philosophical Transactions of the Royal Society and subsequently consolidated, and to an extent revised, in three volumes published by Faden. The results of the 1795 and 1796 triangulation from Thanet to Land's End were first published in 1797 in the PTRS, vol 87, pp 442-50 (Williams, Mudge and Dalby) and for the years 1797, 1798 and 1799 in 1800 in vol 90, pp 672-3 (Mudge). The three Faden volumes were published in 1799 (Mudge and Dalby); 1801 (Mudge) and 1811 (Mudge and Colby).[6]

It is perhaps surprising that the Trigonometrical Survey, which started in Kent and Essex in 1788, should have proceeded so rapidly to the extremities of the West Country. The reason appears to have been the threat of military invasion from France (Mudge 1801, p 78). There was a deliberate policy to fix points along the coast, so making the construction of military maps at short notice much easier and it was this '*...which brought the primary triangulation to Land's End much earlier than might otherwise have been the case.*' (Harley and O'Donoghue, 1977, xii & note 57.). Consequently in 1795 and 1796 the Trigonometrical Survey had been extending its 'great triangles' along the coasts of Dorsetshire, Devonshire and Cornwall to the Land's End and '*...the most important business...*' of 1796 was the observations to determine the distance between the mainland and the Isles of Scilly, and so determine their true latitude and longitude. (Williams, Mudge and Dalby 1797, p 442).

The south coast net of Principal Triangles [7] in Cornwall is shown in Fig 6-1 . As regards the Isles of Scilly, the orientation of the link is unnecessarily skewed and the sightlines are dotted, suggesting that they are less reliable than those on the mainland. The coasts of the Isles themselves are not plotted. Four stations were observed by the Survey but only three are on the map. The two stations used on St Mary's may have been too close to plot on this small scale map.

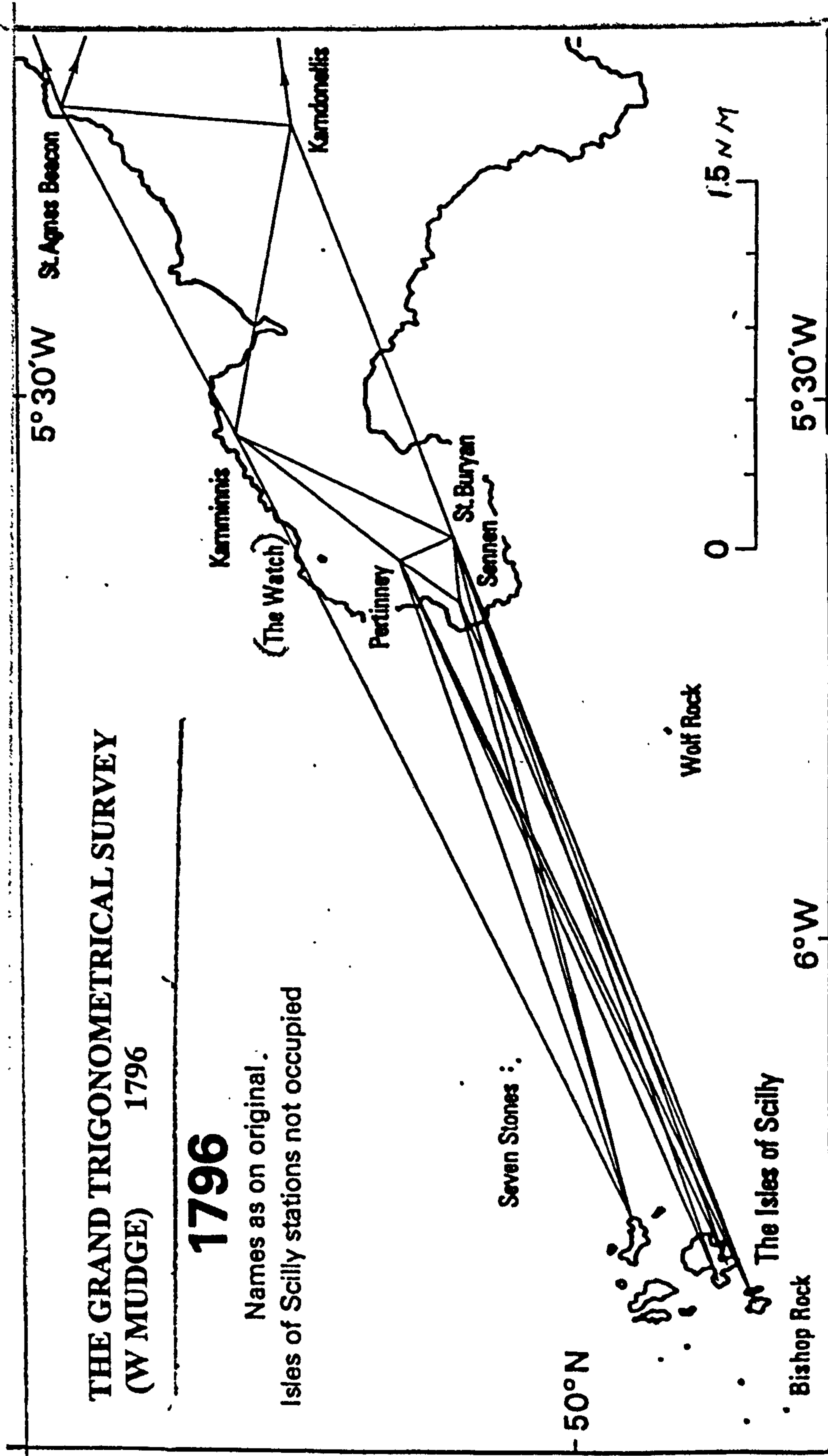


Fig 6-2. Based on Mudge and Dalby, Phil Trans Roy Soc 1797, Plate p 442

Instruments and Field work.

Ramsden's first 3-foot theodolite, commissioned and owned by the Royal Society, was not available after Roy's use of it until January 1799, it being kept in the Society's apartments. The Trigonometrical Survey's formation really became possible because of the purchase by the 3rd Duke of Richmond, Master General of the Board of Ordnance, of Ramsden's second and improved 3-foot theodolite. It became available when the East India Company refused to pay the higher price demanded for the improvements. This purchase enabled the Board of Ordnance to continue Roy's triangulation independently of the Royal Society and it was this second theodolite which was used for the triangulation of the West country and Scilly. Subsequently both instruments were in use for about sixty years, measuring the principal triangles of the Ordnance Survey.

In 1892 the optimum length of triangle sides was found to be 12-18 miles (19.3-28.9 km.) but the sights to Scilly (between 24.7 and 34 miles; 39.7 and 54.7km.) were not exceptional, as elsewhere several sights were taken at distances exceeding 100 miles (160.9km.). The second Ramsden theodolite could read a mark at 70 miles (112.6km.) distance with an angular error of only 2 seconds and was the first instrument able to measure spherical excess, the effect of the earth's curvature on the measurement of the angles of large triangles. In the case of the triangulation to the Isles of Scilly, however, the calculations were '*...computed on the supposition of the earth's surface being a plane, which, within the limits of our fixed meridians, may be considered as true.*' (Mudge 1800, p 672). The same assumption had been made by Spence.

A plan showing the triangulation stations in west Cornwall and the Isles of Scilly accompanies the text of the survey (Mudge & Dalby, Philosophical Transactions of the Royal Society 1797, pp 432-442).

It is clear that a smaller theodolite was also in use, presumably mainly for the secondary triangulations '*...as the small theodolite...was finished early in the summer of 1795, we are enabled to give a series of triangles, extending, in conjunction with those before given, from the Isle of Thanet, in Kent, to the Land's End.*' (Williams et al, 1797, p 432).

The personnel of the Survey, Williams, Mudge and Dalby, were assisted in the field by a working party of artillerymen. Poles, scaffolds, ladders and such apparatus were provided by the Board of Ordnance. Mudge and Dalby [but probably not Williams] worked in the field and Dalby was responsible for the computations. In addition to the new 3-foot theodolite, instruments included two new 100 ft chains and a transit instrument combined with a telescopic level to measure bases, all by Ramsden. (Close 1926, p 30). Further details are in Harley and O' Donoghue (*op cit* 1977).

The Mainland triangulation stations. (Figs 6-1 and 6-2)

By the end of 1795, a double chain of triangles extended from London to Land's End but in west Cornwall the narrowness of the peninsula required only one chain (Fig 6-1). Devon and Cornwall proved difficult to survey; many stations provisionally selected were

not in the final network because of the difficulty of transporting the 200 lbs theodolite to a summit, especially if it were crowned by a granite tor.

The link with the Isles of Scilly met with some difficulties and led to departures from normally accepted procedures.

First, it is clear (Mudge 1800, p 672) that the angles were measured from the mainland to the stations in the Islands and were not checked by reverse observations, as was the usual practice (Spence's survey was the opposite). No reasons are given for this but one may surmise that absolute precision may not have been regarded as essential, as the Islands were not a link in the primary chain of triangles (the sight lines are dotted on Fig 6-1). Furthermore, Ramsden's second great theodolite, which was normally used for all the observations weighed over 200 lbs, and it may have been deemed too cumbersome and too valuable to be ferried to the Isles for the reverse sightings to be made.

Secondly, some of the rays were over 25 miles / 30km long, more than the average length of the sides of primary triangles on the mainland. It was fortunate that the observations were favoured with exceptionally fine weather so that *'...we could sometimes with the telescope of the great instrument, discover the soldiers at exercise in St. Mary's Island.'* (Williams *et al* 1797, p 442-3). The Hugh Garrison parade ground (42m OD) is in the extreme west of the Island and might be assumed to be screened from the mainland by land to the east, but nowhere does the latter exceed 40m (Mt Todden 39m; 927117). It is a remarkable testimony to the quality of Ramsden's theodolite.

Thirdly, to observe the Isles of Scilly the mainland sides of the triangles ideally needed to lie roughly NNW-SSE (*i.e.* perpendicular to the line of sight to the Islands) and to be at least 12 miles / 19 km in length. The narrowness and terrain of the Land's End peninsula proved very difficult. Although *'...it became necessary to find stations affording the longest bases.'* (Williams *et al*, 1797) only very short base-lines could be established (Fig 6-2). The same problem, of course, had faced Spence when observing in the opposite direction.

Mudge selected four mainland stations for the observations to Scilly (Williams *et al* 1797, pp 449-50). This was probably the consequence of an inter-visibility problem; what is a good observing station is not necessarily a good target.

The Survey's first choices were:- *'The hill near Rosemergy, called the Watch, and the station near St. Buryan,[8] are certainly the most advantageous places, because all the islands can be seen from both...'*

The Watch (now Watch Croft, 420357, 252 m OD), is the highest point on the peninsula. However, 'Watch' is not a Cornish name and it does not appear on the on the First Version of the Ordnance Survey sheet 33, Old Series One-inch based, of course, on Mudge's triangulation. The sheet was topographically surveyed 1804-5 and published 1813 (long axis E-W: Messenger 1991). On it, the nearest name to the modern Watch Croft is 'Bosullo Down,' a broad piece of upland. Possibly there was a watch house on or near the summit and Mudge used this local name. What ever the name, the site could not be occupied *'...as*

difficulties almost insuperable would have attended an attempt to get the instrument upon it.' (Mudge and Dalby 1799, p 363). No further explanation is given, yet a well defined track crosses the higher part of Bosullo Down on the 1813 edition of sheet 33). It is not on modern maps.

The later states of the one-inch map (Version Two, post-1839, long axis N-S: Messenger 1991) post-date Mudge's triangulation but there is no evidence that the triangulation was re-observed. Sheet 33 was completely re-engraved c1839 (Messenger 1991, pp 40-1) [9] and the highest part of the broad Bosullo Down was replaced by a much narrower ridge named 'Kerrow Hill', which has no track leading to the summit. The same is true of the current OS Explorer 1:25 000 sheet, Land's End, but Watch Croft now has a Triangulation Pillar on the summit. What is surprising is that Mudge's 'The Watch' is no more covered with hill-side clutter and rock outcrops, nor capped by an exceptional granite tor, than any of the surrounding hills. The Watch was and is an excellent site for a triangulation station to observe Scilly and the 'difficulties' must indeed have been great. This re-engraved version would have been the one used by Clarke.

The replacement site, ~~was~~ Karnminnis, now known as Trendine Hill (480388; 247m OD), near St Ives, was not much better. The surveyors obviously initially thought ~~it, was~~ *'...a spot as well situated as [the Watch]...'* and seem to have been surprised upon occupying it that only the Day-Mark on St Martin's was visible from it. In fact it was not *'... well situated...'* as it was even further from Scilly than Watch Croft, being c.6.3km to the NE and several metres lower. The problems of describing a triangulation station on a tor-capped hill so that it can be recovered at a later date are only too obvious from the following (Philosophical Transactions of the Royal Society, 1797 p 450):-

'The station on top of this hill, [Karnminnis] may be found from the following measurements:

The station from 3 large moor-stones, south of the hedge.

<i>Feet.</i>	<i>In.</i>	
8'	8"	<i>from the south stone</i>
11'	0"	<i>north</i>
14'	1"	<i>west</i>

A more promising station was Pertinney, now called Bartinney Downs (395294; 24m OD), from which all the stations in the Isles of Scilly were visible. Early states of the one-inch OS map 33 show it crowned by a circular earthwork; *'The station is in the middle of the ring on its top. This hill is about 2 miles eastward of St. Just.'* (op. cit p 449). It is named Bartine Castle on modern OS maps, which also show tracks leading to the summit. The Survey clearly managed to haul the 'great instrument' into the ring.

The third station at St Buryan (410257) did afford a view of all the Islands but it was not on the church tower, as might have been expected. Perhaps the 'great instrument' was too heavy for the structure. There is a modern bench-mark on the church at c. 125m OD. The Survey chose instead a site in a field *'...adjoining the town, and by the side of the Penzance road. It is 84½ feet from the stile, and 48 feet from a large stone in the northern hedge. This stone is 81 feet from the stile; the station, this stone and Chapel Karnbury,*

being in a straight line.' The Survey had great faith in the permanence of local features! The writer has walked over the ground but the site cannot be identified. About 0.8km along the Penzance road the ground does rise locally to c124m OD near Higher Trevorian (413263) but this is not a field adjoining the town. To avoid confusion with St Buryan Church, this Triangulation station is here named St Buryan A.

The fourth station was at Sennen (357255, 101m O D) again not the church, but in '*...the north-west corner of a field belonging to Mr. Williams. The field may be easily found, as there is no other spot near the town of Sennen, from which the Longship's Light-house, Pertinney, and St. Buryan, can be seen.*' Sennen cemetery is just north of the village and here the ground rises to a local summit at c 98m OD. As today it fulfils the above criteria, Mr Williams's field was probably here. To avoid confusion with Sennen Church, this Triangulation station is here named Sennen A. Attempts to learn more about Mr Williams in the Cornwall County record office were unsuccessful.

When 'Sennen' is compared on the main map of the Principal Triangles of Cornwall with the insert map of west Cornwall and Scilly, problems arise. First, the coastline is wrongly plotted. Sennen A (village) is plotted in the south of a small SE-NW peninsula which does not exist; it is approximately the position Land's End (unnamed). It was one of the Principal Triangulation stations where two rays met.

The insert map has two Sennen place-names. The southerly one, Sennnen A, is the Principal Triangulation Station on the main map, but north of it is plotted 'Sennen Ch'. Sennen church was not part of the main Triangulation (and so not in the list of Situations of Stations). The small scale and the dotted sight-lines make interpretation difficult, but one triangle Pertinney-St Buryan- Sennen Ch. ties the Church to the main triangulation and another triangle is Sennen Ch-St Martin's Day Mark-Pertinney. Sennen church tower was observed from the Isles of Scilly by Spence in 1792 and is the only station used by both Spence and the Trigonometrical Survey; direct comparison of the Spence and Mudge surveys is restricted to this one sightline. The Longships Lighthouse is located by the triangle Pertinney-Sennen A-Longships Lighthouse, but the Lighthouse was not itself an occupied station.

The Trigonometrical Stations in the Isles of Scilly

'From the stations near Land's End (Sennen A and Pertinney), as well as...St.Buryan [A], St.Agnes Light-house, and two objects in St. Mary's,[only one plotted on map Fig 6-1] were observed; and as the means by which all their distances are determined, except those of the Day-mark (St Martin's), from the shortness of the bases (which were, however, the longest that could be found) are exceptional, it will be right to mention, that...the air was so unusually clear...' (Williams et al 1797, p 442). The four stations were used only as targets; there were no observations from Scilly to the mainland. The sites were the four most obvious choices. No coastlines were added.

TABLE 6-1

Isles of Scilly: Triangulation objectives

St Martin's	The Day Mark	942161	top c 56.4m OD
Agnes	The Lighthouse	880084	top c 49 m OD
St Mary's	The Windmill(Peninnis Mill)	910097	c 35m OD
St Mary's	The Fort Flagstaff(Star Castle)	899107	c 30m OD

'The ball on the top of the Light-house...was always observed; and the Day-Mark being pyramidal... the same point was observed from different stations'. (Williams et al 1797, p 505).

The first two stations had been used by Spence to observe the mainland; the second two were new. The Isle of Tresco (a Spence station) was not used by the Trigonometrical Survey.

The triangles between the mainland and Scilly

Details of 'The Triangles for finding the Distances of the Day-Mark, St. Agnes' Light-house, and other Objects in the Scilly Isles, from particular Stations in the West of Cornwall.' are to be found on p 503 of Williams et al, 1797. The Cornwall stations were:- Karnminnis, St. Buryan A [NE of the church], Pertinney and Sennen A [N of the village]. Of the nine triangles in this Table only seven were observed (*op.cit.* p 504-5). Only selected sight lines and only one station on St Mary's [not identified] are on Fig 6-1 , presumably because of the small scale of the map. The triangles (the Survey's numbers) are:-

TABLE 6-2 (Williams et al 1797, p 503)

309	St Martin's Day Mark	(base line) Karnminnis – St Buryan [A]
310	St Martin's Day Mark	(base line) Karnminnis – Pertinney
311	St Martin's Day Mark	(base line) Pertinney – Sennen [A]
312	St Agnes Lighthouse	(base line) Pertinney – Sennen [A]
313	St Agnes Lighthouse	(base line) Pertinney – St.Buryan [A]
314	St Mary's Windmill	(base line) Pertinney – St Buryan [A]
315	St Mary's fort Flagstaff	(base line) Pertinney – St. Buryan [A]

Triangles not observed were:-

St Mary's fort Flagstaff	(base line) Karnminnis-St. Buryan. [A]
St Agnes Lighthouse	(base line) Karnminnis-Pertinney.

The map (Fig 6-1) inserts a line from St Martin's Day-Mark to St Agnes Lighthouse but it is not mentioned in the text. No observations were made within the Isles of Scilly and the line is presumed to be a drafting error (Fig 6-2). The longest base line would have been

from the Watch to the station St Buryan [A], a distance of about 10 km but, as noted above, the Watch could not be occupied. The base lines used were:

Karnminnis - St Buryan [A]: c.14 km but, because of its NE-SW orientation, equivalent only to c.9.5 km perpendicular to the sight-line to the Islands.

Karnminnis - Pertinney: c.13 km but effectively much shorter because of its orientation.

Pertinney - St. Buryan [A] c.4 km.

Pertinney - Sennen [A] c.5 km but effectively much shorter because of its orientation.

The table on pp 504-5 lists the angles measured from the mainland stations with '*...the necessary corrections...applied for reducing the observed angles to those formed by the chords...*' and the lengths of the sight lines measured.

The angles at the Scilly stations were extremely acute. For triangle 311, the angle at the St Martin's Day-Mark was only 4° 15' 46". The Survey was therefore well pleased when its calculated distances to Scilly from various mainland stations (p 505) were in close agreement:-

Karnminnis - St Martin's Day-Mark:- triangle 309 = 190985ft
triangle 310 = 190989ft

Pertinney - St Martin's Day-Mark:- triangle 310 = 154551ft
triangle 311 = 154568ft

These differences of only 4ft/1.2m and 17 ft/4.7m respectively '*...allowing for the shortness of the bases, must be considered trifling.*' The two measurements to St Agnes lighthouse from Pertinney differed by only 16ft/4.9m and the Survey concluded that single triangles '*...would have afforded the means of computing the distances with sufficient precision.*' There were also small differences in the triangles on the mainland; from different triangles the computed distance between Karnminnis and St Buryan [A] differed by 4ft (1.2m).

In 1791-2 Spence calculated the distance from St Agnes lighthouse to St Buryan Church tower and noted on the chart that this was only 222 yards (202.99m) more than the Grand Trigonometrical Survey distance, which he modestly thought was a smaller difference than might be expected given his less sophisticated instruments. Unfortunately for Spence he had overlooked the fact that he sighted on the Church tower, whereas the Survey's station was NE of the village *i.e.* St Buryan [A]. The latter cannot be identified and so Spence's distance cannot be verified.

Comparison is further complicated as Spence calculated two distances based on two different triangles. Using yards, Spence's distances were 60800 and 60810 yards and the Trigonometrical Survey's (triangle 313) was 61032 yards, which give differences of 232 and 222 yards respectively. On his chart (UKHO 702 Dc) Spence notes that he used 60800 yards in other calculations but on this occasion he obviously preferred 60810 yards. However, it has been shown that he was not comparing like distances and therefore his figure of a difference of 222 yards is of little value.

A further discussion (*op. cit.* p 506) '*...of the Distances of the Objects in the Scilly Isles, (interpreted from the Stations in the West of Cornwall) from Sennen Steeple [Sennen and St Buryan churches do not have steeples]; the Stone [not located] near Land's End; and the Longship's Light-house...*' does, fortunately, provide one sight line for comparing a measurement by Spence and the Trigonometrical Survey; that observed by Spence in 1791-2 from St Agnes lighthouse to Sennen church tower and by the Survey in 1796 in the opposite direction. Spence measured the distance as 55350 yards or 166,050 feet. The Survey in 1796 measured it as 166, 255 feet. The difference of only 205 ft (62.5m) reflects the care which Spence put into his survey. This is the only direct comparison that can be made between the two surveys and Spence would have been well satisfied.

The Trigonometrical Survey concluded that the nearest part of the Isles of Scilly, Menawthen, is about 24.7 miles / 39.5km from Land's End and the farthest, the Bishop Rock, nearly 34 miles / 54.4 km.

The Trigonometrical Survey: Mudge's Latitudes and Longitudes for the Isles of Scilly

Mudge (1800, pp 672-3; 1801, pp 134-5) uses the data obtained from his triangulation to calculate the latitude and longitude of the four stations he observed on the Isles of Scilly. The horizontal and not the chord angles were used; the distances from the meridians and their perpendiculars were computed assuming the earth's surface to be a plane '*...which, within the limits of our fixed meridians, may be considered true.*' In summary, the bearings to St Martin's Day-Mark from the St Buryan [A], Pertinney and Sennen [A] stations were combined with the distances of these stations from the position of St Agnes Beacon to give the latitudes and longitudes (west of the Greenwich meridian) of the stations listed in Table 6-3.

TABLE 6-3

(Phil Trans Roy Soc, 1800, p 673)

	Latitude	Longitude
Agnes Lighthouse	49° 53' 36".8 N	6° 19' 23".4 W
St Mary's Windmill	49° 54' 32".7 N	6° 16' 58".7 W
St Mary's Fort Flagstaff	49° 54' 59".1 N	6° 17' 57".4 W
St Martin's Day-mark	49° 58' 2".9 N	6° 14' 38".8 W

'The longitudes in the West were thus more precisely related to the Greenwich meridian than in any previously published study.' (Harley and O'Donoghue in Margary 1977, p.xiii.),

The errors in Mudge's triangulation

Unfortunately, given the time and care which he had expended on his survey, Mudge's longitudes of the Isles of Scilly, were too small.

In the course of his triangulation, Mudge had observed additional meridians west of Greenwich at about 60 miles intervals, those in the West Country being Butterton Hill (657588, 367m) and ENE of Plymouth, St Agnes Beacon (710502, 191m) on the north

coast of Cornwall, so that the longitude could be carried westward the more accurately. Mudge (1801, p 98) placed St Agnes Beacon at $50^{\circ} 18' 27''$ N and $5^{\circ} 11' 55''.7$ W and claimed that the longitude would be in excess or deficit of no more than 6". At this latitude 6" of longitude is about 120m.

Harley points out '*... partly owing to methods of computation, Mudge's longitudes lack the accuracy of subsequent Ordnance Survey values: they were all too small, an average of about 12 secs. per degree. This meant that they were less accurate in the West Country than further east.*' (op. cit, p xxxv. footnote 76).

All of Mudge's west Cornwall and Isles of Scilly longitudes have to be corrected, as have Spence's longitudes of Scilly, which were based on the Mudge's Trigonometrical Survey's longitude of the west Lizard Lighthouse.

Mudge's longitudes of the St Agnes Beacon meridian and Agnes Lighthouse differ by about $1^{\circ} 7' 27''.7$ and taking account of Harley's comments (*supra*) as an approximation, the Lighthouse's longitude should be moved westwards to c $6^{\circ} 19' 35''.4$ W, compared with Spence's (corrected) 1807 longitude of $6^{\circ} 19' 21''.8$ W. and Mudge's $6^{\circ} 19' 23''.4$ W (TABLE 6-4).

The above can be expressed another way. Mudge's Longitude for the St Agnes Beacon meridian was $1' 3''$ east of the modern position. As the Beacon was one of the Triangulation stations, all Mudge's west Cornwall longitudes have an eastward error of c $1' 3''$, an error passed on to Graeme Spence's calculations .

TABLE 6-4

Longitudes Agnes Lighthouse

Spence 1807	Mudge 1796	Mudge revised
$6^{\circ} 19' 21''.8$ W.	$6^{\circ} 19' 23''.4$ W	$6^{\circ} 19' 35''.4$

This does not imply that the lengthy analysis of Spence's triangulation and its relation to that of Mudge's Triangulation was unnecessary (Chapter Four), but rather that the history of the true longitudes of the Isles of Scilly had moved to the next stage.

The Lizard.

The longitude of the Lizard was of great importance to Spence, in fixing his longitude of the Agnes Lighthouse (Chapter Four). The Lizard was not one of Mudge's Principal Triangulation Stations, as it was not easily visible from other Stations ((Mudge and Dalby: Faden Vol 1 1799 p 362-3); Mudge and Dalby Vol 1 pp 403-5; Harley 1969 sheet 96). It was observed from three stations in the main net : Pertinney (now Bartinney Downs, 395295; 224m OD), Karnbonellis (now Carnmenellis, 695365; 252m OD) and Deadman Point (now Dodman Point, 003394; 114m OD). [10]. Ravenhill (1979) in '*The Marine Cartography of Devon...*' provides a valuable detailed study of the '*Early determinations of the latitude and longitude of Lizard Point*' Fig 2, p 17, with an enlarged insert of the Lizard

area, This shows Spence's 1792 position and OS positions for the Lizard Point in 1796 (Mudge); 1860 (Clarke) and a revision in 1885 .

The Lizard was the place nearest to Scilly whose latitude and longitude Spence believed to be correctly measured. On Spence's 1791-2 / 1807 chart (UKHO 702 Dc) there are two faintly drawn 'lighthouse / tower' profiles, both in use as lighthouses at this time. Spence's observations refer to the western lighthouse / tower, the longitude of which the Trigonometrical Survey measured in 1796 as $5^{\circ} 11' 4''.8$ and 1807 Spence adjusted his longitude of Agnes Lighthouse accordingly, unaware that Mudge's longitude of the west Lizard Lighthouse was itself in error. Mudge's survey did not, therefore, finally resolve the longitude of the Agnes Lighthouse [11].

In the present context, the longitude of Agnes Beacon was more important to Mudge's survey than that of the Lizard.

In a pocket at the end of Captain Martin White's Remarks Book (UKHO OD 537; c1817-21) there are two charts referring to Mudge's survey. (Martin White, the first Admiralty Marine Surveyor, made the first official Charts of the Channel Islands: Chapter Eight). White's observations were made on 26th June 1817 with an Adams theodolite.

The first of White's charts (UKHO 826 Oi*) is promisingly entitled '*A Portion of Colonel Mudge's angles recalculated...to lay down the various soundings round Scilly...to fix the position of the Seven Stones and the Wolf Rock...*' (CHART 6-1). Text relating to it is in UKHO OD 537 but neither chart nor text add much to this account. On the chart there are more sightlines than were observed by Mudge and presumably White observed his own triangulation (e.g. to the Seven Stones and the Wolf and within Scilly), as well as seaborne sightings to locate the numerous depths plotted on the chart. The scale is c 1:16 000.

On the chart the relevant mainland trigonometrical stations to observe Scilly are Pertinny, Sennen and St Buryan churches, the latter both marked with large symbolic crosses. He follows Mudge in calling the church towers steeples. What is not clear from the chart is whether White used the towers as stations or Mudge's 'A' stations near the churches. As this is a 'recalculation' one presumes the latter. There are numerous sight-lines linking the mainland with Scilly and within the islands but the only relevant station that can be used to compare White's recalculation with Mudge's is the position of the Agnes Lighthouse, using the latitudes and longitudes measured on White's chart.

Mudge (1796) :- $49^{\circ} 53' 36''.3$ $06^{\circ} 19' 23''.4$ W

Spence (1807; based on Mudge):- $06^{\circ} 19' 21''.8$ W

White (c1817-21):- $49^{\circ} 53' 37''$ $06^{\circ} 19' 45''$ W

White places the lighthouse's longitude c22" west of Mudge's position.

Neither the Wolf rock nor the Seven Stones were observed by Mudge,

White's position for the Wolf Rock :- $49^{\circ} 56' 45''$ $05^{\circ} 47' 37''$

Clarke's position for the Wolf Rock:- 49° 56 43.38 05° 48 27.40

(1858, p 780)

The second chart by White (Fig XII in UKHO OD 537) is concerned only with the visibility of the Agnes light from the N E. St Martin's Isle is named St Sampson!

THE PRINCIPAL OR RE-CAST TRIANGULATION

ALEXANDER ROSS CLARKE 1858

Captain (later Major General) T.F. Colby (1784-1852) replaced William Mudge as Superintendent of the Ordnance Survey and served from 1820-46. He was an outstanding officer [12]. Although he made no direct contribution to locating Scilly, the one event in his time which was relevant in the present context was the realisation that one-inch sheets 31, 32 and 33 were not up to standard and the major revision and re-engraving of the topography was carried out in the 1830s. After a difficult period in the history of the Ordnance Survey, Major Henry James RE was appointed Superintendent in 1854 and remained in charge until 1875.

Mudge's Trigonometrical Survey was sufficiently accurate for the map of England and Wales, at a scale of one inch to one mile, which the Ordnance Survey published in the early decades of the nineteenth century, but as the century progressed it became clear that the observations and calculations were not accurate enough for the compilation of maps on the larger scales that were being introduced, (25 and 6 inches to the mile). The whole triangulation was therefore revised, or re-cast, in the mid-century, and became known as the Principal Triangulation. The work was largely entrusted to Colonel Alexander Ross Clarke RE.[13], an outstanding mathematician whose many fundamental contributions to science included calculating the spheroid in 1858, 1865 and 1880. He served in the Ordnance Survey for 27 years, considerably raising its scientific profile and 'Re-casting' the Principal Triangulation (Owen and Pilbeam, 1992). Winterbottom (1939, p 48) described him as '*...England's most famous geodesist...*' The title page to Clarke's two volume account of the 're-casting' (1858) states that it was published by the 'Master-General of the Board of Ordnance' and was 'Drawn up by Captain Alexander Ross Clarke R.E. FRAS., under the Direction of Lt. Col. H.James, Superintendent of the Ordnance Survey.'

In 1881, at the age of 52, he was suddenly posted to Mauritius and immediately resigned, leaving the Survey with no one to continue his mathematical work.

The One Inch Old Series [14]

Sheet 33. Penzance/Land's End. Second Version. (nine States; Messenger 1991). Long axis N-S. Serious inaccuracies in the Sheet 33 lead to a complete re-survey in the 1830s (PRO WO 44/614; PRO T 1/4060) and alone among SW England sheets, it was

completely re-engraved. This version was first published by Col. Colby at the Tower 1st Jan 1839. (Harley and O'Donoghue, *in* Margary, 1977, p xliv) The topography and coastal details (partly based on Admiralty charts) were considerably revised. All of Mudge's five mainland trigonometrical stations for observing Scilly on the first version of the sheet can be identified almost unchanged in position on the second version, except that Carnminnis (now Trendine Hill) is named Merra Hill.

At three places on the second version of sheet 33 there appear to be small triangles, similar to those used on modern editions to represent OS trigonometrical stations. The clearest, a triangle with a dot inside, is on Merra Hill (now Trendine Hill). A second triangle lies just NE of the built up area of St Buryan on the Penzance road (411260), near the modern 124m spot height. Might it be Mudge's station St Buryan A? A third triangle is 1/2 mile SW of Sennen church, near Trevescan (354248), ^{but in fact it is a pond.} ~~The latter two could be triangular plots of land but the first is a clear triangle with dot.~~ They may be stations occupied during the 1830s revision of the sheet. Harley has compiled a set of symbols used on the Old Series one-inch (Margary vol.III, 1981 pp.xviii-xx.) but a triangulation station symbol is not included.

Sheet 32 Lizard Head. The Survey was dissatisfied with original map and there was extensive re-engraving in 1830s, especially coastal cliffs, rocks and sandbanks. Some names were added. The revised version was published c.1838 (Messenger 1991) under Colby's direction. (Harley and O'Donoghue *in* Margary 1977, pp.xiii-xliv).

The revised versions of Sheet 32 and 33 would have been invaluable to Clarke when 'Re-casting' Mudge's triangulation and particularly when making the entirely new triangulation to the Isles of Scilly.

Clarke's Instruments and observations

Clarke directed '*...the computation of what became known as the Principal Triangulation. This involved a recalculation of the whole framework from available triangulation data, without recourse to making any new observations. Some of the observations accepted dated from as early as 1792, but the majority came from the 1840s and early 1850s.*' (Owen and Pilbeam 1992, p 55).

When tested by the later [Clarke] triangulation the old work [Mudge et al] stands well as regards the bases, but not so well with respect to the observed angles... Mudge expected an error of 1:6000 but it proved to be 1:10,000, sufficient for the one-inch map... In fact, the old angles at only six stations were used by Clarke in his reduction of 1858. (Close 1926, p 22 and p 54). Clarke was not an active participant in the field work. The Introduction to Clarke's two volumes (1858) refers to '*...the observations and calculations of the principal triangulation...*' and with reference to the Isles of Scilly notes '*Observation with the large instrument.*' Clarke does not make any specific reference in his text to the Isles of Scilly and so we do not have his views on the problems of linking them to the

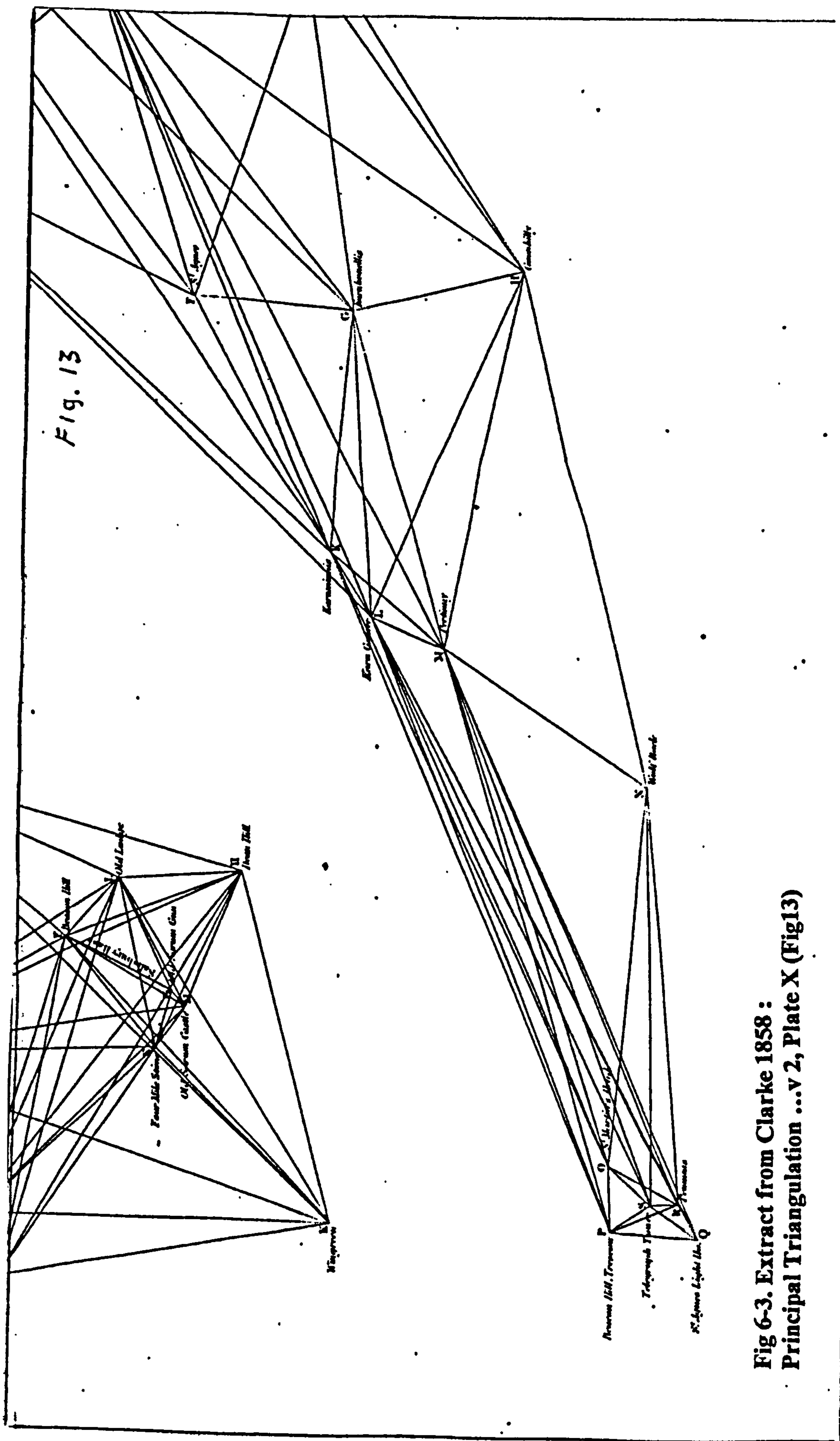
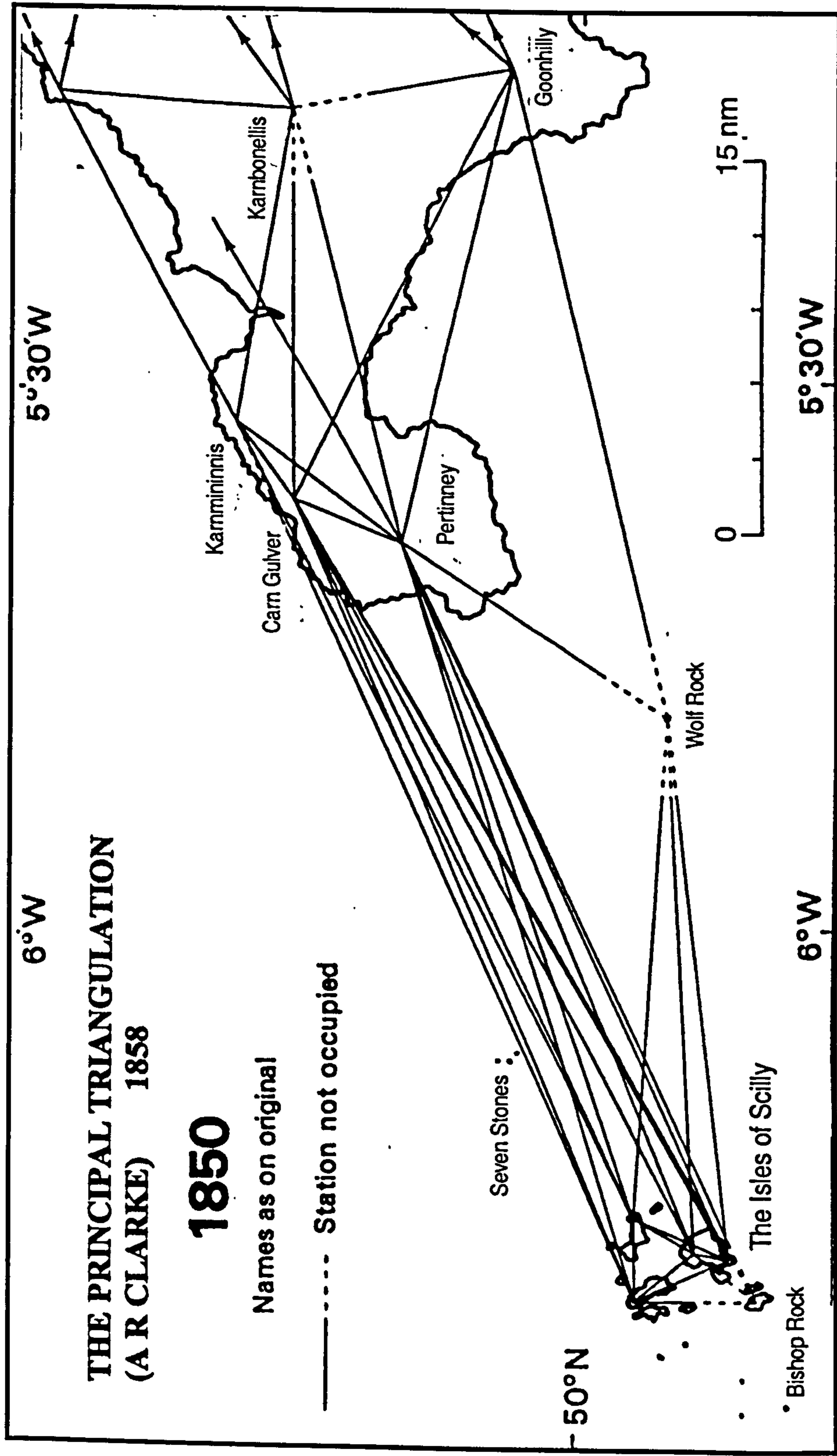


Fig 6-3. Extract from Clarke 1858 :
Principal Triangulation ...v 2, Plate X (Fig13)



**Fig 6-4. Based on Clarke 1858 :
 Principal Triangulation ...v 2, Plate X (Fig13)**

mainland, but a glance at his map (Figs 6-3 and 6-4) shows that he had the same problems as Spence and Mudge of acute angled triangles and very short base-lines.

The Isles of Scilly were an important exception to the general rule that Clarke's triangulation was solely a re-calculation of Mudge's survey. The Islands were not only re-observed from the mainland as part of the primary triangulation but reverse observations were also made to the mainland. Clarke made far more inter-island observations than either Spence or Mudge. Two different theodolites were used. At the mainland stations of Karnminnis and Pertinney the 3ft instrument owned by the Board of Ordnance was ~~for~~ ^{USED} for sights to the Islands, but at Carn Galver the more portable 18" instrument was used. The latter was also used for sights from the Islands to the mainland and between the Islands, again because it was more portable. Thus a much more complete triangulation of the archipelago was made than either Spence or Mudge had found possible.

Clarke's station descriptions are usually much more precise than those of Mudge and earlier observers. Mudge appears to have made the observations to Scilly himself. Clarke delegated the work to NCOs (usually named), the more senior ones on the 3ft theodolite. He records precisely ^{by} the dates of the observations, unlike Spence and Mudge.

This triangulation was undoubtedly the foundation of the first 25" and 6" mapping of the Islands by the Ordnance Survey in the 1887-88 (Spence had compiled an unpublished 6" chart in 1791-2).

Clarke's Mainland Principal Point stations (Figs 6-3 and 6-4)

The mainland stations from which the Islands were observed were reduced in number compared with Mudge's survey and only Karnminnis and Pertinney were re-occupied (Mudge had earlier concluded that a smaller number of stations would suffice).

Clarke describes the stations with the year of observation:-

Karnminnis (1845), 3 miles SW of St Ives, on bare rock SW side of old cairn.

Pertinney (1845) 2.5 miles SSE of St Just. In old fort ruins.

A new station, not fully described, was established at Carn Galver (so named on the 1813 one-inch; Karn Galva on 1839 one-inch; Carn Galver on modern map 425365; c.229m), to the east of Watch Hill, which once again was not used.

Neither the Lizard Point nor the Lizard Lighthouses were a station. Mudge had earlier noted their limited visibility. A new Principal Point station was established in the north of Goonhilly Downs, a large area of uncultivated moorland c 6 miles SE of Helston. It was visible to and from 5 stations and observations were made between 1845 and 1850. The partially re-engraved (1838) Truro one-inch sheet 31 has a triangulation point symbol close to Dry Tree (which is on the earliest states of sheet 31), the height being 366ft. It must have been added to the plate no earlier than the above dates, possibly Messenger's state 16, (c1852-1859) when latitudes and longitudes were added to the sheet margins. On the OS 1:50,000 sheet it is named 'Dry Tree *Standing Stone*', with a trigonometrical point 112m OD. (725201). The site is just south of the Satellite Earth Station compound and on

the OS 1:25000 sheet 103 only 'Standing Stone' is named. The triangulation pillar is right on the compound boundary fence, the height 113m. Its visibility is now much reduced.

Clarke's Isles of Scilly Principal Point stations

Some of Spence's and Mudge's Isles of Scilly were not exactly re-occupied. Thus St Martin's Head was preferred to the summit of the Day-Mark. The new station at ground level was 50.6ft (15.4 m) from the old. There were two stations on St Mary's; Peninnis Windmill station (910097) at centre, top of the mill (now destroyed) and the Telegraph Tower,[15] now the coast guard station (912121); 12.8m high and standing on the highest part of the Island at 49m OD): the trigonometrical station (1850) was the centre of the tower's top.

Tresco was used by the Ordnance Survey for the first time (1850). The station was on Beacon Hill (887157; 44m OD), the highest part of the island, 1.5 miles from Old Grimsby and 60ft (18.3m) from the old Watchhouse and c. 650m SSW of the presumed position of Spence's station M. The hill is named on Admiralty chart 34 (1972) but not on the modern Ordnance Survey 1:25 000 map.

The position of Agnes lighthouse was fixed by sights from other stations, the exact station sited being 219ft (66.7m) NE of the lighthouse, on a small common used as a playground and marked by a stone sunk 0.6m below the surface. The theodolite presumably could not be placed on the lighthouse itself.

The only unchanged mainland stations were therefore Karnminnis and Pertinney and on Scilly not one of Mudge's stations was re-used.

The Wolf Rock, which had been part of Spence's survey, was now incorporated into the Ordnance Survey for the first time. As with Spence, it was not an occupied station, but was observed from five Principal Points.

Observations to Scilly from mainland stations (Fig 6-4)

KARNMINNIS

3ft theodolite (Board of Ordnance); 27/8-7 1845; (Col Sgt Donelan RSM, RE)

(*inter alia*) Pertinney; Cam Galver; St Martin's-Day Mark.

PERTINNEY

3ft theodolite (B of Ord); 31/10-30/11 1845; (Col Sgt Donelan RSM, RE)

(*inter alia*) Wolf Rock; St Agnes Lighthouse; Peninnis Windmill; Telegraph Tower, St Mary's; St Martin's Day-Mark; Beacon Hill, Tresco; Centre of Tor on West Scilly (not identified).

KARN GALVER

18" theodolite; 24/8-12/10 1850; (2nd Corp Wotherspoon RSM, RE)

(*inter alia*) Pertinney; St Agnes Lighthouse; Peninnis; Telegraph Tower, St Mary's; St Martin's Head; Beacon Hill, Tresco.

Observations within Scilly and from Scilly to mainland (Fig 6-2)

BEACON HILL, TESCO

18" theodolite; 24/8-12/10 1850; (2nd Corp Wotherspoon RSM, RE)

St Agnes Lighthouse; St Martin's Head; Telegraph Tower (St Mary's); Peninnis Wind Mill; Kamminnis; Kan Galver; Pertinney.

TELEGRAPH TOWER, ST. MARY'S

18" theodolite; 24/5-19/6 1850; (2nd Corp Wotherspoon RSM,RE)
 Peninis Windmill; St Agnes Lighthouse; Beacon Hill Tresco; St Martin's Head;
 Kam Galver; Pertinney; Wolf Rock.

PENINNIS WINDMILL (top)

18" theodolite; 29/4-21/5 1850; (2nd Corp Wotherspoon RSM,RE)
 St Agnes Lighthouse; Beacon Hill Tresco; St Martin's Day-Mark;
 St Mary's Telegraph Tower; Kam Galver; Pertinney; Wolf Rock.

ST MARTIN'S HEAD

18" theodolite; 29/6-13/7 1850; (2nd Corp Wotherspoon RSM,RE)
 Peninnis Windmill; Telegraph Tower (St Mary's; Beacon Hill Tresco;
 Kamminns; Pertinney; Kam Galver.

WOLF ROCK

St Agnes lighthouse Not used as observing station, 1850.
 Wolf Rock " "

The Goonhilly Principal Point was used only once in the calculations, to determine the position of the Wolf Rock from the mainland:- Pertinney- Goonhilly- Wolf Rock

Because of the different stations used by Clarke, no comparisons can be made with the length of the sides of Spence's or Mudge's triangles. The only comparisons are therefore between the various calculated or (for Scilly) measured latitudes and longitudes. The position of the Agnes and St Martin's Head stations were used in 1850 to compute the latitude and longitude (Clarke 1858).

The Lizard

The positions of the Lizard Point and the two lighthouses east of it have already been discussed at length. Clarke (1858, p 780) gives the position of the two Lizard lighthouses, (presumably by 're-casting' Mudge's data) '*... and apparently did not merit a special extension, as was the case in Mudge's triangulation*'.

Table 6-5

The longitude of the Lizard: Clarke (1858, p 780)

Lizard East LH	49° 57' 34".5 N	05° 12' 4".0 W
Lizard West LH	49° 57' 34".1 N	05° 12' 7".3 W

The longitude of the Lizard: Mudge (1800, p 671)

Lizard, West LH	49°57'44"	5°11'4".8	(20 ^m 44.3 ^s)
Lizard Point	49°57'40".6	5°11'46"	

(according to a plan by Mudge the Point lay 2700 ft west of the lighthouse).

Clarke's calculations placed the Lizard West Lighthouse 1' 2".5 of arc west of Mudge's position *i.e.* 0.67nm. Once again Mudge's longitudes were shown to be too small. Had Graeme Spence known of this error, his longitude of Agnes lighthouse would have been westward of his 1807 longitude (06° 19' 21".8).

Agnes Lighthouse

Clarke lists many more latitudes and longitudes of stations on the Isles of Scilly and the adjacent mainland than either Spence or Mudge.. Such was the detail of his surveys and calculations that he provides three different tables of positions for the whole country. Only the locations of the position of the Isles of Scilly, as represented by the Agnes Lighthouse, are listed below.

i). Geodetical Results (Clarke 1858, Section xii, p 677) *i.e.* the position of places based on astronomical observations computed from the Dunnose meridian.

(Longitude distances are based on 1' longitude at 50° N = 38.69nm)

Clarke	Mudge	Difference
49° 53' 30".776 N	49° 53' 36".8 N	Clarke 06".024 [0.1nm] S of Mudge
06° 20' 40".633 W	06° 19' 23".4 W	Clarke 01' 17".233 [0.8nm] W of Mudge

(Other stations are listed on p 677)

ii). Principal Points. Clarke (1858, Section xiii, p 723) published the latitudes and longitudes of all the Principal Points of his triangulation, including five in the Isles of Scilly, one more than Mudge.

Clarke	Mudge	Difference
49° 53' 32".93 N	49° 53' 36".8 N	Clarke 03".87 [0.06nm] S of Mudge
06° 20' 38".14 W	06° 19' 23".4 W	Clarke 01' 14".74 [0.8nm] W of Mudge

The Principal Points were critical to the Principal Triangulation. These positions were based upon the ground survey. Agnes Lighthouse was a strange choice as a Principal Point as it was not an occupied station.

(Many other stations are listed on p 723)

iii). Position of various Lighthouses. Clarke (1858, p 780).

Clarke	Mudge	Difference
49° 53' 30".8 N	49° 53' 36".8 N	Clarke 06" [0.1nm] S of Mudge
06° 20' 40".6 W	06° 19' 23".4 W	Clarke 01' 17".2 [0.7nm] W of Mudge

Clarke does not record how the lighthouse positions were measured.

In all three tables Clarke's latitudes are south of, and his longitudes west of, Mudge's. The very small differences show that Mudge's triangulation compares favourably with Clarke's.

(Many other stations are listed on p 780)

iv). Admiralty Chart 34. 1866. (for comparison).

49° 53' 32".9 N. 6° 20' 38".1 W

(printed on chart, source not given)

As was noted above, although the Isles of Scilly were part of Mudge's triangulation, no One Inch map of them was published. Consequently, Clarke's triangulation became the basis of the first Ordnance Survey maps of the islands.

THE ISLES OF SCILLY

Ordnance Survey of England, One Inch (Third Edition)

The Isles of Scilly archipelago was first surveyed at the 1:2500 scale in 1887-1880 and was published at the 1:10 560 scale in 1889-1891. The main islands were published at 1:2500 in 1889-1890. These large scale maps were presumably based on Clarke's triangulation and the basis of the first One Inch map of the Islands.

The sheet lines of the One Inch Ordnance Survey of England (Third Edition) bisected the Isles of Scilly, with the north part on sheet 357 and the south on sheet 360. They were published as a combined sheet of standard size, eliminating unnecessary sea areas. The junction of the two sheets is plotted. This Edition is described by Hellyer (1999, pp19-21).

An example of the combined sheet notes 'Surveyed 1887-8'[i.e. the 1:2500 and 1:10 560 surveys] and 'Revised in 1905, Published 1907'. The latitudes and longitudes are along the margins of the sheet in degrees, minutes and 10 seconds. The Agnes Lighthouse is shown by a lighthouse symbol, not easily located because of surrounding detail. Its position according to the marginal numbers is:-

LATITUDE 49° 54' 00" N LONGITUDE 06° 20' 25" W

On Clark's 'lighthouse' table the position of Angnes LH was (*supra*) :

LATITUDE 49° 53' 30".8 N LONGITUDE 06° 20' 40".6 W

These differences are not large but even so place the latitude of the Lighthouse about 0.6 of a statute mile north of Clarke's and the longitude about 0.2 of a statute mile east of Clarke's.

Admiralty Chart 34 (1866) LATITUDE 49° 53' 32".9 N. LONGITUDE 06° 20' 38".1 W differs little from Clarke. The origin of the latitudes / longitudes on the One Inch map has not been resolved.

THE RETRIANGULATION 1935 - 1962

By 1935 [16] it was apparent that Clarke's revised triangulation was itself inadequate for modern map-making. For one thing it was not suitable for a uniform coverage of Britain at the larger Ordnance Survey scales of 1:2500 and 1:10560. These had been published up to this time by counties or in county groups, each with its own central meridian. That for Cornwall passed through Hensbarrow, on St Austell Moor and that for Devon through Rippon Tor, on Dartmoor. By the 1930's the discrepancies at the junctions of these separate surveys were unacceptable and so a third triangulation of the whole country was commenced in 1935 and was named 'The Retriangulation'.

The Second World War seriously delayed the work but the Primary Triangulation of England and Wales was essentially completed between 1935 and 1939 and the rest of Britain from 1949 to 1952. The observations for southwest England, including Cornwall, were made in 1937 but were not carried on to the Isles of Scilly, which were excluded from the Primary Triangulation for the first time and were added later only as a Secondary connection. The writer is grateful to the Ordnance Survey for supplying details of the Scilly connection to the ~~mainland~~. *mainland*

The Secondary Triangulation began in 1938 and was completed in 1962, interrupted by the war. The observations linking the Isles of Scilly to the mainland were begun in mid-1959, with full co-operation from Trinity House for use of Wolf Rock Lighthouse as an observing station (17th July 1959).

Observations linking the Isles of Scilly with the mainland were made in 1960 (between 15th and 20th July). A novel feature was that the Wolf Rock lighthouse was an integral part of the mainland connection. The traditional method of triangulation by angular measurement using a theodolite was augmented by measuring distances between selected triangulation points with a Tellurometer, measuring the transit time outward and return of radio micro waves (plotted on Fig 6-5)

Mainland stations

The Retriangulation to Scilly and the Wolf Rock used four stations on the Land's End peninsula (Fig 6-5). These were:-

Carn Glouce SW 63/14 (354313; 94m OD), on the cliffs due west of St Just;

Bartinney PP 180 (395295; 224m OD), formerly Pertinney, was used by Mudge and Clarke and was the only Principal Point station (P P 180) of the Retriangulation that was part of the connection to the Scilly Isles. This station was the linch-pin of the whole survey, being used to sight the Islands' stations, the Wolf Rock and other mainland stations. Trendine Hill (PP 17, 480388, 247m OD), formerly Karnminnis, was also used by Mudge and Clarke but on this occasion was not used for direct observations to the Islands but as a link with the rest of the mainland triangulation net via Tregonning Hill PP 181 (600300; 194m OD) and Carnmenellis PP 177 (696365; 252m OD);

Cudden Point Sw 63/16 (552278, 60m.O.D.) 4.3km. SE of Marazion

Predannack Head SW 63/18 (662165; 80m O D) 3.5km SSW of Mullion.

Sennen Church Tower (356255) was only observed from Carn Glouce; unfortunately it was not used to observe Scilly and therefore comparison with Spence's measurement is not possible.

The Lizard was not observed on this occasion; its position has to be obtained from another secondary net[17].

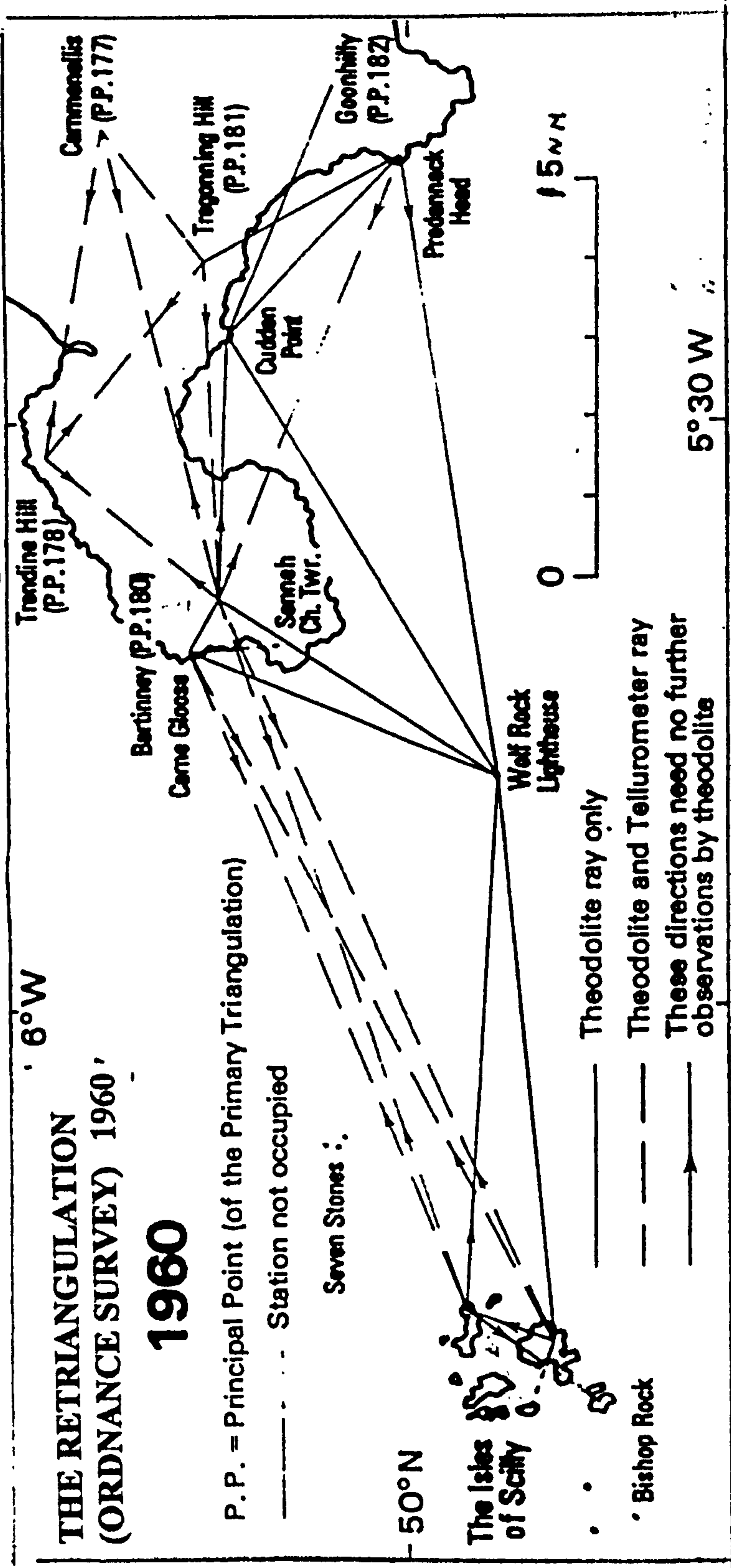


Fig 6-5. Extract
 reproduced from Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office, © Crown Copyright NC/02/40390.

Based on Block SV/91. OBS. DIAG.
 with the permission of the Controller of Her Majesty's Stationery Office, © Crown Copyright NC/02/40390.

ST. MARTIN'S HEAD SV/91/1

ST. AGNES Lighthouse SV/91/1

ST. AGNES Lighthouse SV/91/3

WARD HILL (ST. MARY'S) SV/91/3

Isles of Scilly stations

There were four secondary stations on the Isles of Scilly. Two were full observing stations used to link with the mainland, the Wolf Rock and other Islands viz.:-

St Martin's Head SV 91/3 (47m), presumably not the Beacon, which had been used by Clarke (Mudge used the Day-Mark). With Samson Island SV 91/10 to be observed to provide a third station of the Isles of Scilly triangle.

Ward Hill St Mary's SV 91/3 (922102), close to Salakee Down and the airport.

Samson Island (South Hill, 878123; 42m OD) was another new station.

Agnes Lighthouse was simply observed from St Martin's Head, the lighthouse clearly having lost much of its former status as a survey point.

Wolf Rock lighthouse. The Wolf Rock lighthouse was an observing station for the first time and was linked with Carn Goose, Bartinney, Cudden Point and Predannack on the mainland and St Martin's Head and Ward Hill on Scilly. Trinity House gave full co-operation to the Ordnance Survey for both the reconnaissance (17 July 1959) and the main survey in 1960, when two surveyors were on the lighthouse for ten days.

By making the Wolf Rock an integral part of the triangulation, the need to rely upon extremely short mainland bases, which had caused Spence, Mudge and Clarke so many problems had been eliminated. Stronger triangles were established than had ever before been possible and the best possible results could be obtained.

THE TRIANGULATION (Fig 6-5)

Reciprocal Tellurometer measurements were taken from St. Martin's Head and Ward Hill to Carn Goose and Bartinney. As the map (Fig 6-5) shows there were in all four fully observed triangles with measured bases between the islands and the mainland. At the same time Primary and Secondary triangles were re-observed as far east as Carnmenellis (south of Redruth).

In all there were 4 fully observed triangles with measured bases. These were two reciprocally measured triangles (by both theodolite and tellurometer) from the Carn Goose-Bartinney base to St Martin's Head and Ward Hill respectively and two similarly measured triangles from the St Martin's Head-Ward Hill base to Carn Goose and Bartinney respectively. Samson Island (South Hill.) was sighted from St Martin's Head and Ward Hill to provide a third apex of the Isles of Scilly triangle.

This triangulation is the basis of the current Ordnance Survey maps of the Scilly Isles.

Unfortunately it has not been possible to obtain from the Ordnance Survey the positions of any of the stations on Scilly plotted on Fig 6-5). Apparently the position of triangulation stations is no longer recorded in any documentation. A single measurement (by tellurometer) was made to Agnes Lighthouse from St Martin's Head, the lighthouse clearly having lost much of its former status as a survey point and appears not to have been separately recorded (OS pers comm 08 January 2002).[18]. The position as measured

on the 1:25 000 map [19] is given below, compared with earlier OS positions [20] and with the current Admiralty position [21]

TABLE 6-6 (Agnes Lighthouse)

Mudge 1797	49° 53' 36".8 N	06° 19' 23".4 W
Clarke 1858 [19]	49° 53' 30".8 N	06° 20' 40".6 W
(OS) 1: 25 000 1996	49° 53' 15" N	06° 21' 13" W
Channel Pilot (1999) [20]	49° 53'.5 N (49° 53' 30" N)	06° 20'.7 W (06° 20' 42" N)

The Ordnance Survey continues to be helpful and a recent communication refers ^{to} further investigation which has discovered a disused lighthouse at 49° 53' N and 06° 21' W. This must be the Agnes Lighthouse and possibly its only surviving reference in the OS archives.

END NOTES

[1] Two years before Graeme Spence independently began his survey of the Isles of Scilly.

[2] Clifton, 1995. p 227, 302.

[3] Special mention should be made of the late J.B. Harley '*... who, though he did not invent the study of the Ordnance Survey, nonetheless was largely responsible for nurturing it into its present healthy state.*' (Oliver 1993). It would be inappropriate here to attempt to present a history of the Ordnance Survey; in the following pages use has been made of *inter alia*: Hodson (1991a and 1991b); Margary (1975, 1981); Oliver (1993); Owen and Pilbeam (1992); Seymour (1980); Winterbottom (1939). Specific comments on the Isles of Scilly and the Ordnance Survey are in addition found in *inter alia*: Close (1969); Harley (1969; text for sheets 95 and 96); Margary (1977; text by Harley and O'Donoghue); Messenger (1991).

[4] In the present context there could be confusion over the term 'Principal Triangulation.' It usually means the Primary Triangulation upon which Secondary and Tertiary Triangulations are based. Both Mudge and Clarke refer to their triangulations as the 'Principal Triangulation' and in the context of their surveys this is correct, but in this chronological account, the first Principal Triangulation (with its stations) is referred to as 'Mudge's Triangulation' and the second, Clarke's, as the 'Principal Triangulation' (with its stations).

[5] Edward Williams c.1743-1798

Major Edward Williams and Lieutenant William Mudge, both of the Royal Artillery, (not of the Royal Engineers, who later became so dominant in the Ordnance Survey) were regarded as the best mathematicians of the Artillery and Engineer Officers. Williams' superior military rank ensured his appointment as the first official Superintendent (or Director) of the Survey in June 1791. Little is known of Major Williams R.A.. In 1791 he re-measured Roy's Hounslow base and he is recorded as inspecting the equipment for the 1792 field season. Williams was a nominal Director who took little or no part in the Survey, the driving force being William Mudge.

William Mudge 1762-1820

Captain William Mudge RA was the second Superintendent or Director of the Trigonometrical Survey, from 1798 to his death in 1820. He was the *de facto* leader from its inception in 1791. Born in Plymouth in 1762 and a worthy scion of a distinguished west country scientific family. He was elected FRS in 1798 and, while Director of the Survey he continued to superintend the field surveys. He was succeeded by Colby, who was Director from 1820 to 1847. (Clifton 1995, p195).

Isaac Dalby 1744-1824

Isaac Dalby a civilian, was the first appointee by the Duke of Richmond to the new Trigonometrical Survey, on 22nd June 1791, the day after the presumed establishment of the Survey and about a month before Williams and Mudge joined it. He had impeccable credentials. His experience strengthened the mathematical side of the existing staff in the Board of Ordnance fortifications drawing office. Close regarded Dalby as one of the two most important mathematical specialists attached to the Survey.

[6] There is extant a letter (THGCM 1st February 1798, v 15) from Capt. Wm. Mudge of the Royal Artillery Corps indicating that 4 copies of the Trigonometrical Survey were being made for the Government and the Master of Ordnance [Marquis Cornwallis] instructed that one be sent to Trinity House. The date is interesting, as Spence was reporting on his own survey to Trinity House at this time but the two surveys seem to have been kept in isolation.

The relationship between the Trigonometrical Survey and Trinity House is revealed in the following:-

A letter (THGCM 2nd April 1844) from the TH Agent of Cromer Lighthouse saying that an 'assistant' of the OS had asked for use of the lighthouse, being an object marked on his instructions from which to take observations. He wished to fix a theodolite on the centre of the lantern. This required the removal of vane and ball to erect a platform. There seems to have been some tacit approval from Court re letters of 28th & 30th May, provided that the vane & ball were replaced each night to ensure ventilation of lantern. The Court told the Agent that he had no authority to let the Ordnance Survey make use of the Lighthouse. The Ordnance Survey must have Board's express permission from the Principal Officer in charge of Survey, who should apply to Court directly or through Board of Ordnance.

[7] .The Survey returned to Kent after completing the extreme south west of England (Mudge:Faden 1, p 409).

[8]. "St. Buryan is a noble and lofty granite church within a prominent oval enclosure.." (Thomas 1986, p.204.)

[9] The geologist Sir H T De La Beche was initially part of the survey of the 1" Old Series, adding the geological data to the sheets, and many of his papers are deposited in the Dept.of Geology, National Museum of Wales in Cardiff. A letter of 23rd June 1837 reports that the Geological survey of Cornwall was nearly completed, but in a letter of 8th July 1837 to Col Colby he refers to '... the very defective state of some of the old portions of the Cornish map ...' and that '...the necessary geographical corrections have not yet been completed...' [accession number NMW 84.20G.D379].

[10] The keepers at the present (east) Lizard Lighthouse maintain that it is impossible to see Dodman Point (003394) from the Lizard. It is true that the ground NW of Black Head (778162) rises to c72m and is in the line of sight but the ground at Dodman Point rises quickly to 114m and it may be assumed the Mudge's theodolite was on a tower (Harley and O'Donoghue in Margary 1975, p xii).

[11] The Survey, under Mudge's direction, made no attempt to map the Isles of Scilly topographically. The reasons are not known; it may have been cost and/or the need to use limited resources press to on with the mainland survey or that the Islands were military sensitive Spence had made an excellent uncirculated six inch chart of the Islands and the military may have been privy to it. In 1810 the Admiralty had published Spence's excellent chart of Scilly at a scale of c.1:25,000, which contained much inland detail. The existence of these charts may have discouraged the Ordnance Survey from embarking on an expensive survey of its own, regarding Scilly as the province of Admiralty surveyors.

The Survey's geologist, de la Beche, who added geological details to the 1" maps, published an index map of the 1" of west Cornwall which included the sheet lines for the two sheets that included Scilly (357 and 360).

[12] Captain, later Major General, T F Colby was Superintendent of the Ordnance Survey 1820-47. Winterbottom (1939 p 70) described him as '...the greatest Director General the Ordnance has known...' (Pilbeam 1992 p 25; Hodson 1991, p 38). Colby was succeeded as Superintendent in 1847 by Lt. Col. L.A.Hall, R.E., who had no experience of survey work. A serious clash of personalities developed between Hall and Captain W. Yolland, who had expected to succeed Colby (Owen and Pilbeam 1992, p. 45-6) and Hall sent Yolland to the Irish survey. This left the Survey without anyone at HQ who understood the trigonometrical or astronomical work for several years.

[13] Major W. Reid (Irish survey in 1825-28) later did the Survey "a very good turn" (Close 1969) in 1850 by recommending Hall to employ Lt. A.R.Clarke. This appointment was much to Hall's credit and maintained the scientific tradition of the Survey until 1881 (Close 1968). ~~Hall was succeeded~~
ae

[14] The telegraph tower is marked and named on Admiralty chart 34 (1972 ed.) but only as 'Coast Guard Sta.' on the OS 1:25,000 map of Scilly (1982). The telegraph station was one of the Admiralty Coast signals and had a short life (Wilson 1976, pp.64-6.). 'In 1814 a new station was erected [at a cost of £1,025] on Newford Down (Scilly) and worked by semaphore [sic] from the start.' In 1816 was deemed not to be fulfilling its purpose. The officer "...was often drunk, even if he did not connive at smuggling as has been alleged..." The station was shut but 'Telegraph' remains a place name on St. Mary's. On 30 may 1815 the Admiralty ordered all stations between the North Foreland and Land's End to be re-established but Scilly was not included.

At night these lights can be seen from Telegraph: Seven Stones, Longships and Pendeen, Wolf Rock and the Lizard.

[15]. The mainland primary and secondary trigs.[sic], as far east as Carnmenellis - PP177 were again fully tested with full observations taken in the area.

[16] Based in part upon unpublished information supplied by the Ordnance Survey, and used with the permission of the Director General. (OS pers. comm. 10 2 1982).

[17]. "Military survey fixed the ground station Mount Todden on St. Mary's (928115; 36m O.D.) by satellite doppler methods in 1976."

[18]The only positions the writer was given are :-

Bishops Rock 49° 52' N 6° 27'W

Woolpack Point 49° 54' 59mils N 6° 19' 5mils

Crow Point 49° 56' N 6° 18' W

[19]. As measured on the 1:25 000 OS Explorer sheet 20 (Isles of Scilly) Edition A, Revised 1996.

[20]. Clarke/858, p 780) " Position of various Lighthouses. "

[21]. UKHO Channel Pilot (1999, p 63)

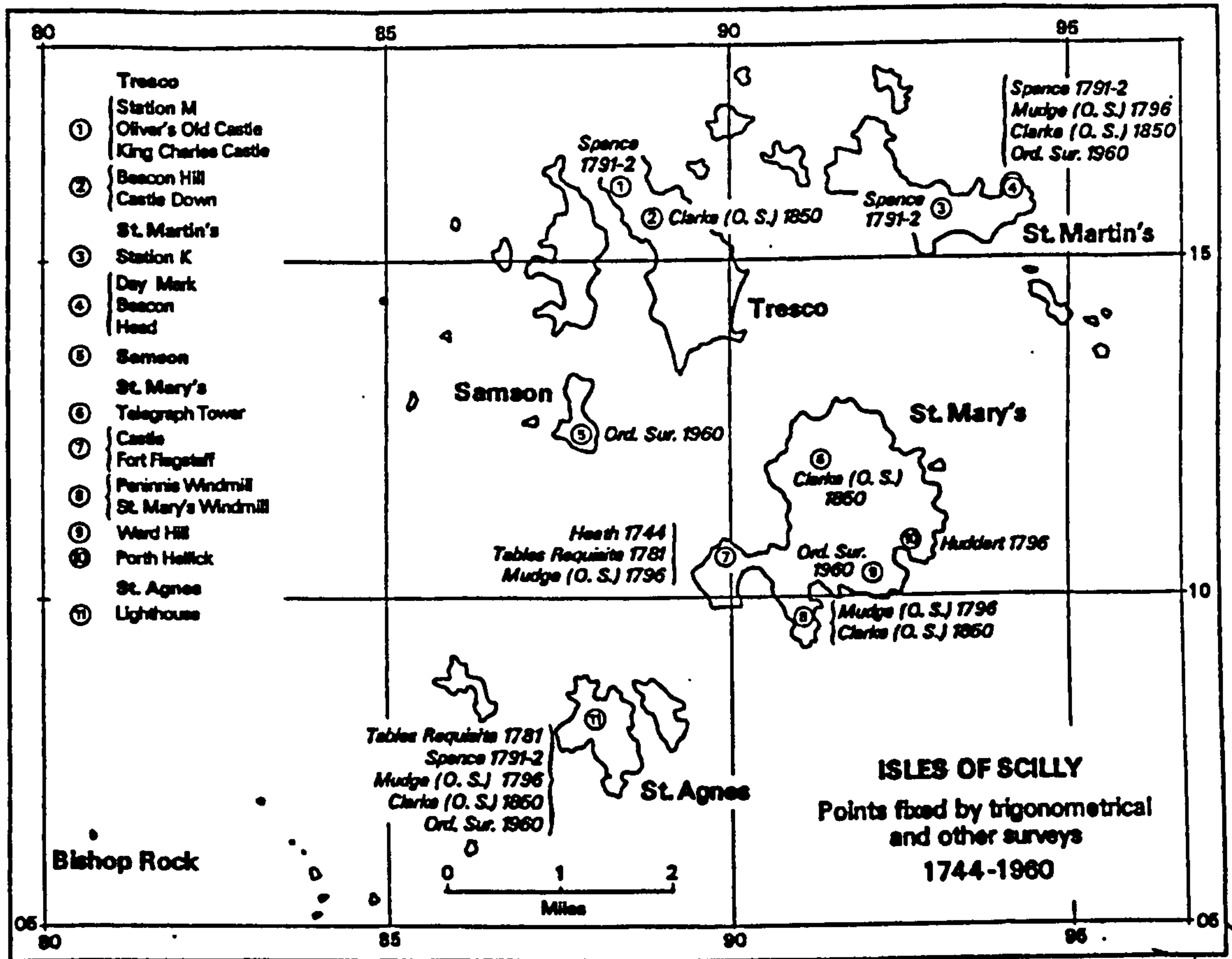


Fig 6-6. Isles of Scilly triangulation stations .

This map plots the triangulation stations used by 'bench mark' surveyors from Robert Heath (1744/50) to the Ordnance Survey (1960). For simplicity, the inter-island stations are not separated from the island – mainland stations. These, of course, were located and described in the preceding Chapters.

PART TWO

THE CHANNEL ISLANDS

CHAPTER SEVEN

An Anglo - Gallic Prelude

Within the parameters set for this study, the identification of an initial 'bench-mark' trigonometrical survey linking the Channel Islands with mainland of France presents far more problems than in the case of links between the Isles of Scilly and mainland Britain. There are many more charts/maps of the Channel Islands and nearby France but it is surprising to discover that the pioneering official British hydrographic surveys were not made until the early 19th century. These surveys were by Capt (later Admiral) Martin White and in their scope, inventiveness and ultimately in the published charts they are Part Two of this thesis. To ignore totally the surveys that preceded and followed White's would, however, fail to place his surveys in the context of his time.

Chapter Seven reviews a small selection of pre-White surveys.

Chapter Eight (with Appendix G listing triangulation stations) is devoted to White's surveys of the Channel Islands and the adjacent French coast.

Chapter Nine outlines post-White surveys and publications.

Britain and France had contrasting navigational and strategic attitudes to this area. Both ^{the} British and French national hydrographic departments and military map-makers were involved, whose surveys progressed at very different speeds and were uncoordinated until the early decades of the 19th century; ~~thirdly,~~ ^{finally,} The two countries were at often at war until 1815.

To the British, the Islands were a navigational hazard on the southern flank of the English Channel shipping lanes but in spite of their proximity to the potential enemy, France (*c.f.* the brief invasion of Jersey, January 1781) they attracted little official British cartographic attention. To the French, however, these foreign islands, rocks and reefs presented a major navigational hazard to their ships trading with ports stretching along their coast from Cherbourg to St Malo and westwards. In addition they offered sanctuary to British privateers attacking French shipping. It was clearly in France's own interest to seek accurate charts [1].

The carto-bibliography of the Channel Islands has yet to be compiled but Warren (1962) has published an invaluable introduction in his 'Evolution of the Map of Guernsey' (1961). In addition to this, the following is based on *inter alia* Warren (1962); 'Précis of Survey History:

Jersey' (PRO OS1/125); Berthou (1898); Cartes des Côtes de Bretagne du XV^e à nos Jours (Anon 1982); Pellitie (1990); Service Historique de la Marine a Cherbourg; Jamieson 1986; Board 1996. The French surveys have a long pedigree; French cartographers on several occasions came close to making the all important triangulation link to the off-shore islands. Jamieson (1986 pp422-23) notes that '*Only in the 18th century did more and better charts appear*'.

NOUVELLE CARTE de FRANCE CORRIGÉE...1682

France was one of the principal founders of modern scientific cartography and it was in France that '*...exact scientific mapping from ground observation...*' began (Tooley 1949).

The French statesman Colbert (1619-83) [2] recognised the need for exact maps and charts of the French Kingdom. In 1666 he founded l'Academie Royal des Sciences one ~~product~~ product of the astronomical observations was Picard and La Hire's '*Nouvelle Carte de France, corrigée par ordre du Roi sur les observations de Mrs. de l'Academie des Science*', at a scale of 1:4,120,000, presented to the Academy in 1682 and published in 1693. The old and corrected coastlines of France were combined and reproduced by Sanson to show how the coastal outline of France had been changed.

The detailed astronomical observations for the north coasts of France were made in 1681 (Picard et La Hire, 1693, pp.65-76). Picard [3] led the observations in the west, including St Malo, Mt St Michel and Caen. Latitude was determined by measuring the altitude of the pole star and longitude (from Paris) by using the method and tables developed by Cassini [4]. The northern coasts of France were therefore surveyed over a century before the English Grand Trigonometrical Survey reached western Cornwall in 1796, from which the Isles of Scilly were observed. The new survey placed the western coasts of France c1.5° east in longitude relative to *further* the Paris meridian. The Cotentin peninsula was replotted to the south and east of its former position but no attempt was made on Sanson's map to adjust the location of the Channel Islands. Consequently the Islands are wrongly shown as lying west of the northernmost part of the Cotentin peninsula (Fig 7-1:Sanson).

The apparent French lack of interest in this strategic archipelagos *the more surprising as in* 15 November 1681 Picard and La Hire ~~and~~ were concluding their observations in the Calais district, ending their report ~~is~~ ^{IN} a short section entitled '*Largeur du Pas de Calais*' [5]. It states that, as the large surveying instruments had been carried all the way to Calais, the surveyors wanted to use the opportunity to determine the distance between the port and Dover Castle. They adapted their astronomical quadrants to make horizontal angular measurements and the observations were made on November 20th 1681. The distance was calculated as 41.63 km. This was the first triangulation across the Strait. The same technique could have been used to observe the Channel Islands but there is no published record of a French triangulation to the Channel Islands at this time.

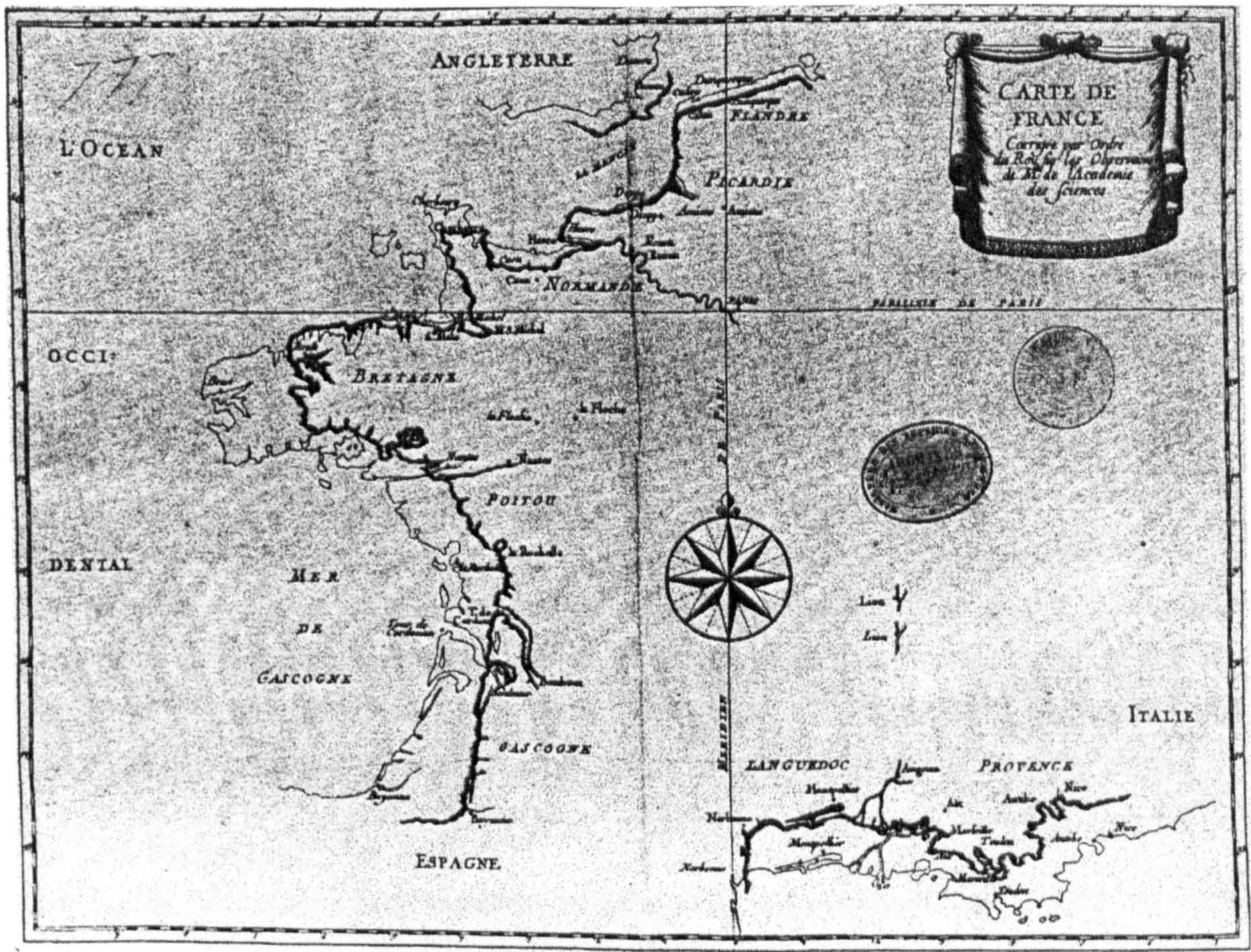


Fig 7-1. Based on 'Cartes Des Côtes de Bretagne ...'. Musée de Brest 1982.

LES INGÉNIEURS DU ROY and LE NEPTUNE FRANCAIS 1693

Another of Colbert's innovations was the initiation of a series of coastal surveys by a small group known as 'Les Ingénieurs du Roy' or 'Ingénieurs géographes' to provide 'Cartes de la Côtes' of the French coast for inclusion in **Le Neptune Français** 1693. Compiled by the distinguished hydrographer Bellin it was a *'seminal work in the development of French sea atlases'*, published in Paris in 1693 for 'Les Armées de Mer'. The charts were based on the official surveys of the Ingénieurs and were made over 100 years before the British had anything comparable (Howe and Sanderson 973). The charts were on Mercator's projection, with longitudes based on the l'île (Ferro) de Fer/Pepys noted that the Dutch preferred it to Greenville Collins' **Coasting Pilot** of the same date.

In the introduction to the second edition, or re-issue, of 1753 Bellin describes the methods used to compile the original 1693 charts. He records that most capes, rocks, bays, banks *etc* had been surveyed by the Ingénieurs and 'skillful pilots' working on the ground from cape to cape by triangulation, using very exact instruments. Nothing had been neglected. Latitude and longitude had also been made by ground observations, again 'with very exact instruments', possibly supplementing those by Picard and La Hire. Degrees of latitude and longitude/London (probably St Paul's) ~~from~~ were marked on nearly all charts. from

The Channel Islands are on two of the 1693 Neptune's charts; the larger scale chart (c1:210,000) is the more relevant here:

'2me. Carte Particulière des Côstes de Normandie Contenant les Côstes du Cotentin depuis le Pointe de la Percie jusqu'a Granville ou sont comprises les Isles de Jerzey, Grenzey, Cers et Aurigny avec les Isles de Bréhet...'

The details of the French coast were surveyed by ingénieurs du Roy Razaud and Chazelles, the latter being one of the main authors of the Neptune. Britain and France were at peace in 1681-1689 but Jersey and Guernsey are not accurate in shape and nothing suggests that the French made any attempt to calculate their positions with reference to the mainland. Further discussion of this chart is deferred until that of the Bellin edition of 1753 (*infra*).

'NOUVELLE CARTE que COMPREND LES TRIANGLES...par MARALDI et CASSINI DE THURY 1744', and 'La CARTE de CASSINI' 1750-1815

The following examines first, the plotting of the Channel Islands on the 'Nouvelle Carte' of the Maraldi-Cassini triangulation, 1744 (reproduced in Pelletier's definitive study, 1990, pp 72-3); secondly, the inclusion of the Islands of Jersey and Chausey in the lengthy location tables printed in the east and west margins of the 1744 map; thirdly, the representation of the Channel Islands on the relevant sheets of the **Carte de Cassini** topographic map [6]. Board (1996, pp 40-41) has discussed this in the context of the First and Second National Maps of France.

The 1744 triangulation.

After the revised outline of France had been established astronomically in 1682, the Cassinis became aware that *'...the hydrographic charts of the French coasts were still considerably short of perfection.'* (Pelletier 1990 pp 59-88; Konvitz 1987; Alinhac 1965 pp 85-6;). A new survey was initiated and the product was a nation-wide map of the chains of the 800 great triangles and 18 bases, published by the Academie Royale in 1744 as the:-

'Nouvelle carte qui comprend les principaux triangles qui servent de fondement à la description géométrique de la France Levée par ordre du Roy par Mss Maraldi et Cassini de Thury, de l'Academie Royale des Sciences. Année 1744...'

It is 59cm. by 91cm. RF scale of 1:1,800,000. It showed the N-S and E-W chains of the primary triangulation, distances in toises from Paris and latitude and longitude gradations in the margins, plus side tables listing the latitudes and longitudes of many towns, islands, forts, lighthouses etc.

The Isles of Aurigny (Alderney), Grensey, Cers (Sark), Jersey and Chausey are shown on the map but are inaccurate in shape. The Cotentin peninsula was less than adequately covered, being a small offshoot of the main network. An extension only one triangle wide extended from Bayeux and Soulainie via Ste Marie du Mont and Mt Besneville to Les Pieux and Flottmanville (sites that were to be re-occupied in later surveys) but suitable observing stations were limited. The north of the peninsula, including Cherbourg, had to be covered by a secondary triangulation. The Institute Géographique Nationale was asked to search its archives for any unrecorded triangulation to the Channel Islands. The reply was (pers. comm.: *'D'après la Nouvelle carte qui comprend les principaux triangles qui serent de fondement à la description géométrique de la France (Année 1744), on releve la position des Isles, mais la chaine de triangles s'arrete à la presqu'ile de Cotentin'*. 'Releve' may be translated as 'to take bearings on' and it seems that

although it would have been possible to include the Channel Isles there is no evidence that it was done. The matter would appear to rest there but for inclusion of Jersey and Chausey on the Location Tables that accompany the map.

The Location Tables.

A ' *Table Alphanetique des Villes Principal de France*' is printed along the east and west margins of the map, giving the latitude and longitude and distance from Paris (presumably perpendicular to its meridian) in toises and lieus. At the end of the town tables is:-

'Table des Lieux le plus remarquables et dont il est plus important de connoitre la Situation'

The subheadings 'Isles, Forts et Tours, Fanaux, Montagnes'. Twelve 'Isles' are listed, eleven being French, including 'I.Chausey'. The one foreign island in the Table is, very surprisingly, the British 'I.Jersey'. Neither Isle is included in the triangulation shown on the map yet their positions are given with some precision to a single toise (but only to the nearest lieue!). La 'Toise de l'Academie' was equal to 6 feet of 12 inches or 1.949m.; the metric system was not legalised until 10th December 1799, These positions do not agree with those on the map which strongly suggests they were not based on the triangulation but taken from other sources, which makes their inclusion in the Table all the more puzzling. Positions have been re-calculated to degrees etc.

TABLE 7-1:(Maraldi et Cassini)

Jersey	49° 12' 42" N	4° 31' 52" W (from Paris) c 2° 11 '37" (from London)	170890 (Toises)	85 (Lieues)
Chausey	48° 52' 28" N	4° 10' 50" W (from Paris) c 1° 50' 35" (from London)	156961(Toises)	78 (Lieues)

The Jersey site is unspecified; St Aubin is the only place in the Island named on the 1744 map but it is not readily visible from Cotentin. If the place is St Aubin, the longitude is nearly correct (from London 2° 11' 37" modern 2° 10') but the latitude is that of Sark. For I.Chausey the longitude is almost correct (from London 1° 50' 35"; modern 1° 50'). The northward latitude displacement is as for St Aubin. Using the toises distances, the position of I.Chausey is approximately correct but it places St Aubin on the west coast of Jersey.

La CARTE de CASSINI 1750-1815

Much has been written on 'La CARTE de CASSINI', 1750-1815 (Pelletier 1990) but unfortunately the three sheets that cover west Cotentin and the adjacent sea add nothing to the present study.

LE NEPTUNE FRANÇAIS 1753

TABLE 7-2

LE NEPTUNE FRANÇAIS 1753: Latitudes

	1753	Modern
La Ville (Alderney)	49° 46' N	49° 43' N
St Peter Port	49° 31' N	49° 28' N
St Aubin Fort	49° 11' N	49° 11' N
Iles Chausey	48° 52' N	48° 52' N

TABLE 7-3

LE NEPTUNE FRANÇAIS 1753: Longitudes (adjusted to Greenwich)

	1753	Modern
La ville ((Aurigny)	2° 03' 30" W	2 8 30 2° 11' 30" W
St Peter Port	2° 26 '18" W	2° 32' W
St Aubin Fort	2° 04' W	2° 10' W
Iles Chausey	1° 42' W	1° 50' W

St. Aubin's Fort (the main British naval base) is just east of the town. It can only be directly sighted from Cotentin from south of Granville. The latitude for St. Aubin is correct, unlike contemporary English charts (Seller etc.). As might be expected, the longitude errors are larger. The sources of the Channel Island latitudes and longitudes are not given.

THE LATE 18th. CENTURY

DE LA ROCHETTE 1781 (CHART 7-1)

THE Capt Martin White's Channel Island surveys for the British Admiralty (1803-14), based on triangulations, are the earliest British surveys to fix accurately the relative positions of the Islands and other hazards within the archipelago. Because of the war with France his triangulation links with French coast were based only on one way observations, from the Channel Islands to France and must be considered as provisional. Nevertheless, any precise link with France at a later date would have been impossible without White's surveys, which are reviewed in Chapter Eight. To the title of his seminal chart 1812 MS 'Rough General Chart' (OKHO 841 5k) of the Channel Islands and the adjacent coast of France, White adds '*Note. The whole of French coast as far as low water is copied from the Configuration of de la Rochette.*' Hence some attention must be made to this chart.

De la Rochette, also recorded as L.S. de la Rochette, L.S. d'Arcy de la Rochette, or Louis Stanislas d'Arcy De la Rochette (1731-1802) was a French cartographer and engraver associated with the English map publisher William Faden. (Tooley 1979 pp156 and 377). ~~de la Rochette not listed in Dawson 1969).~~

'A Chart/of the Islands/of Jersey/and Guernsey/Sark, Herm and Alderney:/with the Adjacent Coast/of France,/by L.S. Rochette. MDCCLXXXI." A separate note states: "London:/Engraved & Published as the Act directs Jan. 1st. 1781/ by W. Faden, Successor to the late T. Jefferies/Geogr. to the King, Charing Cross.' (The copy used is in the Priaux Library, Guernsey). [CHART 7-1]

The chart is c70.0cm. by 50.5cm. and shows the French coast from the Raz du Cap Levi in the north of the Cotentin to Ile de Brehat in Brittany, plus all the Channel Island archipelago.

In the right margin is a scale 'Nautical leagues 20 to a Degree', RF c.1:250,200. Latitude is given in degrees and minutes (numbered every 5'), as is longitude west from 'London', presumably St. Paul's. The graticule indicates the chart is on the Mercator projection.

Warren (1962, p 159-60)) states *'This is an exceedingly clear and precise nautical chart...Bearings to all points are easily found by the compass rose...'* but it is not immediately obvious why White used this chart, made 30 years before his survey, when others with better pedigrees were available, especially that by Dessiou (Master, R.N.) published in 1805 (*infra*), two years after White began his surveys but available during most of the time he was at work (1812 and later). De la Rochette does not name his sources. Presumably the chart was based on French trigonometrical surveys prior to 1781, including LE NEPTUNE FRANÇAIS 1753 (second edition).

The chart is coloured. Along the French coast and Ile Chaussy HW is blue, inter-tidal areas pale buff, marshes blue. On the Channel Islands and Écréhous HW is pink. On the French coast there is little if any inland information but coastal features and buildings that could serve as landmarks are plainly shown; every coastal village (represented by a church symbol) is plotted. It may have been this information that caused White to select this chart rather than that of Dessiou, which has fewer landward sites plotted. The out-lines of Guernsey and Jersey are far from correct but the amount of detail is noteworthy.

There are 14 marginal coastal profiles all but two illustrating the Channel Islands. Coastal features and buildings that could serve as landmarks are plainly shown, There are a few leading lines and the usual rhumb lines. Soundings are mainly around the islands and off the French coast and 'shallows' are plotted. Notes on sea bed deposits are confined to the north of the chart. The mythical 'Bancs Grelats' are shown south of Jersey, indicating that de la Rochette had not done much original surveying. Tidal information includes the Hours of High Water at New and Full Moon, range of tides and depths of water. The explanations are in English but some place names are in French only e.g. les Caskets, others are translated e.g. Aurigny (Alderney); Sercq (Sark); Banc de la Chale (Shoal Bank).

There are notes on nautical events e.g. E of Caskets *'On these rocks the Victory...was lost... 5th. October 1744 O.S.'*

few km. Offshore are Ile d'Aurigny, east Cers (Sark), Pierres de Lecq, Rochers d'Écréhous. No trigonometrical or semaphore stations (*infra*) are plotted.

Alderney, Jersey and Guernsey are reasonably accurately charted.

Vol. II 7^e feuille:-

'Côtes de France / Dépt. de la Manche / et de Ille et Vilaine / depuis le Cap Carteret jusqu'a l'île des Embiez / d'après les Plan levées en 1777 / par La Couldre-La Bretonnière Lieutenant de Vau / et Méchain Astronome Hydrographe de la Marine / Publie par ordre du Ministre / pour le Service des Vaissaux Françias / au Dépôt des Cartes et Plans de la Marine / 1792.'

The chart is 92cm. by 63cm., oriented with north on the righthand side and covers the area south of Carteret. The RF scale is c.1:113,619. Latitude and longitude are graduated in degrees, 10 minute and 3 second intervals. Longitude is west from the Paris Observatory.

The same detailed coast and inland symbols as for the previous chart.

Jersey is shown as far west as St Ouen Bay (omiting Grosnez Point and la Corbière). Off-shore features include: Roches d'Écréhous, Chaus-ey [sic], Les Minquiers, Les Bancs Grelets.

Selected positions:-

TABLE 7-6 (V.11 7th feuille)

NOUVELLE NEPTUNE FRANÇOIS, 1792

	Lat	lat (modern)	Long. Paris Obs	London St P *	London modern St P
Granville	48° 51' 45"	48° 50'	3° 56' 30"	1° 31' 15"	1° 31'
Coutances Cath.	49° 2' 57"	49° 02' 30"	3° 47' 0"	1° 21' 45"	1° 22'
St. Aubin (Jers.)	49° 10' 45"	49° 11'	4° 29' 48"	2° 04' 33"	2° 05'
Chausey (Maitre Ile)*	48° 52' 24"	48° 52'	4° 9' 45"	1° 44' 30"	1° 44'

* Assuming Paris 2° 25' 15" E of St Paul's

The longitudes are nearly correct.

LE CONNAISSANCE des TEMPS, 1786/9 and 1791/3.

French and British official nautical almanacs both included increasingly lengthy tables of the latitude and longitude of important ports, islands *etc.*

The latitudes and longitudes of St Aubin (Jersey) and l'île de Sercq (Sark) first appeared in Le Connaissance des Temps, in 1786/9 and 1791/3 respectively. They were clearly marked with a triangular symbol to show that they were obtained by trigonometrical survey and this is repeated in subsequent editions (at least up to 1822). There is no acknowledgement of the sources. Unlike the Cassini table of 1744, the Connaissance des Temps does not include l'île Chausey.

TABLE 7-7
Le Connaissance des Temps, in 1786/9 and 1791/3

	Lat.	Long. (W. of Paris)	London (Greenwich)
St. Aubin	49° 12' 59"N.	4° 30' 59" W	2° 10' W
Sercq (Sark)	49° 23' 32"N.	4° 44' 45" W	2° 20' " W

Sark can be easily observed from points on the Cotentin coast that would give well-shaped triangles, but St Aubin is screened from the French coast by the peninsula of St. Clement, which rises to over 60 m. It is impossible to get a well-formed triangle unless at least one sight is from Les Minquiers or L'Isle de Chausey, to the south of Jersey; both are low-lying but accessible to the French.

Not until the second edition of the British Nautical Almanac in 1781 was there a table of 'Latitudes of Places with their Longitude from the Meridian of the Royal Observatory at Greenwich'. Although it included a number of ports, headlands etc. in Normandy and Brittany, the Channel Islands were totally ignored. The same is true of the Third Edition (1802). Such, apparently, was Britain's lack of interest in them. The Isles of Scilly, on the other hand, figure in both editions.

WILLIAM GARDINER'S MAPS of GUERNSEY AND JERSEY, 1787 and 1795
(CHART 7-2)

The Board of Ordnance under its Master General the third Duke of Richmond (appointed 1783) ordered the first official surveys of Guernsey and Jersey in 1787 (PRO WO 47/110:f171) and 1788 (PRO WO 47/111;f363) respectively [8], at the large scale of six inches to one mile :-

An Accurate Survey and Measurement of the Island of Guemsey. Surveyed by Order of His Grace the Duke of Richmond... Master General of the Ordnance. By William Gardner, 1787.

An Accurate Survey and Measurement of the Island of Jersey. Surveyed by Order of His Grace the Duke of Richmond... Master General of the Ordnance. Engraved by John Warner 1795.

Gardner was a very competent surveyor who had worked for the Duke and the Board on large scale maps of Sussex (two inches to a mile, 1778-83; PRO MR 1409), Plymouth (six inches to a mile, 1784-6) etc. The ... surveys ...by Gardner's party were under taken for short-term military objectives and not with publication in mind. As they were military surveys (war was declared on France in 1793. References to planned French invasions are in PRO WO 1/927) and the Board of Ordnance had every right to survey the Channel Islands (PRO WO 47/110,111).[9]. Publication was not authorised until 1855 (a second print of Jersey was made in 1863) but reference to the maps was not removed from catalogues until as late as 1920 (PRO OS1/125).

Interesting though the maps are, they lack all reference to latitude and longitude and so can contribute little to the present analysis. They are two quite separate surveys with no attempt

There is a hint of the problem in PRO OS1/112 94A (Cadastral map of Jersey). A letter (11.8.1934) from Winterbottom to Close about the 6" of Jersey (1795). It '*...was put aside by you with instructions it was not even to be mentioned unless specifically asked for. Was it so very inaccurate work? and was it, do you think, the cartographic material employed in making that chart which as you will remember showed Jersey with an error in longitude of about a quarter of a mile?*' The topic is discussed in the next Chapter.

NICHOLAS DOBRÉE,

Warren (1961) devotes two pages to the charts of Dobrée Sen. c1750. Warren states '*Dobrée's three charts are worthy of detailed study*'. The title of one of Guernsey, Sercq etc. ends '*...The whole done from an Actual Survey by Nicholas Dobrée Esq,...Agent to the Admiralty.*' His charts went through several editions and as one of the latest (1794) has latitudes and longitudes.

As regards status of Dobrée's surveys re the 'bench-mark' concept, he was an 'Agent' to the Admiralty, whereas Captain Martin White was a member of the official Naval Surveying Service. Dobrée's contemporaries e.g. Dicey and J Jacob, spoke highly of the accuracy of his surveys, claimed to be his own but the dates are not given.

Latitudes and longitudes (from London) are on a version in the British Library, published by Laurie and Whittle 1794. [BL. Maps 151 f.1 (4)].

A General Chart of the Islands of Guernsey, Jersey, Sark ... with Cape la Hague and the Caskets. By Capt Dobrée. 1794. Published by Laurie and Whittle.

**TABLE 7-8
DOBRÉE Latitudes**

		Modern
St Aubin	49° 05' 30" N	49° 11' N
St Peter Port	49° 28' 35" N	49° 28' N
Alderney Windmill	49° 44' 00" N	49° 43' N
Flammanville	49 34' 00" N	

**TABLE 7-9
DOBRÉE Longitudes ('London' St Paul's)**

		Greenwich	(St Paul's)
St Aubin	2° 18' 30" W	2° 10' W	2° 05' W
St Peter Port	2° 35' 35" W	2° 32' W	2° 27' W
Alderney Windmill	2° 14' 30" W	2 8 30 2° 11' 30" W	2° 06' W
Flammanville	1° 54' 00" W		

SIGNAL AND SEMAPHORE STATIONS 1798-c.1850.

Roughly contemporary with the progressive introduction of accurate trigonometrical surveys was the establishment of a number of signal stations in the Channel islands and along the west coast of Cotentin and north cost of Brittany to facilitate rapid, for the period, transmission of naval and military messages. Some of these stations were incorporated in the trigonometrical surveys of White and others [10](Fig 7-2: Jersey Signal Stations).

'In view of the position and strategic importance of the Channel Islands it is not surprising that in Britain's wars with Revolutionary and Napoleonic France, there was a need for early warning of French naval movements in St Malo Roads.' (Wilson 1976, p 94; reports of French preparations in PRO WO 1/922, PRO WO1/924).

A detailed review is in Wilson (1976) with Chapters on the Channel Islands and France; there are many references in the PRO (e.g. PRO WO/1; PRO WO30/77; PRO WO 1/925 f.197, 204, 205, 210) which have been indexed and partly transcribed by Geoffrey Wilson [11] and deposited as MSS in the Société Jersiaise library. Additional material on Cotentin is in Le Couturier (1988).

Flag and ball stations were set up in Jersey in 1798 by Act of the States (Kavanagh, 1972). Wilson map *op. cit.* p 98) shows a series of stations linked the four main Islands, that on Alderney being completed in 1811. The system was finally closed in 1815 but the buildings remained and some served as triangulation stations. The station which has attracted most historical interest is that at Jerbourg, SW Guernsey. It was essentially pivotal to the whole network of semaphore stations (Fig 7-3: Jerbourg Signal Station).

A 'télégraphe aerien' was progressively built across France after 1793. In 1814 it extended from St Malo to Cherbourg and covered most of France by 1840. By 1850 most stations were abandoned and in a bad state (Wilson 1976, Chapter 10).

In 1801 Depillion developed a three armed semaphore along the whole of the French coastline from about 1803. The system remained in use until the beginning of the 20th century, the relevant stations in the present context being Cherbourg, Granville, Saint Servan, Cap Frehel, Ile de Brehat.

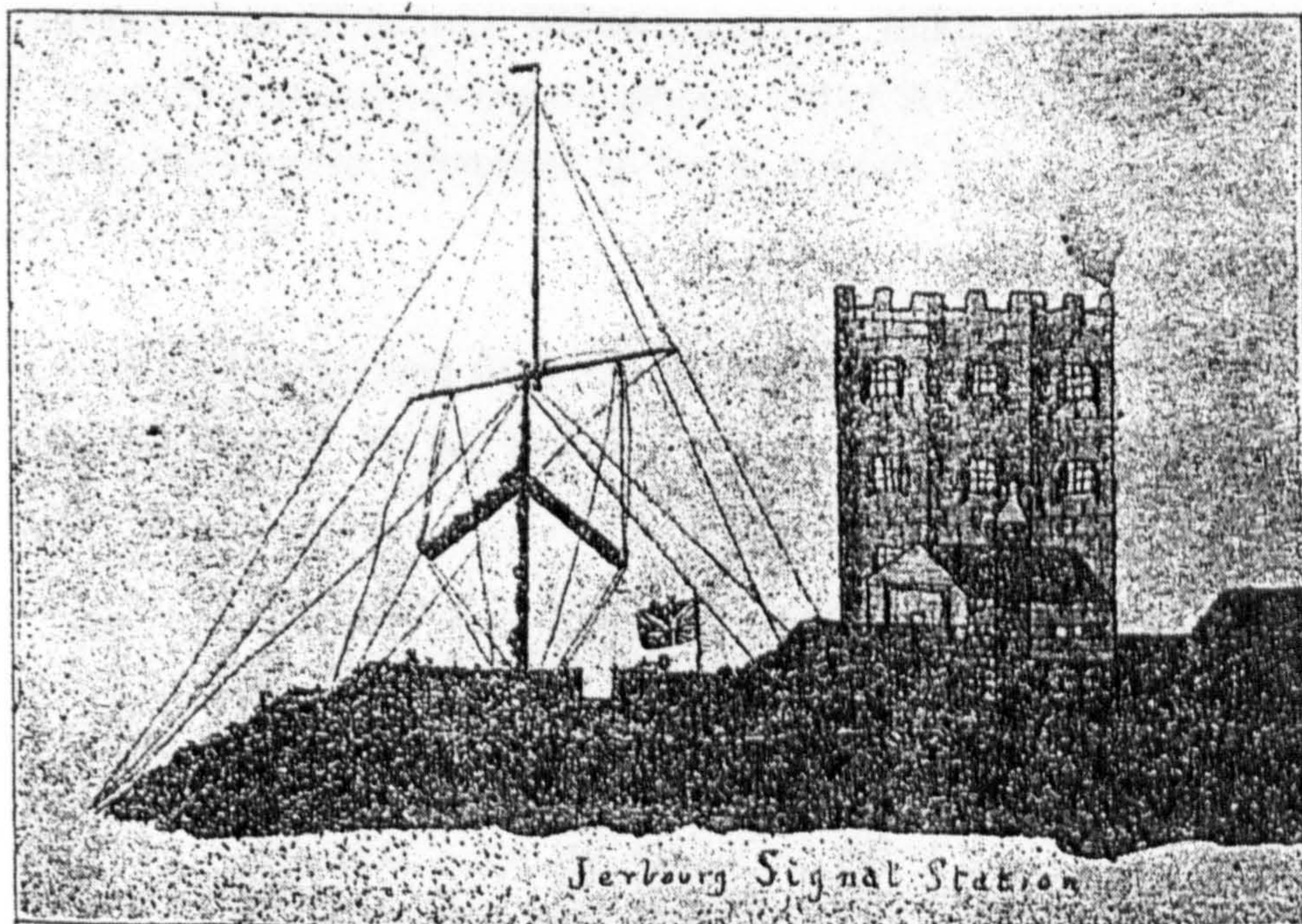


Fig 7-3. Jerbourg Signal Station c 1810.

DESSIOU'S CHART OF 1805 (CHART 7-3)

Dessiou, Joseph Ross, published two charts of the Channel Islands and Cotentin in 1805. The apparently rare large scale chart 89.5cm. x 71.0cm. is the one discussed here.

Laurie and Whittle's/Chart of the Coast of France / from / Cherbourg to Brehat Is. / including / The Islands of Guernsey, / Jersey, Alderney, etc. Compiled from the Trigonometrical Surveys of / Machain and Others, / By Joseph Dessiou.

Published as the Act directs, by Laurie and Whittle, No.53 Fleet Street, London. May 17th. 1805. NMM 527.03 (261.2). (The copy used is in the Prialx Library, Guernsey). [CHART 7-3]

A brief biography of Joseph Foss Dessiou, Master R.N., is in Dawson (1969, p 84).[12] He was appointed Master in August 1805. *'He appears as far back as 1808, to have been engaged in constructing charts, and had evidently paid close attention to hydrography, whenever his professional duties permitted...he compiled several charts, principally of the West Indies and the English coast, for the Hydrographic Department...'* e.g. River Dart and edited *inter alia*, 'Directions for Sailing throughout the English Channel.' (1816) .

It remains a puzzle that White ignored this chart by a Master in his own navy, using the latest French sources, in favour of that by de la Rochette.

The chart is 89.5cm x 71cm, oriented with north at the top. It lacks the detail found on ^{de la} Rochette but is a very 'clean' looking chart. The scale is c1:193,400, larger than de la Rochette's (1781) and covering a larger area. Latitude and longitude (west of Greenwich, unlike de la Rochette) are given in degrees and minutes, numbered every 5' and drawn across the chart. The graticule indicates that the chart is on Mercator's projection. Bearings are easily taken from the large compass rose. Tidal information is *'The set of the Stream in Twelve Hours on the New and Full Moon.'* but unlike de la Rochette it is not repeated over the chart. Based on the trigonometrical surveys of Machain and Bretonnière, (1792, *supra*), it is significant that Dessiou quotes Machain the astronomer and hydrographer, rather than Bretonnière, the naval lieutenant. There are soundings around the islands and off the French coast but not as many as de la Rochette. There are no references to bottom deposits or to the historical events noted *de la* by Rochette.

Dessiou's chart plots Jersey and Guernsey accurately, possibly because he had access to Gardiner's six inch maps of the two islands.

TABLE 7-10
Sample Latitudes: Dessiou 1805 chart

	Latitude	Modern
Granville	48° 50' N	48° 50' N
Coutances	49° 2' 40" N	49° 03' N
St Malo	48° 39' 30" N	48° 39' 30" N
Aurigy (church)	49° 3' 20" N	49° 42' N
St PeterPort	49° 28' 20" N	49° 27' N

TABLE 7-11

Sample Longitudes: Dessiou 1805 chart
West from London (St Paul's). Add 5' for Greenwich.

Modern St Paul's		
Granville	1° 35' 30" W	1° 35' W
Coutances	1 ° 28' W	1° 26'W
St Malo	2° 02' W	2° 00'W
Aurigny (church)	2° 12' 30" W	2° 13' W
St Peter Port	2° 30' W	2 ° 32' 30" W

He gives little inland information, apart from the churches. The Casquets lights are shown as on *de la* Rochette but on Alderney only ~~the~~ Town church. He also plots the mythical Grelets Bank. *is plotted.*

END NOTES

1). French sailors had for long relied on foreign, mainly Dutch, charts, even for their own coasts.

2). The French astronomers and surveyors mentioned in this chapter are listed below, with details of a major biographical study:-

de la CAILLE, N.L., (1713-1762);

Armitage, A. 1956. The astronomical work of Nicolas-Louis de la Caille, *Annals of Science* XII 163-191.

de la HIRE, P. (1640-1718);

Sergescu, P. 1947. La litterature mathematiques...*Archives d'Histoire des Sciences* I 60-99.

MARALDI, G.F. (1665-1729);

Cassini, J.D. 1810. *Memoires pour servir a l'Histoire des Sciences*. Paris 325-47.

PICARD. J. (1620-1682);

Armitage A. 1954. Jean Picard and his Circle. *Endeavour* XIII 17-21.

3). Picard used a quadrant with a ten foot radius.

4). The CASSINI DYNASTY:-

Cassini I: Giovanni Domenico (1625-1712). Professor of Astronomy at Bologna University. Moved to France in 1669 as Director of l'Observatoire Royale.

see: Cassini J-D (IV), 1810. *Memoires pour Servir a l'Histoire des Sciences*, pp. 249-264. Paris.

Cassini II: Jacques (1677-1756). Son of Cassini I and conducted the triangulation of France. Extended the triangulation for the meridian of Paris, 1683-1718.

Cassini III: Cesar Francois (1714-1784). Son of Cassini II. Adopted title of Cassini de Thury. Revised the Paris meridian arc with la Caille 1739-40; continued the triangulation of France; in 1744 began the surveys for the topographic map; initiated the Calais-Dover cross-Channel triangulation.

see: Drapeyron, L. 1896. *La Vie et les Travaux Géographiques de Cassini de Thury Auteur de la Première Carte Topographique de la France*. *Rev. de Geogr.* XXXIX 241-251.

Cassini IV: Jacques-Dominique, (1748-1845). Completed with Maraldi the 'Cassini' map of France in 182 sheets; completed by 1789 but not fully published until 1815 for political reasons.

see: Devic, J-F.S. 1851. *Histoire de la Vie et des Travaux Scientifiques et Littéraires de J.D.Cassini IV*. Clermont.

5). On the morning of November 20th. 1681, at low water, a straight line 2500 toises (4.87km.) long was measured on the beach at Calais, starting at the point of the Bastion du Risban which was on the sea coast and continued in the direction of Boulogne. The quadrant was placed on the point of the Bastion and the angle was measured between the baseline and '*...le milieu des deux Tours les plus*

apparent... of Dover castle. It was $37^{\circ} 58'$. The instrument was then carried to the other end of the base, where the angle was found to be $137^{\circ} 30'$. de la Hire calculated the distance between the Point of the Bastion and Dover castle as 21360 toises '*...mesure du Chastelet de Paris.*' equivalent to 41.63km. la Hire noted that this was only about two thirds of the width of the Strait on contemporary maps and the "Corrected Map" was adjusted accordingly. The measurements were from a very short baseline, a problem already met with in surveys from Scilly to the mainland of Britain.

6). Konvitz argues at length that the 1744 triangulation was a scientific exercise, not an end in itself, published in 18 sheets and only incidentally made the basis of the famous topographic survey (Konvitz 1980, p16). '*The map finished in 1744 completely fulfilled the scientific and political objectives pursued by Colbert, Picard and Cassini between 1668 and 1683, and by Orry, Cassini II and Cassini III after 1730. Yet this map has been conventionally represented, in error I believe, as a preliminary effort to the national survey launched by Cassini in 1747-50. The second survey covered France in greater detail, in 180 sheets instead of 18. In 1744, however, Cassini III did not anticipate making another, more detailed map survey. We should therefore speak of two Cassini national surveys of France, one finished in 1744, the other in 1788, each independently conceived and executed.*' (Board, 1996).

7). Lieutenant Bretonnière, Couldre la. Surveyor for charts for Dépôt de Marine, Calais and Somme areas 1792-97 (Tooley 1979).

Méchain, P.F.A. (1744-1805). Astronomer, Hydrographer to Marine Dépôt. Charts of coast of France 1776, pub. 1797. Worked with Cassini and Delambre in establishing precise length of a meter. 'ingénieur du Roy?' (Tooley 1979 & Tooley R V 1973. Map Collectors' Circle vol 10 no.91 p.308).

The trigonometrical survey was well observed. The Bibliothèque nationale de France, Dép. des Cartes et Plans and the Archives de France (pers comms) suggest that the charts of the triangulation no longer exist. It was suggested that the earlier triangulations of les ingénieurs géographiques of the coasts of Normandy and Brittany at the scale of 1:14 000 may have been used by the above surveyors, but not including the Channel Islands. '*Toutefois, sur le manuscrit de la carte de LA COULDRE LA BRETONNIÈRE ET MÉCHAIN sur laquelle figurent Coutances, le Mont Saint-Michel, et Saint-Malo, il y a des lignes tracées au crayon reliant Granville à Jersey, mais accompagnées de corrections, ce qui laisse supposer qu'il s'agit d'ajouts postérieurs.*' The writer acknowledges the copyright of the BNR for the above information.

8). 57 members of the 'Corps of Royal Military Surveyors and Draughtsmen' were still in Jersey in 1816 (PRO WO 44/517). Presumably they were concerned with fortifications, as there is no evidence that the six inch map was ever revised.

9). The Channel Islands were never included in the Ordnance Survey's remit as they do not contribute to the British treasury, which funds the Survey. Some 20th. century surveys have been made by the former War Office as exercises for the Royal Engineers, (or by private companies, or the Ordnance Survey, paid for by the respective States)

10). The collection was deposited in April 1952 under "Signal stations in Channel Islands, est. 1805-1814." There are well over 20 references to material in the PRO under the ADM class.

11). 'Map of Jersey...Presented to General Don, Lt. Governor of Jersey, 1806-14
Showing the position of all the Signal Stations'.
(Library Société Jersiaise)

12). There were three generations of 'Joseph Dessiou', son, father and grandfather, all hydrographers.

CHAPTER EIGHT

ADMIRAL MARTIN WHITE R.N. 1779-1865.

INTRODUCTION

Martin White was the first and undoubtedly the most interesting member of the 'HM Naval Surveying Service' (as it was originally named) to chart the Channel Islands and the adjacent coasts of Normandy and Brittany. *'Commander White was the first fairly recognised officer of that rank employed in the Naval Surveying Service...The early charts of the [English] Channel... were the work of Commander White.'* (Dawson 1885). Warren (1962, p163) wrongly states that White's charts *'...were the immediate predecessor of the official Admiralty charts.'* [1] White makes it clear on seven of his ten MS charts that they were commissioned by the Admiralty e.g. the 1812 Rough General Chart was *'...Undertaken in the Year 1812 by Captain Martin White, Royal Navy per order of the Right Honourable the Lords Commissioners of the Admiralty.'* *'...Surveys of the English and Irish Channels and the Channel Islands ... are glaringly imperfect,... few if any of the publications now extant possess any claim to science or originality... the Right Honourable Lords Commissioners of the Admiralty were pleased, ... to select me for the purpose of carrying this important [survey]...[commenced]... in the month of August 1812...'*

Martin White, Captain of the Royal Navy.'

The *'...approbation of their Lordships.'* is noted in the first edition of the **'Sailing Directions...'** 1835. (UKHO Book 83):- *'The extensive survey from which the following directions have been derived was begun by Captain Martin White in 1812 and continued with little intermission, to 1829... a minute examination of the Channel Islands... The principal charts and plans which resulted from this survey having already been published, the Lords Commissioners of the Admiralty have ordered **The Sailing Directions** to be likewise printed...'*

Hydrographic Office March 1835.

This chapter is mainly concerned with Martin White's naval career, based on archive material in the UKHO, PRO etc but an invaluable chronology covering practically all of White's life has been compiled by the late Mr W Davies and deposited in the Library of the Société Jersiaise. The writer has been given permission by his son, Mr P Davies, to quote extracts from it, in this Chapter and in Appendix B (acknowledged: WHD). In total White served on 13 ships, engaged in a wide range of duties but particularly hydrographic surveying, which occupied some 43 of the 53 years of his service career.

This Chapter should be read in conjunction with Appendix G. The former discusses the practicalities of surveys and the compilation of White's 'bench-mark' charts; the latter describes the trigonometrical stations used by White and for most stations lists the successive latitudes and longitudes as White refined his observations, from 1812 to 1835.

White's surveys in the Channel Islands and the adjacent coasts of France may be divided into four phases, which inevitably overlap chronologically:-

- i). The first and longest phase, that of White's main surveys, spans the years 1803 to 1817 when Britain and France were at times at war (WHD 001-027). White's first contact with the Channel Islands came during the Napoleonic Wars. In addition to other duties in 1803 watching the French ports, he was '*...at the same time surveying the approaches of each.*' (PRO ADM 9/59). The three relevant vessels he commanded were *HMS Pygmy* (1803; WHD 028) , *HMS Vulture* (1808-11; WHD 040-041) and the cutter *Fox* plus small open boats. Almost all surveying was carried out using the *Fox* or open boats, a not unusual practice (WHD 044-045). In September 1808, White returned to the Channel Islands for three years as Captain of the sloop *HMS Vulture*, a Guard Ship, '*... but at the same time every opportunity was taken, and every exertion used to obtain correct Soundings around them and also along the French coast in Ship's boats.*' (This phase ends with White having to correct latitude and longitude errors on what he had assumed would have been his definitive chart (1812; UKHO 841 5k).

- ii). The second phase was 1821-29 when, although in command of *HMS Shamrock* (WHD 050) on survey work elsewhere in the English and Irish Channels, he was required to prepare c1828/ 1829 two further MS versions / copies of his earlier MS Rough General Charts. He visited the Channel Islands in 1821, 1823 and 1826 in *HMS Shamrock*. Napoleon was sent to St Helena in 1815 and the ensuing peace totally changed the attitude of the two previous combatants to hydrographic surveying in this region; collaboration became possible.

- iii). The third phase opened in 1824 with the publication of printed charts based on White's surveys. The Admiralty printed successive revisions of his charts until 1865, the year of his death. At this time White was involved in the discussions to build a harbour of refuge in Jersey. St Catherine's Bay was chosen, against White's advice. Today only one breakwater remains (Fig 8-6 and WHD 062-087).

- iv). The last phase, which has been transferred to Chapter Nine., began about 1829 when White settled in Jersey and covers the joint Anglo-French triangulation surveys linking the Channel islands to France, 1829-30 (Chapter Nine). In 1834 White published the first edition of his highly regarded **Sailing Directions for the English and Irish Channels and Channel Islands...** (second edition 1841). White retired from active service with Post Captain rank in October 1846 but continued his own hydrographic surveys in and around the Channel Islands until at least 1850. He was promoted to full Admiral (Rtd) in 1862. He died in Jersey in his early eighties on 30th June 1865. Surveys which were founded on Martin White's MSS charts and Remarks Books are described briefly in Chapter Nine.

The Martin White MS archive in the Hydrographic Office, Taunton, UK, consists of seven large scale MS 'Rough Charts' made up of four MS charts of the Channel Islands with the adjacent coast of France, (the 'General Charts'), and one each of Jersey; Guernsey with Herm and Serq; and Alderney with Burhou, Ortach and the Casquets. In addition there are three MSS 'Rough Remarks Books', being detailed reports on the charting,

trigonometrical calculations, coastal views, *etc.* spanning the period 1810-c1840 and some MS letters. The printed charts date from 1821 (Jersey) and 1822 (Guernsey). Regretfully it must be left to others to make a comprehensive cartographic description and analysis of the superb Martin White MS archive in the Hydrographic Office at Taunton. Here attention is directed specifically to White's trigonometrical surveys linking the Channel Islands' archipelago with the adjacent coast of France.

To the usual hydrographic data on the four General Charts, White added a wealth of information on the face of the charts in the form of lengthy descriptive titles, supported by more detail in cartouches, tables of latitudes and longitudes of important places and long NOTES describing problems of chart construction *etc.* and comments added to or elaborated in the **Rough Remarks Books**. Only a fraction of this detail can be accommodated in this chapter. The impression is given that much of this additional chart information was aimed at White's superiors who, while prepared to study the charts, would never have looked at the background detail in the Rough Remarks Books. Little of the supplementary information on the MSS charts was transferred to the printed versions. Unfortunately, some of the 'General Charts' are too large and fragile to reproduce. The staff of the UKHO Data Centre have been most helpful. Some additional information on White's charting is to be found in the Captains' and Masters' Logs (PRO ADM 51 and 52). Dawson (1885) notes that White was assisted by Denham [2] who probably drew some of White's MS charts, as the style is the same as that of Denham's own later work.

There are problems establishing the chronology of White's MS charts. His first MS chart of the Channel Islands and the French coast is dated 1812, the same year that he was officially appointed! Clearly much surveying had been in progress before that date, as early as 1803. His MS charts of the main Islands are dated 1813 or 1814. However, the surveys of these must have been completed prior to 1812, so that trigonometrical stations for observing the coast of France could be selected. Clearly White delayed the final compilation and submission of these Island charts to the Admiralty until after the 1812 MS chart had reached the Admiralty (WHD 046: 5th Oct 1815). The first published chart is dated 1821, but White was correcting his MS charts as late as 1829. This topic is discussed in more detail with the descriptions of the charts.

The titles of White's MS charts can be very long. They are here given in full when first mentioned and subsequently abbreviated as listed below. The UK Hydrographic Office references are followed by the dates and abbreviations, with suggested dates for compilation and/or deposition with the Admiralty of the Charts and Remarks Books related to Martin White's '1812' and later surveys.

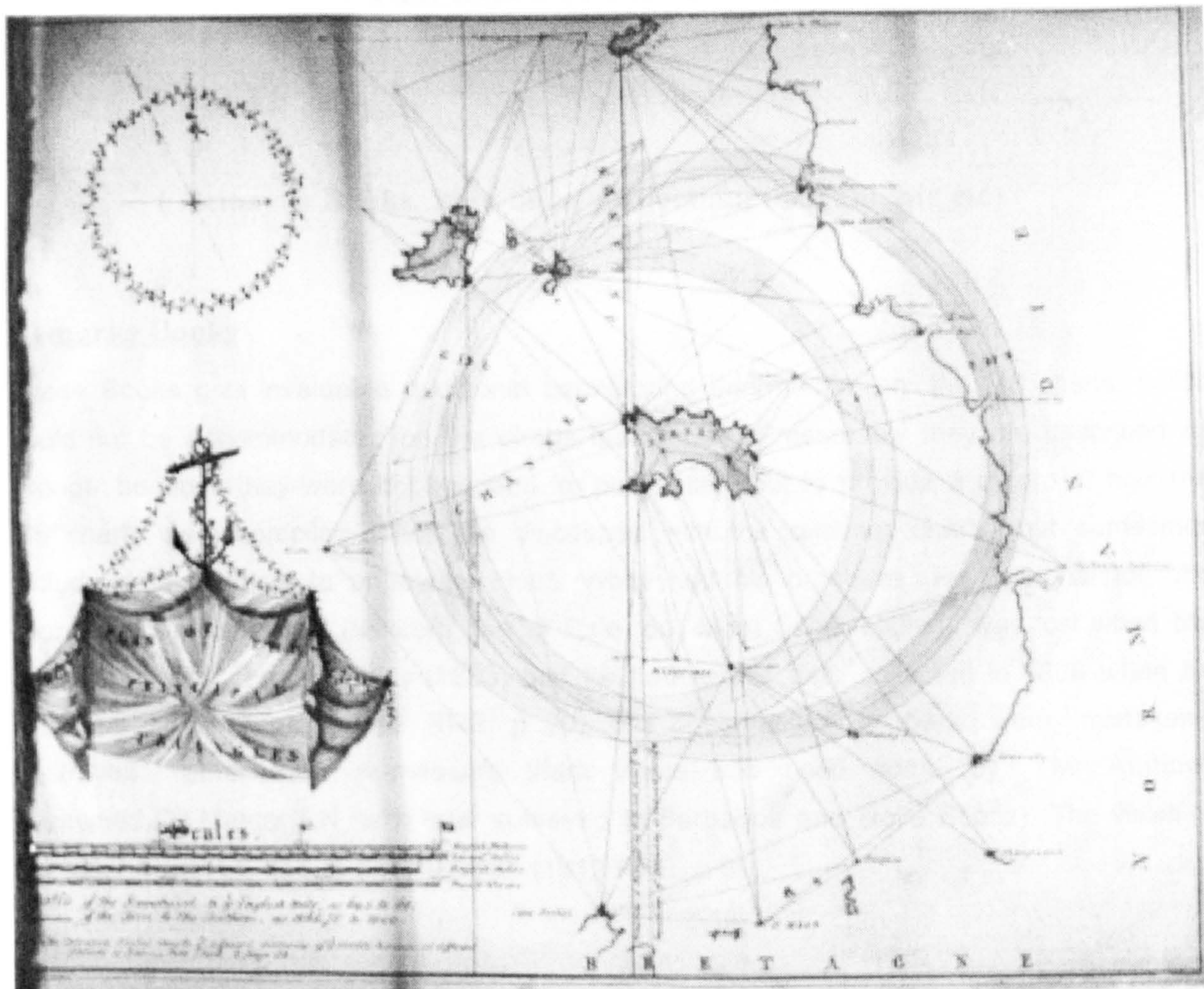


Fig. 8-1 Plan of Principal Triangles. Chart 8-1 UKHO RB1840 OD537

Reproduced from Admiralty Publications/Charts by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office.

- i). UKHO 841 5k. 1812 RGC (Rough General Chart) ?deposited 1815.
(Channel Isles / Cotentin coast).
- ii). UKHO 842 5f. 1813 Jersey chart.
- iii). UKHO 824 5f. 1813 Guernsey chart.
- iv). UKHO 843 43a. 1814 Alderney chart.
- v). UKHO 542 A. 1812 RRB (Rough Remarks Book) ?deposited 1815
- vi). UKHO 817 5k. 1815+ Supplement RGC (Rough General Chart) ?deposited 1815/16
(Channel Isles / Cotentin coast).
- vii). UKHO OD 537. 1815 Appendix RB (Remarks Book) ?deposited 1817
- viii). UKHO E 827 5k. 1828/29 Reduced Clarence GC (General Chart).
(Channel Isles / Cotentin coast).
- ix). UKHO G3 5c. 1829 Reduced GC (General Chart) ?deposited 1826
(Channel Isles / Cotentin coast).
- x). UKHO OD 542. c 1840 RB ((Remarks Book) 1834/40

PHASE 1 (1803-1817)

(a)

(Remarks Books, base lines, projection, instruments etc)

Remarks Books .

These Books give invaluable additional background information on the MS charts, which could not be accommodated on the charts themselves. Presumably they are described as 'Rough' because they were not intended for publication, but to provide a record of how the MS charts were compiled. They are discussed with the relevant charts, but sometimes include data relevant to an earlier chart. White had his problems. His 'Material for the Survey of Canelle Bay' (western part of Baie du Mont Saint Michel) was lost when the Dutch captured *HMS Manley* (1803) and he had to use data collected in 1808 when he was on *HMS Pygmy* (1812 RRB, p 20). His observations to Sark were mistakenly destroyed: rather than re-measure them White had used some by Mr Anthony Lockwood,[3] Master RN (who later surveyed in Barbados and Nova Scotia). The views of the land, however, had to be re-drawn (1812 RRB, p 9).

(1) 1812 RRB: UKHO 542 A.

Rough remarks for the survey of the Islands of Jersey, Guernsey, Alderney, Sercq and coast of France: undertaken in the year 1812 by Capt. M. White, Royal Navy, by order of the Right Honourable the Lords Commissioners of the Admiralty. (the survey could not have been completed in one year)

[To accompany chart UKHO 841 5k; 1812 RGC; deposited 1815]

The type of information in the 1812 RRB includes:-

- i). The angles measured in the triangulations (actual angles and corrected angles pp 196-217, using the logarithmic calculations of Sherwin and la Lande [3a];
- ii). The main triangles used to fix stations on the French coast; p 112/3 latitude observations
- iii). Details of the baselines on Alderney, Guernsey and Jersey
- iv). Large scale coloured charts of Les ~~Echou~~ and Minquiers **ÉCUREUOUS** which were occupied by the survey.

(2) 1815 Appendix RB ?1817 UKHO OD 537. Appendix [supplement] to the **General Remarks Book [1812 RRB: UKHO 542 A] deposited in the**

Hydrographic Office in November 1815 and continued by order of the right honourable the Lords Commissioner of the Admiralty. Captain Martin White.

[To accompany chart UKHO 817 5k; 1815+ Supplement RGC ?1815/16]
 BOOK TWO deals with the Channel Islands and France. It opens with a whole page coloured cartouche.

(3) Supplement [UKHO OD 537; 1815 Appendix RB] to the General Rough Remarks [1812 RRB; UKHO 542 A.] deposited in the Hydrographic office in the month of November 1815 showing the error of the meridian as deduced from the Sun and continued by order of the Right Honourable the Lords Commissioners of the Admiralty Captain Martin White, Royal Navy.

Although White's 'definitive' 1812 RGC [UKHO 841 5k] was the result of many years of meticulous surveying, founded upon an extensive regional triangulation, it unfortunately contained errors of latitude and longitude, which led to a replacement chart being hastily compiled c 1815 (UKHO 817 5k. 1815+ Supplement RGC), with details discussed in Supplement [UKHO OD 537; 1815 Appendix RB]. It includes lengthy accounts, complete with watercolour sketches of methods of working *etc.* The first entry is the very important scaled down 'Plan of the Principal Triangles' of the Channel Islands and nearby France (Fig 8-1 and 8-2) with a bar scale of 15.65cm to 30 [White's] Geometrical Miles, c 1:1,171,000. It also has plotted on it the uncorrected and corrected 'Alderney' meridians (Fig 8-3) and the 'visibility circles' from 1815+ Supplement RGC. There follow various references to measurements of latitude and longitude (not all of the Channel Islands) and methods of survey which are discussed below in the relevant sections. At the end of ~~THE~~ book are loose sheets on various topics, including charts by William Mudge. (Chapter Six).

(4) c 1840 RB ((Remarks Book) 1834/40 UKHO OD 542.

Captain Martin White's Remark Book for the Channel Islands and the coast of France.' [deposited 1840] (pp. 130+). A cartouche on an inner page: '**Remarks Book etc. Channel Islands and Coast of France.**' Coloured profile of St Malo. N.D.

This book is undated but may have been deposited in the Hydrographic Office c1840. It is written on paper water-marked 1827. Its Tables of latitude and longitude are the same as those in the Tables on chart HO G3 5c (post Feb. 1829 Reduced GC). The Book refers to White's published Sailing Directions (first edition 1835), so must post-date that year.

The Book appears to be a late summary of White's work and might even be regarded as the definitive Remarks Book, covering ~~of~~ all of Martin White's surveys in the Channel Islands and the French coast. It includes all the angles and lengths of sides for all the Principal Triangles, also bearings and distances between the Channel Islands and the French coast. Importantly, there are sailing directions especially for the French coast (pp xxi-lxiv). Those for entering French harbours are very detailed and

were probably obtained during White's collaboration with the French in 1829 *etc.* (Chapter Nine) There are 25 coloured 'coastal views' including Dinant, St Malo, Mt St Michel, which could only have been made after the peace with France.

Projection

The projection used is recorded twice on the 1812 RGC.

Title (top right):-**On the Principle that the earth is a perfect sphere... between the arc of the sphere and of the oblate spheroid within the limits of this construction being nearly insensible. The Mercator Chart... of the area is constructed ...on the Principle that the Earth is a perfect sphere...** (The title is flanked by columns of 'Computed Latitudes" and 'Computed Longitudes.' which are repeated and augmented in the 1812 RRB.)

White comments that the difference between the arc of the sphere and the oblate spheroid on this chart is '*...nearly insensible*'. Given the instruments available to White this is probably correct. He notes (UKHO Ad.Lib. Va.I.) that the small theodolites he had to use and the type of sextant, prevented the '*...spherical excess from being accurately appreciated by measurement.*' It was too small for computation, yet he emphasises that he allowed for the height of the observer above the water-line when taking observations:- poop deck, 16 feet; maindeck, 10 feet; sitting on maindeck, 7 feet. Mercator's projection is, of course, essential for navigation but he gives no construction details. The individual island charts were on the same projection. The charts of the north French coast in the 1693 *Neptune Francais* were drawn on Mercator's projection, more than a century before White's survey of the Channel Islands.

The principles of hydrographic surveying were sufficiently well established to make it unnecessary for White to dwell upon details. One standard practice was in the marking of trigonometrical stations: '*Station staves with small flags were invariably used in every possible case.*' (UKHO OD 537; letter 24 9 1815). Graeme Spence had done the same in 1792. The Remarks Books, especially the 1815 Appendix RB and the c1840 RB, show in detail by large scale coloured plans how small bays *etc* were surveyed and plotted (CHART 8-1).

Instruments

White pointedly draws attention to the poor quality of some of the instruments he had to use e.g. in the 1812 RRB and in Notes written on the 1828 MS copy of his 1812 chart (UKHO E 827 5k). This copy was prepared for the Duke of Clarence [4] and it is a measure of White's dissatisfaction that he was prepared to air his complaints on it. The 1815 Appendix RB (UKHO 542A) records that the chain to measure the trigonometrical baselines, issued at Portsmouth in August 1812, was '*...a common chain...*' and White ordered one for his use to be made in Jersey, presumably a standard Gunter chain of

22 yards.'... *at trifling expense*' obviously to his own specifications (Fig 8-4). White has similar comments on this chain in UKHO Ad. Lib. V.a. I. (c1830).

White also had trouble with his sextants. The one White had to use at the commencement of his survey was by Gilbert [5].(1828 Clarence GC; Note A):- **'Remarks on the Flexibility of Gilbert's Sextant the instrument with which the Channel Islands Survey commenced. To be found in Original Remarks Book of Nov. 1815.'** To summarise:- the Gilbert's Sextant used at the commencement of the Channel Islands' survey was very heavy, large in radius and was not firmly constructed nor strongly connected. White believed, therefore, that all latitudes measured with it and plotted on the 1812 RGC were more or less affected and erroneous because of the weight of the instrument and its defects. Because of the weight of supporting the Gilbert instrument, White suspected an error of 2'45" *'...which has always been allowed for.'* (1815 App.RB). A further error of 2' 21" was found later. The Gilbert sextant was, therefore, very unreliable.

Triangulation to off-shore shoals etc. was sometimes by sextant rather than theodolite. There is only one specific reference (dated 1817) to a theodolite (1815 RRB p19). White endeavoured to measure all three angles of his triangles but if one station was a church *'... sometimes only two angles were obtained because there was no room for the theodolite.'* He used one made by Adams [6]. (*'...completed azimuth variation by Adams theodolite, Jersey...' 1817*) [1815 App. RB p19]. and seems to have measured all his horizontal angles with it. White makes no comments on the manufacturer or performance of the instrument, so it may be presumed that he was satisfied with it.

Chronometers were used for measuring longitude, but White seems to have preferred astronomical methods. Barometric records were kept for the regulation of chronometers (UKHO Ad. Lib. Va.I.). He lists a number of longitude measurements using Arnold watches (chronometers) nos 326 and 410. For example, at St Aubin's Castle, Jersey, the mean of six measurements was 2° 9' 37".158, which was within 1' 11".832 of the mean lunar distances. (1' longitude at 50° N is 0.64nm. The difference is not encouraging.)

Units of Measurement and Scales

White does not specifically state the basic unit of measurement he used in his surveys. On their respective charts, the baselines on Alderney and Jersey are recorded in fathoms and Guernsey in feet, but when described in the 1812 RRB Jersey base is recorded in fathoms, Alderney in feet and chains and Guernsey in chains. When White is quoting distances derived from his triangulations, however, he always refers to fathoms, never chains (Spence, Chapter Four, used yards) Thus when demonstrating the accuracy of his calculations (Notes on the 1812 RGC):- *'Joburg Nez - Sercq Telegraph is 21,207.18 fa. when worked from Alderney and when counter worked from Gosnez is 21,208.25 fa.,*

differing by 1.07 fa.' or again 'Likewise Cape Rossell when worked from Grosnez is 19,825.022 fa. and when counter worked from Alderney is 19,824.607 fa., a difference of 2ft.5.88inches.'

It is therefore assumed here that the fathom was the basic unit of measurement but that all distances calculated from the triangulations were in fathoms.

White (note on 1815+ Supp RGC), using the distance Alderney - Minquiers, calculated the length of the meridional degree as 61,159 fa, and therefore one nautical mile as 1019.3 fa. In his survey, however, for reasons unknown, he adopted 1018 fathoms (6108ft) as one geometrical or nautical mile (1815 RRB); the official UK nautical mile is 6080 ft or 1013.33 fa, so White's mile was 28ft longer than the modern nautical mile. This small error is irrelevant when White used only fathoms for measuring, calculating and plotting distances. The problems arise on the occasions, not necessarily known, when he converted his distances from fathom lengths into his nautical miles before plotting them.

The immediately obvious examples are the bar scales of nautical miles drawn on some of White's charts. Taking the 1812 RGC as an example, it has a bar scale 4.7cm long, representing one league or three of White's nautical miles ie $3 \times 6108 = 18324$ fa. Three UK nautical miles are 18240 fa, so the 4.7cm bar scale actually represents 3.01 UK nautical miles. This gives an excess error of just under half a UK nautical mile in the N-S dimension of the 1812 RGC.

The RF calculated from bar scales based on White's nautical miles will, of course, be wrong. The RF for the 1812 RGC is c.1:118,800 using White's nautical mile but c 1:118,300 using the UK nautical mile. Some charts have bar scales graduated in fathoms as well as in nautical miles. For example, the 1814 chart of Alderney has one scale of 8.5cm. representing 500 fa, so no error is introduced here and the (true) RF is c1:10,760. On the second scale 17.2cm = 1 (White) nautical mile, an RF of c 1:10,800.

Baselines

White measured baselines on the three main islands (Alderney, Guernsey and Jersey) from which the triangulation of each was developed, embracing many offshore features as well as the Islands themselves. The three baselines are included on the small scale chart of 'Principal Triangles' (1815 Appendix RB). Selected triangulation stations were used to inter-connect the Islands. Short temporary baselines were laid out on the shores of a number of bays etc. (Fig 8-1) so that detailed plots could be made which were later incorporated into the Islands' charts. In the 1812 RRB is found most of the information on baselines. Baselines were, of course, fundamental to White's survey. It was not 'authorised' until August 1812, yet he was measuring baselines in 1809 (Guernsey) and 1810 (Jersey), which suggests that he and Hurd (who had proposed him) had the survey underway well before the Admiralty was officially approached!

Alderney baseline:- measured in August 1813, on the north shore intertidal sands lying south of Braye Road in ~~1814~~ (Alderney chart UKHO 843 43a). On the chart a flag marks one end. Length recorded as 413 fa on the chart. According to the 1812 RRB the baseline was above HWMOST: '*...for the particular survey of the Island.*'

Jersey (Grouville) baseline 1810 (Fig 8-4, 1813 chart UKHO 842 5f) was 1022 fa (on both chart and in 1812 RRB). Measured in 1810, when White was still on *HMS Vulture*, it was located on the intertidal sands south of Grouville, from near Fort William southwards to near La Roque Tower, '*...a perfect plain*'.

Guernsey (chart UKHO 824 5f;1813). The base was first measured in 1809 (UKHO Ad. Lib. Va.I), when White commanded *HMS Vulture*. Elm pickets marked each end. The 1812 RRB (p 29-30) has a detailed coloured '*Plan and section of the fundamental base... of the originally measured base in Le Braye de Valle, Guernsey, and the One subsequently adopted by constructive measurement...*' the length was 93.007 chains. No reason is given for using chains instead of fathoms. Le Braye de Valle is a reclaimed area of marsh in the north of the Island. Later reclamation and cultivation rendered this base useless and so one by 'constructive measurement' was laid out. This was found by calculation to agree closely with the length of the 1809 base and so its length was adopted.

As the survey progressed White made it clear (1812 RRB, p 26) that he was using the Guernsey baseline as the '*...fundamental base...*' for his overall survey and that, apart from their essential part in charting each Island, the '*...Alderney and Grouville [Jersey] bases are unnecessary...*' This is repeated in a MS note on the chart of Jersey, implying that White's whole survey was founded on the Guernsey baseline measured in feet and chains.

WHITE'S MS charts of the main Channel Islands

These are brief accounts of the triangulations of the individual islands, upon which the Principal Triangulations were based.

'The Rough Chart of the Island of Jersey.' (Chart UKHO 842 ~f. 1813)

MS note in pencil: '**Transmitted to the Hydrographic Office January 1813.**'

'MARTIN WHITE. Commander Royal Navy.'

The chart is c 211cm x 96cm and on a large scale: there is a linear scale of 'Geometrical Miles', equivalent to c.1:21,500, using White's nautical mile. Surprisingly the chart has no latitude or longitude gradations. The parallel of 49° 11' 12" N is drawn through Mt Orgeil Castle, as is the 'True Meridian' but it is not numbered. No Magnetic Variation is recorded. The chart is coloured but lacks a detailed 'Reference' or key to the colours and symbols: these are as on other charts. Inland features include parish and vintaign boundaries, military roads, fresh water sites etc and a large number of 'Remarks' referring to leading lines etc.

Triangulation stations and rays for the Island's own survey, as well as those selected for the Principal Triangulation, are inserted; the baseline is shown on the sands of Grouville Bay. Notes on the chart refer to two classes of triangulation. Certain stations are circled:- These circles serve to point out those [crucial] stations where the calculation was worked and measured in both directions around the Periphery. [of the Island]. *'These are:- La Roque Tower, Auvergues House, St Peters Church, St Mary's Church, Windmill near St Ouen's Church (above St Ouen's Bay). Of these only St Peter's Church was used in the Principal Triangulation.* Other stations were Noirmont Signal Post (G), Fort Grey signal station ((Y), St Samson's Church (A), Fort d'Etac (W). *'The sides of those Triangles, which appear to be drawn coarser than the others are those selected for fixing the Position of Soundings and dangers in the Offing, by approximate Angles.'* The triangulation, foresights only, extends far off shore.

The 1812 RRB identifies the triangulation stations which were used in the Principal Triangulation including Grosnez (D).

PRINTED CHARTS

OCB L 1823 (Stamped 'ORIGINAL MASTER'):

"A Survey / of the / Island of Jersey, / and its Surrounding Dangers" / By Capt. Martin White, R.N."

Published according to Act of Parliament by Capt. Hurd R.N. Hydrographer to the Admiralty, June 26th 1821. J.Walker Sculpt.

The chart is c.62cm by c.95cm It includes the Pater Nosters and Les Écréhous Its approximate limits are:

49° 19' 30" N

49° 07' 30" N

1° 50' 55" W.

2° 19'15"W

There is no linear scale but that based on the latitude is c. 1;37,000. ^{There} ~~The~~ is a short key to the symbols and a longer *"References to the Leading Marks - Bearings Magnetic"*

Although the chart is stamped 'ORIGINAL MASTER' there is the following MS note along the bottom margin:- *"The New Work on this sheet appears in Red Ink, and is corrected to 31st August 1839. Martin White Capt. R.N."* The corrections/additions are mainly sailing directions, apparently in White's hand and added to the printed chart some nine years after his settlement in Jersey but before his official retirement in 1846. He was obviously still actively amending his charts and sending the corrected versions to the Admiralty.

Subsequent printed versions are dated ...

' The Rough Chart of Guernsey, Herm, Sercq ' (UKHO 824 5f. 1813)

The chart is unsigned but similar in style to White's other charts of the Channel Islands. The chart is undated but the Variation (25°37' W) is for May 1813. The pencil graticule of squares by which the chart detail was plotted remains and it appears to be a 'clean' plot of a working chart. The chart is badly creased but is c 83cm. by c 140cm. Only part of the linear scale of nautical can be seen but using White's nautical mile the scale is c 1:24,300.

This fully detailed chart is coloured in the same style as White's other charts. There is very little inland detail, no fields etc. (compare Jersey) but some land relief, blue for valleys, slopes etc., red for rocks, yellow for sand etc. There are soundings, bed rock details, tidal currents etc. 'St Peter's' [St Peter Port] is shown as a couple of streets and a breakwater.

No latitude or longitude gradations are on the chart. The Parallel of 49° 29' 00" N is plotted on the chart: it lies just north of Sercq but inexplicably does not pass through any significant place. The meridian of Jerbourg Tower (close to St Martin's Point) is on the chart, its value is put as 2° 33' 36" W of Greenwich; no latitude is given.

As for the Jersey chart, that of Guernsey has the complete triangulation detail upon which it was constructed, including many offshore features. The baseline was in the north of the island, in Le Braye de Valle, a reclaimed area of marsh. The only Principal Triangulation stations were Jerbourg Tower and Noirmount Signal Post.

Printed Charts

OCB Shelf Ps* 824a.

A / Survey of the Islands / of / Guernsey, Sercq and Herm, / with the surrounding dangers / By Capt. Martin White R.N."

Published according to Act of Parliament by Capt. Hurd R. N. Hydrographer to the Admiralty August 30th 1822. J Walker Sculpt.

The chart is c. 6²/₃cm by 93 5cm. Its approximate limits are:

49° 22' 0" N

49° 34' 0" N

1° 17' 0" W

1° 45' 15" W,

There is no linear scale but that based on the latitude is c. 1:37,000. There is a short key to the symbols and longer "References to the Leading Marks - Bearings Magnetic"

'The Rough Chart of Alderney with Burhou, Ortac and the Casquets etc. Martin White, Commander'. (Chart UKHO 843 43a. 1814).

The References note that it is a Mercator chart. The chart is undated but the Variation ($25^{\circ} 15' 0.12''$ W) is for November 1814. The pencil graticule remains on the chart. The chart is c 66cm. by 300cm. The linear scale is equivalent to c 1:10,800, using White's length for the nautical mile. The chart is coloured and in the same style as for Jersey and Guernsey. It shows the complete triangulation from which it was plotted. The baseline was on the north shore intertidal area near La Braye. There are no latitude or longitude gradations on the chart.

The local triangulation stations were the Telegraph Tower (J), Le Hogue windmill (H), the windmill east of The Town (E) and the Alarrn Beacon, near Gt Monize Guard House. The Telegraph Tower (284 786.5m asl) was the only station used for the Principal Triangulation. Its parallel is drawn on the chart and is given as $49^{\circ} 45' 37.53''$ N. The 'true north' meridian is drawn through it but no figure is given on the chart. Burhou was fixed by a minor (secondary) triangulation and in the 'References' is the description of how the Casquets Lighthouse was plotted from Alderney Telegraph Tower and Sercq Telegraph.

(b)

THE PRINCIPAL TRIANGULATION

White used a very large number of trigonometrical stations, some of them Signal Stations or Telegraph Towers [7], to construct his detailed charts of the individual main islands and offshore rocks and reefs *etc.* (Fig 8-2 and CHART 8-1). He selected a much smaller number of well placed stations to establish the triangulation which was the basis of his General Charts of the archipelago and the adjacent French coast, as plotted on the chart in the 1840 RRB (Fig 8-1). These are the **Principal Triangles** [1815 chart] but there are other triangles to France *etc.* and to some of the minor rocks [UKHO 542 A, p 4].

One set of **Principal Triangles**, (**The Inter-Island Triangulation**,) linked the Channel Islands to one another; these are the thick lines on Fig 8-2. Included are the Casquets, Roche Douvre and The Minquiers, the survey pivoting on the Telegraph Tower on Sark. Triangulation to offshore shoals *etc* was sometimes by sextant rather than theodolite. A second set of **Principal Triangles** linked the Channel Islands to the coast of France. These are the pecked lines in Fig 8-2. The Iles Chausey were French and so no landing was attempted for the purpose of survey, to avoid '*jealousy*' *on the part of the French government. Observations were made from 'certain external stations' to fix the position of the group.* (1812 RRB, p 20; 1815 Appendix RB, p 9). In addition, White took the means of several [unspecified] charts for the distance between Chausey and the Gt Herpin Rock

so that the Principal Triangles could be carried on. Strangely, the 1812 RGC has British and French flags against both Chausey and Minquiers. The former is French.

**MARTIN WHITE'S FIRST GENERAL CHART of the TRIANGULATION of
the CHANNEL ISLANDS and the link to FRANCE (the Principal
Triangulation)**

UKHO 841 5k 1812 RGC (Rough General Chart), with additional data in

UKHO 542 A 1812 RRB (Rough Remarks Book) *and*

UKHO OD 537 1815 Appendix RB (Remarks Book)

This chart was clearly intended to be White's definitive chart of the Channel Islands and nearby France. In common with some of his other charts, its objectives and construction are set out in both a Title and a Cartouche. Immediately below the cartouche is:- Variation [8] for May 1813: 25° 37' W."

Cartouche(bottom left):- **'The Rough General Chart of the Islands of Guernsey, Jersey, Alderney and Sercq with the Rocks and Soundings in their vicinity upon the principles of Gerrard Mercator connected with the adjacent Coast of France Trigonometrically Undertaken in the Year 1812 by Captain Martin White, Royal Navy per order of the Right Honourable the Lords Commissioners of the Admiralty.'** (UKHO 841 5k. 1812 RGC.)

Title (top right):- **On the Principle that the earth is a perfect sphere... between the arc of the sphere and of the oblate spheroid within the limits of this construction being nearly insensible. The Mercator Chart ... of the area is constructed ...on the Principle that the Earth is a perfect sphere... The title is flanked by columns of '*Computed Latitudes*' and '*Computed Longitudes*.'** which are repeated and augmented in the 1812 RRB.

This has to be used in conjunction with the information in the 1812 RRB:-

- i). The angles measured in the triangulations (actual angles p 2- and corrected angles pp 196-217, using the logarithmic calculations of Sherwin and la Lande)
- ii). The main triangles used to fix stations on the French coast; p 112/3 latitude observations
- iii). Details of the baselines on Alderney, Guernsey and Jersey

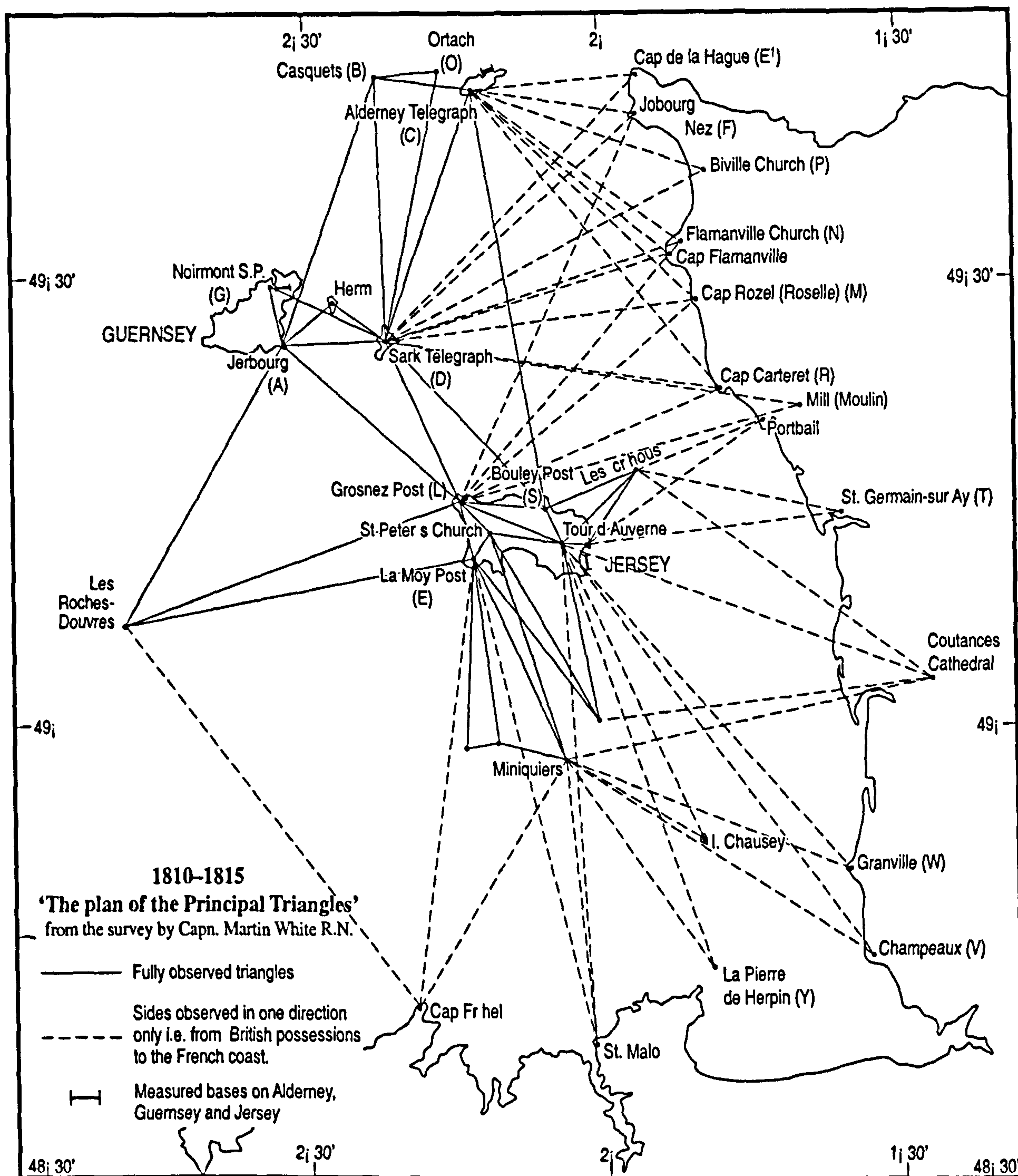


Fig. 8-2 White's detailed Triangulation. UKHO 1815 APPENDIX RRB
 Reproduced from Admiralty Publications/Charts by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office.

iv). Large scale coloured charts of Les Écréhous and Minquiers which were occupied by the survey.

The chart is very large, 146cm x 126cm, covering the area $48^{\circ} 35'N / 50^{\circ} N$ and $1^{\circ} 20' W / 3^{\circ} 10'W$, including all the Channel Islands to well beyond the Casquets, and the French coast from just east of Cherbourg to 10' west of Cap Frhel. There is a bar scale of c4.7cm to one league. White's nautical mile was slightly longer than the modern one. An

RF based on the former is approximately 1:118 000. Latitude and longitude gradations in degrees, minutes and ten seconds are in the chart margins, the longitude from Greenwich.

The Chart shows in great detail the triangulation used to plot the Channel Islands relative to each other and to the coast of France. In the 1812 RRB are listed all the measured angles (pp1-25) and corrected angles (allowing for sphericity: pp 196-217). *'The Logarithmic Calculations of the various sides and angles which constitute the Survey of the Islands... [are based on Tables by]...Messieurs Sherwin and la Lande.'* In the 1815 Appendix RB (pp 1-3), three classes of angles were identified. Angles in BLACK were those actually observed or produced by hypothensual calculation; those in RED were corrected and reduced to the horizontal; those under 'p' were produced by construction *i.e.* those on the French coast which could be observed from one direction only.

Fortunately, a small scale chart (c1:355 000) of the same area as UKHO 841 5k, plotting only the **'Principal Triangles'** is in the 1815 Appendix RRB (Fig 8-2, **CHART 8-1**), together with the location of the baselines on Alderney, Guernsey and Jersey. This Appendix book contains invaluable additional material about chart UKHO 841 5k. The **Principal Triangles** were observed from specially selected stations. One set of these triangles links the Channel Islands to one another; these are the solid lines on Fig 8-2), the survey apparently pivoting on the Telegraph Tower on Sark. White gives worked examples to check the accuracy of his observations, *e.g.* (1812 RRB) Jobourg Nez-Sercq Telegraph is 21,207.18 fa when worked from Alderney and 21,208.25 fa when worked from Grosnez, differing by 1.07fa or an error of about 6ft in c 24nm.

To the usual hydrographic material on the General Charts, White added a wealth of information on the face of the charts in the form of lengthy descriptive titles, supported by more detail in cartouches, tables of latitudes and longitudes of important places and long NOTES describing problems of chart construction *etc*, comments added to or elaborated in the Rough Remarks Books. Little of the supplementary information on the MSS charts was transferred to the printed versions. Numerous notes on and around chart surface give much additional information. The chart is coloured, very detailed in both hydrographic and trigonometrical information and is in many respects a hydrographic masterpiece. The original pencilled gradations (Mercator graticule) used to plot detail survive.

White's positions are in degrees, minutes and seconds. The positions of his 1812 trigonometrical stations are described and listed at length in **Appendix G**, together with subsequent amendments. White's most important navigational discovery was that the **'Banc Grelets'** shown on many respected earlier charts, including de la Rochette 1781[9] and Dessiou 1805,[10] as lying between Jersey and the Minquiers did not exist. (1815 Appendix RB).

The 1812 RRB lists the many stations, of varying status, occupied for the surveys of the main Islands and the fixing of positions of many offshore objects of varying size: from these were selected the stations for the **Principal Triangulation**.

THE CHANNEL ISLANDS PRINCIPAL TRIANGULATION

For Descriptions of the stations used see Appendix G

Each main Island had its own triangulation, with its own base line. Large scale coloured sketch plans in the RRBs show that numerous short, temporary bases were measured for recording in detail minor shore features, which were later used to plot the Islands' shorelines. For example, in the 1812 RRB is a plan of Grand Havre between Towers 10 and 11, with a baseline of 494.121 ft. The plan also shows the anchorage for the surveying cutter. The plan of St Brelades Bay has the MS note; '*Capt Hurd intends this to be engraved.*' showing that Hurd was closely involved with details of White's survey as early as 1812. Among similar plans is one for St Sampson Harbour. In addition there are 'eye sketches' of rocks reefs, small inlets etc; e.g. Bourd^uaux Havre (**CHART 8-2**) again often with location of surveying cutter; all this coastal detail was to be incorporated later into the chart of Jersey and similar details could be given for the other Islands. Triangulation stations were marked on the ground by small flags or station staves (1815 RRB). White identified triangulation stations on his charts by letters of the alphabet eg Jerbourg (J), Noirmont Signal Post (G), Alderney Telegraph (C), Grosnez (D). Unfortunately, he was not consistent over the whole survey and two or more stations (on different charts) sometimes share the same letter which can make station identification difficult.

CHANNEL ISLANDS' STATIONS for the PRINCIPAL TRIANGULATION.

CASQUETS LIGHTS.

ORTACH ROCK.

ALDERNEY: Telegraph.[11].

GUERNSEY:

Jerbourg or Jerbourg Tower; [St Martin's Point]; Noirmont Signal Post; [Fort St George].

HERM:

Herm Mill.

SARK (Serq):

Sercq Telegraph.

JERSEY:

Bouley Post or Telegraph; Grosnez Post; La Moye Post; [St Peter's Church]; Tour d' Auvergne; Mount Orgeuil Castle; [Fort Regent, St Helier]; Noirmont Tower.

OFF SHORE ISLETS AND REEFS:

Les Écréhous ; Minquiers; Roche Douvre.

The 1812 RRB has several large scale, detailed and coloured charts of features which would not merit a separate published chart but which were nevertheless based on a triangulation and were part of the main network. Their large scale plans are usually accompanied by a separate note saying that they were to be engraved at a smaller scale, presumably on the General Chart. Thus 'An Orometric [Orographic] Survey of the Casquets' a coloured contoured plan of the platform with the three towers and a chart of the islands, reefs etc with a bar scale in fathoms, c1:6,150. There is a full or 'Particular Description' of whole area including light houses, dwelling house, telegraph on the east of the E platform etc.

The scale of the 'Orometric Survey of Les Écréhous Rocks' is c1:20,900. It was obviously occupied and surveyed on the ground. It is fully coloured, showing rocks, sands, shingle, sea contours etc and is followed on p 42 by an 'Orometric Survey of the Minquiers' again occupied and surveyed on ground. In contrast (p 43) is reference to an 'Ambulatory draught' of the Paternosters, which suggests a reconnaissance survey only.

THE CHANNEL ISLANDS – FRANCE PRINCIPAL TRIANGULATION

WEST COTENTIN STATIONS for the PRINCIPAL TRIANGULATION.

For Descriptions of the stations used see Appendix G

The cartouche and title of the 1812 Chart state that the Islands were '*...connected with the adjacent Coast of France Trigonometrically...*' A Note rather obscurely placed in the top righthand corner of the chart reveals that '*The Whole of the French Coast as far down as Low water mark is copied from the Configuration of de la Rochette.*' [9] The war with France obliged White to use a French chart for the French coast but ^{de la} Rochette's 1781 chart was a peculiar choice, that of Dessou [10] being a more obvious choice. De la Rochette's chart gave White a passable outline of the French coast for a distance of about 180 km and his observations based on it provided the first official British attempt to place the Channel Isles in their correct relationship to mainland France (Chapter Seven).

The Principal Stations are plotted on Fig 8-2 and **CHART 8-1**.

Cap de la Hague; Nez de Jobourg; Biville Church; Flamanville Church; Cap ou Gros-nez de Flamanville; Cap Rozel; Cap ou Cor-nez de Roz; Pointe du Rozel; Cap Carteret; Mill de Bosqueville; Portbail; St-Germain-sur-Ay; Coutances Cathedral; Granville Church; Champeaux;

[Tombelane] ; [Mt St Michel]; Iles Chausey ; Herpin; St Malo; Cap Fréhel.

It has to be emphasised that White was attempting to chart, under wartime conditions, an extremely dangerous coast. The west coast of Cotentin between Pte. des Champeaux and Cap de la Hague [c100km] is most inhospitable. There are few prominent objects and it is bordered by the dangerous Iles Chausey, Minquiers etc. The tidal streams are strong and it is exposed to west and north winds. White was well aware that the coast of Brittany '*...is intricate almost beyond belief*' but added that if he were given more time he could complete the Brittany coast with only a cutter and crew and would not need any extra resources. The inaccessibility of the French coast was also, of course, reflected in the plotting of detail: '*Most of the soundings along the French coast were plotted by eye, as the objects angled were not seen*' (1812 RRB, p178).

The triangulation plotted on 1812 RGC shows triangulation sightlines between stations on the French coast e.g. Joburg Nez - Biville Church - Cap Roselle. These must have been calculated from observations from British stations.

On the small chart of the Principal Triangulation (1815 RB) are the sightlines from the Channel Island to France (pecked lines on Fig 8-2) used for the '*Angles by construction, worked out and plotted on the French coast*'. Earlier, White had presented '*The Calculations for connecting the Islands and French Headlands.*' (1812 RRB, p 202).

The triangles link selected stations of the main Channel Island network to headlands, church steeples etc in France, from Cap de la Hague in the north to Cap Fréhel in the west. As Britain was at war with France, no back sights from French stations were possible and so the results were inevitably less accurate than those of the network established wholly on British territory.

White, however, did his best, for in a letter of 24th September 1815 (1815 RRB) he states: '*Some of the positions of the French coast are counter angled from three places [in the Channel Isles] in consequence of their obliquity...I hope the objects I have fixed upon will be approved of...*'. Objects on the French coast were not always easily identified. Flamanville Church was substituted for Cape Flamanville as the latter could not be distinguished from either Grosnez or Bouley. It was sighted from Alderney and Sercq only and could not be counter-worked from the two former stations. (1812 RRB).

The Iles Chausey were French and so:- '*As it was apprehended that no landing could be attempted on the Island of Chausey, for the purpose of survey, without creating the risk of incurring jealousy on the part of the French government, certain external stations have been determined by appointing angles, for the purpose of surveying round it, from whence angles necessary for its internal construction were taken in order to fix the position of the group*'. (1812 RRB, p 20; 1815 Appendix RB, p 9). In addition, White took the means of several [unspecified] charts for the distance between Chausey and the Gt Herpin Rock

'...so that the triangles [Principal Triangles] could be carried on.' Strangely, the 1812 RGC has both British and French flags against Chausey and Minquiers.

An unusual feature of the chart is that, unlike all other French locations, White has plotted two positions for the towns of Granville, Coutances (Cathedral) and St Malo. One is calculated from his own trigonometrical survey and the other recorded on the chart as '*...according to the French Astronomical Observations*', (undoubtedly as published in the *Connaissance des Temps* for 1795). The French positions are all a short distance (c 4.0-4.5km) to SSE of White's survey position. These discrepancies were much too large to be ignored and may have obliged White to reconsider his latitude and longitude measurements at a later date and to compile a revised Rough General Chart (UKHO 817 5k).

Additional information for the 1812 chart is in the Rough Remarks Books of 1812 (HO 542 A), 1815 (HO OD 537) and 1840 (HO OD 542).

White (1812) based his plotting of the west Cotentin coast on de la Rochette's 1781 chart, which names well over 60 coastal villages and towns between Cap de la Hague and Cap Frehel. White selected 16 of these to link the French coast with his triangulation of the Channel Islands but, because of the Napoleonic war he could not land in France and so was obliged to plot them by intersection from the Channel Islands by what he called '*Angles by construction, worked out and plotted on the French coast*'. [1812 RRB.]. White sighted on churches, headlands and a few telegraph or semaphore stations.

White's desire to be as thorough as possible is demonstrated by the following extracts from a letter dated Sept 24 1815 (1815 Appendix RB; WHD 047):- the coast of Brittany is '*...intricate almost beyond conception...*' with more time he could complete the coast of Brittany and would only need a cutter and crew, with no extra resources.

'I have no doubt whatsoever that with the indulgence of a few months, I should be enabled to complete the coast of Brittany... I have every reason to think also that I could perfect this work without giving umbrage to the French government during the period that the whole coast is so lined with the Foreign Troops, the apathy on the part of the French authorities and indeed on the part of almost all the French people in this quarter seems particularly favourable for such an attempt, in the execution of which service your approbation joined with that of their Lordships, on my humble endeavours to succeed will more than repay me for the visititudes I may chance to experience, ... that with a little latitude I shall be able to effect it and on the occasion I would solicit from their Lordships a discretionary power to land occasionally on the French territory, as many of the dangers I allude to and comprised in the cruising ground between Les Minquiers and Brittany can only be seen from there. Their position could then easily be roughly estimated and afterwards verified afloat.' Permission was refused.

(C)

**WHITE'S CORRECTIONS OF LATITUDE AND LONGITUDE ERRORS
ON THE 1812 ROUGH GENERAL CHART (UKHO 841 5k)**

Soon after White (probably in 1815) had submitted his MS 1812 Rough General Chart (UKHO 841 5k) to the Admiralty, he discovered that the latitudes and longitudes plotted on the chart and listed in the 1812 RRB (p107), were incorrect. As already noted, White's positions of Granville, Coutances Cathedral and St Malo differed from those of the more accurate French mainland triangulation and this may have caused him to re-consider the accuracy of his own observations. He did in fact find an error in his central meridian, which in turn, of course, affected the latitudes. The latter also had separate errors.

Therefore, in or shortly after 1815 White hastily compiled a less detailed MS Supplement RGC (UKHO 817 5k) of part of the area covered by chart 1812 RGC, (UKHO 841 5k) correcting a serious meridional orientation error. This was reported to the Hydrographer Hurd in a letter dated 18th 2 1816 (1815 /17 App.RB: UKHO OD 537). White, anxious to make public his error, had no time to replot the 1812 chart and full revision appears to have waited until the compilation of his two 1828/1829 charts.

The revised chart

Cartouche: [Supplement RGC (UKHO 817 5k) '**Supplement to the Rough General Chart of the Islands of Guernsey, Jersey, Alderney, Sercq, Herm etc. with the Rocks, Shoals, Soundings, Tides in their vicinity upon the Principals of Gerrard Mercator as applied to the surface of a perfect sphere, and duly connected with the adjacent Coast of France, Trigonometrically, undertaken in the year 1812 by Captain Martin White, Royal Navy per order of the Right Honourable the Lords Commissioners of the Admiralty.'**

Title: '**Supplement to the Chart*** lodged in the Hydrographic Office in September 1815, Shewing the error in the direction of the meridian as deduced from the Sun.' UKHO 817 5k. [1815+ Supplement RGC.] (Fig 8-3).

**The chart referred to is the 1812 RGC (UKHO 841 5k)*

It would seem logical to discuss simultaneously the corrected latitude and longitude of each trigonometrical station but this would lead to much repetition. In the following, therefore, the problems of the latitudes and longitudes of the 1812 'definitive' chart and its 1815 provisional replacement are discussed separately.

Longitude errors.

The meticulously compiled MS chart 1812 RGC (UKHO 841 5k) was intended to be White's definitive chart of the Channel Islands and the adjacent coast of France.

As noted above, an unusual feature of the chart is that, unlike all other French locations, White has plotted two positions for the towns of Granville, Coutances (Cathedral) and St Malo. One is calculated from his own trigonometrical survey and the other recorded on the chart as '*...according to the French Astronomical Observations*', The French positions are all a short distance (c 4.0-4.5km) to SSE of White's survey position. These discrepancies were much too large to be ignored and given the acknowledged high quality of the French survey, White had to reconsider his own latitude and longitude measurements..

The 'Supplement Chart' (UKHO 817 5k. [1815+ Supplement RGC.]) is 155cm x 160cm and is surrounded by numerous NOTES. The limits are; 48° 30'N / 49° 30'N and 1° 20' W / 3° 10' W. The latitude and longitude gradations in the margins are in degrees, minutes and 15" divisions. The chart omits the northern part of chart 1812 RGC, the northern boundary passing through north Guernsey and the French coast just north of Carteret. Much of the Channel Islands and the French coast are in outline only (extending to the south of St Malo) but the Iles Chausey are coloured. There are a number of triangulation stations and sightlines. Under 'References' It is stated:- '*The General and Particular References in the Rough Remarks Book [1812 RRB] and Mercator's Chart [1812 RGC: an unusual description of it] are strongly applicable to the present Supplement, without the smallest deviation*'. but it is in no way a replacement for the 1812 RGC. This had to await until the following were compiled:-

UKHO E 827 5k. 1828/29 Reduced Clarence GC . [1815/1828]

UKHO G3 5c. 1829 Reduced GC 1826

UKHO OD 542. c 1840 RB 1834/40

The RF based on White's length for the nautical mile is c.1:118 000 (the same as for the 1812 RGC).

There are three bar scales:

Miles [nautical] divided into fathoms;

Miles [nautical] divided into Toises;

English miles reduced to geometrical [nautical] miles in ratio 60 / 69.5.

The French toise is 6.4 ft (1.94m); it is not clear why White included this scale.

The main purpose of the chart was to plot the '*Meridian of Alderney Telegraph as deduced from the sun and as determined from the Polar Star...*' (and to correct) '*...the Error in the direction of the Meridian as deduced from the Sun.*' The two meridians are drawn on the chart, but for some inexplicable reason, the chart's northern boundary passes through

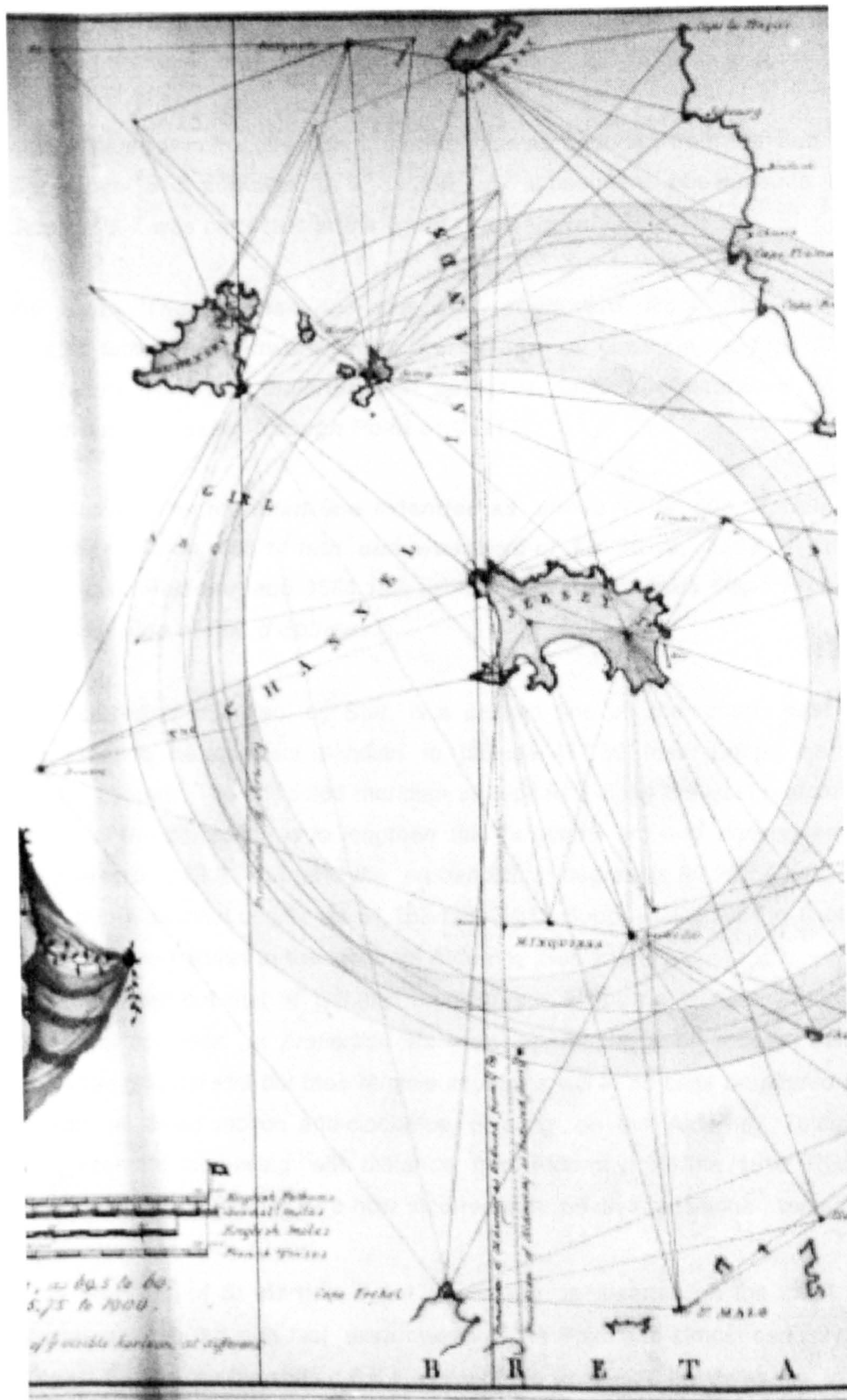


Fig. 8-3 White's Two Meridians.

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north Guernsey and just north of Carteret and so does not extend far enough north to include the Alderney Telegraph! The two meridians are still converging when they cut off by the northern edge of the chart. Their positions are presented in great detail. White deduced the divergence of the two meridians as $1^{\circ} 22' 15''.38$. ARE

In fact the error in the direction of the meridian as deduced from the Sun was suspected in December 1813 and was $1^{\circ} 9' 39.380''$ by subsequent observations at Guernsey and Jersey but it was corrected to the figure given above.

By Sun:- 'The meridian line extended southward from Alderney Telegraph falls 244.78 fath. due westwards from the station on Grosnez heights, 3345.903 fath. due westward from Les Maisons and 2076.184 fath. due eastward from Cape Frehel lighthouse, passing through Point St Cast.'

By Star:- 'The meridian line extended as above falls 404.57 fath. due eastward of Grosnez Station, 458.14 fath. due westward of La Moye, 2269.01 fath. due westward from Les Maisons and 3588.102 fath. due eastward from Cape Frehel, passing near the west side of Isle d'Ebiheus.'

The corrected meridian, by Star, is a pecked line on the chart, east of the solid line representing the incorrect meridian. In latitude $48^{\circ} 30'$ [near Dinan] the two meridians are about 2' apart. The corrected meridian is repeated along the east margin of the chart. *'The effect of the correction is to lengthen the Terrestrial arc and consequently the meridional degree is 60,983.3 fath. and the perpendicular degree is 60,908.4 fath.'* Elsewhere White puts the meridional degree as 61,159 fath (1815 Supp. RGC). All the lines of longitude on the chart are parallel to the incorrect Alderney 'Sun' meridian.

White pointed out that *'It will also more or less affect the latitudes and longitudes of the different positions, in proportion as they approach to or recede from the [corrected] meridian and parallel but their relative situations will in no case be altered thereby.'* In other words, all detail moves anti-clockwise, pivoting on the Alderney Telegraph Station, the displacement increasing with distance from Alderney. All the 1812 RGC and 1812 RRB latitudes and longitudes are now incorrect but relative positions remain unaltered.

The 'Meridian of St Martin's Point', Guernsey, is inserted on the chart and named in the bottom margin but is in fact drawn west of the Point and almost certainly through Jerbourg Signal Station, on the cliffs c 0.8 km NW of the Point. White gives no value: measured on the chart it is c $2^{\circ} 33' 40''$ W. In 1812 White measured it as $2^{\circ} 33' 36''$ W. As noted above, all meridians are parallel to the uncorrected meridian and why that of St Martin's Point should be singled out remains unclear.

As noted earlier, White used both astronomical (lunar) methods and chronometers to measure longitude. Barometric records were kept for the regulation of chronometers (UKHO Ad. Lib. Va.I). He lists a number of longitude measurements using Arnold watches

(chronometers) nos 326 and 410. For St Aubin's Castle the mean of six measurements was $2^{\circ} 9' 37.158''$ W, within $1'11''.832$ of the mean lunar distances.

Latitude errors. UKHO 817 5k. [1815+ Supplement RGC.]

Latitude problems originated with the unreliability of the Gilbert sextant initially issued to White. He emphasised this at a later date (UKHO E 827 5k: 1828 Reduced Clarence GC: Note A)... *latitudes measured with it were more or less affected...*. This he had found by comparing the latitude of St Aubyn's Fort using Gilbert's sextant with his own *'very good but since lost'* sextant when on *HMS Vulture* in 1809; $49^{\circ} 13' 13''.9$ N and $49^{\circ} 10' 52''.2$ N respectively, a difference of $2' 21''$. *'If such a quantity [2' 21"] therefore be deducted from the Guernsey base as well as such Latitudes as have been found by observation with the Gilbert] sextant, the latitudes will successively approximate very near the truth.'* (1828 Clarence GC: Note A: UKHO E 827 5k:). This recalls the earlier comment in the 1815 App.RB (OD 537) that, because of the weight of supporting the Gilbert instrument, White suspected an error of $2'45''$ *'...which has always been allowed for.'* The $2' 21''$ error was in addition to this, which made the Gilbert sextant very unreliable. White's latitude for the Iles Chausey was $2' 2''$ N of that by Capt Brown of the sloop *Sapphire*, *'whose sextant is certainly one of the best'* (1812 RRB, p113: UKHO 542 A).

On the 1812 RGC (UKHO 841 5k) White plots two latitudes for Coutances Cathedral, Granville and St. Malo. He says that he does not exactly agree with the latitudes [and longitudes] as determined by the French astronomers professional that he was, he obviously felt obliged to put both his and the French positions on his chart and quantify the errors: *'... my latitude of Coutances Cathedral as carried on by the Triangles being about $2' 30''$ N of that given by the French astronomers and St Malo being $2' 06''$ to N.'* (1812 RRB, p 112/3: UKHO 542 A). Subsequently (1815 App. RB; letter 24 9 1815; UKHO OD 537) White listed the latitude differences as:-

Coutances	$2' 36''. 21'''$
Granville	$1' 45''. 16'''$
St Malo	$2' 06''. 5'''$

White set about tracing the cause of these discrepancies. They may have arisen because of an error in his latitude of St Martin's Point, Guernsey. He measured the latitude of St Martin's Point by the Sun's Meridian Altitude over a period of three days and concluded that it was $49^{\circ} 27' 20''$ N. (1812 RRB p105). The Point was the linch-pin of his survey, as later he calls it *'...the point of departure or 1st parallel.'* (letter 24 September 1815; 1815 Appendix RB). Part of his problem arose because he used St Martin's Point as the latitudinal base for his surveys but used the Signal Station for the celestial longitudes measurements. St Martin's Point was one of Martin White's main astronomical sites.

He discovered later that he had placed the Point 2' 21" too far north by his own reckoning. It is very surprising to read, long after White had completed his survey, that *'This reduction of 2' 21" would have been made originally [on the 1812 chart] but my lamented friend Capt. Hurd, [Admiralty Hydrographer] no doubt for good reasons, deemed it irregular.'* (1828 Clarence GC; Note A).

It is a mystery why White used St Martin's Point as his '1st parallel'. The Point is only a few feet above sea-level, it was not a triangulation station because of its extremely limited visibility *vis a vis* other stations and on high ground only a short distance to the north lay the Jedbourg Signal Station (c 98m). This well-known land and sea mark and triangulation station would appear to have been a more suitable site for latitude observations. In fact the meridian through the Jerbourg station is inserted: c 2° 33' 40" W, as measured from the gradations on ^{the} chart. The choice of latitudes drawn on some of White's charts seems to be arbitrary. Thus on the 1815 Guernsey chart (UKHO 824 5f) only 'The Parallel of 49° 29' 00" ' is plotted and named. It lies just north of Sark but inexplicably does not pass through any significant place.

Along the bottom of the chart UKHO 817 5k. [1815+ Supplement RGC.] is a pecked line drawn at right angles to the corrected longitude: 'The parallel answering to the corrected meridian.' but all the other parallels on the chart remain uncorrected, (ie at right angles to the uncorrected meridian), as is all the 1812 chart detail. The 'corrected parallel' was not plotted on the 'plan of Principal Triangles' (UKHO OD 537. 1815 Appendix RB).

Having completed his 1812 'definitive' and 1815 'corrected supplement' charts of the Channel Isles, White was transferred in 1817 to *HMS Shamrock* to survey parts of the English and Irish Channels. While on the *Shamrock*, however, he was required to compile two more charts of the Channel Islands and paid short visits to them in 1821, 1823 and 1826, before compiling two charts dated 1828/29. On these charts White emphasised that latitudes and longitudes had been corrected.

PHASE 2

MS CORRECTED CHARTS (1828-1829)

(Cartouche) Captain Martin White's Chart of the Channel Islands and coast of France adapted to the scale directed by the circular dated 1828 of His Royal Highness the Duke of Clarence submitted with great deference & respect to

the Right Honourable the Lords Commissioners of the Admiralty. [Reduced

Clarence GC: UKHO E 827 5k]

(Title) This Chart has been reduced to its present limits from the original Manuscript* in pursuance of a Circular of His Royal Highness the Duke of Clarence, dated 28th. June 1828. For References [ie key] vide Original Chart* and for the Set of the Tides vide the Printed Sailing Directions.**

* The 1812 RGC.

** This comment raises a dating problems. White's 'Sailing Directions for the English Channel...and a Detailed Account of the Channel Islands'. were first printed and published in 1835. There is a reference to 'The Printed Prefactory Remarks' in Note B on the Chart. Jamieson (1986, p423) 'In 1822 White produced his sailing directions for the English Channel, including the Channel Islands...'. These 'Sailing Directions' have proved elusive but would have been available to White when compiling the chart [Reduced Clarence GC: UKHO E 827 5k]. The accepted printed first edition of the Directions would post-date the chart by seven years. The wording of the chart's cartouche and title leave little doubt that it was compiled in 1828. The UKHO Data Centre has kindly informed the writer that in its archives printed Sailing Directions (ref. Ua1) page 339 is of Channel Island latitudes and longitudes from a possible early version of Sailing Directions. There is no title page. Its suggested date 1818 is based/a reference in the first letter book (ref. LB1). Regrettably the writer has been unable to resolve this conflict of evidence.



Fig. 8-4 Site of White's base-line, Royal Bay Jersey, looking south from Fort William.

On the chart is a Table of the positions of eight of the primary trigonometrical stations in the Channel Islands and most of the stations on the French coast. The title is : **Latitudes and Longitudes corrected for the Flexibility of Gilbert's Sextant Error in direction of the original Observations.**(i.e. those on chart 1812 UKHO 841 5k). **Differences between the lunar Observations and the chronometer is 1' 11.832".**

These corrected Latitudes and Longitudes are given in the descriptions of the Principal Triangulation Stations (refer to Appendix G).

Note B (UKHO E 827 5k).

'On the error in the direction of the original Meridian deduced from the Sun'.

'The error in the direction of the meridian Originally deduced from the Sun and particularly described in the original manuscript chart [UKHO 841 5k] has here [UKHO E 827 5k] been corrected and to this corrected Longitude 1' 11.832" has been applied minus generally, because the mean Longitude of St Aubyn's Fort, as found by lunar distances, and that found by Chronometer differed exactly that quantity vide last page in the Printed Prefactory Remarks [Sailing Directions] now in [Hydrographic] Office.' In a different hand *'This reduction would have also originally been made but Capt. Hurd's opinion was against it.'*

The chart is 156cm x 134 cm. Latitudes are graduated in degrees, minutes and 15 second intervals, longitudes in degrees, minutes and 30 second intervals. Both are drawn across the chart at 10' intervals. There are numerous leading lines plotted but there is no triangulation information. The magnetic variation (23° 56' W) is for April 1828. The chart extends from north of Alderney to south of St Malo and west to Roche Douvre. The Channel Islands are in fully coloured detail, as is the coast of France from Bec d'Agon to St Malo but in outline only west of St Malo and north of Bec d'Agon. There are several coloured coastal profiles e.g. south of Granville.

Note in bottom margin:- *'The coastline as far down as Low Water mark and stated on the Original Manuscript [1812] to have been copied from de la Rochette is again copied here, except that those parts thereof which are shaded, have been regularly surveyed, [i.e. Gremouville Church near Coutances to St Malo]. the part copied are left in outline.'* The scale (using White's nautical mile) is c.1:146,500, smaller than that of the 1812 RGC or the 1815+ Supplement RGC. Hence the reference to it as the 'Reduced Chart'. A reduced chart was probably requested because of the large size of the 1812 original.

The positions of five of the primary trigonometrical stations in the Channel Islands and most of those in France are listed in a Table on the chart, with the following comment:-

'NOTE. Some differences will be found between the Latitudes and Longitudes in the Table [on this chart] and those contained in my Reduced Chart [UKHO E 827 5k

1828/29. Clarence] sent to the [Hydrographic] Office in February 1829.' This clearly dates the present chart as later than February 1829.

There are two long Notes. NOTE A refers to latitude observations and NOTE B emphasises that the error in the Original Meridian, first plotted on the 1815 Supplement Chart, has been corrected on this chart.

What appears to be White's last MS chart of the Channel Islands is:-

'Copy of Captain M. White's Reduced General Chart of February 1829 Augmented to the original scale of 1826 and submitted with great deference and respect by their Lordships obedient and faithful servant MARTIN WHITE Captain Royal Navy.' (UKHO G3 5c: Reduced and Augmented G C).

(Fig 8-5)

Dating this chart presents problems.

- i) The 'Reduced General Chart' (UKHO E 827 5k) is dated 1828 three times but according to the above it must have been submitted to the Admiralty in February 1829.
- ii) This 'Reduced ... Augmented ' chart (UKHO G3 5c: Reduced and Augmented G C). is undated but the Variation ($23^{\circ} 50' W$) is for April 1828. However, a Note on this chart, refers to another (probably UKHO G3 5c *supra*) sent to the Hydrographic Office in February 1829, so this chart must post-date February 1829.
- iii) There is no bar scale but from the latitude gradations (using White's nautical mile) the scale is c.1:122,000, close to that of the 1812 RGC (c.1:118,000).
- iv) The title continues 'Augmented to the original scale of 1826...' There appears to be no chart dated 1826 in the Martin White archive in the Hydrographic Office; it may now be lost. The real 'original scale' was, of course, that of the 1812 RGC and as the present chart's scale is close to it, it is provisionally assumed here that either the 1826 date is incorrect or that a now lost chart of 1826 had an RF scale of c. 1:118.000.
- vi) The positions of five of the primary trigonometrical stations in the Channel Islands and most of those in France are listed in a Table on the chart, with the following comment:-

'NOTE. Some differences will be found between the Latitudes and Longitudes in the Table [on this chart] and those contained in my Reduced Chart [UKHO E 827 5k 1828/29. Clarence] sent to the [Hydrographic] Office in February 1829.' This clearly dates the present chart as later than February 1829.

The NOTE continues: "These [lat & long] are all calculated Spherically, taking the original radius 21024960 ft., the reciprocal differences in the Latitude of Mt St Michel and Cape Fréhel (whether the Earth be taken as a Sphere or as a Spheroid whose arcs are as 229 to 230) is only $1''.2$ and in the Longitude $1''.4$. Cape Frehel was one of White's triangulation stations; Mt St Michel was never observed by him but it was an important French station and White may have extended his calculations to include it. 'The

small differences of latitudes and longitudes between these two charts are to be found in the trigonometrical stations in the Notes 1 and 2 (~~p.1~~)'.

White, perhaps because he did not have the MS 1812 RGC to hand (he was Commander of *HMS Shamrock* in 1829 but did not visit the Channel Islands after 1826), enlarged a copy of the 'Clarence' reduced scale chart to approximately the larger scale of the 1812 RGC and submitted it to the Admiralty. The need for the larger scale is not known. The pencil graticule used to plot chart detail has survived, but varies in orientation, suggesting that the chart was plotted by more than one person or from different charts..

The user is referred to the 'Original Chart' for the 'References' or key to the symbols etc. The same phrase is used on the Reduced Clarence GC and must refer to the 1812 RGC.

The chart is c130cm by 92cm, whereas the 1812 RGC is 146cm x 126cm. That the two cover approximately the same area is partly accommodated by the 1812 RGC being slightly larger in scale. There is little inland detail; only that which could be seen from ~~THE~~ coast. Relief on the Islands is in shades of blue. There are no trigonometrical stations or rays on the chart and none are listed. In the margins are gradations for latitude (degrees, 5 minutes and 15 seconds) and longitude from Greenwich (degrees, 5 minutes and 10 seconds).

In addition to slight discrepancies^{ies} of latitudes and longitudes^{ies} the 'Reduced' and ~~ON~~ 'Augmented' charts, White's corrected latitudes and longitudes still differed slightly from the French:-

(on chart):- *'Differences between the position on the chart and those of the French Connaissances des Temps of 1791 and 1827'.*

1829	Lat. diff.	Long. diff.
Coutances Cathedral	2".3	26".9
Granville Church	5".1	6".0
Mt St Michel	8".2	10".22
Cape Frehel	27".0	1".7

[compare 1812 latitude differences]

Coutances	2' 36". 21"
Granville	1' 45". 16"
St Malo	2' 06" 5"

The positional differences could be the result of slight inaccuracies^{ies} in observations or of specifying the exact trigonometrical station. In the above the French appear to have used the church, White the lighthouse.

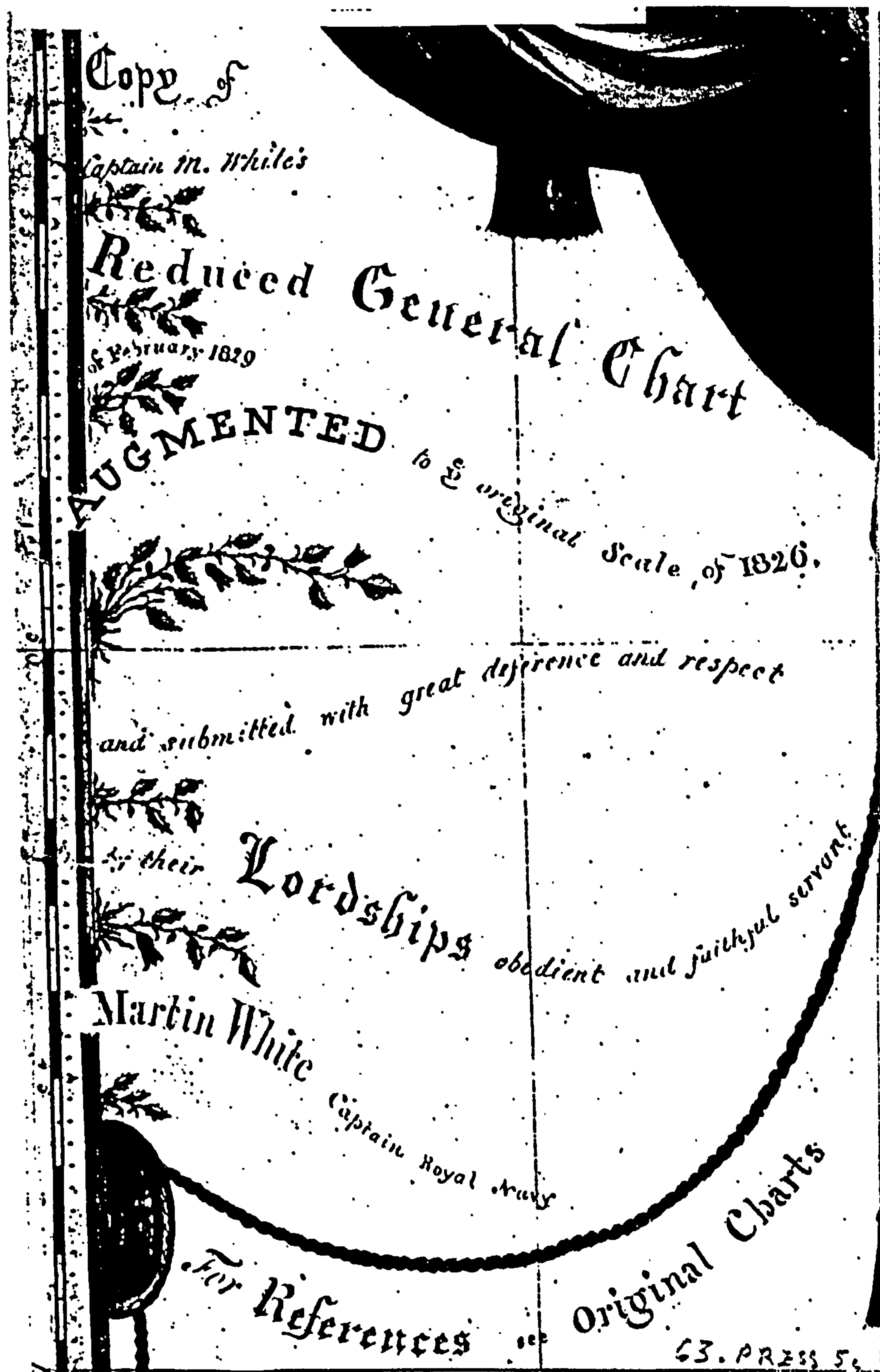


Fig. 8-5 Detail of Cartouche, RGC 1829, Augmented 1826.

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Granville 'last French authorities' [1827]:- 48° 50' 16" N, 1° 36' 36" W.

1840 RB: Martin White: :- Granville LH 48° 50' 8".2 N, 1° 37' 10".9 W

1835 Sailing Directions. 'Granville' 48° 52' 1".16 N 1° 36' 42".16 W.

White subsequently produced 'corrected' lists on his charts of 1828 and 1829, in the c1840 RB (UKHO 542) and finally in the c1829-30[?] original and 1835 official **Sailing Directions**. Latitudes and longitudes for selected places are in Tables published in White's first edition official **Sailing Directions** (1835; p.223). They are presumably White's definitive values. The 28 entries in the 1835 **Sailing Directions** Tables distinguishes [✓]by symbols, latitudes *are* deduced from the Sun's altitude, longitudes by chronometers, and positions fixed trigonometrically (latitude and longitude).

White used another interesting technique for measuring distances in addition to triangulation, which was not uncommon in the early and mid 19 th. Century (1812 UKHO 542A, p109). He records that on 1.1.1814 the distance between Castle Cornet, Guernsey and the Casquets was determined by the interval between the flash and the report of the former's Sunset Gun as 16.40 miles, compared with 16.45 miles by the trigonometrical survey. The next a similar observation gave the distance between the Casquets and Alderney as 7.29 miles by flash and sound of gun; it being trigonometrically. 7.269 miles.

PHASE 3 1821-1869

PRINTED CHARTS of the CHANNEL ISLANDS and the adjacent FRENCH COAST

The Hydrographic Office has both 'master copies' and microfilm copies of White's printed charts, the latter making it very easy to trace successive editions and revisions. The Admiralty published White's survey of Jersey in 1821[12] and Guernsey in 1822. The first official chart of the Channel Islands and adjacent French coast chart was in fact published on two sheets:

No 58 (1824-1857) covering the area north of the latitude of Cap Carteret

No 59 (1826-1848) covering that to the south of the Cap.

(These were later combined into one sheet, No 2701, 1860-69, which was not based on White's surveys.)

OCB 58 SERIES A.1.

'A Chart of the Coast of France from the Isle de Marcouf to Cape Carteret (copied from French Publications) including the Islands of Guernsey, Alderney, Serq and Herm with the Rocks and Shoals etc. in their vicinity, from the surveys of Capt. Martin White R.N.'

'London. Published according to Act of Parliament by the Hydrographic Office of the Admiralty 28th December 1824. Additions to Jan. 1831.' [according to the numbering, the UKHO does not apparently possess a copy of the 1824 unrevised, chart].

Britain and France had been at peace since 1815 and so it was to be expected that the two countries would share their surveys, as White and the distinguished French hydrographer C F Beautemps-Beaupré had formed a close working relationship. This would include the French coastal survey for the 1824 chart (WHD 060: 'Letter of effusive praise from M. C F Beautemps-Beaupré, Hydrographer of the French Navy, to Martin White.' 3rd Jun 1829. [Letter No 10 – PRO ADM 9 /959].

The chart is c 62cm x c 96cm. Over half is occupied by the northern part of the Cotentin peninsula, extending eight km off its eastern coast to the Isle de Marcouf. Of the Channel Islands, only Alderney, Guernsey and the north part of Jersey are included. There is no bar scale but based on the length of 10' of latitude it is c 1:118,700. [cf 1812 chart: 1:118 000 and 1829 chart: 1:122 000] Latitude is by degrees, minutes and six second intervals; longitude (from Greenwich) by degrees, minutes and ten second intervals. The chart of course includes detailed soundings, nature of seabed, leading lines, navigational hazards etc. What is surprising is that the chart is dominated by the inland detail on the Cotentin peninsula.

The peninsula has obviously been copied in full from a topographic map, showing far more inland detail than is required on a chart. The 'French Publications' are not identified. The chart pre-dates the publication of the relevant sheets of 'Les Cartes de France L'État Major', published in the 1840s (e.g. Les Pieux 1843, Barnville 1843 and Granville 1841). The most likely source was the relevant sheets of:-

CÔTES de FRANCE Dépt de la MANCHE depuis Isigny et le Gd Vary jusqu'a CAP CARTERET [sheet 6] and Cap Carteret jusqu'a l'île de Embiez [sheet 7] d'après les Plan levés en 1727 par La Coudre-la Bretonnière Lieutenant de Vau et Machain Astronome Hydrographe de la Marine. Publie ...Dépôt des Cartes et Plans de la Marine 1792. c63cm x c96cm. The scale is c 1:112 242. There is considerable marine and topographic detail on each sheet.(Cambridge University: maps:Atlas 176.9).

The only other detailed topographic maps of the peninsula would appear to be the obsolescent Miraldi-Cassini 'Nouvelle Carte de France.' Its sheets 125, 126 and 127 cover the west coast of the peninsula and were published c1767. There is a surprising amount of terrestrial as well as maritime detail. The relief is by hachures. Survey stations later used by White are plotted e.g. on Alderney the 'Govt. Telegraph and Tower'; on Guernsey Jerbourg 'Tower' and 'Varde Noirmont'; on Jersey the 'Signal Post' on 'Gros Nez Heights', plus roads, settlements etc.

A.01. Published 9th April 1860; No Cotentin detail; No C I Hachures.

A.02. Corr to 1861.

A.03. Corr to Oct 1863.

A.04. Corr to Dec 1865 (67)

A.05. Corr to Dec 1865 (68)

A.06. Corr to Dec 1865 (69)

Having lasted until 1869, with constant revision, Martin White's surveys of the Channel Islands and the adjacent French coast were replaced. The basic MS is the '**Channel Islands triangulation sheet by Cmdr F W Sidney [13], Staff Cmdr J Richards [14] 1859-1868**' UKHO A1958 43a [1863], upon which was based **OCB CHART 2669 SERIES**, first published in 1869 in three sheets. [15]. [16].

PHASE 4 (see Chapter Nine)

Strictly speaking no 'Bench-Mark' surveys were made in this Phase but as it was a time when each country acknowledged using the surveys of the other, a short summary of events is included here. Napoleon was sent to St Helena in 1815 and the ensuing peace totally changed the attitude of the two previous combatants to hydrographic surveying in this region; collaboration became possible. White's name and contribution was acknowledged on some French charts and on his printed charts he acknowledged that the hydrography of the French coast was from 'French sources' *i.e.* official French charts and Sailing Directions.



Fig. 8-6 St Catherine's Breakwater.
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END NOTES

1). Warren (1962 p163) has unfortunately confused two Captain Whites in his account of the maps and charts of Guernsey: *'I believe that Capt. M. White, like Capt. Deschamps, served as Harbour Master at St. Peter Port. In 1810 he was in charge of a signal station at Jerbourg...'* It is clear from contemporary newspaper accounts (eg the Star March 21, 1901) that Warren was referring to Captain William Pitts White R.N., wounded on active service and in charge of the signal station 1810-16. He made a painting of the station in 1810 (fig.). His Log of ships passing the station includes three references to HMS *Vulture* between 1810 and 1814. William White died in Guernsey in 1846; his descendants still live on the island.

2). Some additional information on White's charting is to be found in the Captains' and Masters' Logs (PRO ADM 51 and 52). Dawson (1885) notes that White's *'... assistants who afterwards shone forth in the same sphere, were Denham and Kendall.'* Denham probably drew some of White's MS charts, as the style is the same as that of Denham's own later work.

3a). Sherwin:- Henry Sherwin (fl. 1705-17) mathematician. Sherwin's mathematical tables were used for 70 or more years.

La Lande:- Joseph Jérôme Le Francis de (1732-1807) French astronomer. From 1795 was director of Paris Observatory. Chief work *Traité d'Astronomie (1764-1792)*

3). Lockwood , Master RN. UKHO m17 Pr* . MS dated 1805 gives details of base line measurement and triangulation of Guernsey, Jethou and Sark.

CAREER 4). The Duke of Clarence, 1765-1837, was originally Prince William, son of George III. His naval career was undistinguished. A midshipman in January 1780, he was a captain by April 1786. In May 1789 he was created Earl of Munster and Duke of Clarence and St Andrews and in December 1790 was specially promoted to Rear-Admiral. This ended his 11 year naval career, nine of them on active service in the Channel, Gibraltar, New York, the West Indies etc. He was a great friend of Nelson, was well read in naval history and maintained an interest in the navy.

Nominal promotions eventually made him Admiral of the Fleet and Commander in Chief in 1811. The Duke flaunted his unwarrented rank on many occasions. Heir to the throne in January 1827, he later made himself Lord High Admiral and First Sea Lord. It is no surprise, therefore, that Captain Martin White readily provided him with a copy of the Channel Islands chart in June 1828, possibly because at the time the Duke had put himself in command of the Channel Fleet. This rash act was followed by a period of obscurity. On 26th June 1830 the Duke succeeded to the throne as William IV.

(DNB, v.21, pp.325-31).

5). The Gilbert family (Taylor 1966, pp. 159,262,393) were instrument makers at least from 1726, when John Gilbert (snr. fl.1726-63) of Tower Hill was referred to as making a 'most accurate' 'Portatories' for Biester. This Gilbert was the father, or possibly the uncle, of John Gilbert jnr. (fl. 1767-94) who succeeded to the business at addresses on Tower Hill and St Paul's Churchyard. He was in partnership with other well-known instrument makers on Tower Hill. It is almost certain that his son William, apprenticed to the same trade in 1794, was the Gilbert who made Martin White's sextant. In 1820 William with Thomas Gilbert (trading as Gilbert and Son), became mathematical instrument makers to the East India Company. Given the Gilberts' reputation, it is surprising that White found so many faults with his sextant. Possibly it was in need of repair before it was issued to him; cf his problem with the Gunter chain issued at Portsmouth. Is it possible that White was not highly regarded in the Naval Surveying Service and was not issued with the best instruments?

6). Taylor (1966) lists several Adams who were mathematical instrument makers etc. Of them, two seem to be possible candidates for White's theodolite: John Adams 1757-1807 (p277) and Dudley Adams c1760-1826 (p 303). The former was a Navigation Teacher at Edmonton, and wrote about the compass and compass variation. The latter was an optician and mathematical instrument maker, variously at Charing Cross, Jewery and Fleet Street. He was the younger son of George Adams (c1704-730 who was instrument maker to George III. In neither case does Taylor refer mention theodolites as among the instruments made.

7). See Chapter Seven.

8). Variation or magnetic declination is the angle between the bearing of the magnetic north pole and that of the true North pole at the position of the observer. It is named east or west according to whether the direction of the magnetic pole lies to the right or left respectively of the true pole. (Kemp 1988, p.908.)

9). See Chapter Seven.

de la Rochette's chart of 1781 (also recorded as L.S. de la Rochette, L.S. d'Arcy de la Rochette, or Louis Stanislas d'Arcy Delarochette: 1731-1802) was a French cartographer and engraver associated with the English map publisher William Faden, who published:- 'A Chart of the Islands of Jersey and Guernsey Sark, Herm and Alderney: with the Adjacent Coast of France, by L.S. Rochette. MDCCLXXXI.' 'London: Engraved & Published ...Jan 1st 1781 by W Faden...'

Tooley 1979 pp.156 and 377; copies in Priaulx Library, Guernsey and BL

10). See Chapter Seven.

DESSIOU'S CHART OF 1805

'Laurie and Whittle's Chart of the Coast of France from Cherbourg to Brehat Is. Including The Islands of Guernsey, Jersey, Alderney, ... Compiled from the Trigonometrical Surveys of Machain and Others, By Joseph Dessiou.'

'Published as the Act directs, by Laurie and Whittle, No.53 Fleet Street, London. May 17th. 1805.'

Guille-Allès library Guernsey.

11). ALDERNEY:

Sailing Directions c1830: 'The little island of Alderney (Aurigny) is only 3 miles and one third in length from east to west and not more than one mile where broadest, which is at its SW end.

The Government Telegraph thereon is situated in latitude 49° 43' 40".45", longitude 2° 50' 47".09" from Greenwich and is 276 feet above the level of the sea.'

12). OCB L 1823 (Stamped 'ORIGINAL MASTER):-

"A Survey of the Island of Jersey, and its Surrounding Dangers" By Capt. Martin White, R.N."

Published according to Act of Parliament by Capt. Hurd R.N. Hydrographer to the Admiralty, June 26th 1821. J.Walker Sculpt.

Although the chart is stamped 'ORIGINAL MASTER' there is the following MS note along the bottom margin:- '*The New Work on this sheet appears in Red Ink, and is corrected to 31st August 1839. Martin White Capt. R.N.*' The corrections/additions are mainly sailing directions, apparently in White's hand and added to the printed chart some nine years after his settlement in Jersey but before his official retirement in 1846. He was obviously still actively amending his charts and sending the corrected versions to the Admiralty.

13). OCB Chart 59 SERIES A.1.

'The Coast of France from Cape Carteret to Cape Fréhel including the Island of Jersey by Capt. Martin White.'

'London. Published according to Act of Parliament by the Hydrographic Office of the Admiralty 1st May 1826. [Corrected to 1831].'

From state A.4. (corrected to 1840) to State A.7 (Corrected to 1848), it is recorded that the chart was '*Corrected by Captain White*'. In 1848 White had been retired two years and had lived in Jersey some 18 years but was obviously in close touch with the Admiralty, revising charts. On the HO 'Original Copies' White's corrections were added in red.

13 ~~14~~). PRO ADM 9/54 3705. F W Sidney

14 ~~15~~). PRO ADM/9/50 3400 J Richards

15 ~~16~~). In 1913 the Ordnance Survey updated its triangulation of the Channel Islands, which disagreed with the UKHO charted positions.. After a lengthy correspondence the charted positions were amended. ((UKHO B 10; Geographical Positions). The Ordnance Survey had further doubts about the Islands' position in 1934, when Winterbottom, the current DG, wrote to Close, a former DG, about a possible error of a $\frac{1}{4}$ mile in the longitude of Jersey. (11 8 1934. PRO OA 1/112 CR 9483) . $\frac{1}{4}$

Unfortunately these intriguing topics cannot be pursued here.

Chapter Nine

Channel Islands 1829 - 1980

Within
~~In keeping with~~ the parameters of the thesis, the 'bench-mark' surveys of the Channel Islands *surprisingly* began and ended with Admiral Martin White's 1803-1812 survey, pursued in spite *of* Anglo-French hostilities. As ~~it~~ with the Isles of Scilly and Graeme Spence's 'bench-mark' survey, so in the Channel Islands, other surveys followed White's pioneering work. Those selected for brief comment here are:

1829: WHITE, DAUSSEY and BÉGAT

1818: 'ANCIENNE' TRIANGULATION

1859-69: SIDNEY & RICHARDS

1942-3 : GERMAN OCCUPATION

1980: CHANNEL ISLANDS & FRANCE

Much of the following is based on ~~the~~ ~~the~~ *Nouvelle Description Géométrique de la France. Tome V11. 1840; Annales Hydrographique 4th Series V 1 1951; Rolle tDe Lisle Etude Historique et le service hydrographique de la mer 1814-1914; Board Sheetines No. 47, pp39-45; Correspondence with the French Hydrographique Service; the UK Hydrographic Office.*

THE WHITE, DAUSSEY AND BÉGAT SURVEY, 1829

(Fig 9-1)

(The 1828/9 locations in Appendix G refer to this survey)

A comparison of Chart Fig 9-1(1829) with that in Fig 8-1(1812) might suggest that the former ought to be the 'bench-mark' survey. In the writer's opinion, however, White's war-time triangulation was the first official attempt to locate the Channel Islands in relation to the French mainland and that the 1829 survey is a derivative of the earlier one.

The first reciprocal triangulation link between the Channel Islands and mainland France came in the more peaceable era which followed the ending of the Napoleonic Wars in 1815. It was the result of a joint venture between British and French hydrographers, the former providing a stimulus to the French effort, the latter contributing the fundamental cartographic background survey. The French surveys spanned the period 1829-1838. As Fig 9-1 shows, the French observed a coastal triangulation from Cap Fréhel to Granville and then a very detailed coastal net north from Granville to Cherbourg and beyond. Alderney, Guernsey and Jersey were linked with the French coastal network.

In 1792 the French Dépôt des Cartes et Plans de la Marine had been established, to be actively involved in hydrographic surveying from the start, unlike its British counterpart (founded 1795)

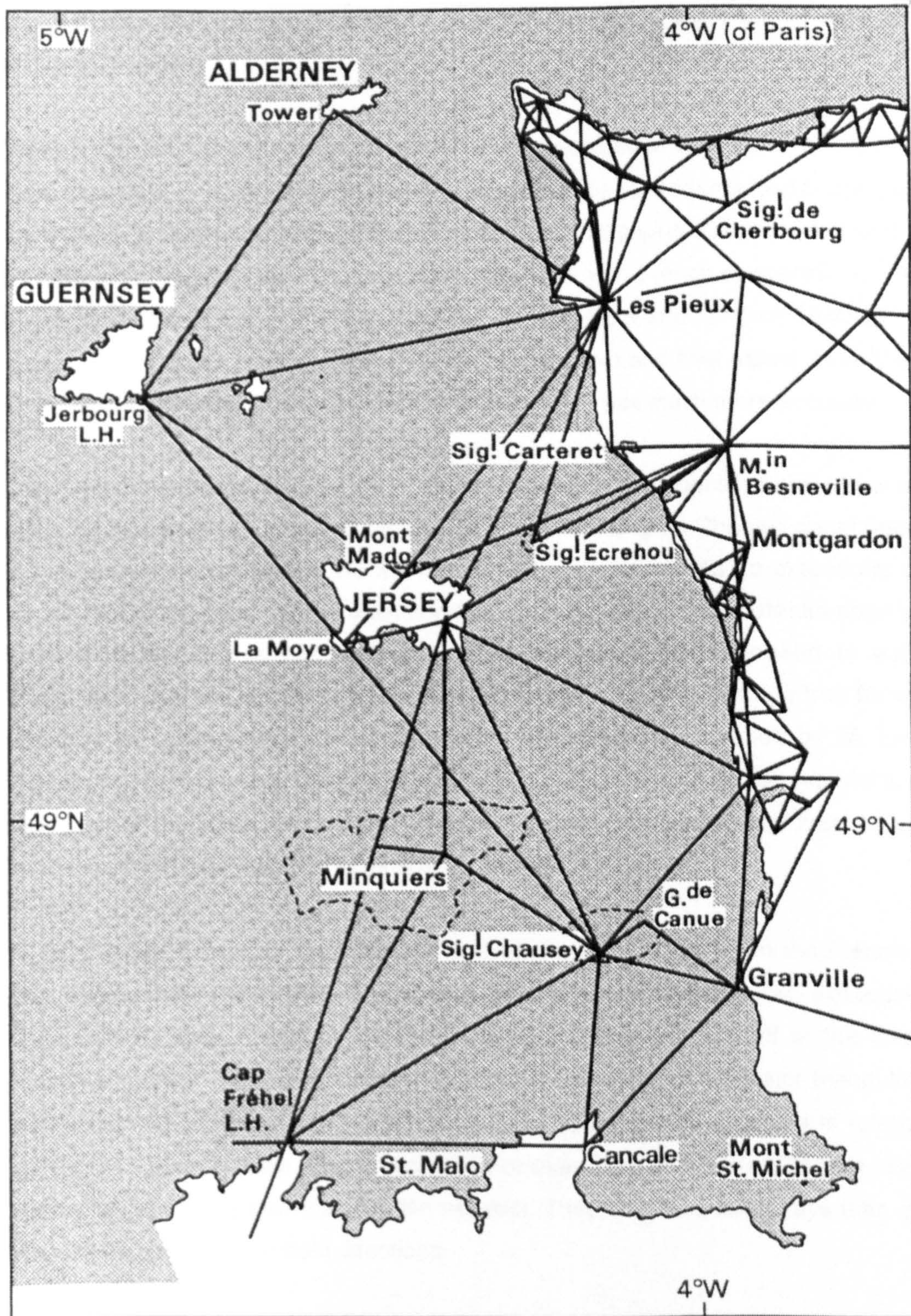


Fig 9-1. White, Daussey and Begat Survey: 1828–1829.

(based on chart in archives of IGN, Service de Géodésie. © acknowledged)

which at first acted merely as a clearing house for existing surveys. A Royal Ordinance of 6.6.1814 set up Le Corps des Ingénieurs Hydrographes de la Marine and surveys began of the French Atlantic coast. In overall charge of the French contribution was the renowned hydrographer, Charles-Francois Beautemps-Beaupré (1766-1854). A Royal Ordinance of 6.6.1814 set up Le Corps des Ingénieurs Hydrographes de la Marine [1] and Louis 18th

charged him with revising the out-dated charts of the French shores. The work began in 1816 and took 23 years.

White's 'Remarks Books' make no reference to co-operation with the French, not even in the book deposited in 1840 (UKHO OD 542), long after the joint triangulation was completed. Yet there are excellent coloured coastal profiles and detailed sailing directions for west Cotentin and east Brittany, which would only have been attainable with French cooperation in the post 1814 peace. It seems probable that White wished to make sure that his own 1810-1814 clandestine survey of the French coast was recorded as his definitive and final report, even though the later Daussey-Bégat (1829) survey (in which he participated) was much more accurate.

The French completed their survey of the west coast to the Spanish border between 1816 and 1826. It then became a matter of urgency to survey the English Channel coast because Captain White had asked permission, *via* the British Ambassador in Paris, to extend his operations as far as the French coast. The French surveys of north Brittany and Cotentin spanned the period 1829-1838 and it was agreed that Capt White would be authorised to establish some triangulation stations on the French coast. He would have to guarantee that he was genuinely engaged on hydrographic surveying and he would be accompanied by M. Le Saubrier de Vohello, a '*capitaine commandant le bâtiment de l'Etat*' lest he abuse his visits. The wartime suspicion of the British remained. Vohello had been previously employed on work of 'great importance' and was regarded as absolutely trustworthy.

In 1829 ~~to~~ the Director of the Dépôt de la Marine observed that when the French came to do their survey, they would require reciprocal arrangements on the British possessions. In due course White was ordered by the British government to put himself at the disposal of the French engineers. The French were authorised to use some of the major triangulation stations that White had set up on the Channel Islands, so as to fix them precisely in relation to nearby parts of the French coast. The French did not use many of White's Channel Island stations, setting up an entirely new triangulation network. They observed fewer rays than did White, as they were able to sight in both directions.

So began the Daussey- Bégat triangulation of the north Brittany coast. In 1830 the survey covered Cap Fréhel - L'île de Bréhat and in 1831-2 from Granville to Cherbourg. There is no reference in this part of the survey to the Channel Islands.

The French pressed ahead with their own surveys because they feared that if the British went ahead independently they might publish their own charts of the French coast and they believed that their surveys would be far superior to anything made by a British officer. This was undoubtedly true, as the French were using their own ground triangulation for the whole coast. Without French co-operation, which seems to have been limited, White mainly observed from the Channel Islands, repeating in his pre-peace survey of the French coast.

On 18th June 1829 White sent to the Hydrographic Office a MS survey of the French coast with triangulation from Cap Cartaret to Montmartin (SW of Coutances). This no doubt fulfilled the fears of the French about having charts of their coast published by foreigners. The first reconnaissance with British engineers was on a base on the L'île des Ebiens (between Cap Fréhel and St. Malo) which revealed that the British had already begun operations on French territory, before obtaining formal approval, which was what the French had suspected. HAD

The survey began in 1829 under Daussey 'ingénieur-hydrographe en chef de la marine' but Bégat, his deputy, succeeded him in 1830. The triangulation initially 'rested' on that observed by Cassini for his topographic map (1744) but the 'ingénieurs géographes de la guerre' were extending the great triangles of the Ancienne Triangulation [Etat Major] to the west coast and they reached Cotentin in 1832-35.[2] The hydrographers subsequently attached their triangulation to this more accurate network but of course it was of no use to the 1829 survey.

The Cotentin part of the ['hydrographers'] triangulation was joined to points in the Isles of Jersey, Guernsey and Alderney. Bégat notes: the angles of the triangles which attach the continent to Jersey, Guernsey and Alderney were observed in 1829 by Daussey, 'ingenieur-hydrographe en chef de la marine'. thanks to the cooperation of the British and to the reciprocal arrangements made. Bégat was his deputy. In 1829 the survey was at Granville to Cap Fréhel and in 1832 reached Cherbourg.

White must have had a close rapport with the French because the Memorial du Dépôt General de la Guerre, (VII 1840) records that his surveys of the Channel Islands and the coast of France were associated with those of the eminent French hydrographer M. Beautemps-Beaupré. White's name is acknowledged on some French charts.

Three main Channel Island stations were used for the 1829 triangulation and their positions differ little from White's revisions of his 1812 survey. The French were constructing an entirely new net whereas White had enough faith in his own earlier survey to simply correct it. The 1824 measurements are based on White's 1812 survey; those dated 1828 strongly suggest that he was already ahead of the French in the new 1829 survey. It was noted above that the French were well aware of the 'Perfidious Albion'

Alderney Telegraph Tower:

1824:-	49° 41' N	2° 15' W
1828:-	49° 41' 19".4 N	2° 14' 37".8 W
modern:-	49° 42' 18" N	2° 13' 12" W

Jerboung Tower (Guernsey):

1824:-	49° 25' 15" N	2° 32' 50" W
1828:-	49° 25' 15" N	2° 32' 58".2 W
modern:-	49° 25' 30" N	2° 32' W

Tour d'Auvergne (Jersey):-

1821:-	49° 11' N	2° 4' W
1828:-	49° 11' 48" N	2° 4' 21.7 W
modern:-	49° 12' N	2° 3' 50" W

End Notes

1). PRO OS 1/125. This file includes i) an OS publication '*List of maps, charts and surveys of Jersey*'. OSO Southampton, 1901, from the collection of Mr Ph. Le Maistre. ii) 1837 - Triangulation of the Channel Islands by the French Hydrographic Service. [*Memorial du Depot General de la Guerre, v. VII, 1840*] This is the same reference as Begat, but we do not know why the date is 1837 instead of 1829.

2). There is in the UKHO a survey of the French coast with triangulation received from White in June 1829.

ANCIENNE TRIANGULATION DU DEPOT DE LA GUERRE**1818-1845 .****(Notice sur la Nouvelle Carte de France ...) Paris, 1832. [BL Maps H.3 (1)]**

A project to replace the Maraldi - Cassini map,(Chapter Seven) began in 1818 with many chains of great triangles. Much of the Volume is devoted to '**Position géographique et hauteurs absolutes des principaux points de la feuille**'. A map of the fundamental chains and 1st. order triangles shows no connections with the Channel Islands but one of the 1:80,000 sheets derived from 3rd order triangulations includes Alderney.

Feuille 5-13 N-O (Les Pieux) [16] pub.1843.

NW Cotentin, Alderney, Sark, St Saviour. Alderney is c. 18km. from Cap de la Hague. The book records five 3rd. order stations on Alderney, some of which are not easily identified. The position of the Alderney Telegraph is given as an example, recalculated to British measurements.

Ancien Télégraph, sommet * 49° 41' 28" 4° 33' 24" (Paris) 2° 18' 14" (Greenwich)

Modern 49° 42' 18" 2° 13' 12"

* named on map

There is no further reference in this survey to the Channel Islands until 1888. The Min[quiers] had not been covered in detail by surveys under Bea^utemps-Beaupré and a second class engineer given task. Bad weather and the rocky terrain~~e~~ extended survey to 1889. There were diplomatic ~~THE~~ difficulties because the nationality of the islands~~^~~not defined with certainty. Jersey fishermen ~~WAS~~ objected. The French government ordered that permanent signals in the English waters

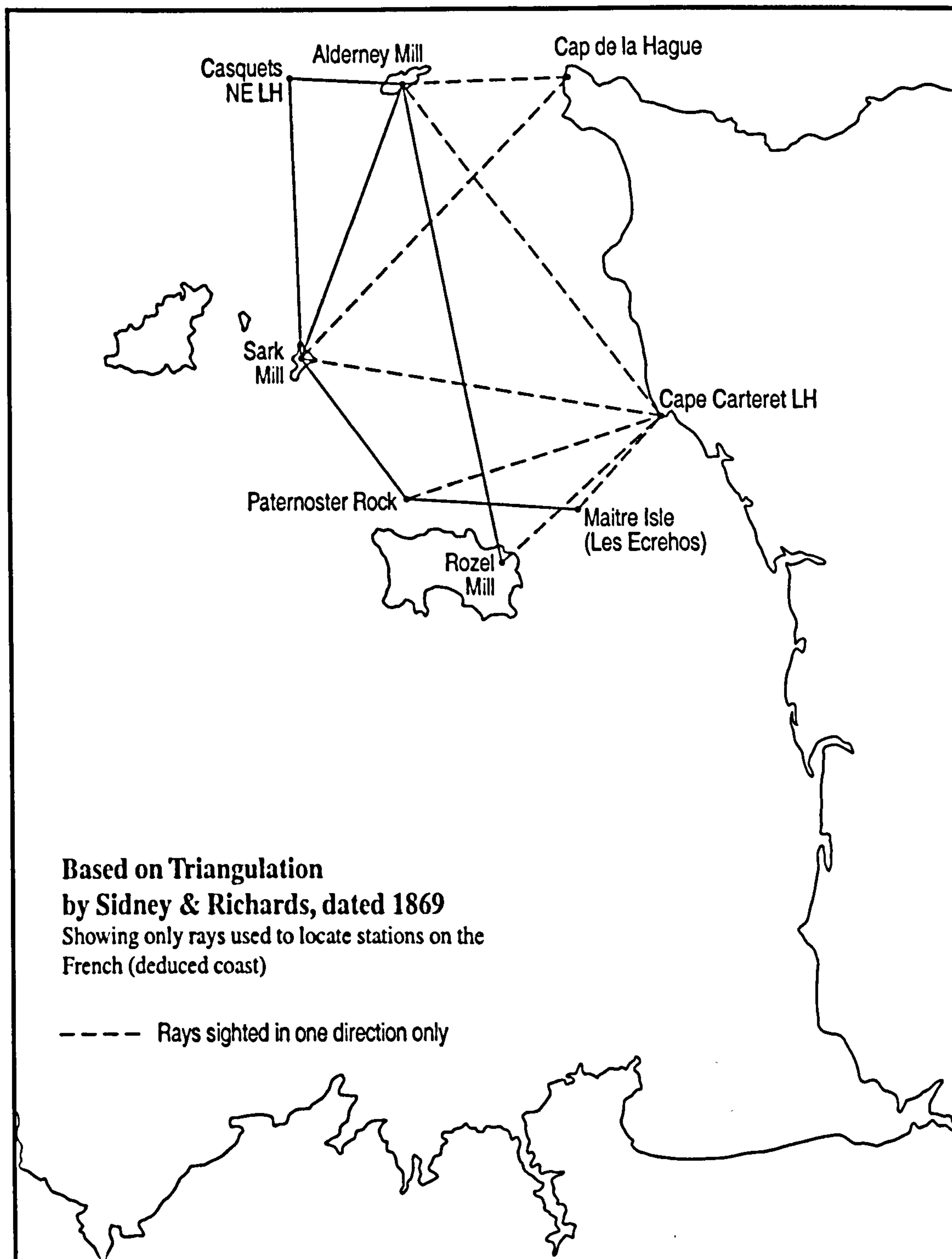


Fig 9-2. Sidney and Richards survey: 1850–1868. UKHO MSA 1958 PRESS 43a
Reproduced from Admiralty Publications/Charts by permission of the Controller of Her Majesty's
Stationery Office and the UK Hydrographic Office.

of Jersey should only be erected to help the work of the hydrographic survey. The French did not at the time accept the British claim to sovereignty.

THE SIDNEY – RICHARDS SURVEY, 1850-68.

(Fig 9-2)

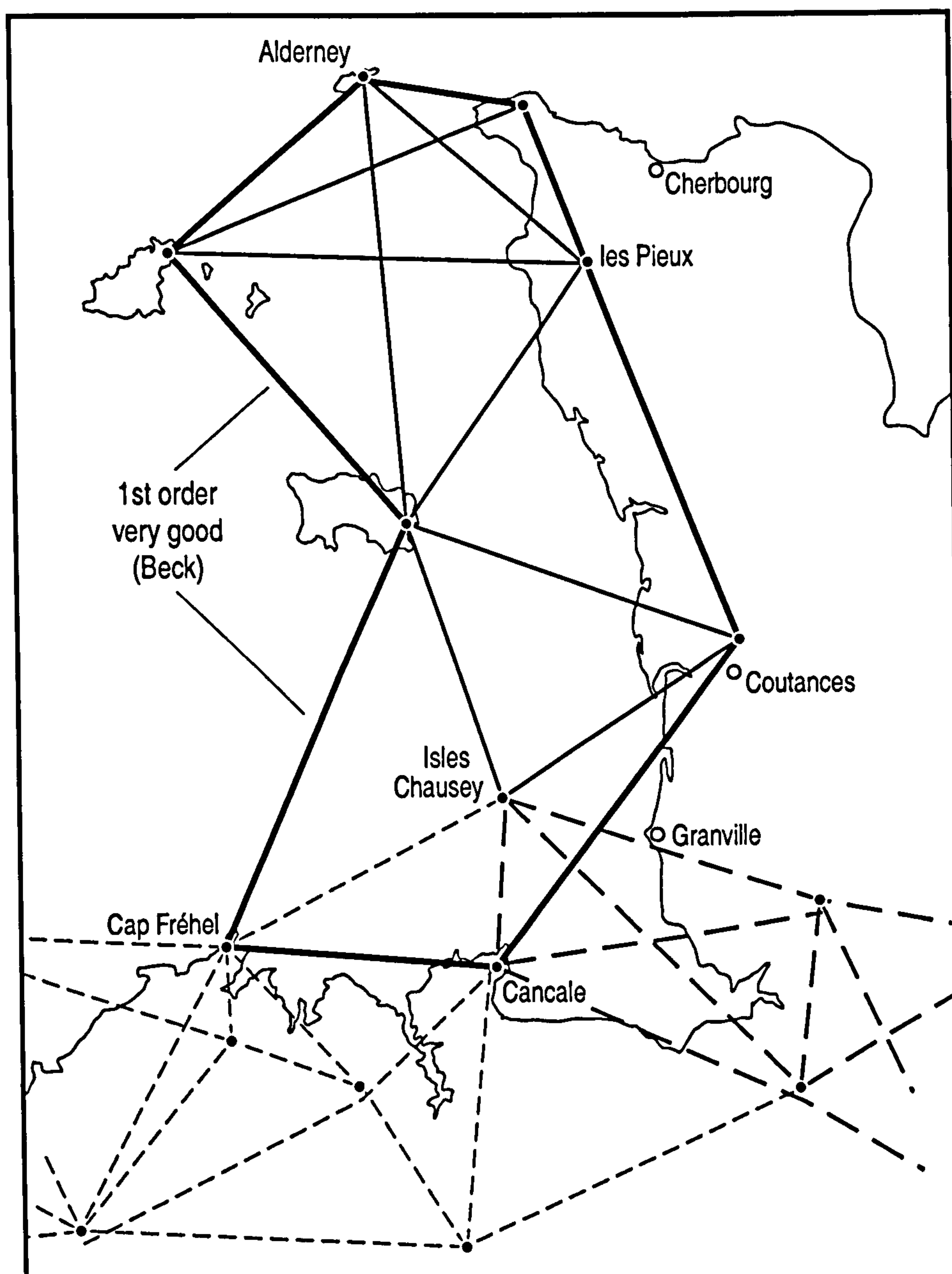
'Channel Islands triangulation sheet by [Cmdr F W Sidney and Staff Cmdr J Richards 1859-1868']. (Signed Richards Jersey December 1889) Results of Observations for Astronomical Base (UKHO MS A 1958 Press 43a).

There is a surprising amount of literature about this survey in the UKHO and the PRO. What follows is a short summary. The document quoted above is a detailed account of the survey. Only latitudes were measured. An astronomical base was established between Alderney Mill and Rozel Mill, Jersey (Fig G-14), the mean being $49^{\circ} 13' 39''.5$ N. Terrestrial bases were measured in Jersey and Guernsey. Part of the triangulation is plotted in Fig 9-2. There were 11 stations on Jersey and 5 on Guernsey. Of these Alderney Mill, Sark Mill, Rozel Mill (Jersey), Paternoster Rock and Maitre Isle (Les Écréhous) were the chief inter-island trigonometrical stations (solid lines on Fig 9-3). The prominent Corbière Lighthouse was also an important station, the surveyors paying particular attention to its latitude, unlike Martin White.

There were no reciprocal sightings observed from the French coast (pecked lines Fig 9-2). The Sidney / Richards survey hinged on the position of Cap Carteret signal station and accepted its position as listed in the 'Mémorial du Dépôt de la Guerre Tome VII (1840): $49^{\circ} 22' 31''.2$ N $1^{\circ} 47' 46''.9$ W. It was, in fact, the same as that of Bégat, 1829. On the basis of this presumed accurately measured site, the surveyors concluded that Channel Island latitudes were $+10''$ and longitudes $+8''$ in error and made the necessary corrections. (It was noted in the previous Chapter that the 1840 location had for years been the 'Historic Datum' for the Channel Islands, as late as 1914).

This survey lasted ^{until the mid-20th century,} e.g. 'Sheet 262a. Guernsey, Herm and Sark. Surveyed by Cmdr. Sidney and J Richards Master RN 1859-62, with amendments to 1954. ~~Site of Doyles Column [now destroyed] ... from French observation 1840.~~' The chart was still being amended in 1963.

In 1913 the Ordnance Survey updated the topographical mapping (*of the Channel Islands*) with some re-triangulation, which disagreed with (*Admiralty*) charted geographical positions. The UKHO carried out an investigation and found that the position of Cap Carteret Light House accepted by Richards differed from that accepted in 1913 by the same amount as the OS discrepancies. The charts' positions were corrected to agree with the OS positions. (As noted above) the geographical positions were based on the French Hydrographic Office survey as published in the Mémorial du Dépôt de la Guerre, Tome V11 1840. (Adapted from pers. comm. H1470 / 17 / 87).



Triangulation de l'Armée allemande (Lt. Beck) 1942-1943

Link to Channel Islands classed as "1st ordre, très bon"

— — — 1st order chain

- - - - - 1st order triangulation

Fig 9-3. German survey: 1942-1943.

(based on chart in archives of IGN, Service de Géodésie. © acknowledged)

THE GERMAN ARMY OF OCCUPATION

(Fig 9- 3)

(based on information kindly supplied by IGN Service de Géodésie and MEC TECHNICAL MEMORANDUM No 1 / 82).

The Introduction to the Memorandum notes that '... *the only modern survey connection between France and the Channel islands was that observed by German military units in the period 1942/43. The connection was based on stations of the French PARALLELE DE PARIS....as part of the French NOUVELLE TRIANGULATION...but no details or records of the 1942/43 are known to exist in either France or Germany.*' ©

A new survey of France began in 1914-1918 war but the triangulation progressed slowly and as late as 1948, although one of the 'great chains' had extended to Chaussey (see map), the whole of Cotentin remained unrevised. This was the situation which faced the German army of occupation in 1940 and presumably as part of the defence works it began to complete the unfinished triangulation, including the second and third orders. Through the courtesy of the Institute Géographique Nationale we have some information about the survey. It was, of course, the only occasion when France and the Channel Islands were under one survey authority: no permission was required to survey from one to the other. THE

A letter and map from the IGN Service de Géodésie gave details of the German survey. The Copyright is acknowledged.

'1942-43. Lt. Beck of the German Army effected geodetic operations as part of the continental network, basing himself on the New French triangulation. After publication of the coordinates in German memoranda, and after comparisons made of a part on 2 steeples in Jersey [?which] intersected in 1950, from 3 points of the second order, the other part on the old measurements of 1829, it has been possible to adapt the German values to the Unified European system. These provisional values were enough until the new link made in 1950.' ©

The map supplied ^{is} ~~an~~ an extract from a larger one: 'Work executed by occupation troops'. The extract bears the original comment '1er. ordre tres bon (Beck).'

In 1942-3 Lieutenant Beck of the German Army carried ^{out} geodetic operations as part of the German continental network, basing himself on the French 'Nouvelle Triangulation', in so far as it existed. The map of the link between France and the Channel Islands bears the comment '1er. ordre tres bon (Beck)' and for the Cotentin peninsula in general '1er., 2e. et 3eme. ordres obs. calc. Tres bon travail'. The French did not complete the area until 1950. Beck's Channel Island stations are not named.

A note on the IGN map suggests that Beck may have belonged to the '760 Régiment d'Artillerie'.

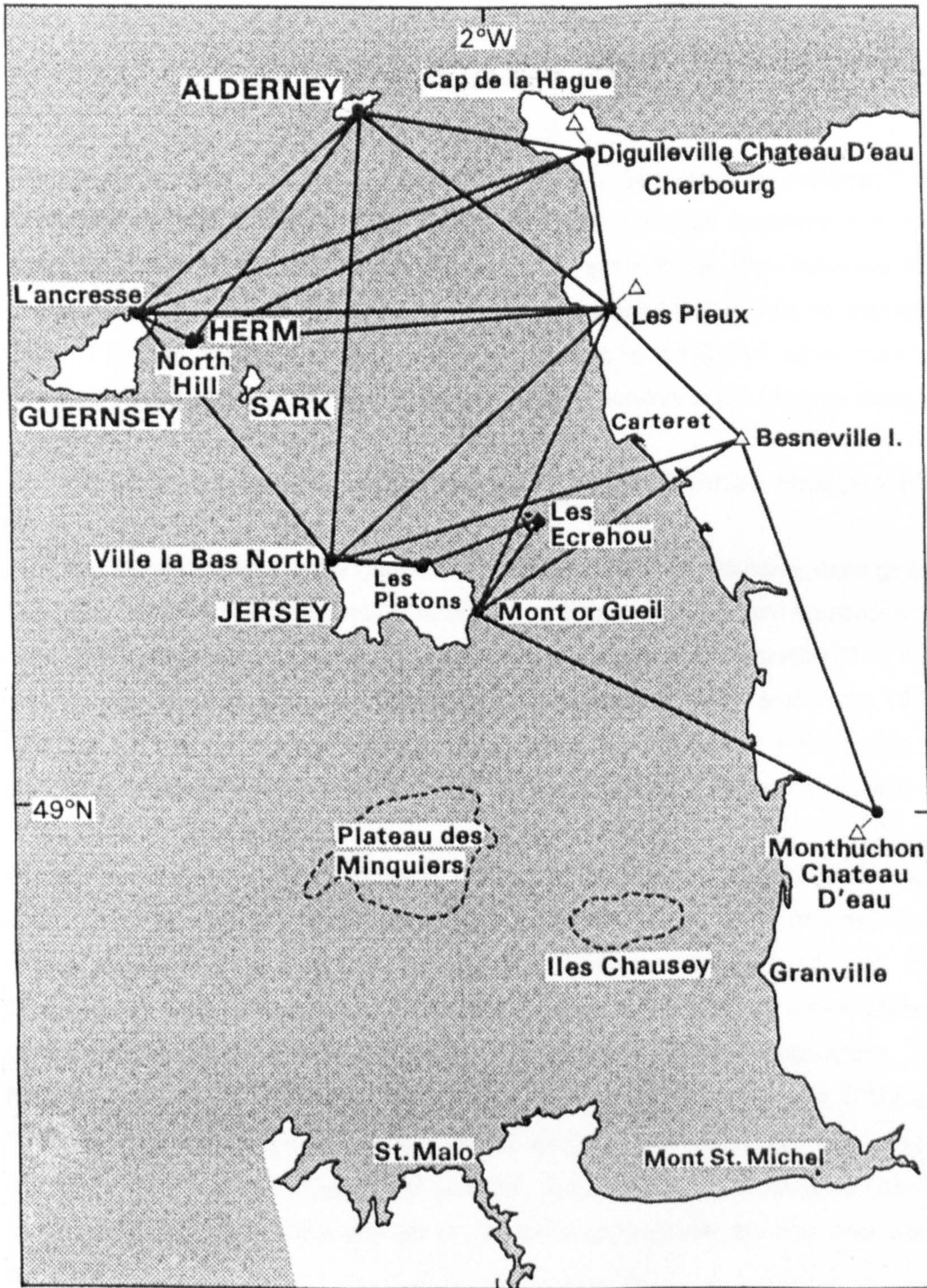


Fig 9-4. Geodetic connection: 1980.

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THE GEODETIC CONNECTION BETWEEN THE CHANNEL ISLANDS AND FRANCE 1980

(Fig 9-4)

This connection was observed jointly by the Institute Géographique National, France and the Directorate of Military Survey MOD, United Kingdom. Although therefore in France it was the body responsible for the national survey, the equivalent in Britain, the Ordnance Survey was not involved. This may in part reflect the fact that the Ordnance Survey has no statutory rights in the Channel Islands, because of their unique relationship to the Crown rather than to Parliament. There are precedents for the Royal Engineers making surveys of the Channel Islands.

This account is based wholly upon the 1982 report: MEC TECHNICAL MEMORANDUM No 1 / 82).

'The five Doppler stations in the Channel Islands (30742-30746 inclusive), were observed by 512 Specialist Team RE in November/December 1976 using Geociever equipment in the single-point positioning mode; 40 satellite passes were measured at each station.' The new connection was agreed in 1979 and the observations were made in May and June 1980, the Royal Engineers of 19 Topographic Squadron carrying out the British contribution. Seven main stations in the Channel Islands were connected with four main stations in France.

Of the French stations, only Besneville I is part of the Principal Triangulation Net. In order to be able to sight the Islands' stations the other three are on the roofs of water towers (chateaux d'eau) adjacent to a Principal Triangulation Station, (between 18 and 721 m distant). Observations were of course corrected for this. Four of the Channel Island stations are existing control stations which had been re-occupied for the 1976 Doppler observations. The Old German Fort, Guernsey could not be used for intervisibility reasons and a new one, L'Ancrese was set up 6m away. The two Doppler stations in Jersey were not inter-visible but had to be linked to avoid the Net splitting into two independent portions. Stations were established at Les Platons and Les Écréhous to achieve this link and the odd shape was obviously the only one feasible in the time available.

Each country was responsible for all observations made on its own territory. *'The joint efforts of IGN and IGS have produced a survey connection of the Channel Islands to NW France which, despite a slight weakness in the angular observations at one station, is of geodetic quality and of ample accuracy to meet foreseeable practical needs for a number of years. Its results are the bases of the modern maps of each country.'*

