I.O.S.

SIZEWELL–DUNWICH BANKS FIELD STUDY

TOPIC REPORT: 2

A P Carr

Long–term changes in the coastline and offshore banks

Report No 89

1979

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

Wormley, Godalming,
Surrey, GU8 5UB.
(0428 - 79 - 4141)

(Director: Dr. A.S. Laughton)

Bidston Observatory,
Birkenhead,
Merseyside, L43 7RA.
(051 - 653 - 8633)

(Assistant Director: Dr. D.E. Cartwright)

Crossway,
Taunton,
Somerset, TA1 2DW.
(0823 - 86211)

(Assistant Director: M.J. Tucker

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Crossway
Taunton
Somerset

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SUMMARY

Historical and survey data have been examined in order to describe and quantify the well known erosion of the Dunwich area of Suffolk and the development of the offshore Banks.

Prior to about 1840 the majority of the documentary evidence is in the form of legal records and court rolls. From that data onwards maps and charts are sufficiently numerous and accurate so as to afford the main source of comparative data.

The early historical records concentrate on the former city of Dunwich and show its progressive decline primarily due to erosion of the coastline but also through blocking up of the harbour approaches and attacks by foreign vessels.

Particularly from 1836 onwards there is a greater number of specific measurements at points along the coast. These highlight:

(a) the variability of erosion over time (ranging from zero to 18.3 m yr^{-1})

(b) the often simultaneous erosive events at different sites in the Aldeburgh to Easton Bavents area.

The hydrographic charts cover the period 1824–1965. They show the progressive development of Sizewell Bank towards the north until it joined the Dunwich Bank about 1921–2. Between 1824 and 1965 this northerly progression was at the rate of 49 m yr^{-1}. The Sizewell–Dunwich system also moved landwards up to 10.7 m yr^{-1} between 1867 and 1965 so that it was less than two-thirds as far from the coast near Minsmere in 1965 as it was at the beginning of the period.

Calculations suggest that the volume of sediment lost from the coast between Easton Bavents and Thorpeness over the period 1867–1965 is similar to that gained on the offshore banks in the area. However, various reservations must be made and it is not tenable to argue for a simple exchange of material between the two.

INTRODUCTION

The East Anglian coast is well known for its long history of shoreline erosion. Indeed, it has been suggested (eg Reid 1958) that recession of the order of 2 to 3 miles (3.2 to 4.8 km) has taken place on the Norfolk coast since Roman times. Steers (1946), writing of the stretch from Lowestoft to Aldeburgh, said: 'Exaggerated figures are often quoted without authority'. 'It is at any rate possible that there has been a loss of anything up to 2 miles as a result of erosion. But this is far from justifying the assumption that all parts of the Suffolk Coast have suffered as much'. Hellard (1907), then Director of the Ordnance Survey, reported to the Royal Commission on Coast Erosion that OS Maps

showed Suffolk to have the greatest loss along the coastline of any county in England. Between 1885 and 1904 there was a net loss of 367 acres (148.5 ha). Of this 250 acres (101.2 ha) was at Dunwich and Southwold. (All the places mentioned are shown in Fig 1.)

Cartographic evidence is of considerable value, mainly from about 1840 onwards. Before that time information is largely, but not exclusively, in the form of historical records.

1. Historical background:

Whitaker (1907) observed that Dunwich 'has a large literature, ... partly fabulous but partly true'. (In the opinion of V B Redstone (1908) it was Stowe who caused much of the mythical content of Dunwich's history.) There are, however, a series of documents, principally court records, which trace salient aspects of Dunwich's evolution and decline.

Dunwich was important in the seventh century. The first bishop of East Anglia was probably created in 636 AD and named after the town while, according to Bede, Dunwich grammar school was the first in Suffolk (631 AD) and one of the first in England (Steele Hutton 1908). Redstone(1908) believed that between then and about 1150 half the original town was 'washed away'; nevertheless the number of burgesses almost doubled and there were 3 churches instead of the one in the time of Edward the Confessor (1042-66). Certainly in 1168 Dunwich could afford to contribute the then princely sum of £133.6s.8d. towards Henry II's daughter's marriage (Balding and Turner 1908).

Copinger (1904) lists the various legal records spanning the period from Edward I's accession (1272) until the reign of Charles II (1661). While natural erosion predominates, accretion and human destruction seem to have been important also. (Before 1272 human intervention took the form of Norse raids; in the time of Edward I attacks by rebel barons, notably Earl Bigot; later on, especially in the sixteenth and seventeenth centuries, on depredations mainly by the French.)

In 1279 the town was subject to a yearly rent of £65, the agreement to run 'for ever'. Yet, only 21 years later, a commission was set up to investigate complaints of shipping losses and damage to the port. Redstone (1908) notes that in the time of Edward II (1307-27) the harbour was blocked by shingle once or twice yearly and effectively closed in the succeeding reign.

In 1324-25 the burgesses applied for a reduction of their rent ('fee farm'), one third of the town having been destroyed by the sea. Some details of the effect on individual parishes are available. Redstone records that originally the

church of St Nicholas was taxed at 6½ marks (£4.6s.8d.) but by 1342 this was reduced to 50 pence because the number of houses had dropped from 300 to 18. In the parish of St Martin only 7 houses remained out of the original 100; the 'whole parish' of St Peter was devastated, although the chaplain was forced to remain. There are records indicating depopulation in 1347–8 (Copinger 1904) but it is possible that these may relate to the town's losses against the French or even the Black Death. St Nicholas' church was in ruins by 1413 but St Peter's was still standing then (Redstone 1908), and, indeed, the remains appear to have survived for a further 300 years.

It is not certain that the lack of representations in the next 2 centuries reflected more clement conditions or whether there was relatively little of the town left. At any rate by the early 17th century new appeals for help were being made and these are coincident with others at Aldeburgh (Macray 1907). In 1628 there was a petition to the Duke of Buckingham saying that only 1 out of Dunwich's 52 parishes still remained intact. Further damage to houses in the town by the sea, and hence inability to pay the rent, was recorded in 1650. The rent was finally reduced to £5 per year, in or soon after 1661, due to this cause and to decay of trade.

Dunwich's fate may have been extreme but it was not atypical. While Southwold was incorporated as a town in 1489 and Walberswick also gained in importance, other places such as Newton-by-Corton, Covehithe and Easton Bavents suffered through prolonged coast erosion: erosion that was to continue beyond the reign of Charles II.

2. Land Surveys:

Dunwich: One reasonably accurate survey overlaps the time of court and parliamentary rolls. This was Badulph Agas' plan of the City of Dunwich dating from 1587 (and republished by the historian Thomas Gardner in 1754). Agas was a highly respected surveyor (Carr 1969). To his map Gardner added the 1753 cliff line. Figure 2 shows these data. In addition the 1976 cliff line, based on Ordnance Survey revisions for that year, has been incorporated. The results suggest a mean annual rate of erosion from 1587 to 1753 of between 0.99 and 1.61 m yr^{-1} depending on the specific site. Comparable values for 1753 to 1976 range between 0.68 and 0.96 m yr^{-1}. Whitaker (1887) noted that in the 108 year period, 1732 to 1880, the average rate of recession based on specific measurements at All Saints' Church was 18½" (0.47 m) yr^{-1} (Table 1). Thus, by difference, between 1753 and 1772 it was some 3.48 m yr^{-1}. The 1772–1880 recession must have been concentrated into a fairly

short period also. In 1772, the distance from the cliff edge to the chancel was 64 m. The 1826 map of the parish of Dunwich by Richard Barnes gives this distance as approximately 59 m. Redman (1865) measured between the same features in about 1863 and obtained a value of 56.7 m, so that there appears to have been negligible erosion over 90 years. Redman contrasted this church site with Dunwich Common 'where masses of crag and bright yellow sand may be seen sliding down the face of the cliff', and the intervening area which 'was literally an inclined plane of sand'. The distance from cliff to chancel recorded by Whitaker in 1880 was only 13.1 m, making an average rate of retreat of 2.56 m yr^{-1} between 1863 and 1880.

The 1882–3 and 1903 Ordnance Survey maps suggest virtually no recession during the intervening period, yet between 1903 and 1919 the cliff retreated approximately 56.5 m, an average of 3.53 m yr^{-1}. The figures given above help to demonstrate the order of variability of erosion rates over time as well as space. There is no reason to believe that the variability recorded by Whitaker (1887) at Covehithe just north of Easton Bavents did not occur at Dunwich or Easton itself. This ranged between barely 1.0 and 18.3 m yr^{-1} during the period 1878 to 1887 with the maximum during the first half of that timespan.

Dunwich village had negligible erosion during much of the 19th century but dramatic losses after 1897. Figure 3 shows a view looking south along the coast in 1890. The last traces of the church building disappeared over the cliff in 1919. Whitaker reported to the 1907 Royal Commission on Coast Erosion that 'there had been a long interval in which little erosion had taken placed after a very long one in which great erosion had taken place. Now again, apparently, erosion has set in'. In evidence to the Commission, Cooper emphasised that 'attacks' were 'not continuous, they come periodically' (Cooper 1907). Likewise, in reply to the question: 'It sometimes happens that erosion is intermittent?', Clement Reid replied 'Generally it is so ..... just like Dunwich' (Reid 1907).

Easton Bavents: Whitaker (1907) also noted the intermittent erosion at Easton while Cooper (1907) cited Spiller (1904) with regard to the then current rates of loss there. Spiller recorded recession during the 9 year period between 1895 and 1904. He stated that erosion of 23, 49 and 105 m had taken place at sites at the north, centre and south ends of Easton cliffs, respectively. Comparison of the 1849 tithe map and the 1970–72 Ordnance Survey sheets suggest that during that timespan of 122 years, total erosion for the comparable locations was about 335, 300 and 262 m respectively. Thus not only had the rate varied markedly but the longer-term trends in the relative rates appear to be the opposite of the short-term ones.

Spiller's stated annual rate of erosion for the north end of the

cliffs was similar to the long-term trend (2.56 versus 2.75m yr^{-1}) but the central and southern sites considerably exceeded it (5.44 and 11.67 m yr^{-1}, against 2.46 and 2.15 m yr^{-1}).

At least one earlier period of marked erosion at Easton Bavents is recorded in some detail. Alexander (1841) undertook 'careful observations' over the 5 years previous to 1841 and found that the annual rate of loss for all but the south end of the cliff exceeded 7 yards (6.4 m). He believed that local statements of 350 yards (320 m) in breadth having been destroyed in the previous 35 years (9.1 m yr^{-1}) 'are not much over-rated'. In one case Alexander showed recession during that 35 year period must have exceeded 6.2 m yr^{-1}; in another case it equalled 7.2 m yr^{-1}.

A comparison of the bearings he gave and the cliff edge shown on the 1849 tithe map suggests that erosion of at least these rates continued during the 1840's. A further comparison of the 1849 tithe map and measurements taken in July 1865 (Redman 1865) shows that the distance from the cliff edge to the farm buildings then located midway along the cliff had been reduced from 61 m to 12.8 m, an annual retreat of almost exactly 3 m. This rate is not greatly different from the 1849 to 1970-2 average quoted earlier.

Whitaker (1887) took measurements at the same location between 1877 and 1882. They appear to indicate recession at an average rate of 7.8 m yr^{-1} with a maximum of 9.1 m yr^{-1}. The erosion rates were lower along the cliffs immediately towards the north as Spiller also found, although this was the reverse of the long-term trend.

Other areas: It would appear that, at about the beginning of the 20th century, erosion rates were higher than the long-term average at both Easton Bavents and Dunwich. It is not certain, however, that this relationship applied elsewhere along the coast or at other periods in time but the Easton Bavents and Covehithe peaks between 1877 and 1882 coincide as had those for Aldeburgh and Dunwich previously. The high erosion rates at Easton up to about 1850 seem to be contemporaneous with relative stability at the town of Dunwich, but not of the cliffs immediately to the south. If erosion were widespread it would indicate general destruction by wave attack rather than localised ebb current effects as advocated by Robinson (1966). Furthermore, the fact that the phases of erosion and quiescence occurred prior to and since the development of the Sizewell-Dunwich banks suggests that the latter only exert a protective effect from a restricted range of directions and when waves equal are in excess of about 2.0 m at which height they would break on the Bank crest.

Table 2 records the changes (mostly) at high water mark for the coastline between Easton Broad in the north and the Martello tower ('CC') just south of

Aldeburgh, based on the appropriate tithe maps (1838–49) and the most recent Ordnance Survey records (1970–76). Tithe map information is not available for the town of Southwold, but is complete elsewhere. Comparisons are made at intervals corresponding to the National Grid whole kilometre northings. Comment on the specific tithe map sources are given in Appendix 1. In general the Tithe surveys of the area are of high accuracy, appreciably better than in some other districts. The Table shows an eroding coastline from at least Easton Bavents in the north as far south as the limit of the Dunwich and Minsmere cliffs. The extent varies between 360 m in the north and 65 m in the south but there are variations within the overall trend. These appear to be attributable to the groynes along the foreshore at Southwold (C) and the jetties on each side of the River Blyth. The latter trap sediment on the north side and may well cause the greater degree of recession at Dingle marshes (N). However, no obvious relationship explains the long-term focus of erosion at Dunwich cliffs.

Over the period from about 1840 to 1976 there appears to have been no net loss or gain for the 3 km from Minsmere (C) to Sizewell (N) although the existence of narrow dunes fronting both the Minsmere marshes and the degraded cliff-line occupied by the Sizewell nuclear power station implies some accretion at an earlier period. A very small amount of accretion is suggested from the village of Sizewell towards Thorpeness and again south of Thorpeness. The northern of these two areas is exclusively sand: the southern one sand with a progressively increasing proportion of shingle towards the south. Erosion of the same order appears to have taken place at the small headland of Thorpeness and rather more extensively at the southern end of Aldeburgh. The latter area is now protected by a sea wall, as well as groynes, and has been the site of a beach nourishment scheme.

The range in average annual erosion rates calculated from the Tithe maps and the most recent OS surveys, for the coast between the town of Dunwich and the southern end of Minsmere cliffs, is 0.48 to 1.58 m yr^{-1} (Table 1). These values are similar to the range for Dunwich town itself in the various sites and periods from 1587 onwards.

The short-term variations, ie monthly changes over the period March 1978 to May 1979, will be discussed in detail elsewhere(Blackley 1979: Topic Report No 3). In the present context it is sufficient to say that at zero OD (approximately mean sea level) there was an overall range of movement normal to the coastline of between 3 m, in the Sluice section south of Thorpeness (Section 2), and 24 m at Thorpeness itself (Section 3), with a mean range, based on all 10 surveyed sections, of 12.6 m. Assuming that the period 1978–79 is representative, and that

the plotting accuracy of the maps used for comparison is about 8 m, then all the comparisons in Table 1 for sites north of the southern limit of Minsmere cliffs are real. Further south, however, only 5 out of the 12 would necessarily be. These are Sizewell (C) and the Sluice with limited accretion, and Thorpeness north and central and the Martello with a tendency to erode.

3. Changes Offshore:

The Sizewell–Dunwich area has been completely surveyed by the Hydrographic Department in 1824, 1867, 1921–22, 1930 and 1965. Details are given in Appendix 2. Figures 4a, b; 5a, b; and 6 show the coastline and the 3, 4 and 5 fathom contours for these dates. In addition, the 6 fathom contour has been added, where applicable, for the area between the banks and the shore. The prolongation of the Sizewell Bank and its amalgamation with the Dunwich Bank is well-known. The translation of the banks shorewards is less familiar. These trends are listed in Table 3. The average extension of the banks northwards between 1824 and 1965 was 49 m yr^{-1}. The apparent fall in rate between the 1867 and 1921/2 surveys is largely attributable to the amalgamation of the Sizewell and Dunwich banks during that period and subsequent adjustments in alignment. Table 2b shows that during the period 1867–1965 the crest line of the banks moved shorewards at a mean rate of up to 10.7 m yr^{-1}. Both at Minsmere cliff where the 10.7 m yr^{-1} was determined, and at the next comparable site southwards, Minsmere sluice, where the bank crest migrated by 0.9 km over 98 years (9.2 m yr^{-1}), the overall distance between bank and shoreline, has been reduced by more than one-third. (If these rates continued the Sizewell Bank would become attached to the shoreline – forming a new ridge or ness structure in about 180 years!) The intervening surveys (Figs 4–6) show that the landward migration was progressive in character.

Between 1824 and 1965 the charts show that there has been little net change off Thorpeness but within that period a marked southerly tongue developed. Apart from at the northern end of the banks, the 5 fathom contour between the banks and the coastline remained relatively constant throughout the whole period. There has been little evidence of increasing depth over time. Such changes as occur in the 1965 survey may be partly attributable to a change of 0.6' (0.2 m) in datum from the earlier ones. Some of the changes between the 5 surveys are listed in Appendix 4.

The 1867 and 1965 surveys were redrawn onto a common scale of 1:25000 and contoured at a 1 m interval. From these a map showing isopleths of erosion and

accretion was produced. A reduction of this is shown as Fig 7. The map helps to demonstrate the movement of the banks landward and, less obviously, towards the north. It also indicates the erosion offshore near the coastline. The latter extends from Dunwich south to Minsmere sluice, ie in good agreement with the shore data. Additionally, the figure demonstrates accretion offshore, southeast of Sizewell Bank. Because the 1965 survey does not go far enough seaward it is not possible to calculate the total value of sediment gained in this area and therefore the calculation given in Table 4 (see below) for accretion of the banks must be regarded as conservative.

4. Changes in the volume of sediments:

Table 4 is based on the recession rates which have occurred along the coast from Easton Broad, southwards, and the net changes in the offshore area as far as the seaward edge of the offshore banks. In both cases Thorpeness is regarded as the southern limit. The table shows that the losses from the coastline and the gains in the banksare of the same order. This is not to say that there is a simple relationship between them, and several qualifications must be made regarding the calculation. Firstly, the interval between the land surveys is not always constant and, in any event, is greater than that between the 1967 and 1965 hydrographic charts. For the present purpose it has been assumed that there is a linear relationship between erosion and timespan for the beach data, ie if the survey interval on land were 125 years and that offshore 100 years, then the losses from the shoreline for the 100 years are 80% of those calculated for the whole period. Evidence given above suggests that this argument is only partly justified. Secondly, the 'probable losses' between low water mark and the -3 m zone are assumed to be of the same grade of sediment as the cliffs; that is along the cliffed coastline the beach and nearshore material only represent a thin and constant veneer over bedrock. This assumption appears valid. Thirdly, chart datum has been regarded as constant. Fourthly, although there is considerable overlap in grain size, the material comprising the offshore banks is not identical with that derived from the cliffs (Blackley 1979: Topic Report No 3). Fifthly, in line with McCave's concept of a drift divide at Covehithe (McCave 1978), it has been assumed that no sediment enters the coastal system from the north at Easton Broad; nor does it leave along the shoreline south of Thorpeness, although it is probable that gravels do so. Finally, because suspended load is relatively so important offshore (Lees 1979) a simple direct relationship of transport from the coastline to the banks may not be entirely real.

Table 4 represents the sum of the changes between 1867 and 1965. The intervening hydrographic surveys suggest that the gains in volume of material on the banks may not have been regular, but then neither was the erosion of the coastline.

5. Conclusions:

Both the literary and cartographic evidence point to the long-term net erosion of much of the Easton Bavents to Aldeburgh, Suffolk, coastline. The records show that while there appears to have been some synchroneity in peaks of erosion along the coastline as a whole, the rates of erosion over time have been highly variable ranging from zero to over 18 m yr^{-1}.

The hydrographic charts cover the period 1824-1965. These demonstrate the growth of Sizewell Bank towards the north and the progression of the bank system shorewards. Between 1867 and 1965 the overall distance between the coast and the bank crest was reduced by more than one-third (0.9 km).

A comparison of the losses of sediment from the coastline, and the gains on the offshore banks, suggests that these are of the same order of magnitude. However, there are various reasons which militate against a simple exchange of material between the two environments.

REFERENCES

ALEXANDER H, 1841. On the annual destruction of land at Easton Bavents cliff, near Southwold. Proceedings Geological Society, 3, 445-6.

BALDING B J and TURNER P, 1908. Orford Castle, its history and structure in Memorials of old Suffolk, ed. V B Redstone.

CARR A P, 1969. The growth of Orford spit: cartographic and historical evidence from the sixteenth century. Geographical Journal, 135, 28-39.

COOPER E R, 1907. Evidence to the Royal Commission on Coast Erosion.

COPINGER W A, 1904. Suffolk Records and Mss & Co. 5 volumes

HELLARD R C, 1907. Evidence to the Royal Commission on Coast Erosion

LEES B J, 1979. Sediment transport measurements in the Sizewell-Dunwich Banks area, East Anglia, UK. International Meeting on Holocene marine sedimentation in the North Sea basin, International Association of Sedimentologists, Texel, Netherlands. Abstract No 37

MACRAY W D, 1907. Records of the Corporation of Aldeburgh in the County of Suffolk, pp 279-312 of Reports on manuscripts in various collections, Vol IV. Historical Manuscripts Commission, HMSO, Dublin

McCAVE I N, 1978. Grain-size trends and transport along beaches: Example fro, Eastern England. Marine Geology, 28, M43-M51

Royal Commission on Coast Erosion and the Reclamation of Tidal Lands in the United Kingdom, 1907. Vol 1, Part 2: Minutes of evidence accompanying 1st report. 504 pp + 516 pp Appendix

REDMAN J B, 1865. The East Coast between the Thames and the Wash estuaries. Minut. Proceedings Institution of Civil Engineers, 23, 186-256

REID C, 1907. Evidence to the Royal Commission on Coast Erosion

REID W J, 1968. Coastal experiments with radioactive tracers. Dock and Harbour Authority, 39, 84-88

REDSTONE V B, 1908(a). 'Roman villas and Saxon burghs' in Memorials of old Suffolk, ed. V B Redstone

REDSTONE V B, 1908(b). 'The Suffolk shore' in Memorials of old Suffolk, ed V B Redstone

ROBINSON A H W, 1966. Residual currents in relation to shoreline evolution of the East Anglian coast. Marine Geology, 4, 57-84

SPILLER J, 1904. Abstract of paper read to British Association, in evidence of E R Cooper before Royal Commission on Coast Erosion

STEELE HUTTON L P, 1908. 'The story of Suffolk schools' in Memorials of old Suffolk, ed V B Redstone

STEERS J A, 1946. The coastline of England and Wales, 1st ed. Cambridge University Press, 644 pp

WHITAKER W, 1887. The geology of Southwold, and of the Suffolk Coast from Dunwich to Covehithe. Mem. Geological Survey England and Wales, 87 pp

WHITAKER W, 1907. Evidence to the Royal Commission on Coast Erosion

TABLE 1

Rates of erosion at All Saints' Church, Dunwich

AD	m yr^{-1}	% of average (1587-1975)(1.15m yr^{-1})	
1587 - 1753	1.61	140.0	Generalised value: no intervening data
1753 - 1772	3.48	302.6	
1772 - 1826	0.09	7.8	
1826 - 1863	0.06	5.2	
1863 - 1880	2.57	223.5	
1880 - 1882/3	0.16	13.9	
1882/3 - 1903	0.08	7.0	
1903 - 1919	3.53	307.0	
1919 - 1975	0.26	22.6	

TABLE 2

Coastal change: Easton Bavents to Aldeburgh

Location	National Grid (northings)	Recession(-) or accretion(+) metres*	Rate (m yr^{-1})	Dates of surveys	Average height of cliff (m) (where applicable)	Notes (* Mostly at High Water Mark)
Easton Bavents(N)	(2)79	-360	-2.95	1849/1970-72	8	) Cliff falls to below 5m
(C)	78	-328	-2.69	" " "	11	) between
Southwold (N)	77	-178	-1.35	1839/ " "		At Northings772
(C)	76	-	-	-		Southwold(C) groyned
(S)	75	-	-	-		)
Walberswick	74	-98	-0.66	1826/1975		) Training walls between
Dingle Marshes (N)	73	-178	-1.19	" "		
(C)	72	-98	-0.66	" "		
(S)	71	-130	-0.87	" "		
Dunwich Cliffs(N)	70	-135	-0.91	" "	19	Estimated from data to N and S.
(S)	69	-238	-1.59	" /1976	16	Cliff reaches maximum height at Northings 684
Minsmere Cliffs(S)	68	-200	-1.33	1826/ "	15)Cliffs	-185 between 1838 & 1976
Coney Hill/ Minsmere Marshes (N)	67	-65	-0.48	1840/ "	)cease)between	Difference approx.40m between 1826 and 1840 on overlap
Minsmere Marshes (C)	66	0	0	" /1975		
(S)	65	0	0	" /1976		
Sizewell(N)	64	0	0	" /1970	7(?))	Not significant because
(C)	63	+33	+0.25	" / "	8)	coastline not eroding
(S)	62	+15	+0.11	1839/ "	10)	
Thorpeness(N)	61	-40	-0.31	" "	7(atypically low)	) 11m high between
(C)	60	-60	-0.46	" "	8	)
(S)	59	+5	+0.04	(pre)1846/1970-71		)Tithe map:water-line not
Sluice	58	+65	+0.52	" "		) defined and poor survey
Aldeburgh(N)	57	+13	+0.10	" "		) Sluice to Martello tower:
(S)	56	-18	-0.14	" "		) mainly pebble beach.
Martello 'CC'	55	-83	-0.66	" "		

TABLE 3

Changes in relative position of Sizewell Bank

(a): Northerly displacement

Survey dates	Period (yr)	Distance (km) 3f	Distance (km) 4f	Rate (m yr^{-1}) 3f	Rate (m yr^{-1}) 4f
1824 - 67	43	3.78	5.59	88	130
1867 1921/2	54 - 55	1.43	0.31	26	6
1921/2 - 30	8 - 9	0.91	0.10	107	12
1930 - 65	35	0.80	0.96	23	27
		Average (1824 - 1965)		49	49

(b) Landward (ie approx Westerly) displacement of crest line: 1867 - 1965

Position (opposite):	National Grid (northings)	Distance (km)	Rate (m yr^{-1})
Dunwich cliff (N)	706	nil*	-
Minsmere cliffs	684	1.05	10.7
Minsmere sluice	661	0.90	9.2
Sizewell Nuclear Power Stn.	633	0.65	6.6
Sizewell village	627	0.61	6.2
Thorpeness (N)	610	nil	-

* Complex readjustments consequent upon amalgamation of formerly discrete banks

f = fathoms below Chart Datum

TABLE 4

Calculation of changes in volume of cliffs and Sizewell-Dunwich Bank (1867-1965)

		m^3	Period	m^3 (1867-1965)
LOSSES FROM COAST				
Losses from cliffs:	Easton Bavents	-4,395,600	(1849-1971 average)	-3,530,900
	Dunwich-Minsmere	-8,609,550	(1826*-1976 average)	-5,624,900
	Thorpeness	- 329,500	(1839-1976)	- 235,700
			Sub-Total	-9,391,500
Losses offshore (near coastline)			" "	-7,750,000
Probable losses (between LWM and -3m zone: gap in surveys)				
	Easton Bavents	-1,040,000	(1849-1971 average)	- 835,400
	Dunwich-Minsmere	-1,050,000	(1826*-1976 average)	- 686,000
			Sub-Total	-1,521,400
			TOTAL LOSSES (1867-1965)	-18,662,900
GAINS TO OFFSHORE BANKS				
Gains in volume of Sizewell-Dunwich banks (minimum)				21,921,900

Change in volume of bank between 1867-1965 relative loss of cliff material for same period = 117%

*mostly

APPENDIX 1 : List of Tithe Maps used for comparisons

Date*	Surveyor	Title	Scale	Public Record Office Ref:	Notes
(1846)	-	Parish of Aldborough	1:2376	IR 30/33/3	Certified as map referred to; not necessarily correct. Some obvious errors.
1839	J Smy	Parish of Aldringham and Thorpe	1:2376	IR 30/33/6	Certified as correct. Specifies HWM with another line (LWM?) below.
1838	Lenny & Croft	Borough and Parish of Dunwich	1:3960	IR 30/33/138	Certified as map referred to. A partial revision of Richard Barnes' map of 1826. Labels both HWM and LWM.
1849	Lenny & Croft	Easton Bavents	1:3960	IR 30/33/142	Certified as map referred to. Tide line not specified but agrees well with HWM of plan of Reydon where overlap.
1840	J Smy	Leiston-cum-Sizewell	1:3148	IR 30/33/270	Certified as correct. Solid boundary at sea edge not specified but shows 2 other pecked lines above.
1839	Lenny & Croft	Reydon	1:2376	IR 30/33/335	Certified as correct. Short length of coast with HWM.
1840	Lenny & Croft	Southwold: Part 1	1:2376	IR 30/33/372	Certified as map referred to. Irregular area with much detail including tide lines missing.
1841	-	Walberswick	1:6336	IR 30/33/428	Certified as map referred to. Seawards boundary is probably HWM.

*Date of survey where given or date certified (in brackets) if not supplied.

APPENDIX 2 : List of principal hydrographic surveys

Date	Surveyor(s)	Title	Scale	Hydrographic Dept ref.	Notes
1824	- G Thomas	Lowestoft Roads to Orfordness	1:31,800	E194	For datums see Appendix 3
1867	Cdr E K Calver	Lowestoft Roads to Orfordness	1:48,900	A1136	
1921/2	Cdrs F E B Haselfoot and J R Harvey	Sizewell and Dunwich Banks	1:48,900 (approx)	C8951	
1930	Lt Cdr D H Fryer	Walberswick to Aldeburgh: Dunwich and Sizewell Banks	1:50,000	H4858	
1965	Lt Cdr D R Benson	Dunwich and Sizewell Banks	1:25,000	K4799/1	

Other partial surveys include Bullock (1851: L7742d); Penfold (1912: C4737); Harvey (1921:C8526); Kelvin and Hughes (1958: K1949) and Lowndes (1976: K7631/1-2).

APPENDIX 3: Changes between successive hydrographic surveys

1824-1867 (43 years) Dunwich Bank is shown slightly smaller in 1867 as compared with 1824 but in virtually the same position. There is considerable detailed change off Thorpeness between the two surveys but this is not very significant. The major change is in the northward progression of Sizewell Bank where the 3f contour is now 3.78km and the 4f contour 5.59km further N. The 5f contour is not appreciably different. Both surveys show occasional depth equal to or exceeding 6f between the banks and the coastline.

1867-1921/2 Banks show:
(a) Complete elimination of Dunwich Bank as a separate entity. The original location is now mostly at ~ 5f.
(b) Continuing growth of 3f line towards N (by 1.43km) but only 0.31km in 4f line.
(c) Beginning of landward displacement of banks by, typically, 0.3 to 0.4km.
Apart from changes in 5f line opposite Dunwich little change. Survey shows occasional local 6f depth between Sizewell Bank and coastline (as before).

1921/2-1930 Banks show:
(a) Continuing growth of 3f line towards N (by 0.91km) and 4f line (by approx 0.1km).
(b) Continuing landward displacement of banks esp between N of Thorpeness and Minsmere cottages (shown in Fig 7) by between 0.13 and 0.32km.
(c) No obvious trends opposite Thorpeness except that seaward limit of 3f line is up to 0.25km further seaward while immediately S a southern tongue has retreated (about 0.9km for the 3f contour but little change on 4f line).
(d) Except at former site of Dunwich Bank and slight landward displacement of 5f contour on seawards face of Sizewell bank, 5f contour is virtually constant.

1930-1965 Banks show:
(a) Continuing growth of 3f (by 0.80km) and 4f (by 0.96km) contours towards N.
(b) Continuing landward displacement of bank everywhere N of nuclear power station (by between 0.25 and 0.60km) on both 3f and 4f contours as well as crest line. 5f has been displaced slightly less (by up to 0.46km).
(c) Elimination of 3f and 4f tongue formerly extending from Thorpeness (by retreat of approx 2.05 and 2.60km respectively).
(d) Other detail at Thorpeness is very similar however.
Some increase in depths of 6f and above between bank and coastline; probably greater than the change in datum (0.6 feet) would warrant. 5f contour at N end of bank very similar between surveys.

Notes: (i) In general the triangulation control is very good from the 1824 survey onwards.
(ii) Datums: 1824 not known but 1804 to 1847 charts in adjacent Orford area were corrected to extreme low water springs. For Southwold this would be -4.76' ODN.
1867 not clear. Calver used Lowestoft and Orfordness for his datums. Calculations suggest a chart datum of between 3.8 and 4.5 feet below ODN. 4.2' has been used.
1921/2 and 1930 = 4.8' below Ordnance Datum, Newlyn. 1921/2 specifies at Southwold.
1965 = 4.2' below OD(N) at Southwold.
Because the tidal range in the Dunwich area is comparatively small, the problem is not considered to be too critical.

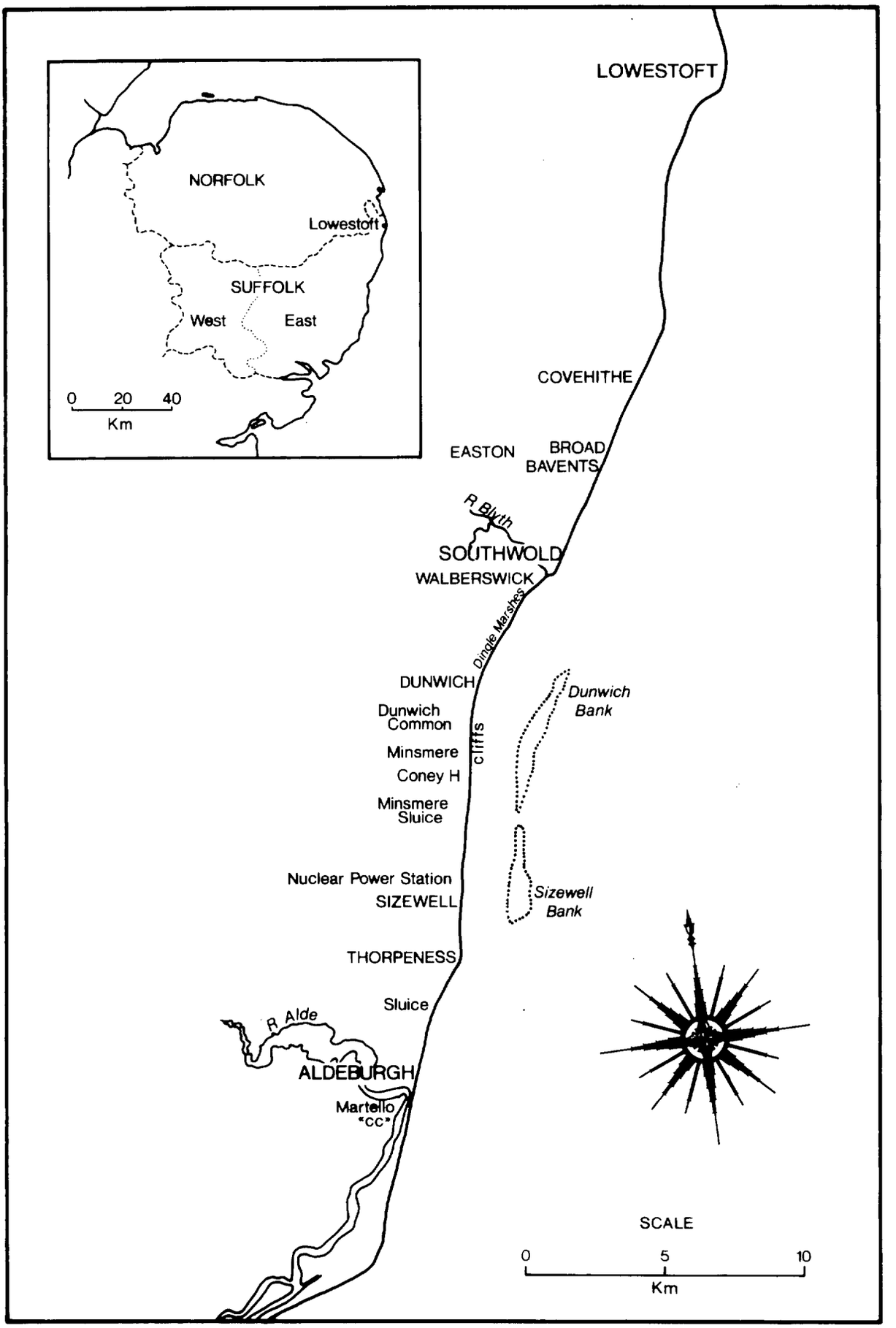

LOWESTOFT
NORFOLK
Lowestoft
SUFFOLK
West
East
0 20 40
Km
COVEHITHE
EASTON
BROAD
BAVENTS
R Blyth
SOUTHWOLD
WALBERSWICK
Dingle Marshes
DUNWICH
Dunwich
Common
Minsmere
Coney H
Minsmere
Sluice
cliffs
Dunwich
Bank
Sizewell
Bank
Nuclear Power Station
SIZEWELL
THORPENESS
Sluice
R Alde
ALDEBURGH
Martello
"cc"
SCALE
0 5 10
Km

Fig.1

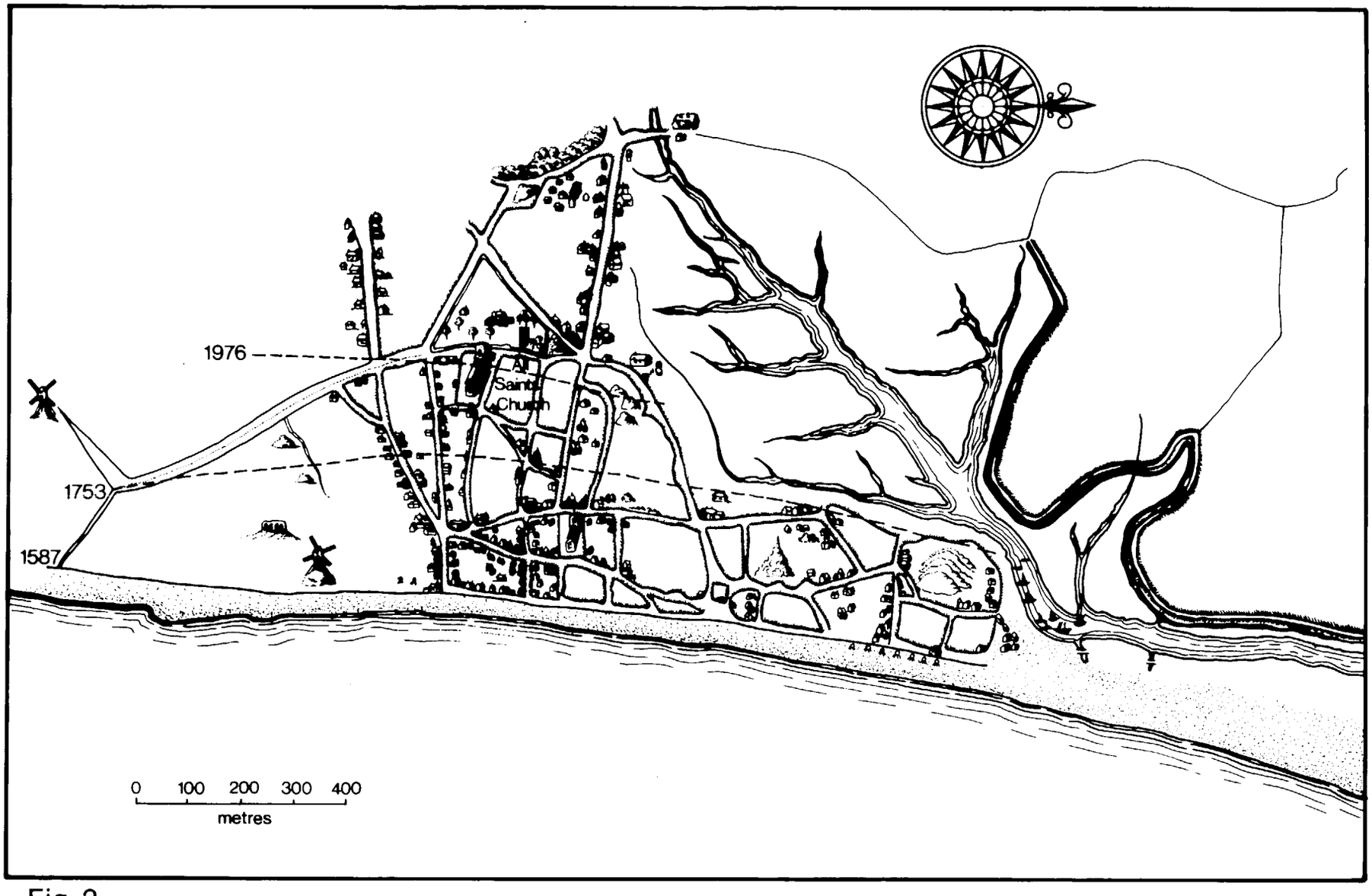
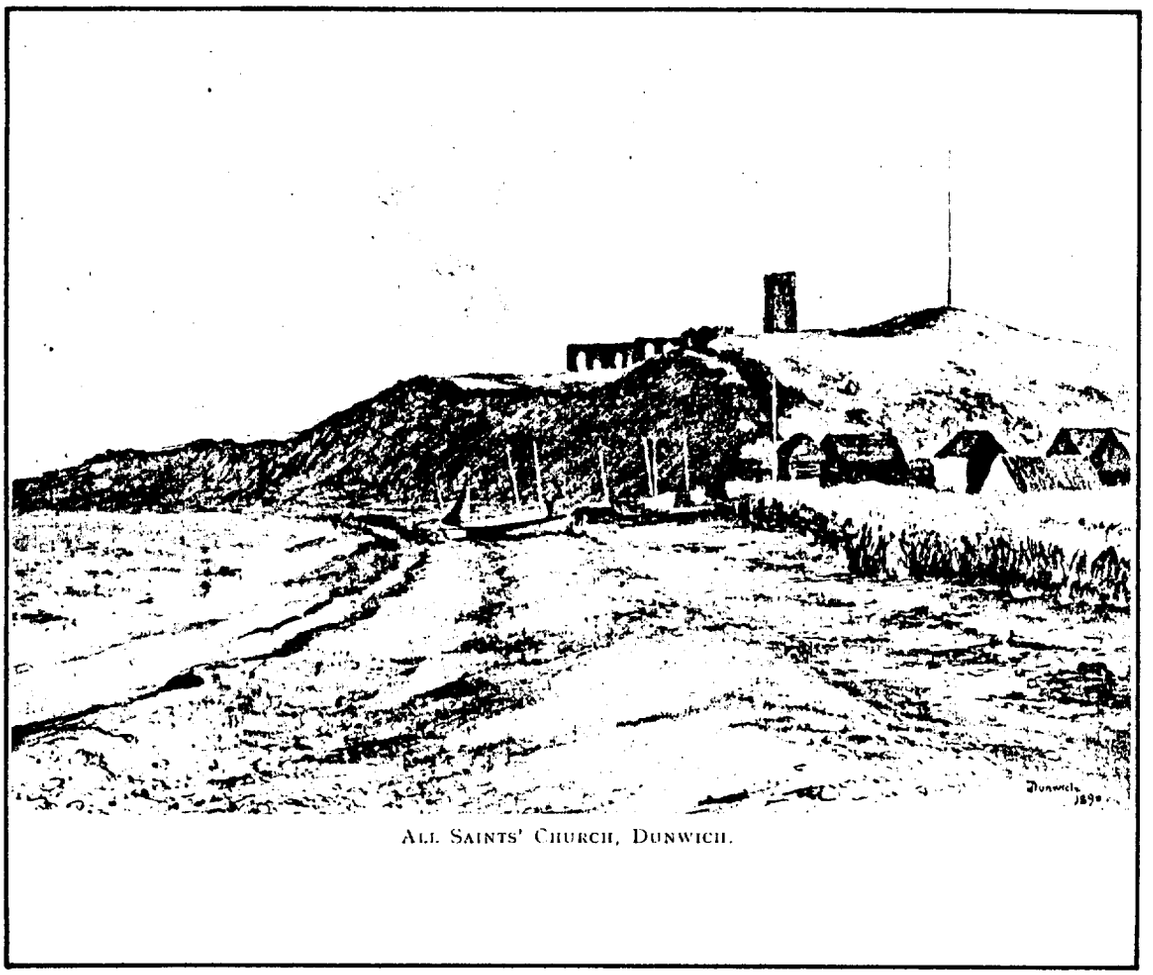


Fig. 2



All Saints' Church, Dunwich.

Fig .3

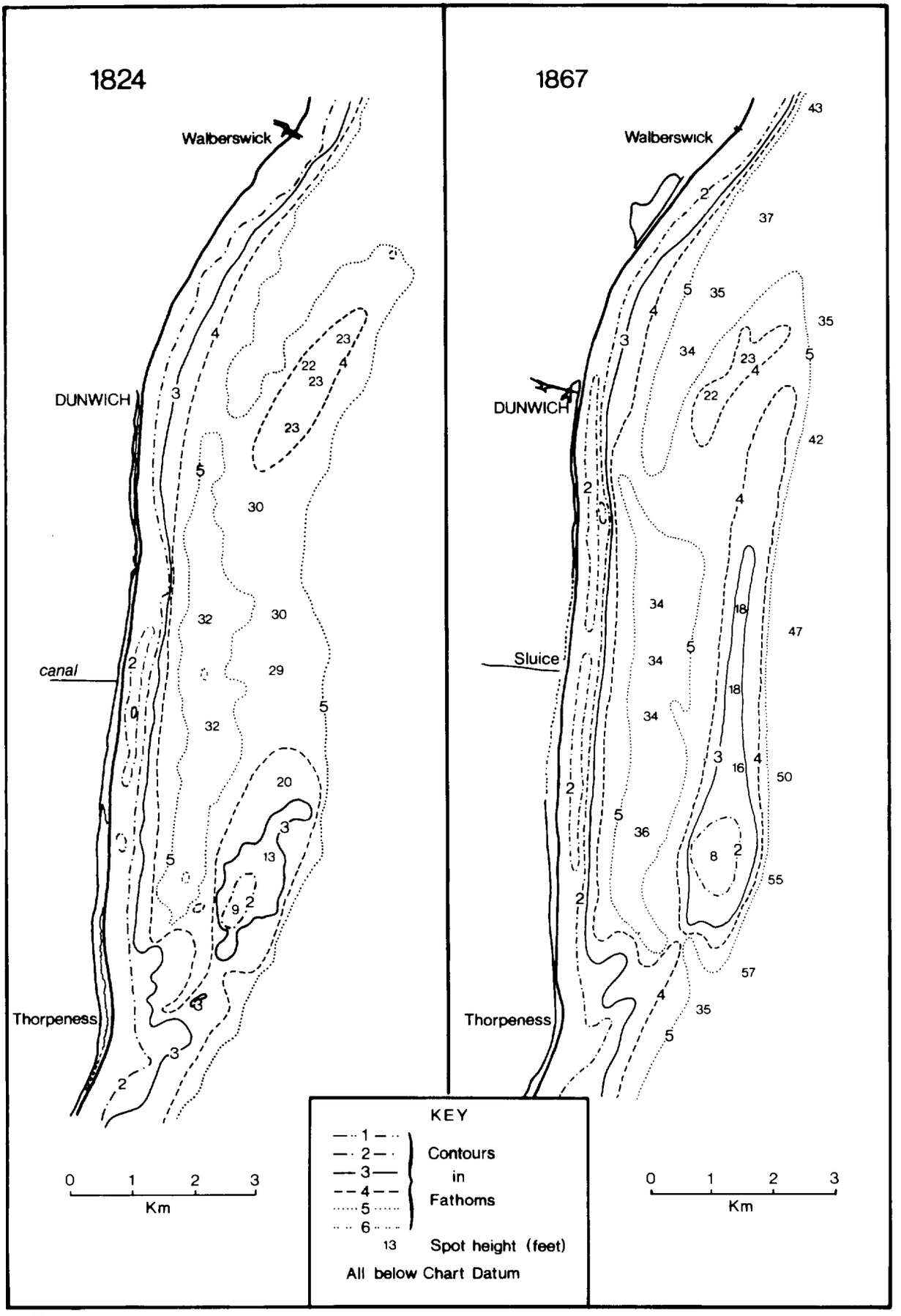

1824
Walberswick
DUNWICH
canal
Thorpeness
1867
Walberswick
DUNWICH
Sluice
Thorpeness
0 1 2 3
Km
KEY
1
2
3
4
5
6
Contours in Fathoms
13 Spot height (feet)
All below Chart Datum

Fig.4

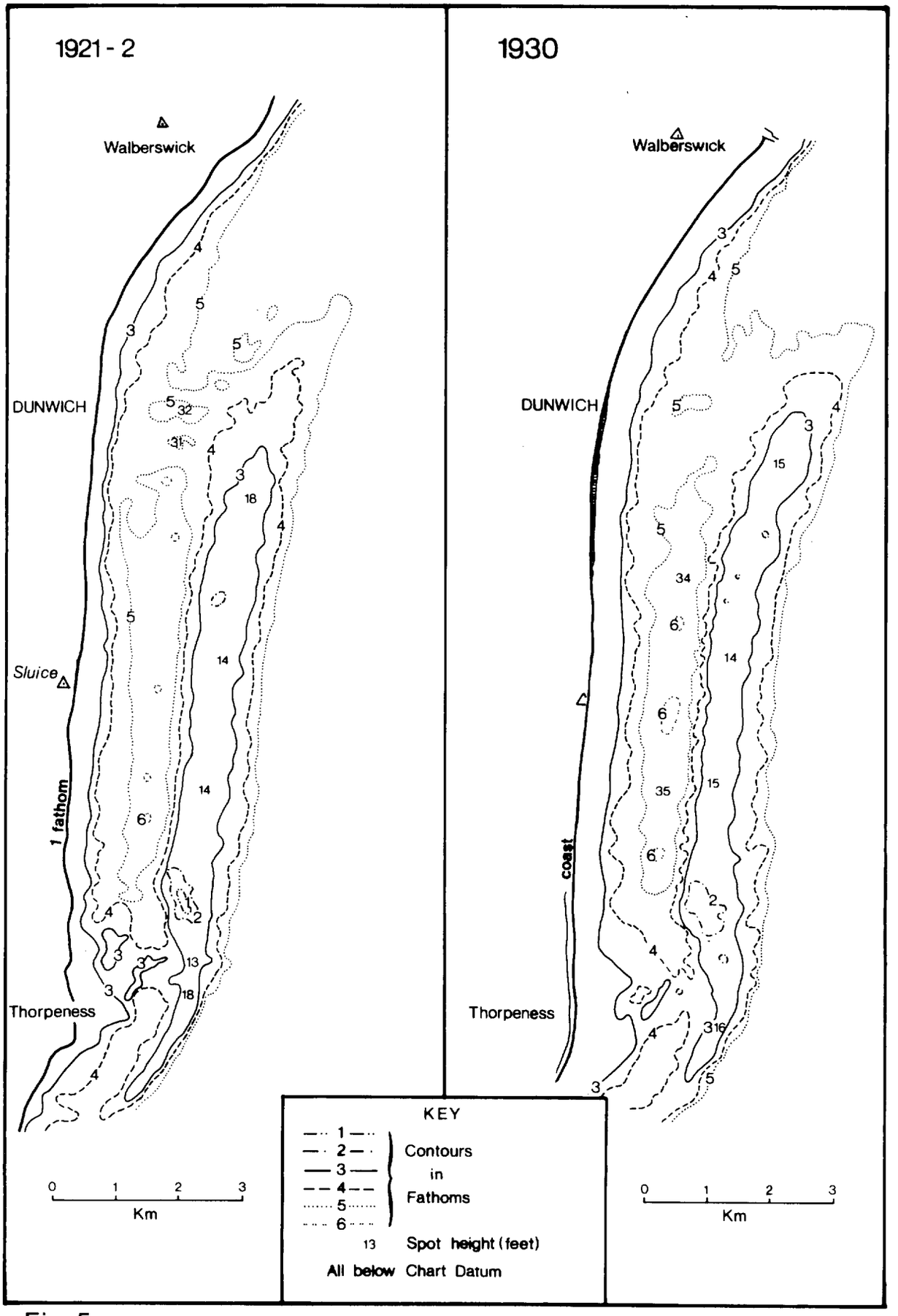

1921 - 2
Walberswick
DUNWICH
Sluice
1 fathom
Thorpeness
0 1 2 3
Km
1930
Walberswick
DUNWICH
coast
Thorpeness
0 1 2 3
Km
KEY
1
2
3
4
5
6
Contours in Fathoms
13 Spot height (feet)
All below Chart Datum

Fig. 5

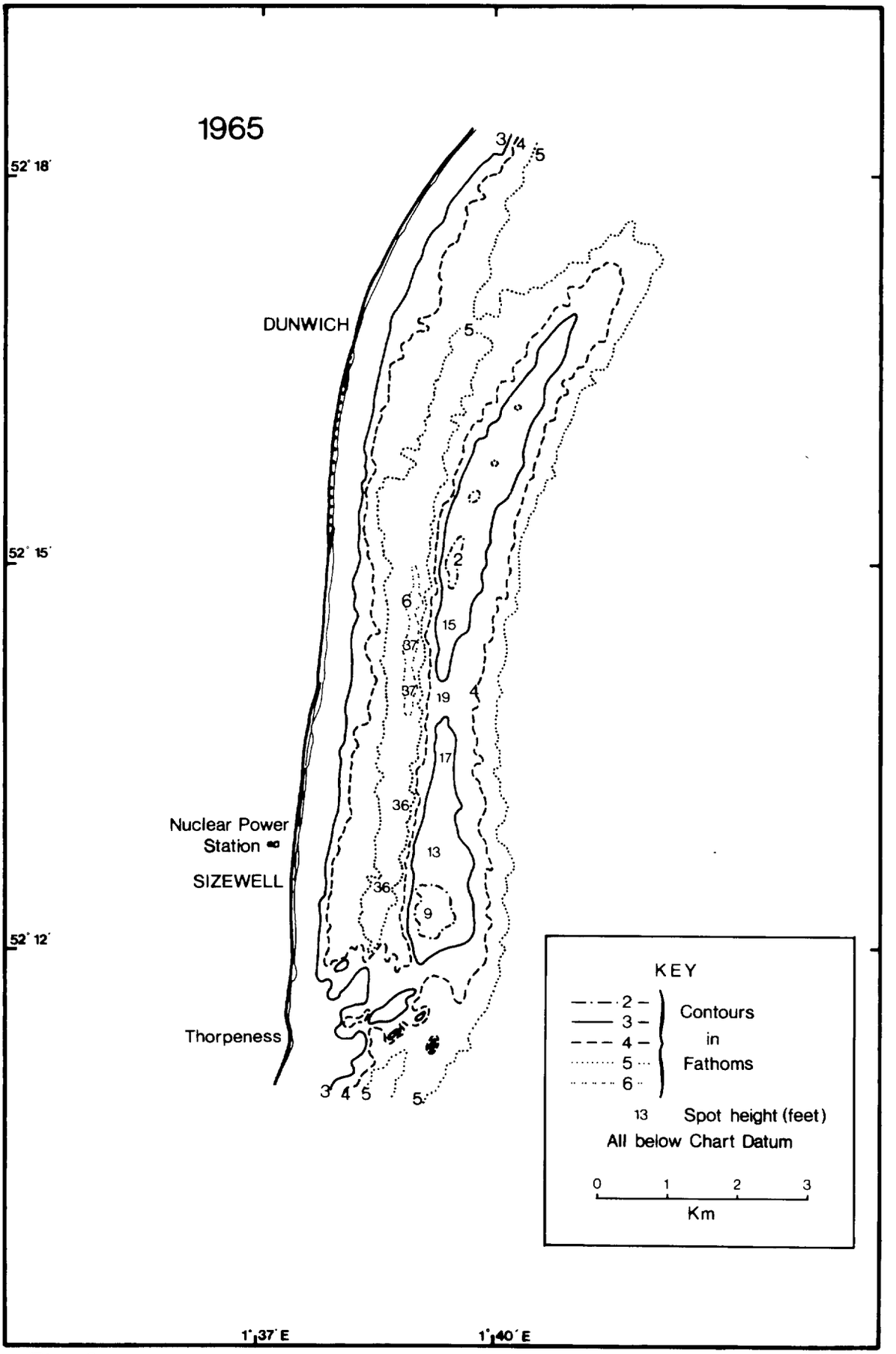

1965
52° 18'
52° 15'
52° 12'
1° 37' E
1° 40' E
DUNWICH
Nuclear Power Station
SIZEWELL
Thorpeness
3
4
5
2
6
15
37
19
17
36
13
9
KEY
2
3
4
5
6
Contours in Fathoms
13 Spot height (feet)
All below Chart Datum
0 1 2 3
Km

Fig. 6

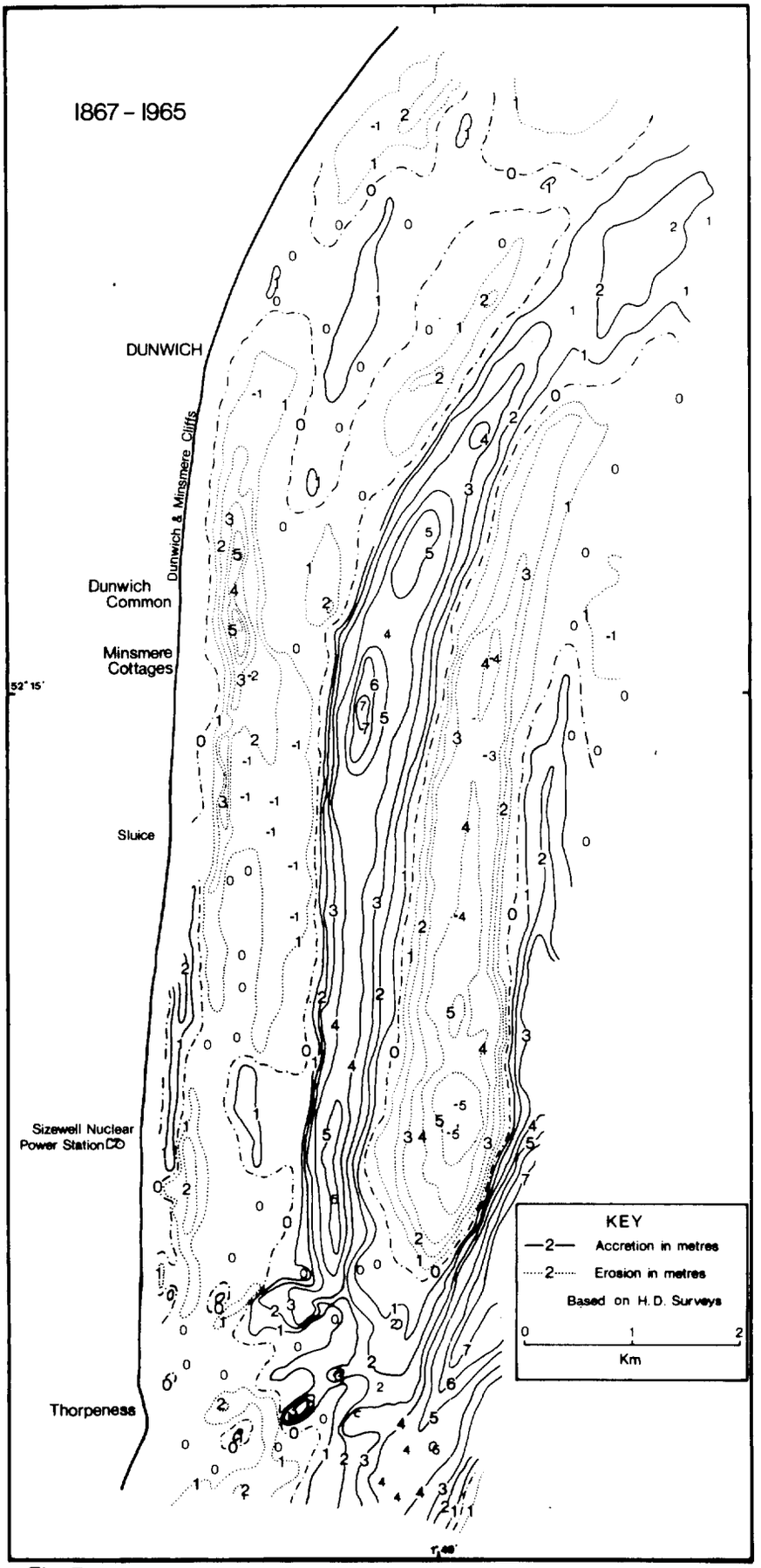

1867 - 1965
DUNWICH
Dunwich & Minsmere Cliffs
Dunwich Common
Minsmere Cottages
52° 15'
Sluice
Sizewell Nuclear Power Station
Thorpeness
KEY
2 Accretion in metres
2 Erosion in metres
Based on H.D. Surveys
0 1 2
Km

Fig. 7