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## *Some aspects of the geomorphology of the Durham coast*

W. A. Westgate

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SOME ASPECTS OF THE GEOMORPHOLOGY  
OF THE DURHAM COAST

W.A. Westgate, B.Sc.

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Submitted for the Degree of Ph.D. in  
the University of Durham.

February, 1957.



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FIG. 1.

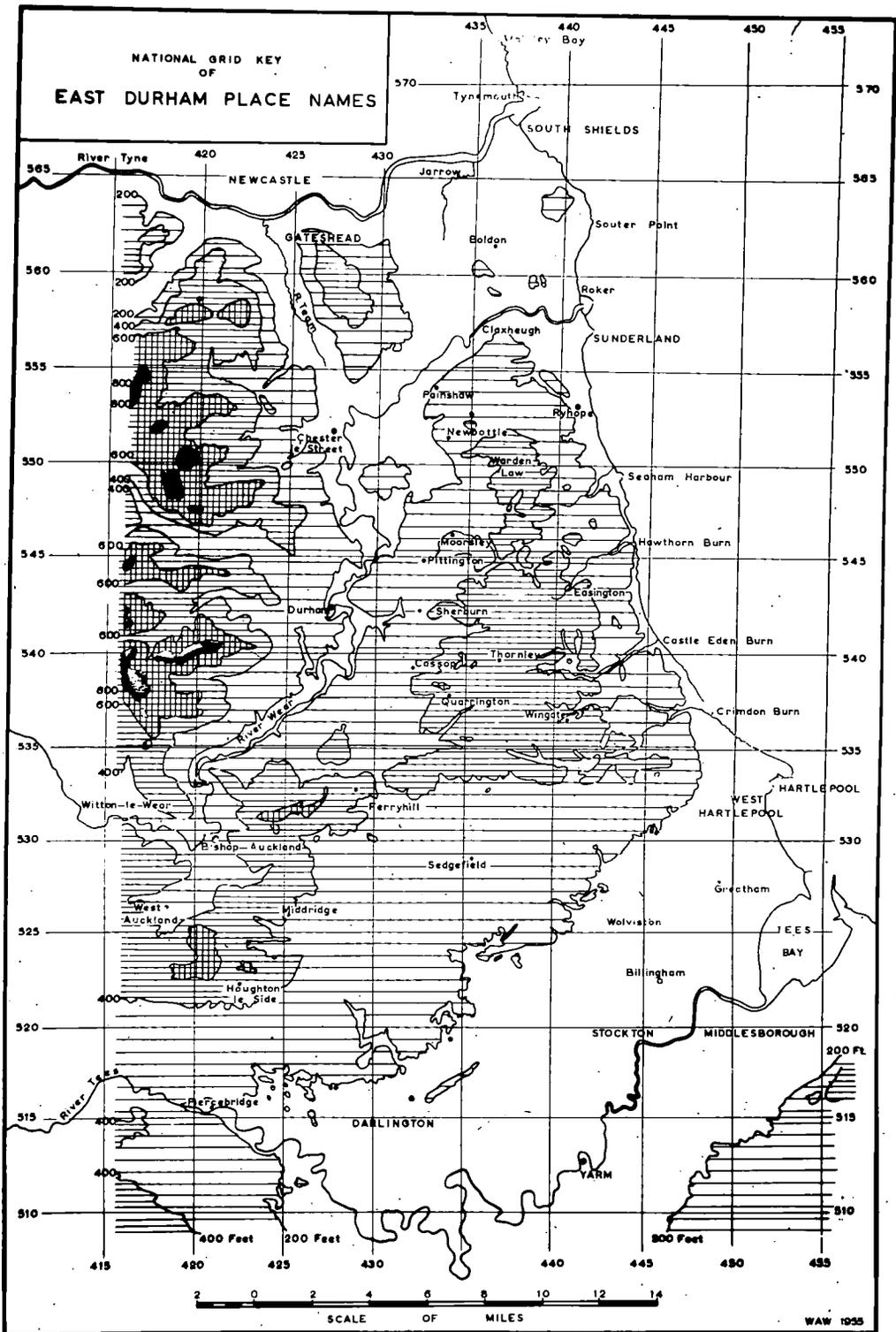
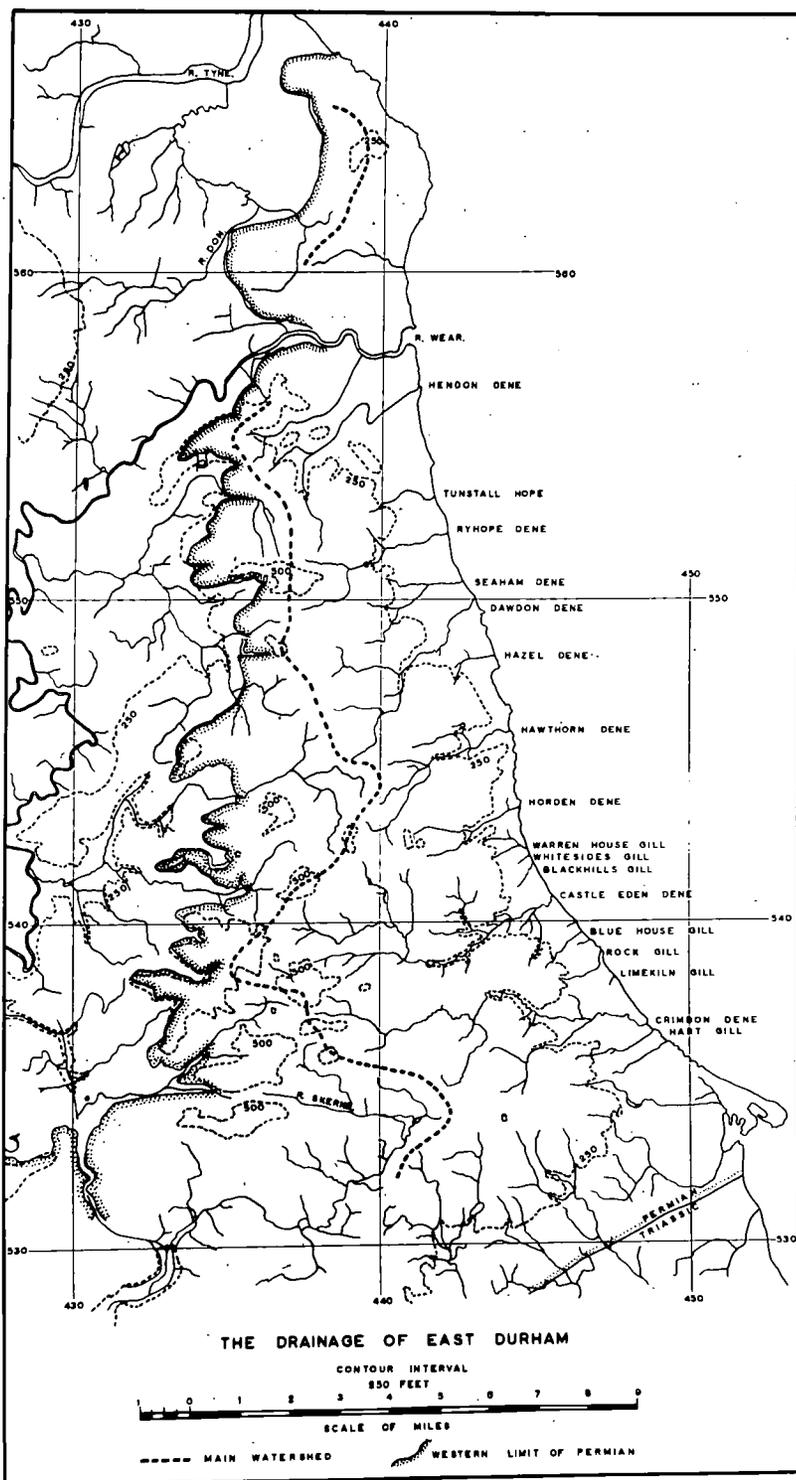


FIG. 2.



ALTIMETRIC FREQUENCY CURVES EAST DURHAM

BASED ON THE HIGHEST POINTS PER SQUARE KM.

- (A) 20 foot Grouping
- (B) 40 foot Grouping
- (C) 60 foot Grouping

BASED ON THE HIGHEST POINTS PER 1/4 SQUARE KM.

- (D) 20 foot Grouping
- (E) 40 foot Grouping
- (F) 60 foot Grouping

BASED ON THE HIGHEST POINTS PER 4 SQUARE KMS.

- (G) 20 foot Grouping
- (H) 40 foot Grouping

BASED ON G.E. ONE INCH MAPS, NEW POPULAR EDITION.

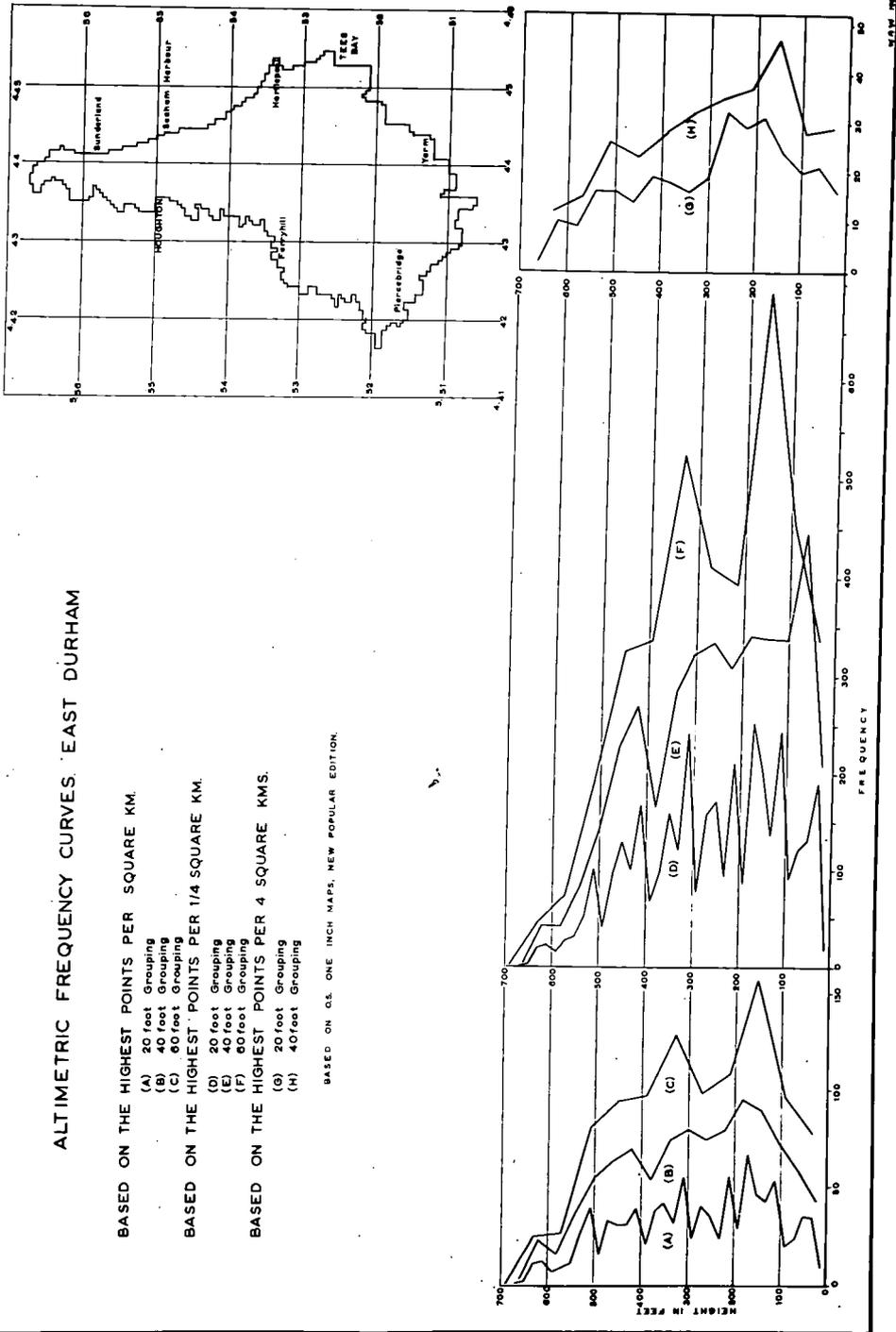


FIG. 4.

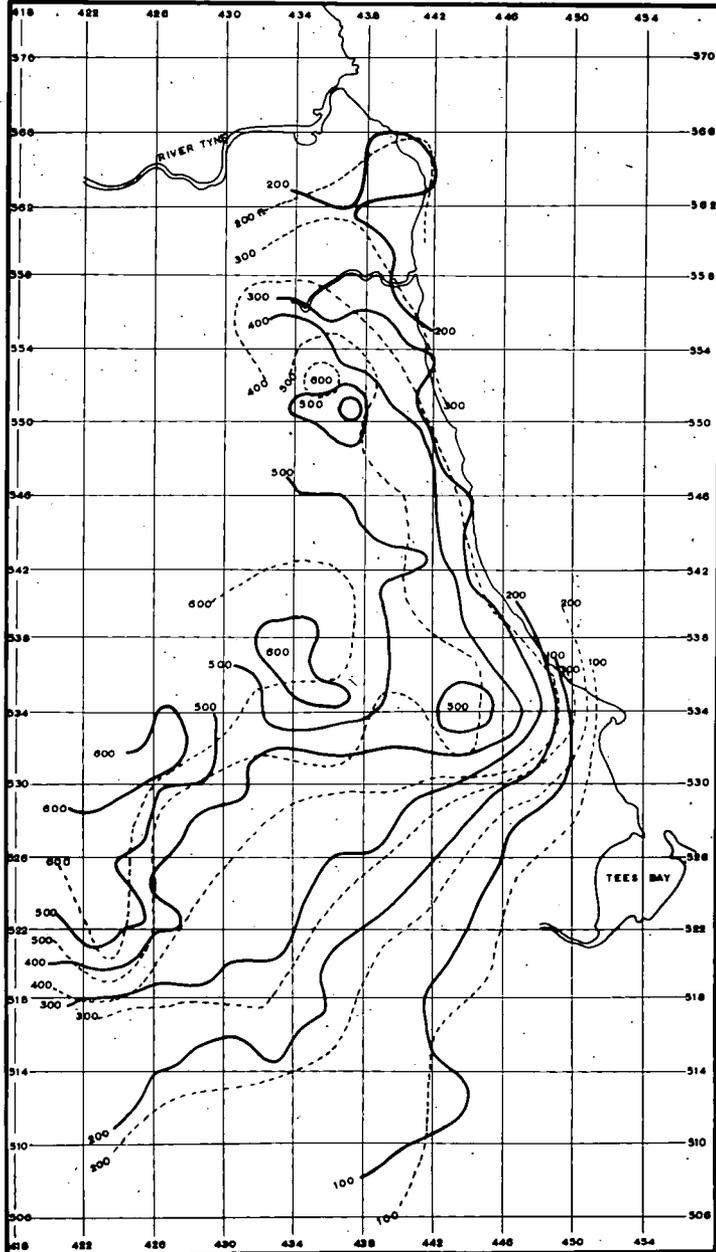
Generalised Contours. East Durham.

- BASED ON HIGHEST POINTS PER 4 SQUARE KMS.
- - - BASED ON HIGHEST POINTS PER 16 SQUARE KMS.

CONTOUR INTERVAL 100 FEET.



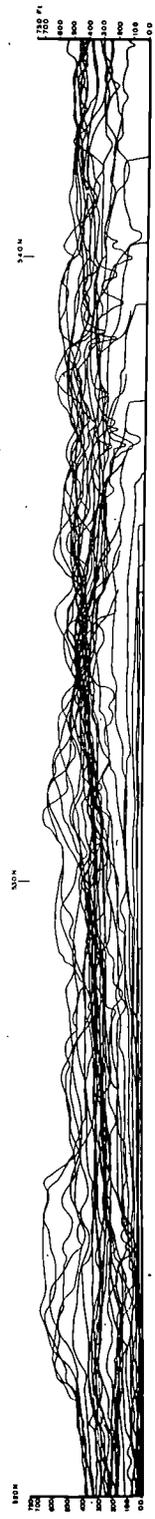
BASED ON OS ONE INCH MAPS, POPULAR EDITION.





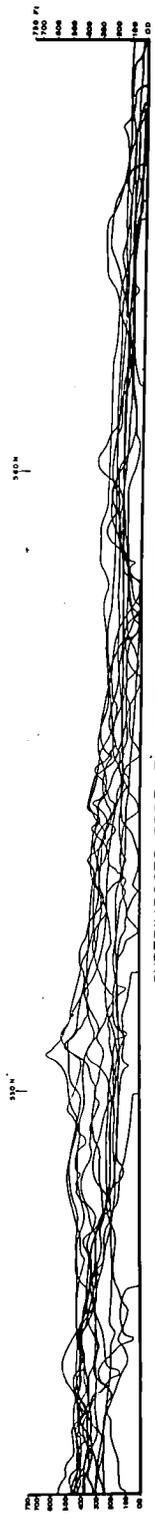
**SUPERIMPOSED PROFILES ACROSS EAST DURHAM**

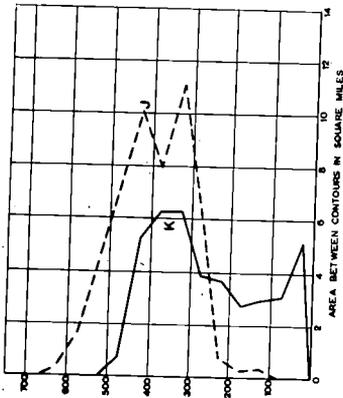
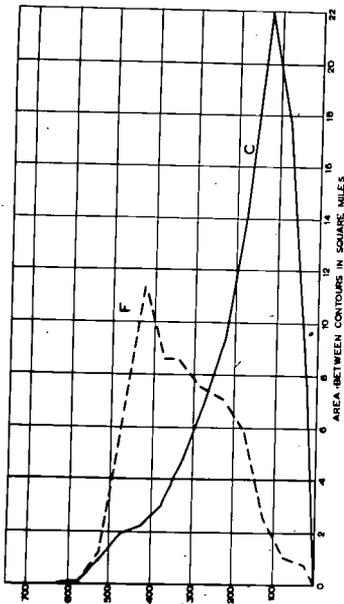
Profiles taken from OS 1:25000 Provisional Edition measured West to East along National Grid Lines between 570N & 525N inclusive, northwards from 430E to the sea.



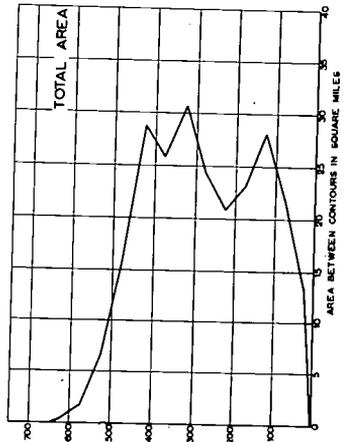
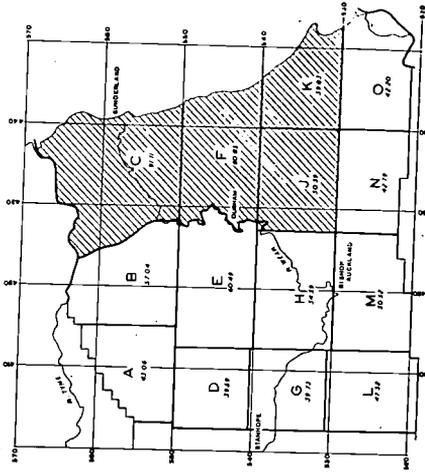
**SUPERIMPOSED PROFILES ACROSS EAST DURHAM**

Profiles taken from OS 1:25000 Provisional Edition measured South to North along National Grid Lines between 420E & 452E inclusive, northwards from 520 N to the River Wear, the River Tyne and to the sea coast





AREA-HEIGHT CURVES OF EAST DURHAM  
EXCLUDING THE TEES LOWLANDS



KEY TO AREAS MEASURED  
WITH AREAS IN SQUARE MILES

FIG. 7.

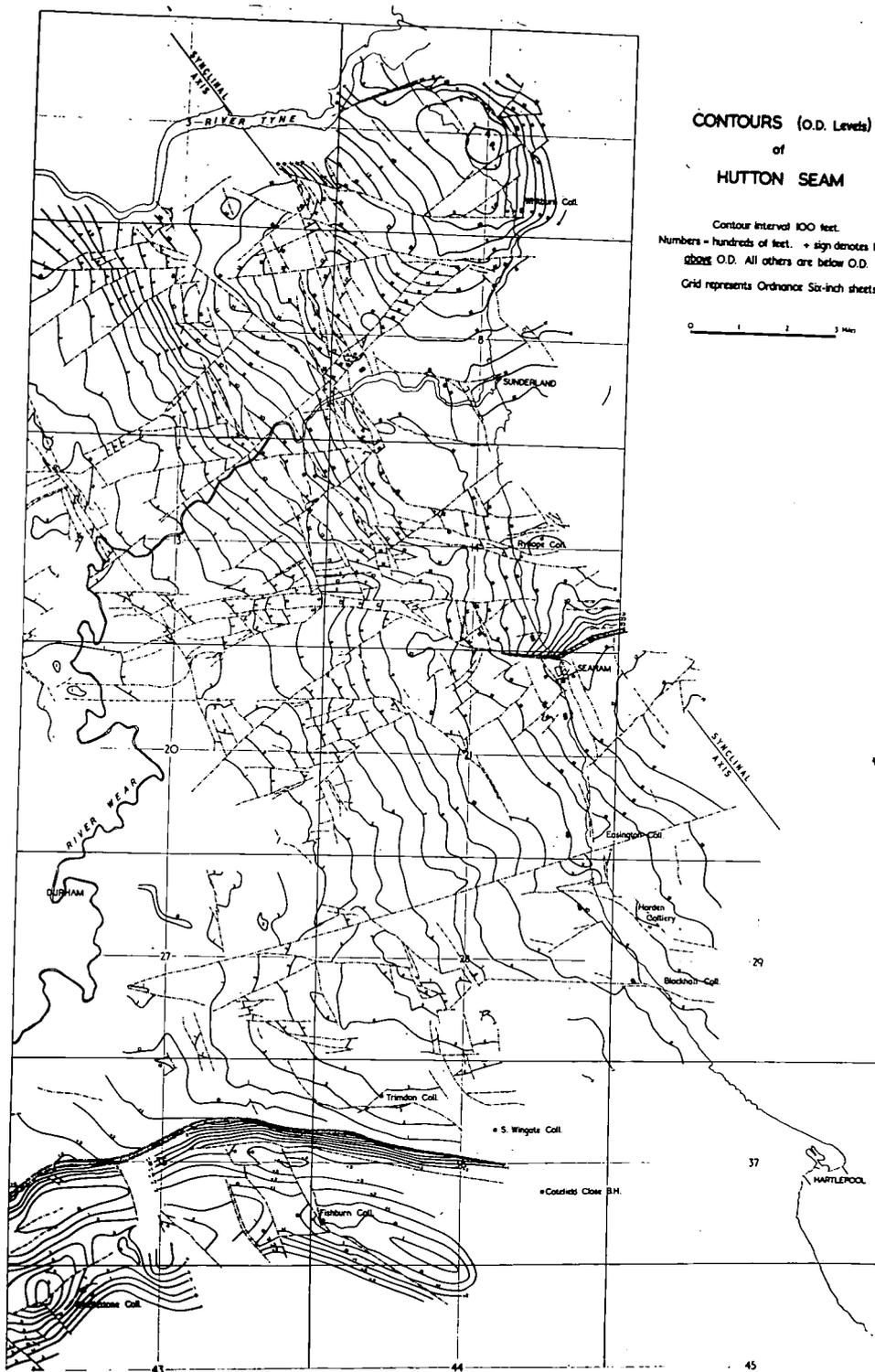
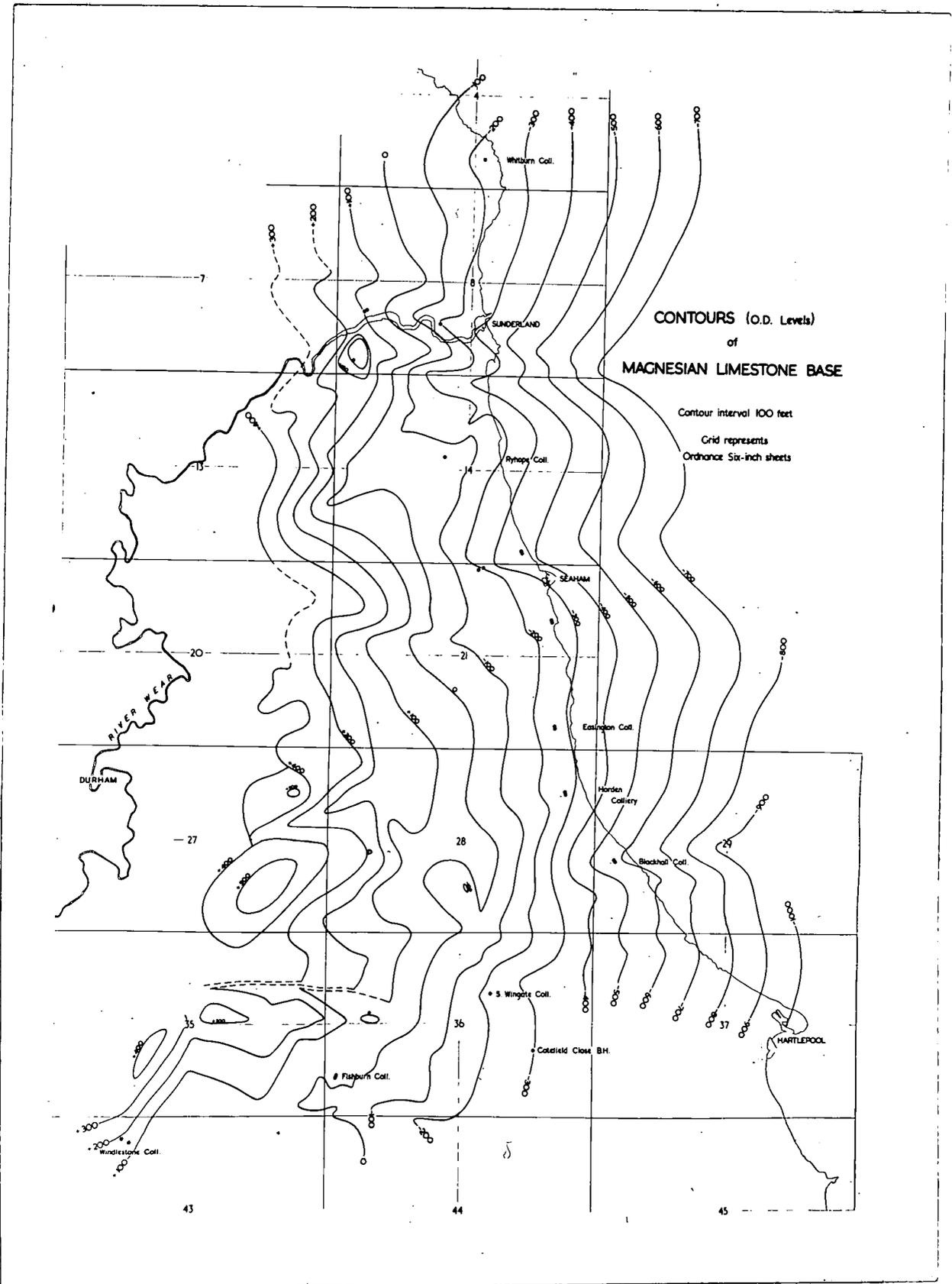
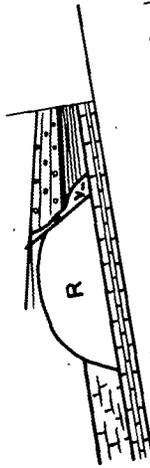


FIG. 8.



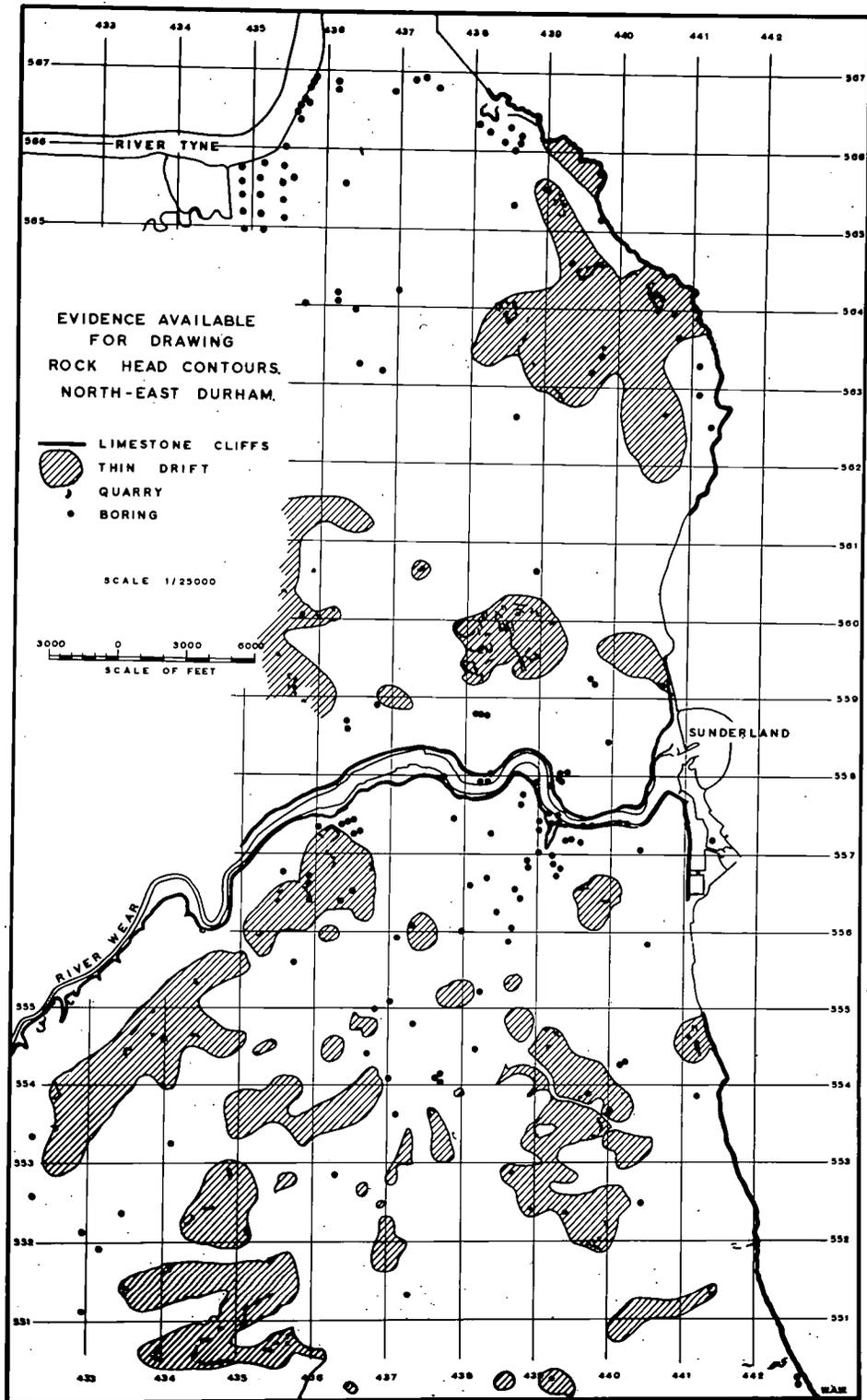
IDEAL SECTIONS THROUGH THE DURHAM PERMIAN.

(B).



-  INTERBEDDED FOSSILIFEROUS BRECCIA.
-  BRYOZOA REEF.
-  MIDDLE LIMESTONE. FOSSILIFEROUS.
-  LOWER LIMESTONE.
-  MIDDLE LIMESTONE. UNFOSSILIFEROUS.
-  FLEXIBLE LIMESTONE.
-  UPPER LIMESTONE. CONCRETIONARY.
-  BRYOZOA REEF.
-  MIDDLE LIMESTONE. UNFOSSILIFEROUS.
-  UPPER LIMESTONE. CONCRETIONARY.
-  ROKER OOLITE.
-  MIDDLE DOLOMITE. FOSSILIFEROUS.
-  LOWER DOLOMITE.
-  MARL SLATE.
-  YELLOW SANDS.
-  COAL MEASURES.
-  BRYOZOA REEF.
-  MIDDLE LIMESTONE. UNFOSSILIFEROUS.
-  UPPER LIMESTONE. CONCRETIONARY.
-  ROKER OOLITE.

FIG. 10.



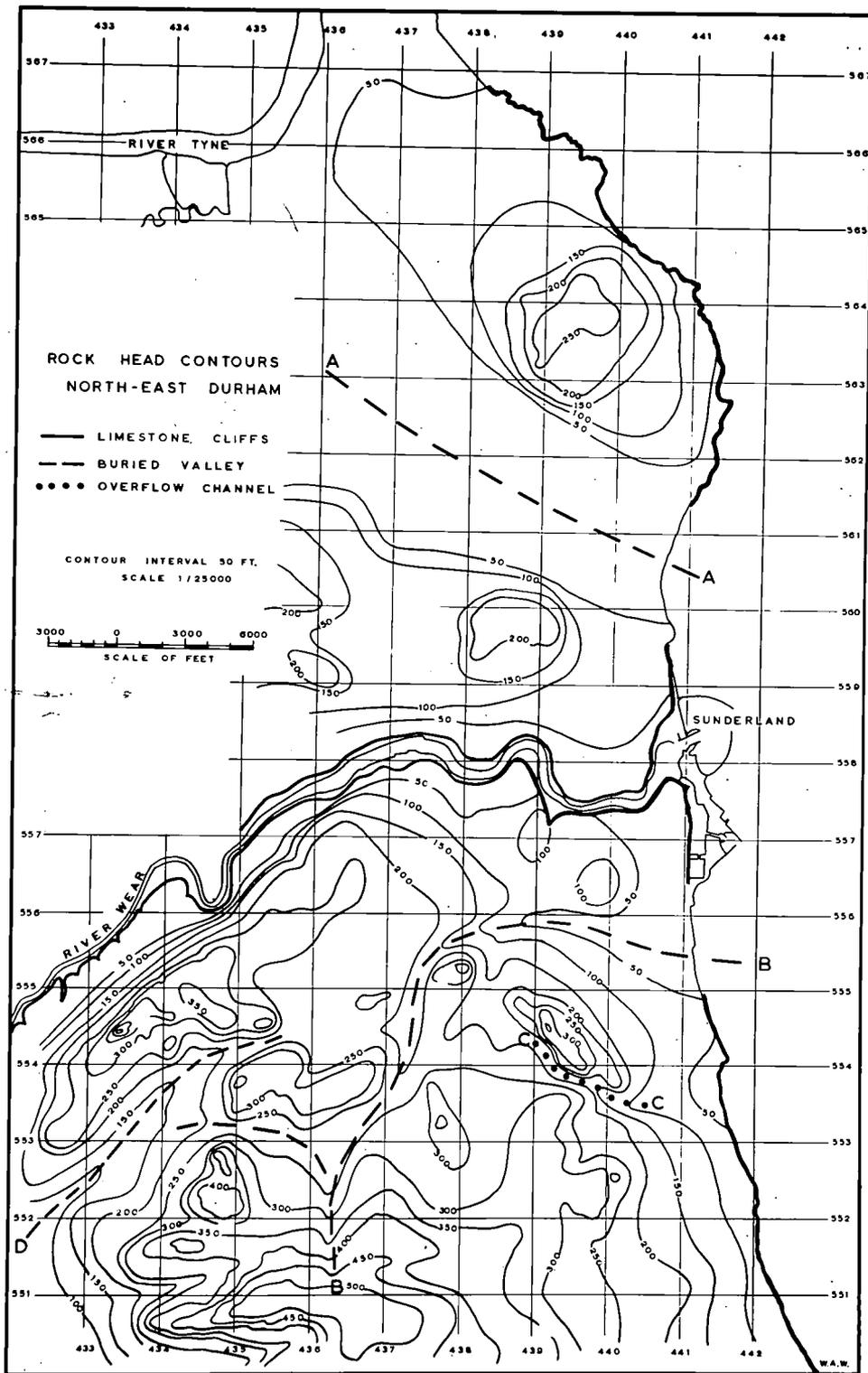


FIG. 12.

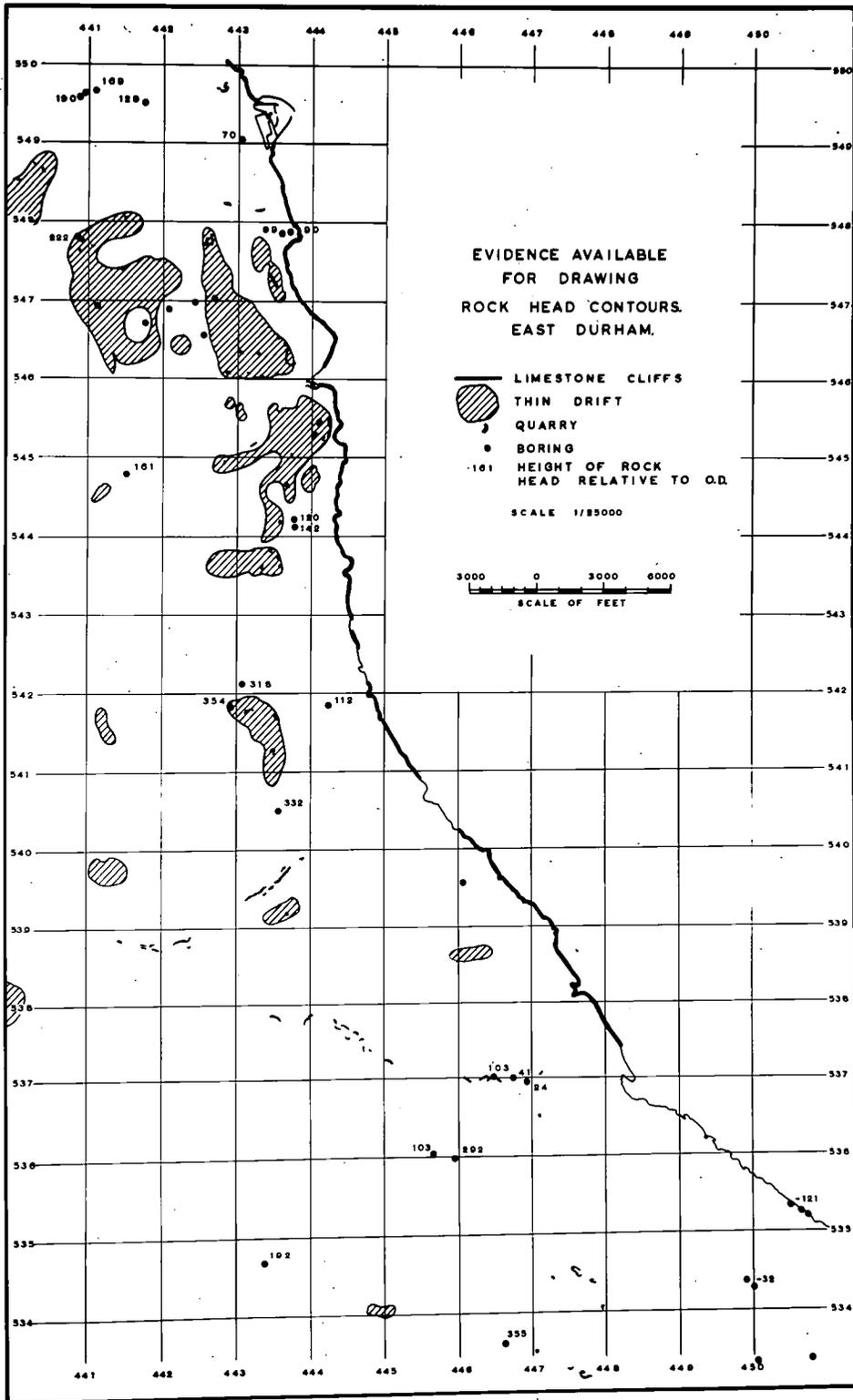




FIG. 14

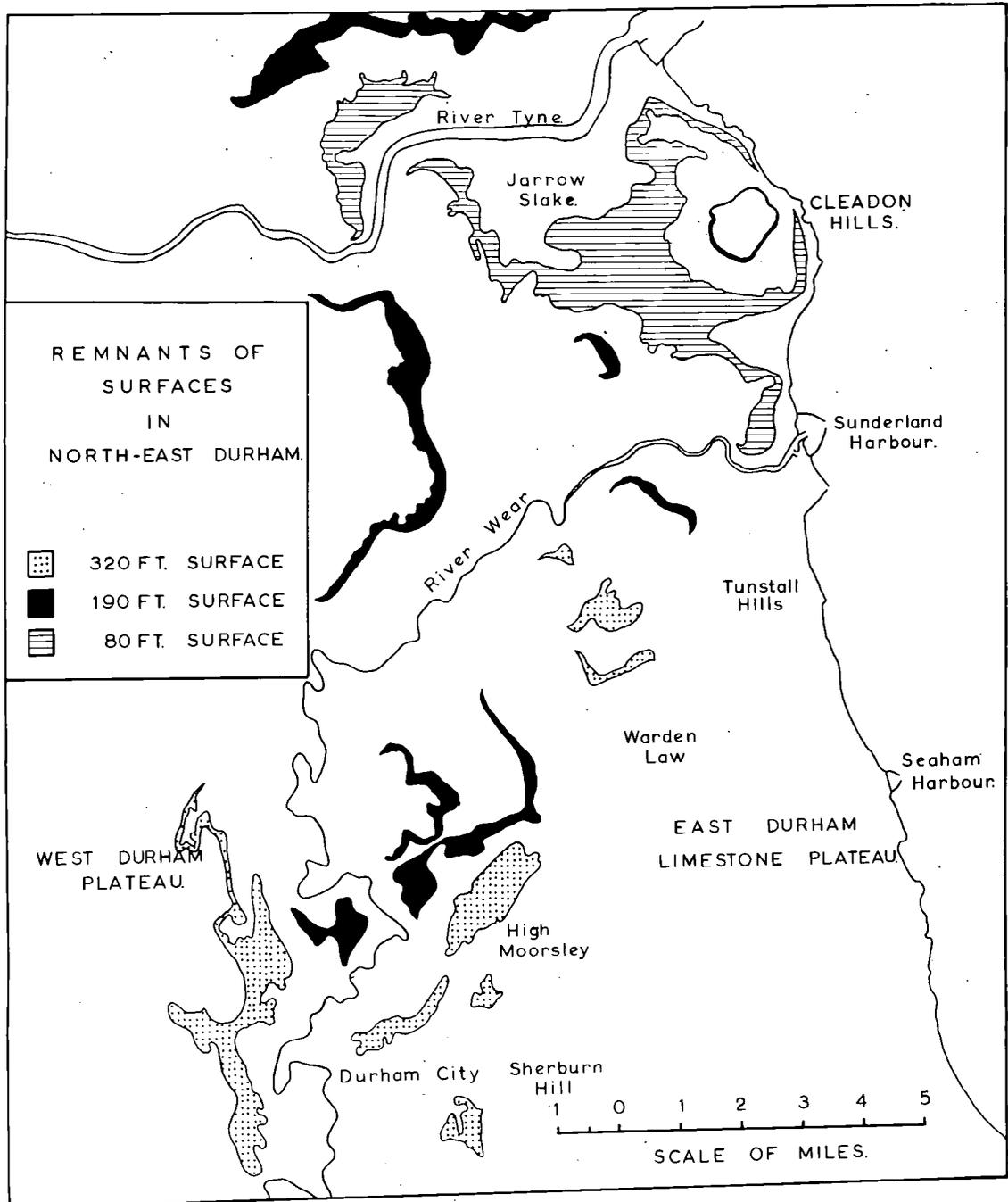


FIG. 15

SELECTED BORINGS ABOUT JARROW "SLACK" & TYNE DOCK.  
LOCATION CHART.

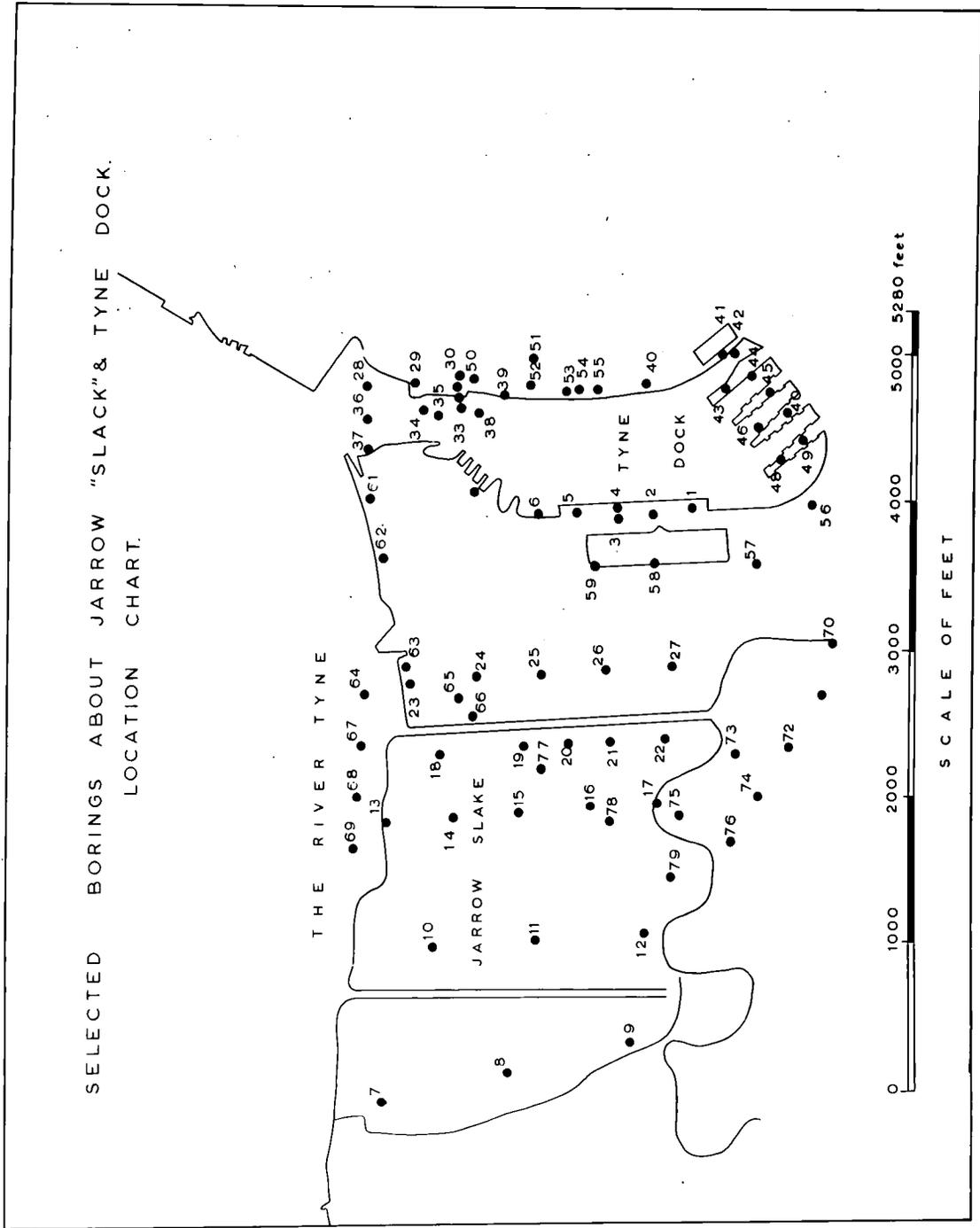
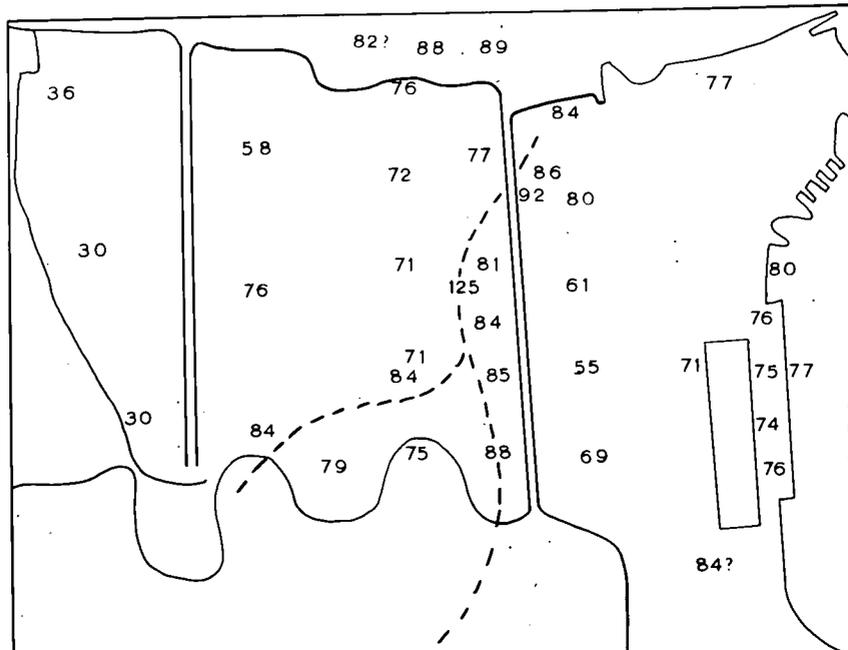
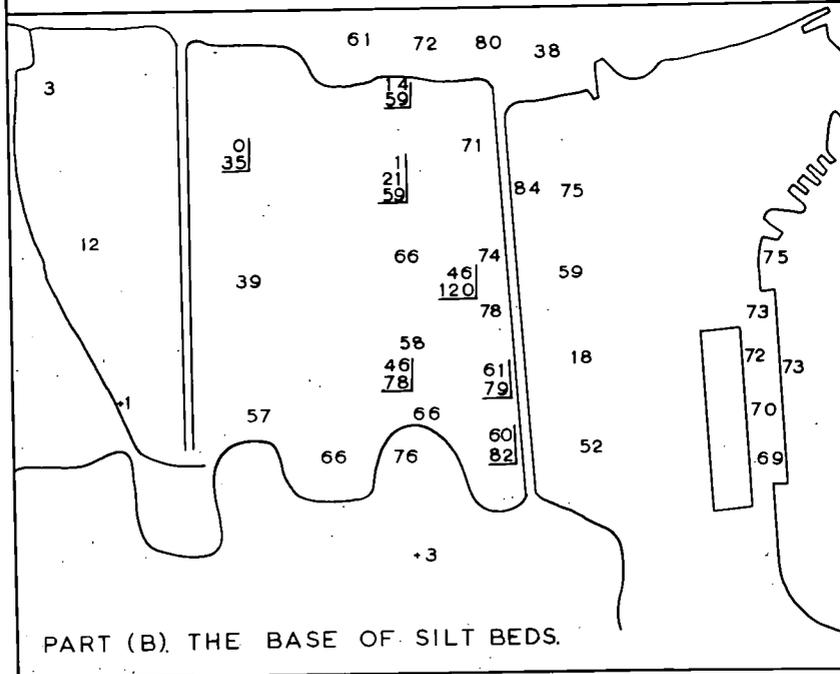


FIG. 16



PART (A). THE ROCK FLOOR.



PART (B). THE BASE OF SILT BEDS.

JARROW SLAKE DETAILS.

Depths below O.D.

Scale of feet.

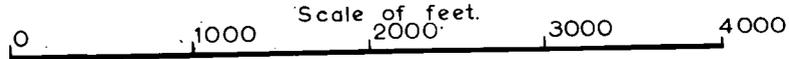
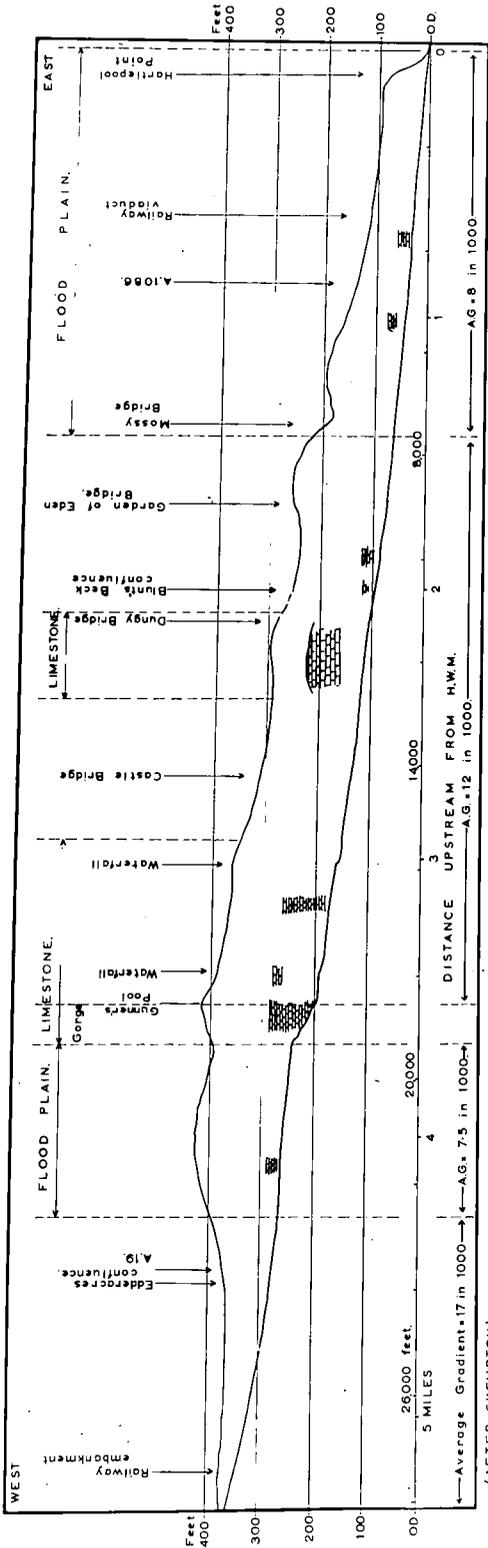


FIG. 18

FIG. 17



LONGITUDINAL PROFILE OF CASTLE EDEN BURN.

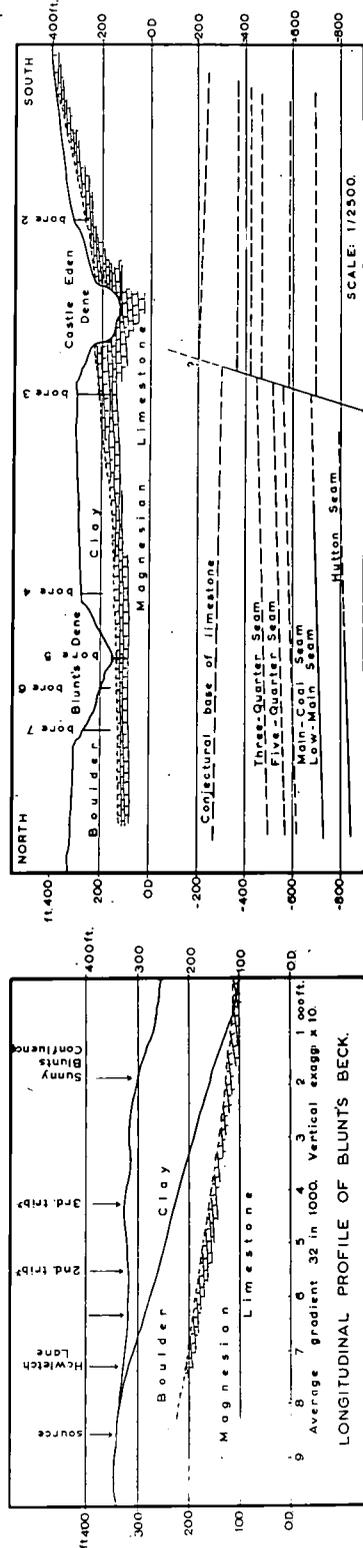
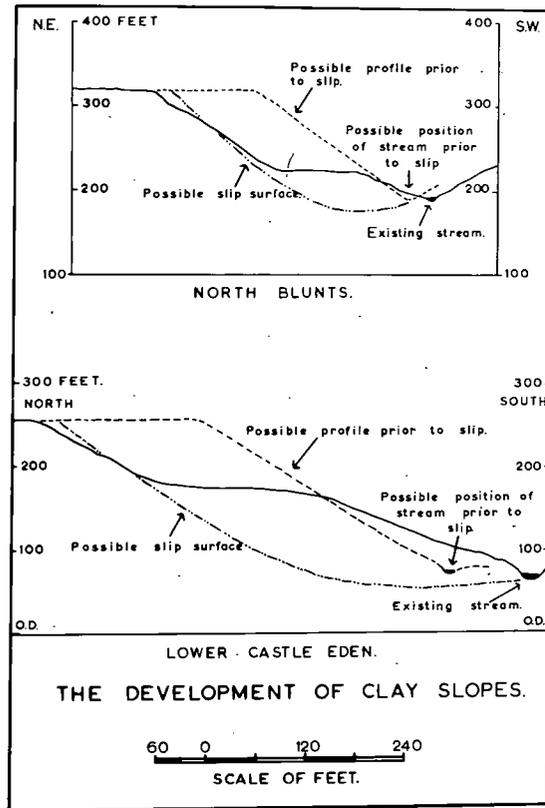


FIG. 19

FIG. 20.





DIAGRAMS OF THE DURHAM COAST

PARTS A, B, AND C.

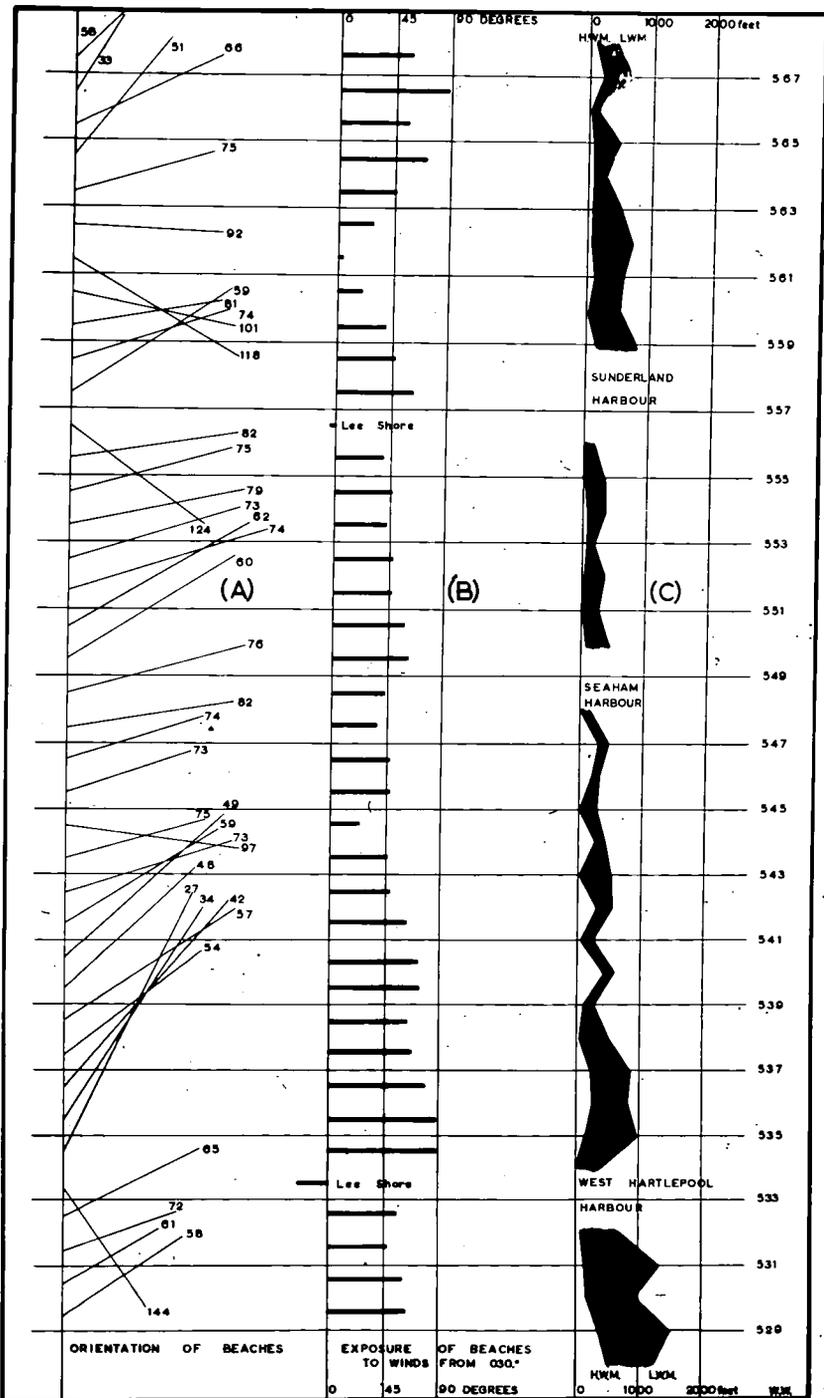


FIG. 23

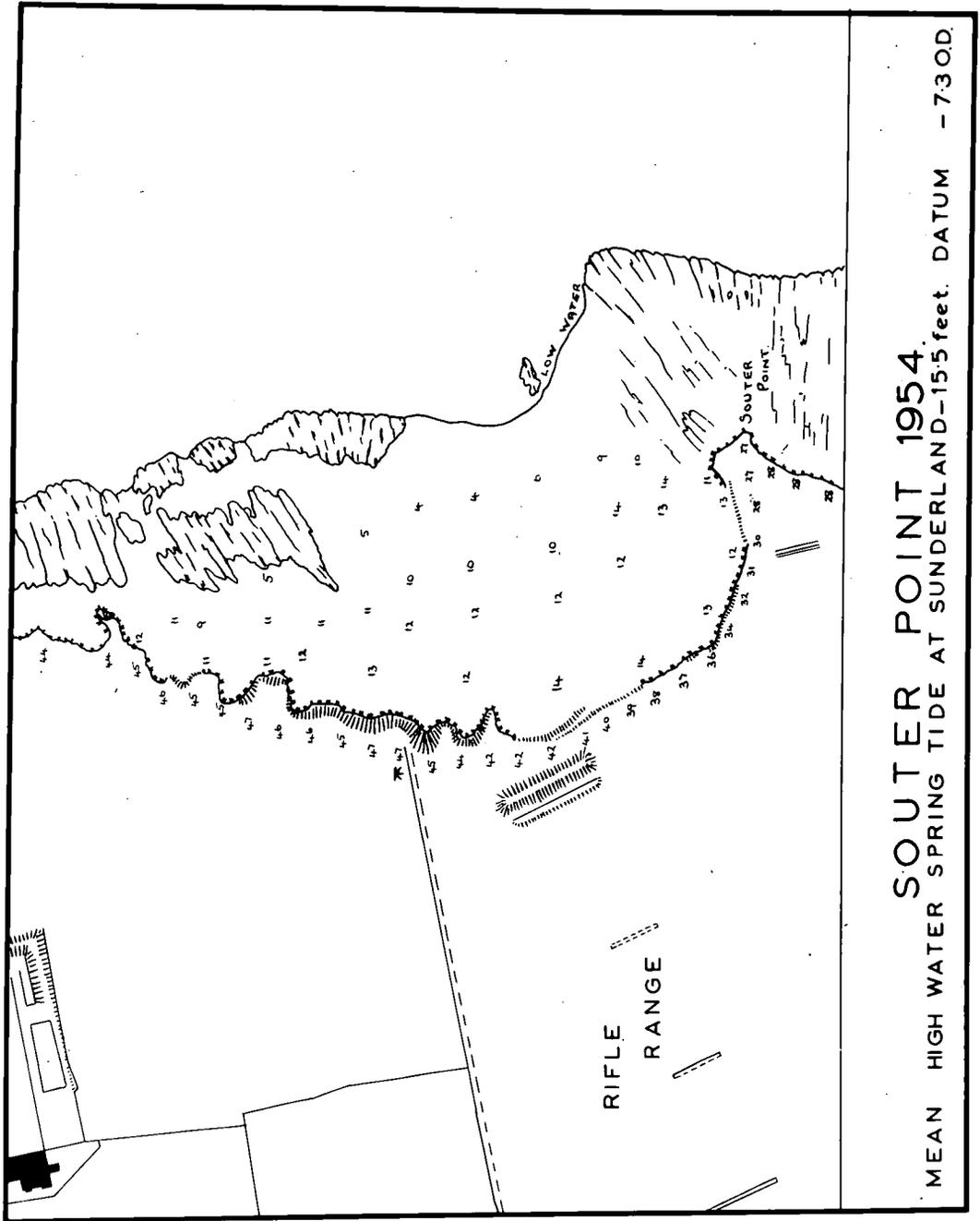
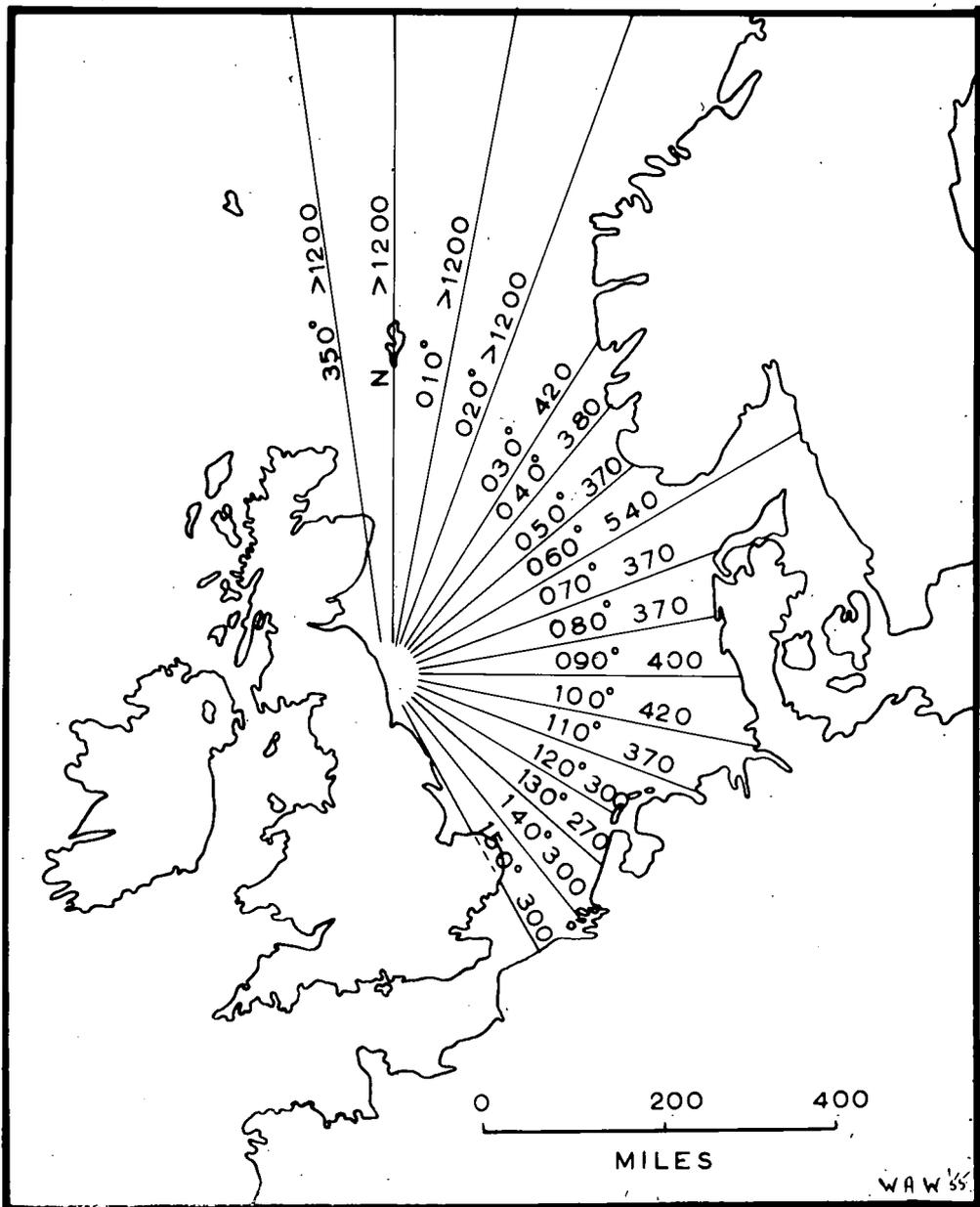
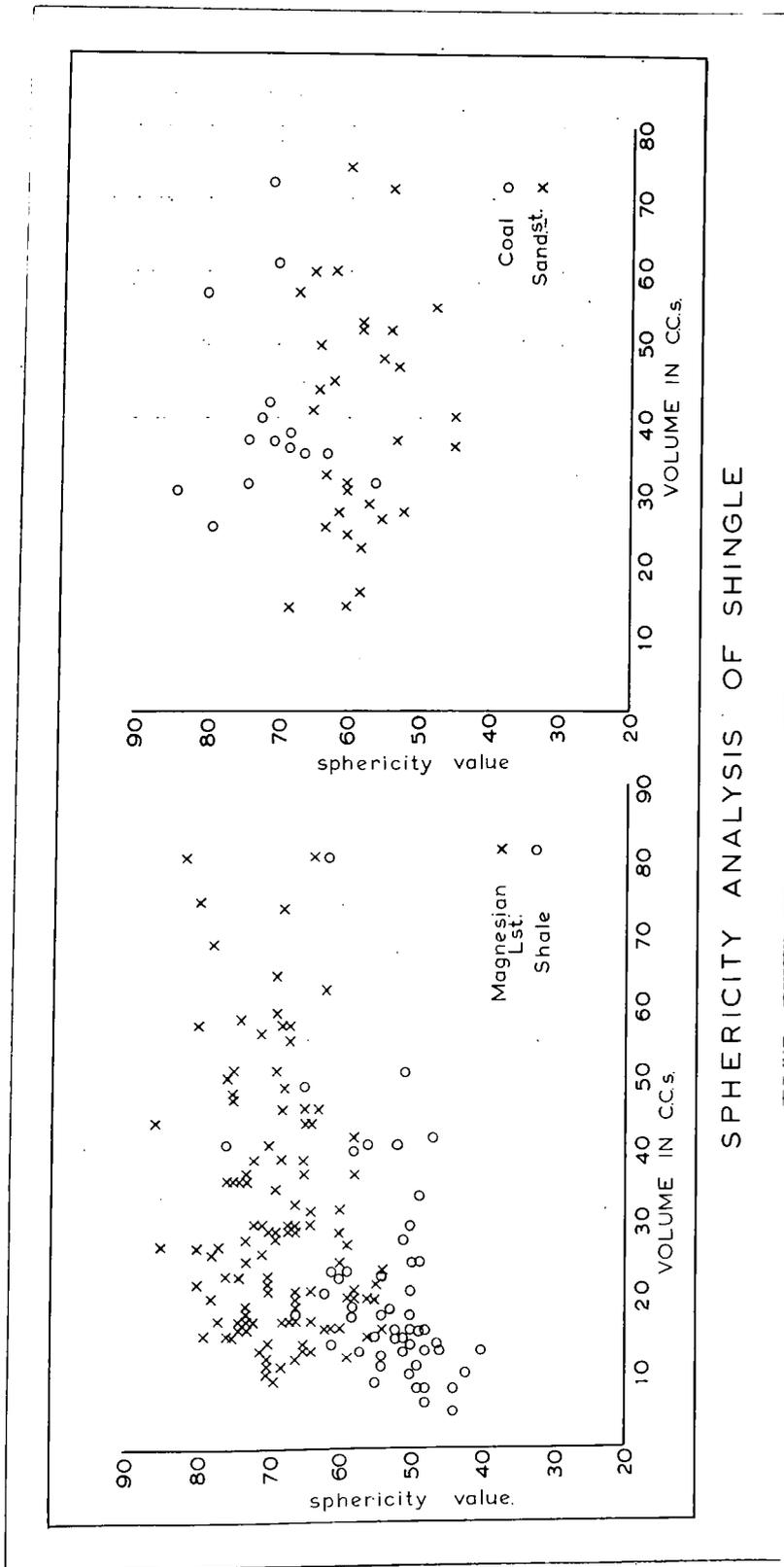


FIG. 24



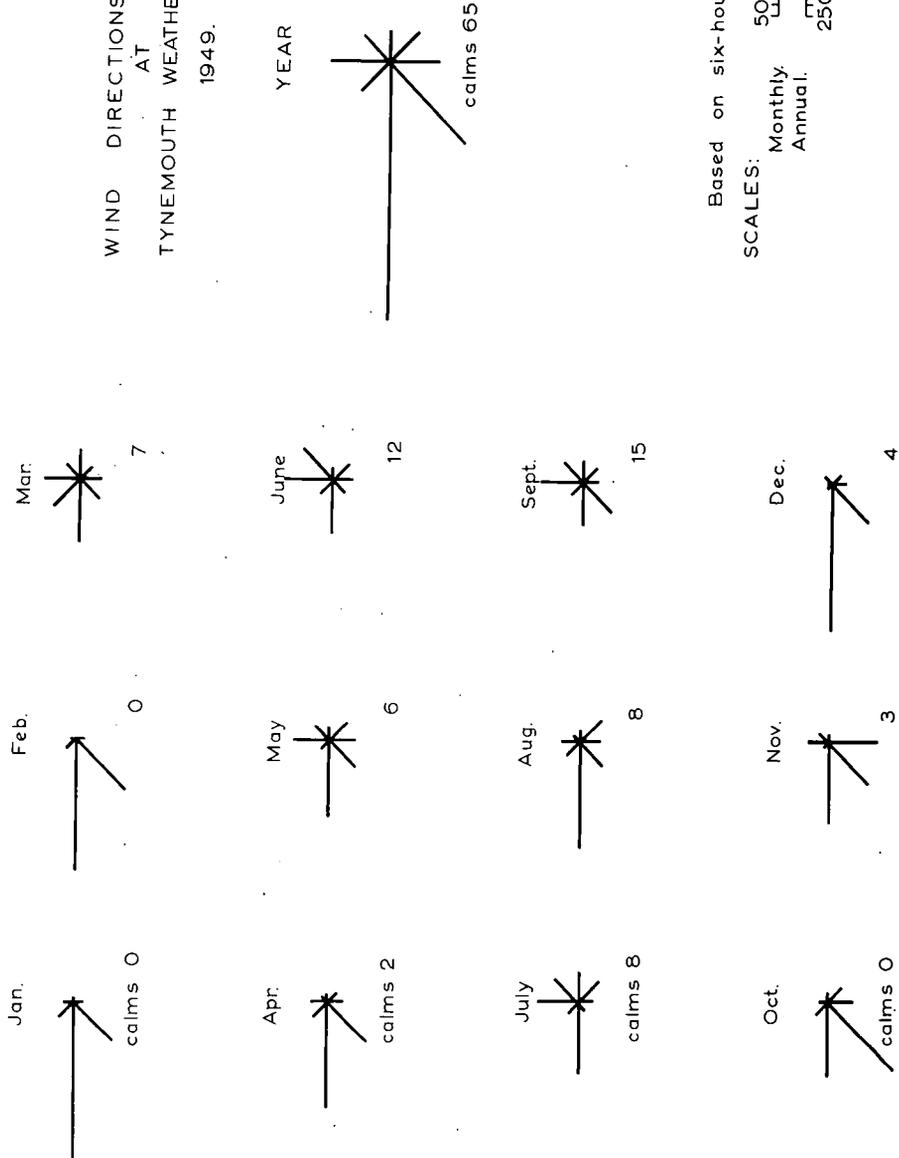
THE EXPOSURE OF NORTH EAST ENGLAND  
SHOWING FETCH IN MILES



SPHERICITY ANALYSIS OF SHINGLE

FIG. 26

WIND DIRECTIONS RECORDED  
AT  
TYNEMOUTH WEATHER STATION.  
1949.



Based on six-hourly observations.  
 SCALES: Monthly 50 0 150  
 Annual 250 0 750  
 number of winds.

FIG. 27

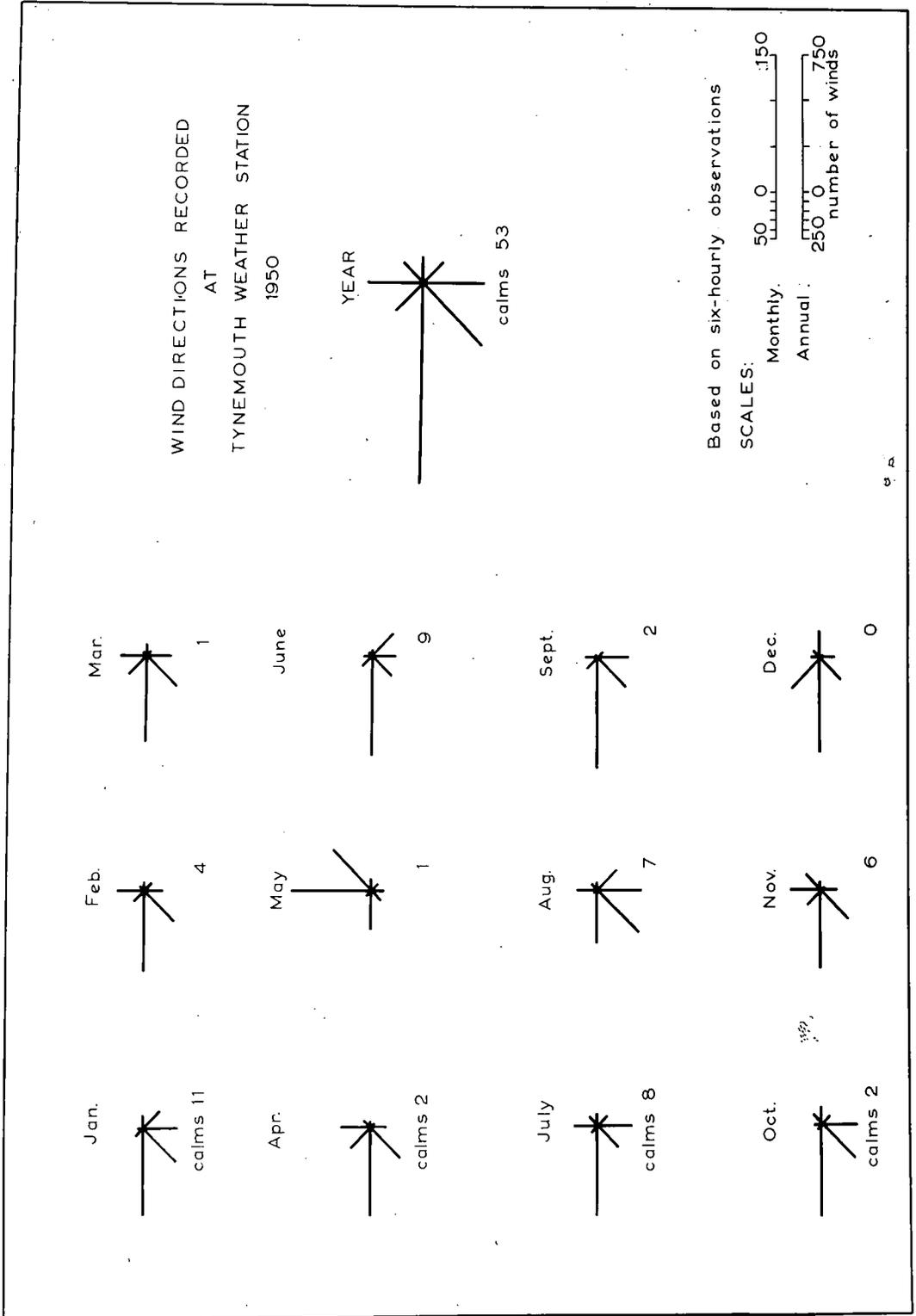


FIG. 28

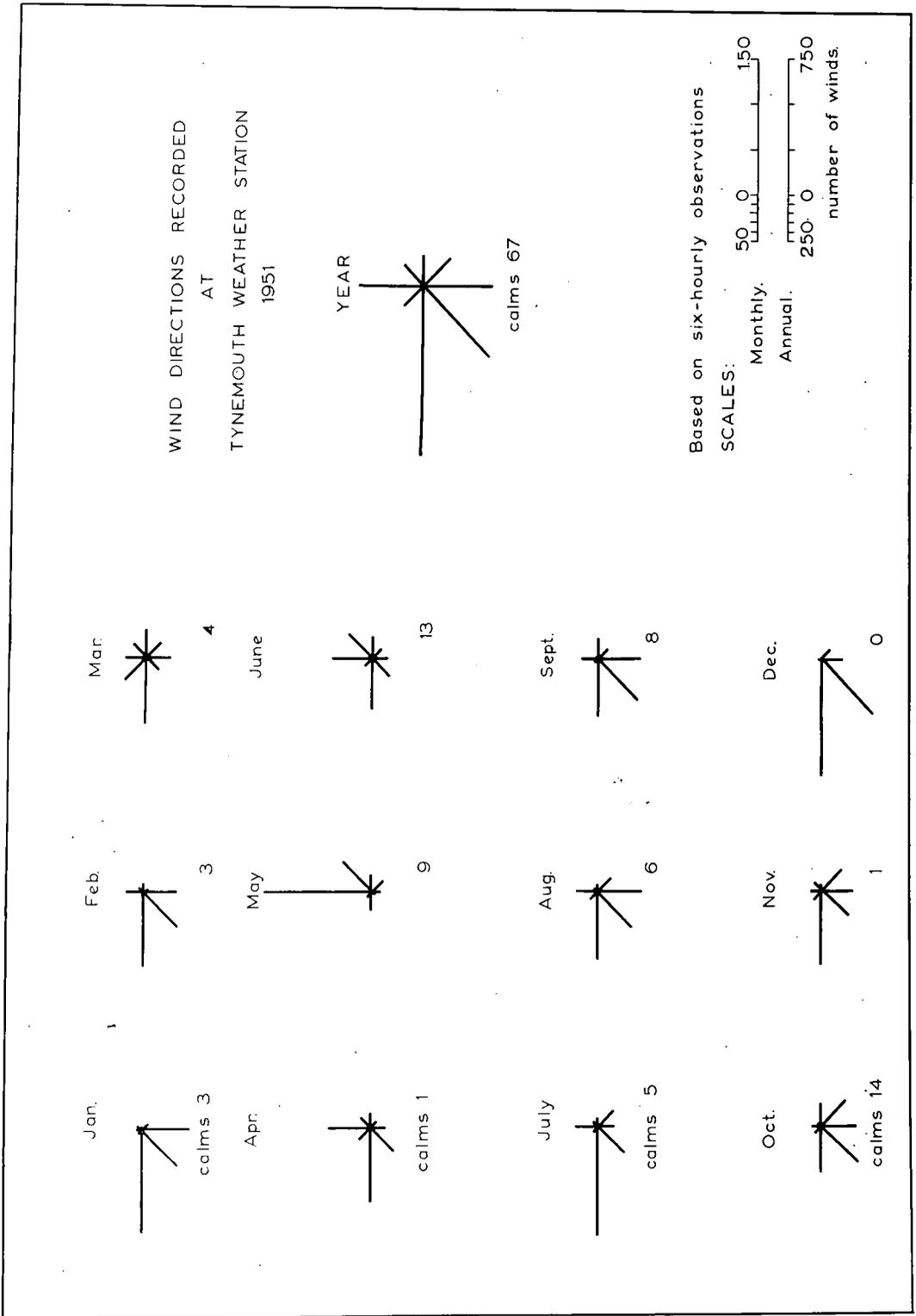


FIG. 29

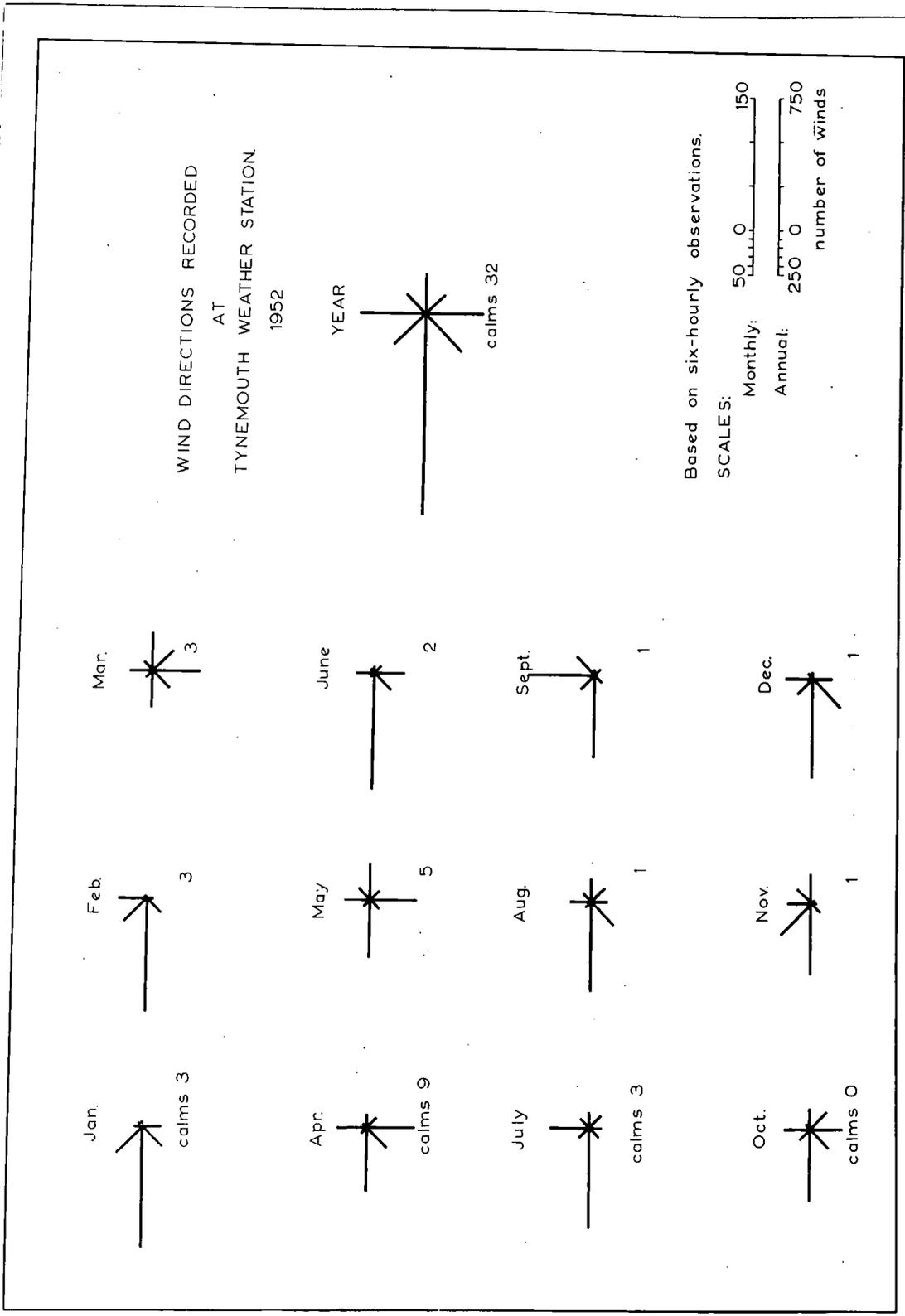


FIG. 30

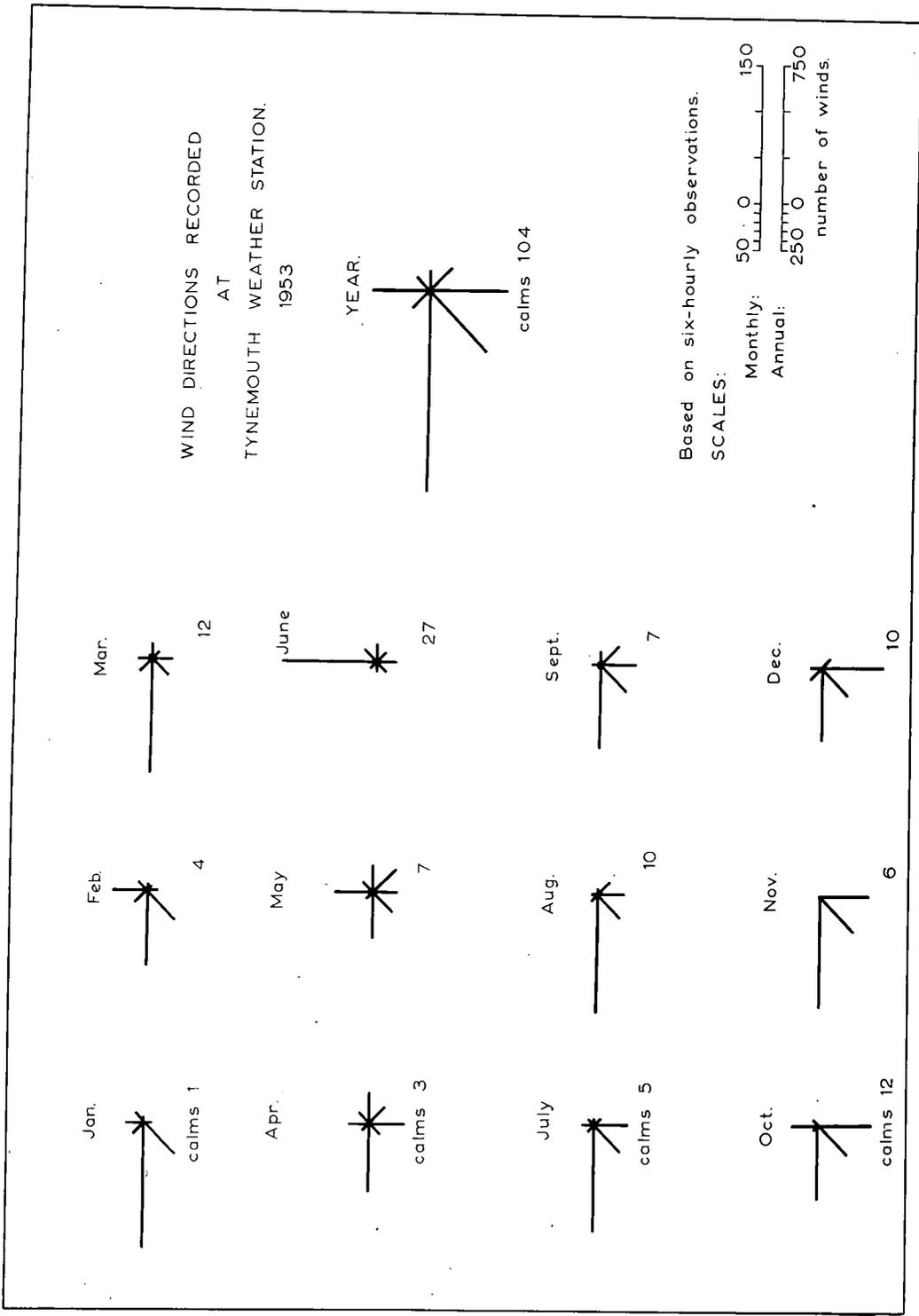


FIG. 31

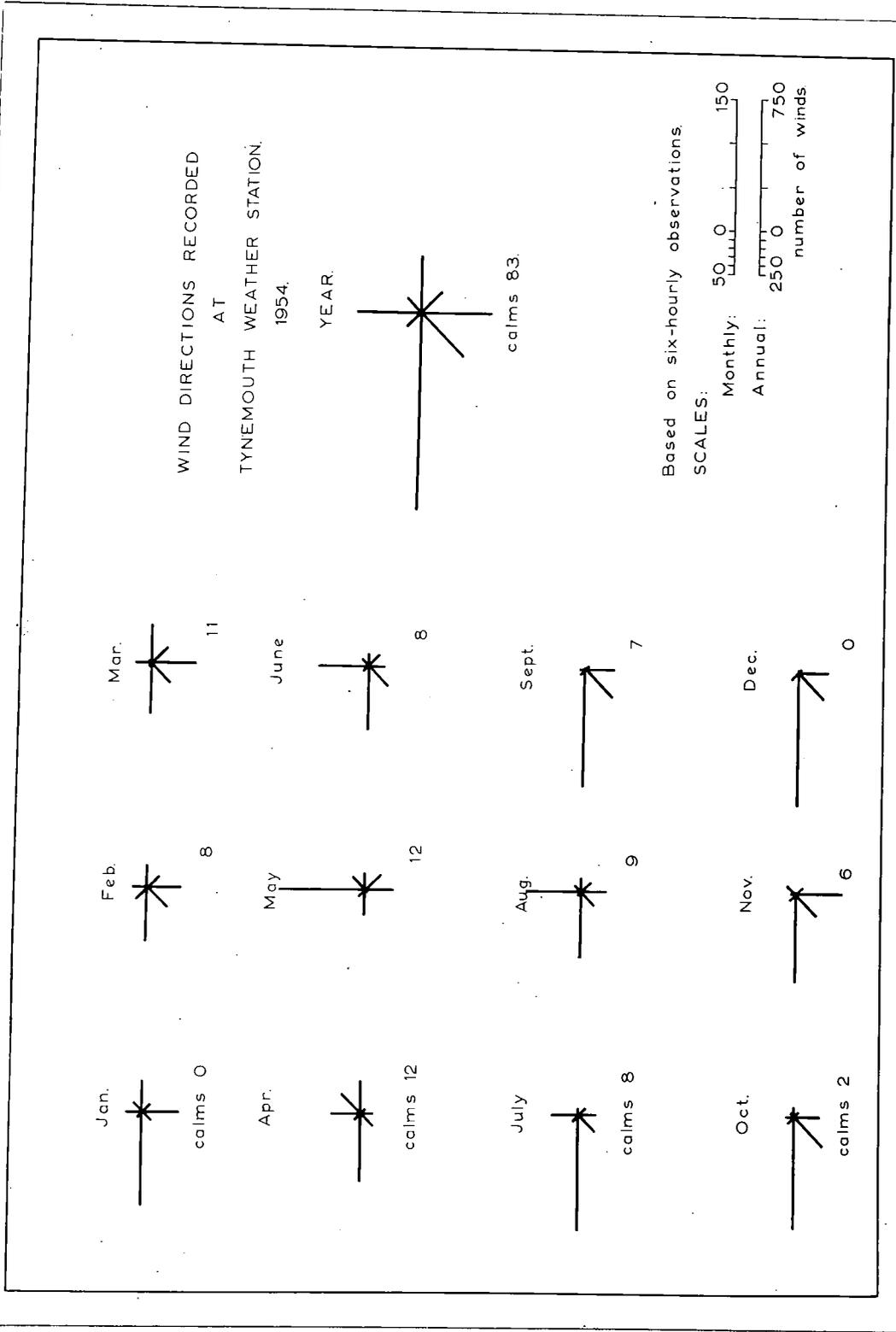
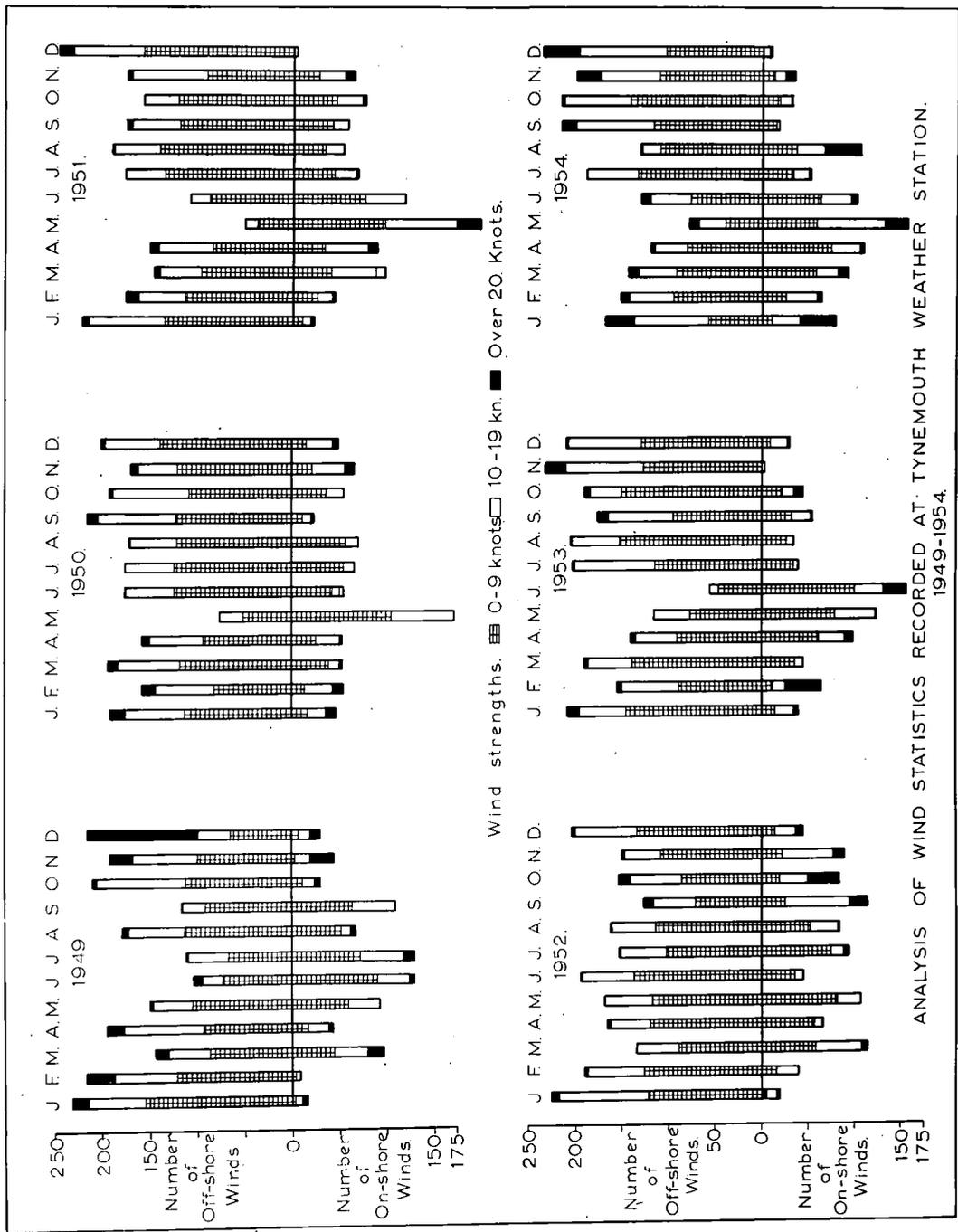
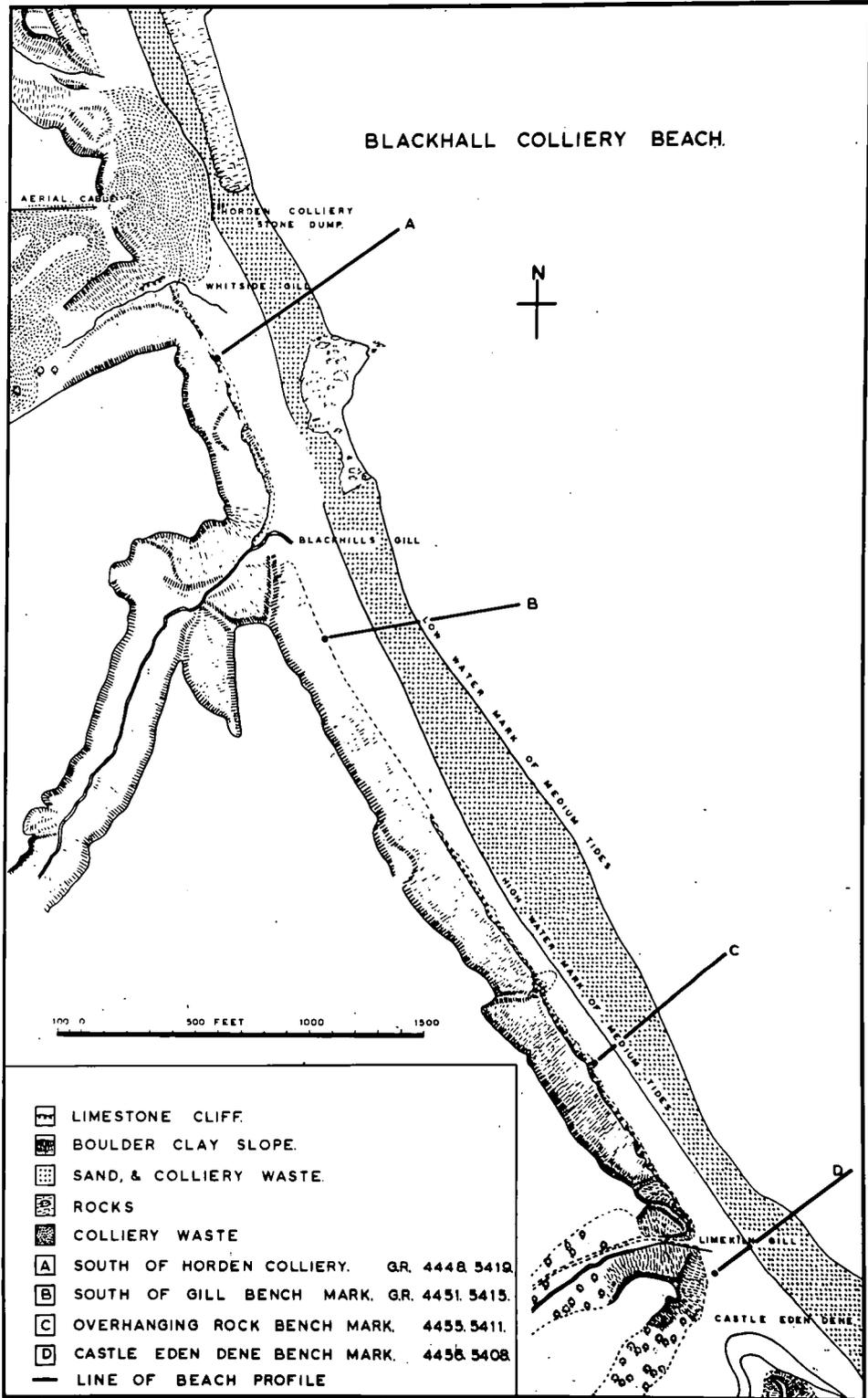
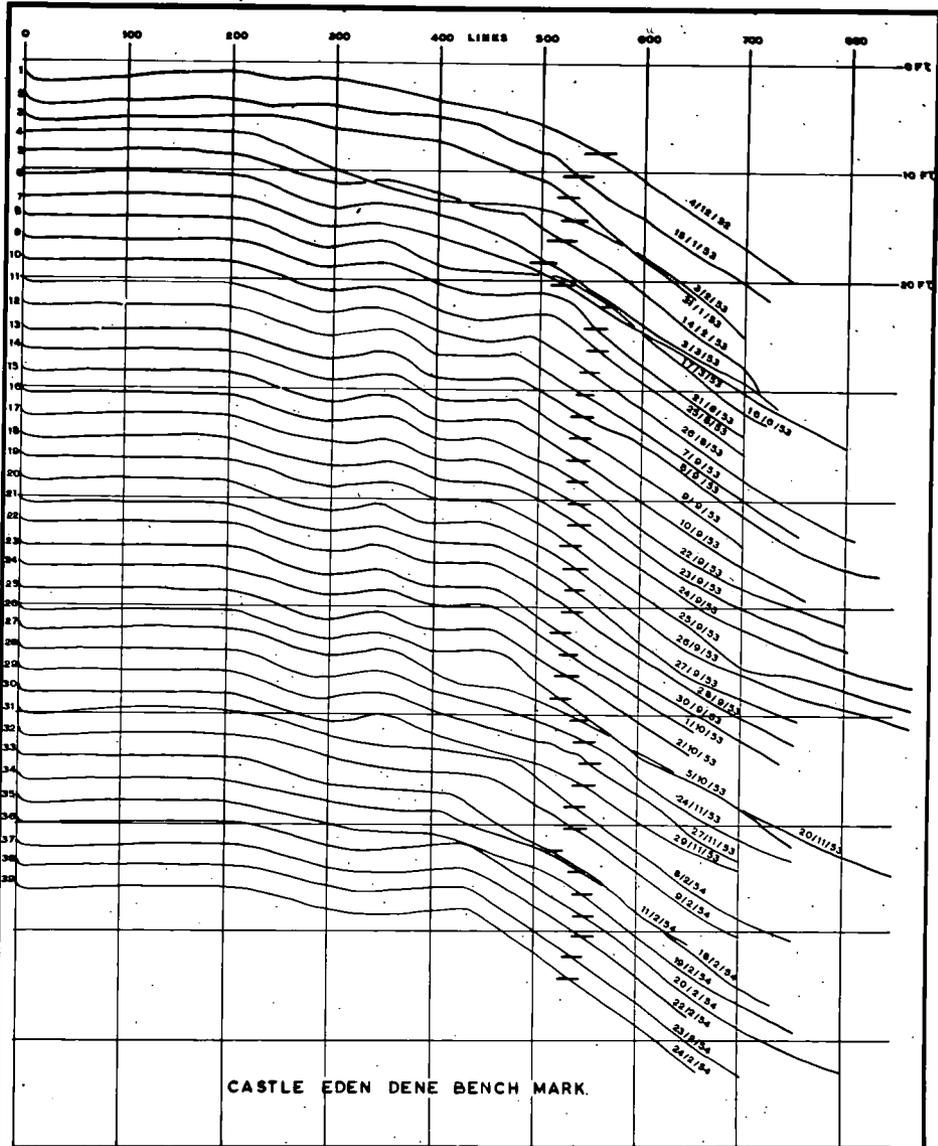


FIG. 32







**BEACH PROFILES**  
**MEASURED NORTH OF CASTLE EDEN DENE MOUTH.**

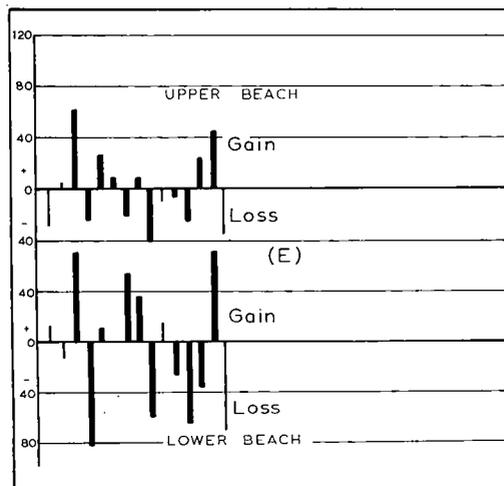
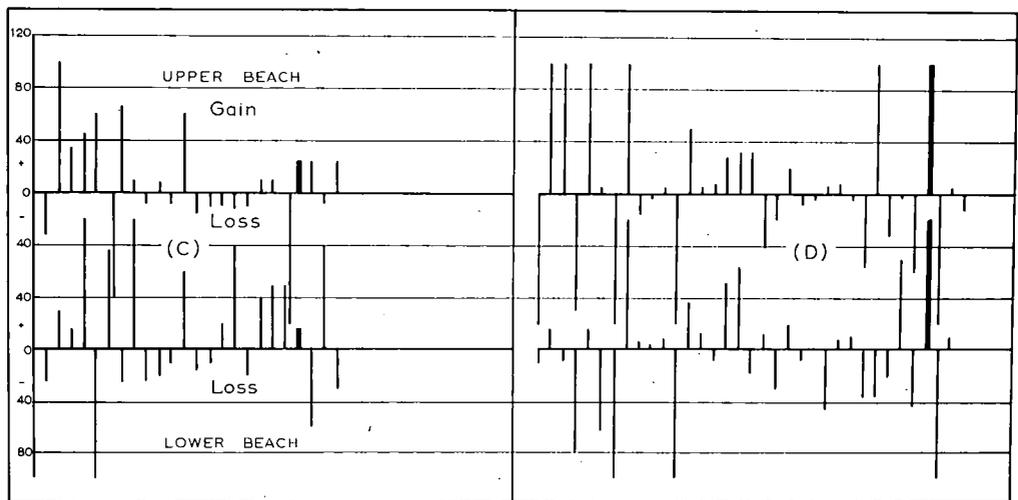
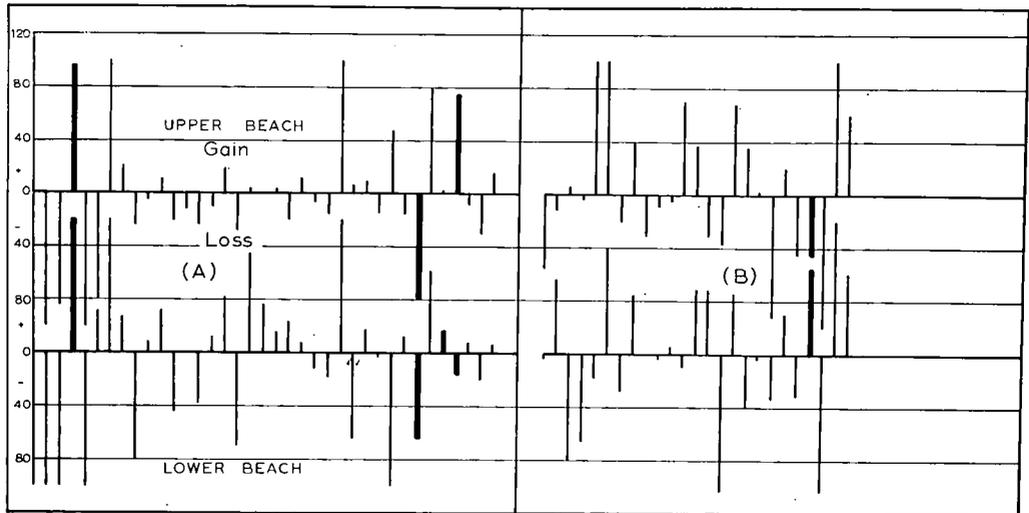
GRID REFERENCE 4456 5408.

HORIZONTAL SCALE: ONE INCH = 50 (GUNTER) LINKS  
 OR 33 FEET

VERTICAL SCALE: ONE INCH = 5 FEET

☐ : Mean High Water Spring Tides.  
 Height Of Temporary Bench Mark 16.08 ft.Q.D.

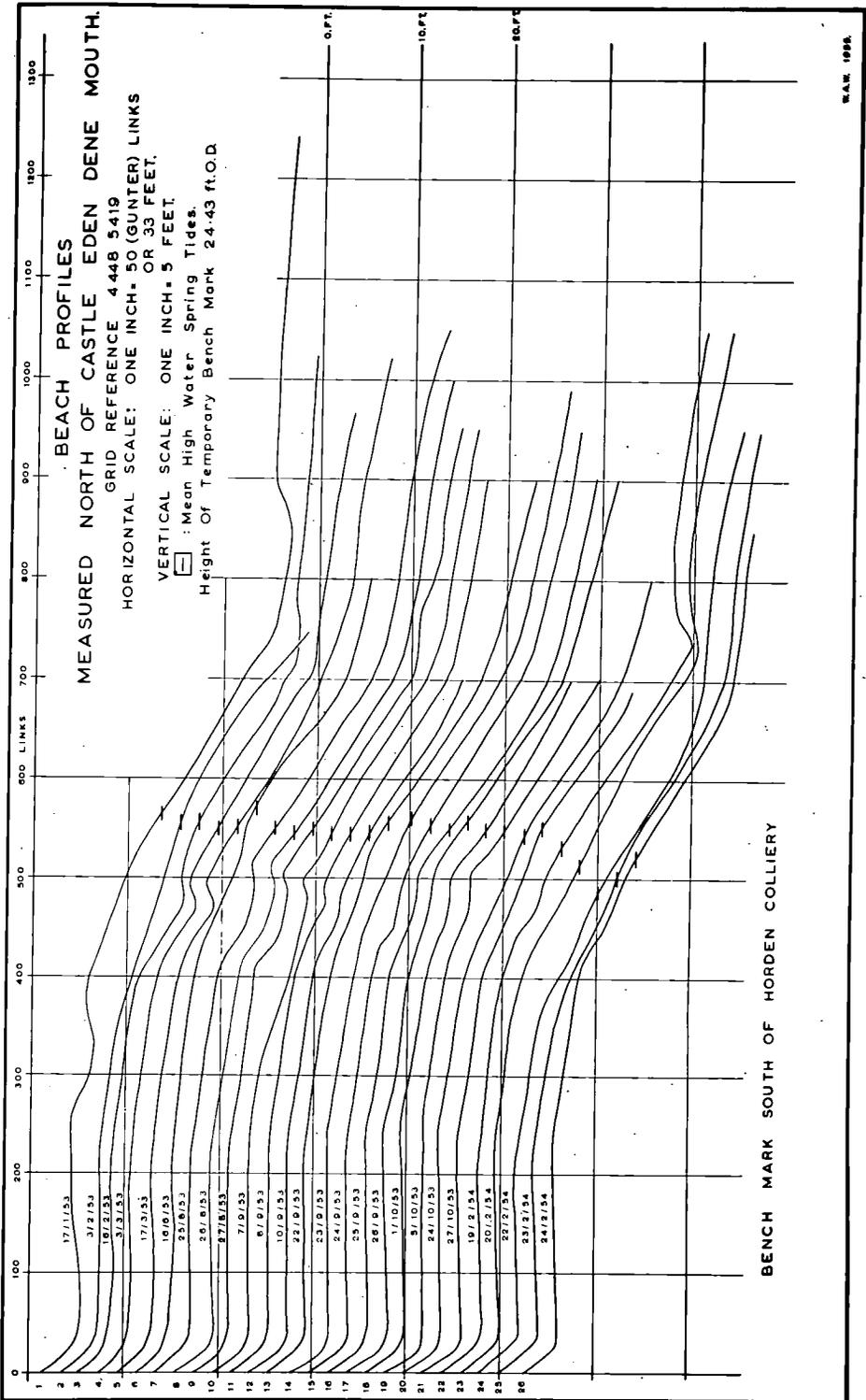
FIG. 35

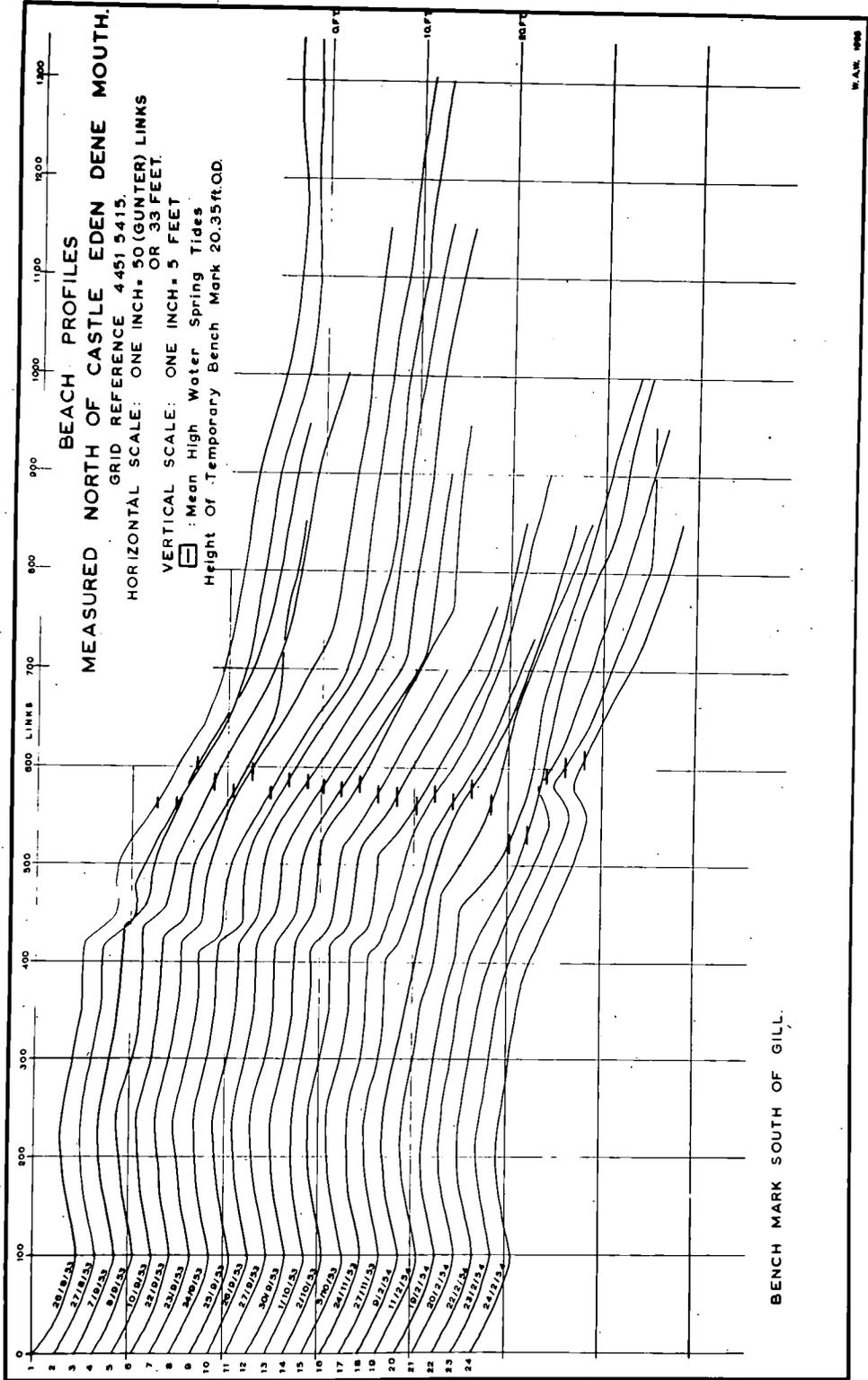


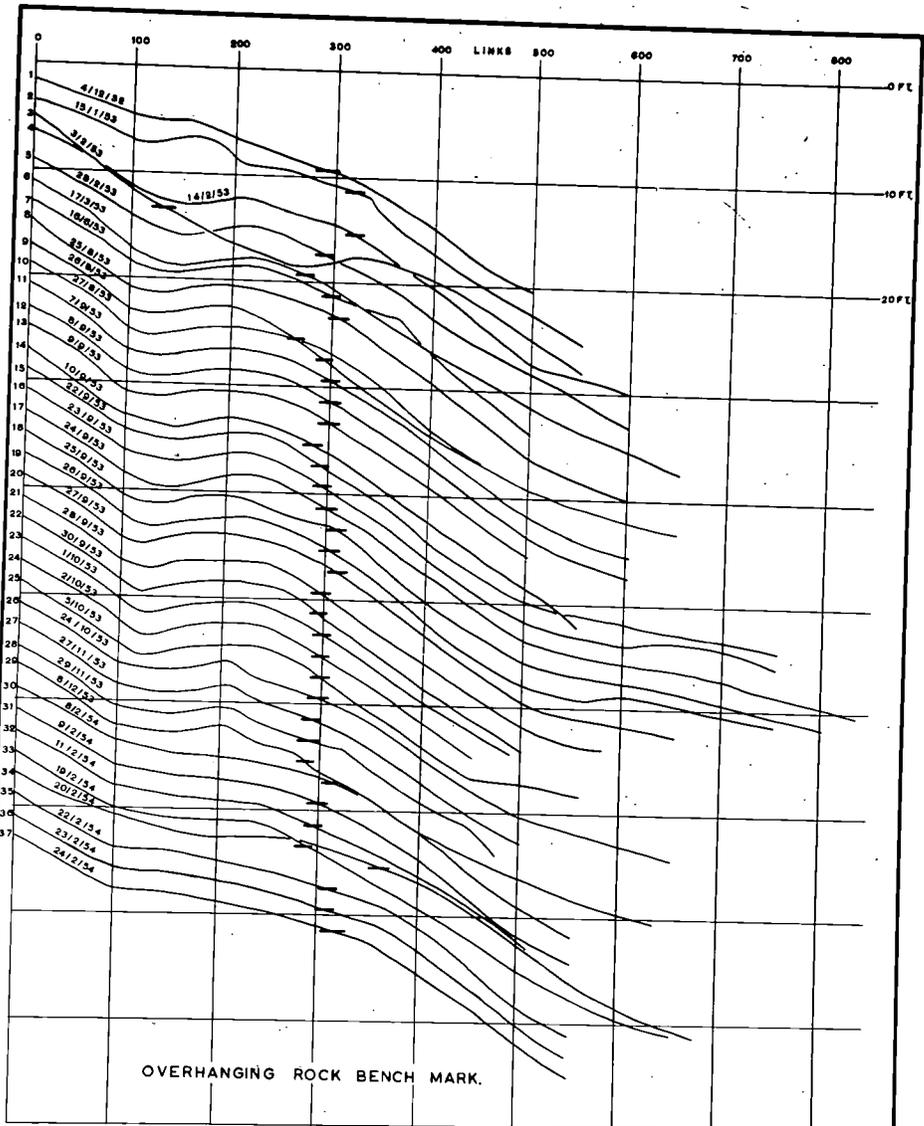
ANALYSIS OF BEACH PROFILE OBSERVATIONS.

- A Castle Eden Dene
- B Horden Colliery
- C South of Gill
- D Overhanging Rock
- E Crimdon Dene

— On-shore Winds  
 — Off- " "







BEACH PROFILES  
 MEASURED NORTH OF CASTLE EDEN DENE MOUTH.  
 GRID REFERENCE 4455 5411.

HORIZONTAL SCALE: ONE INCH = 50 (GUNTER) LINKS  
 OR 33 FEET

VERTICAL SCALE: ONE INCH = 5 FEET

☐ : Mean High Water Spring Tides

Height Of Temporary Bench Mark 25.01ft±0.0.

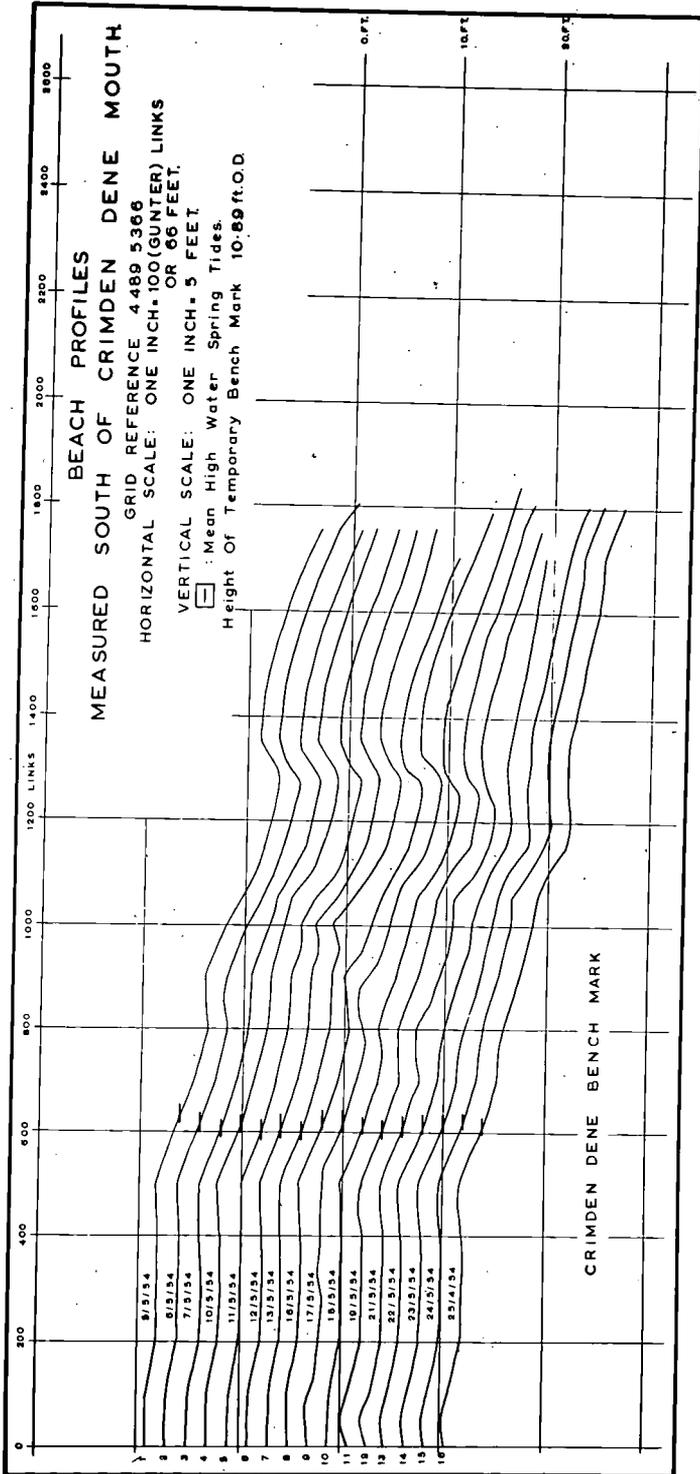
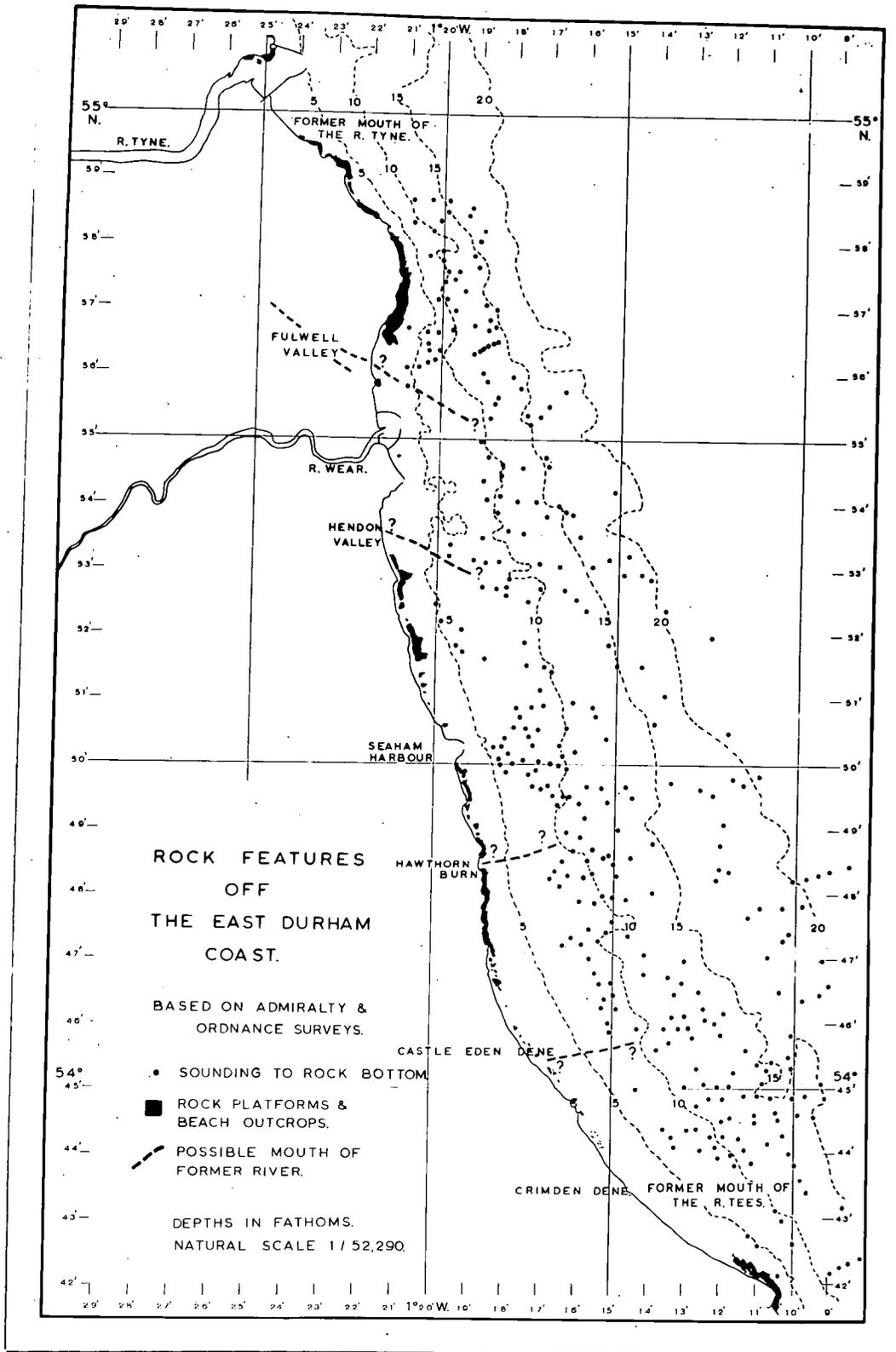
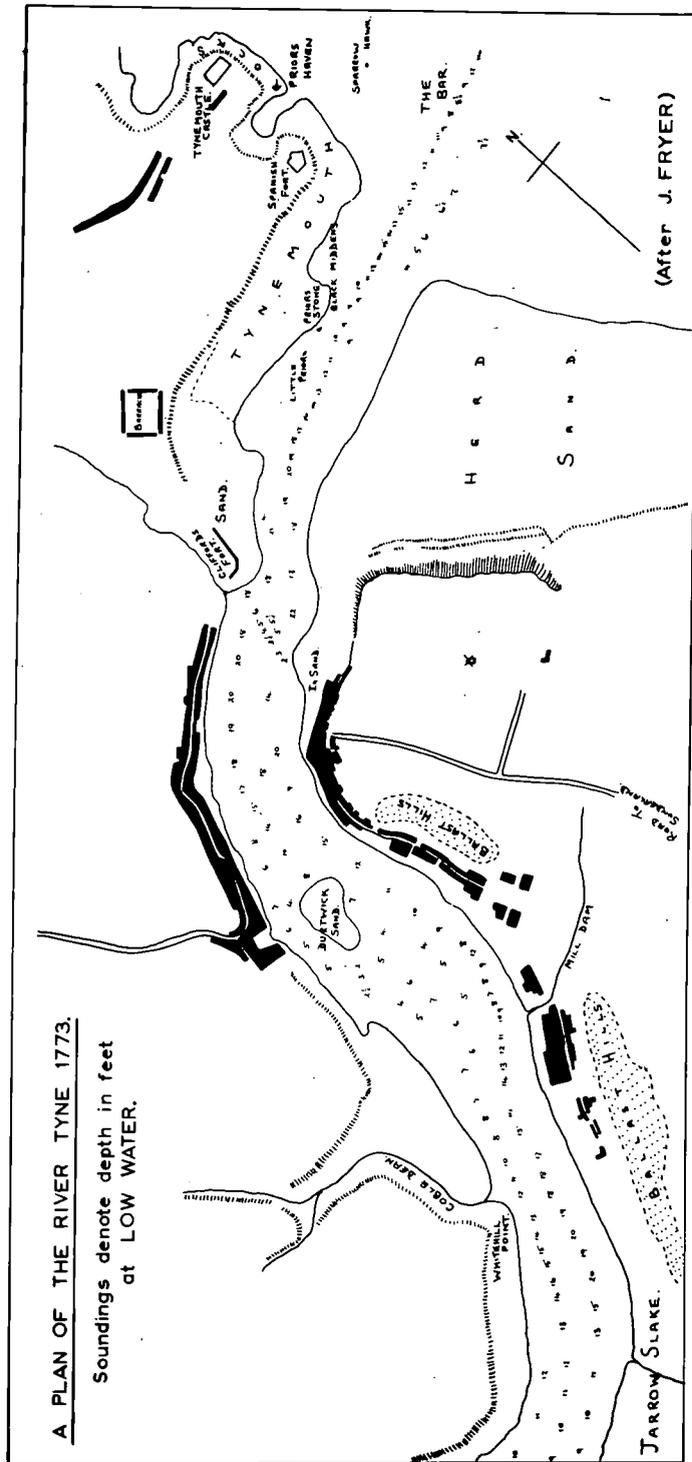


FIG. 40

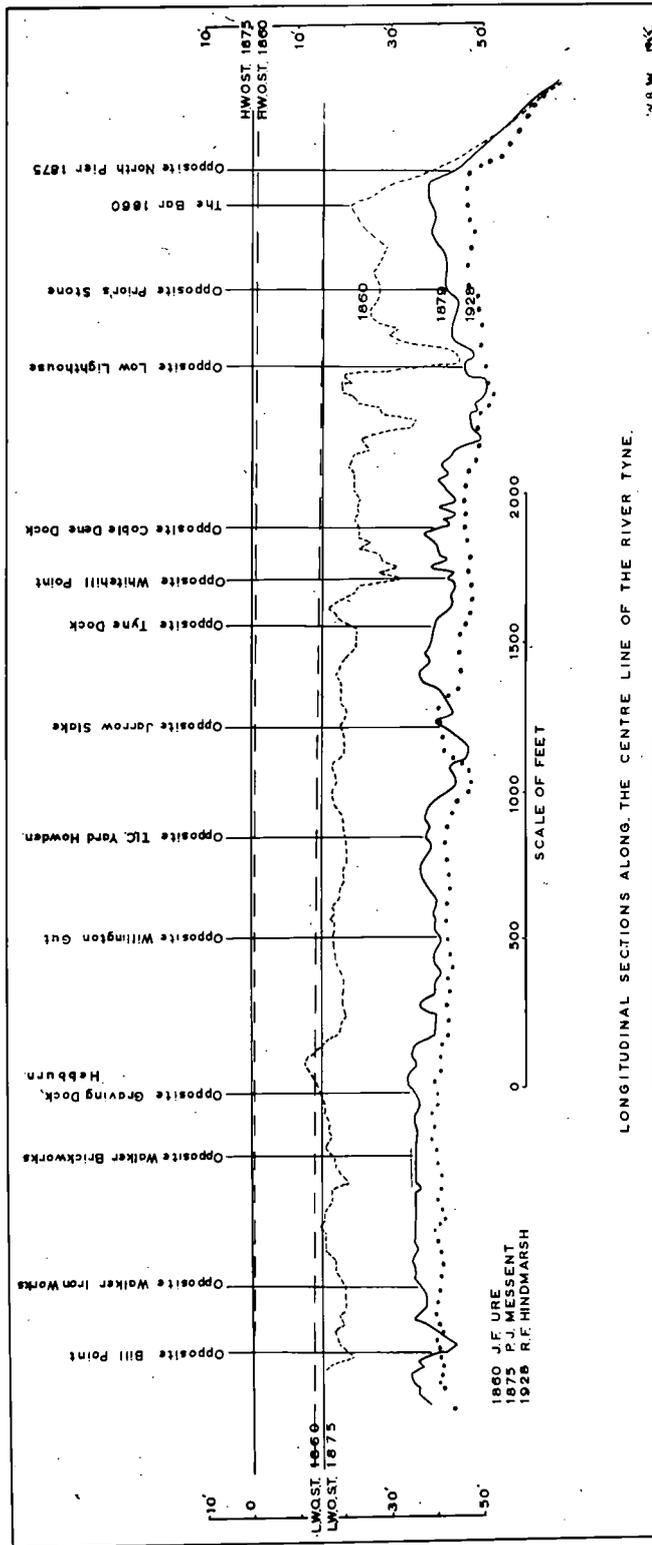




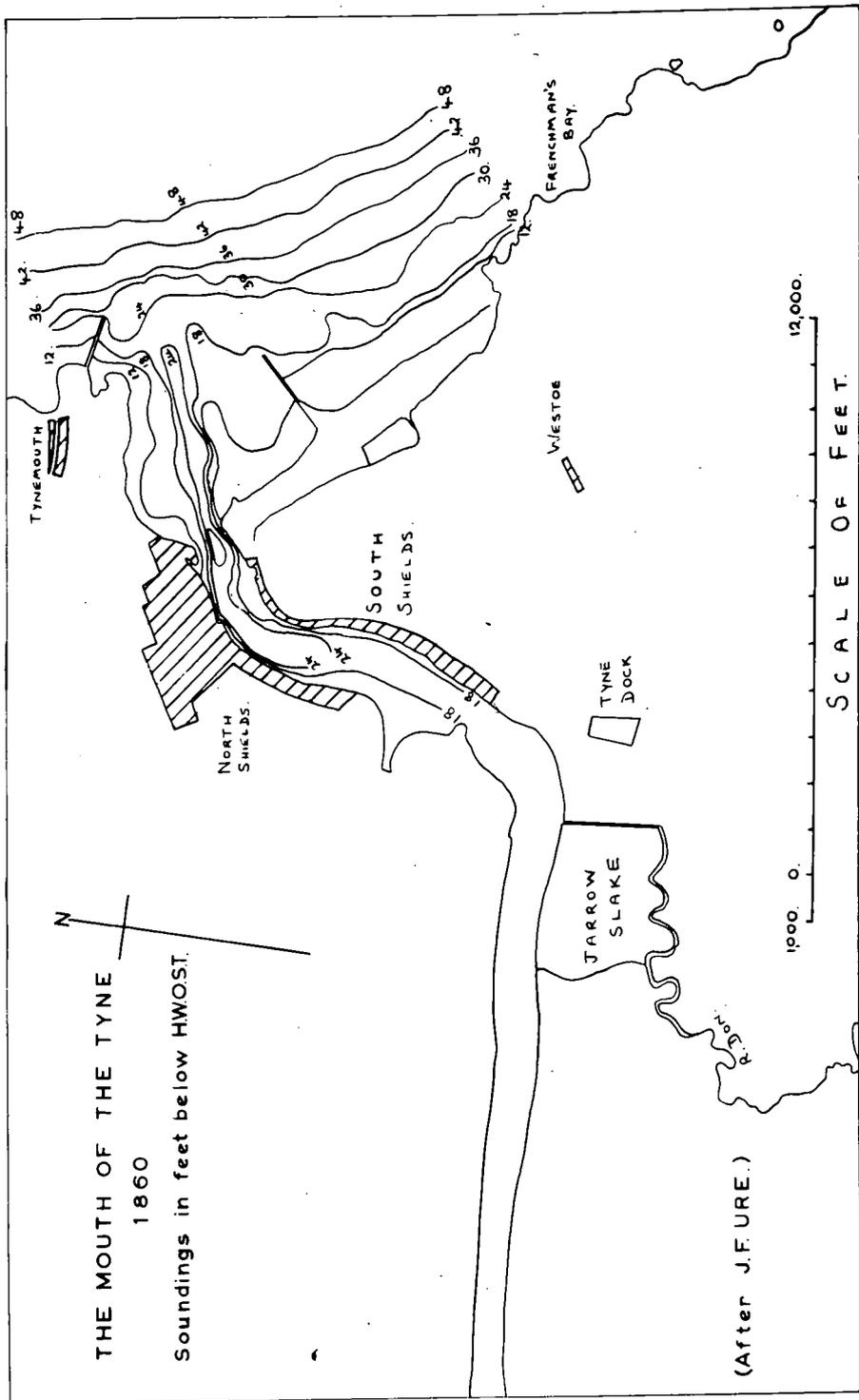


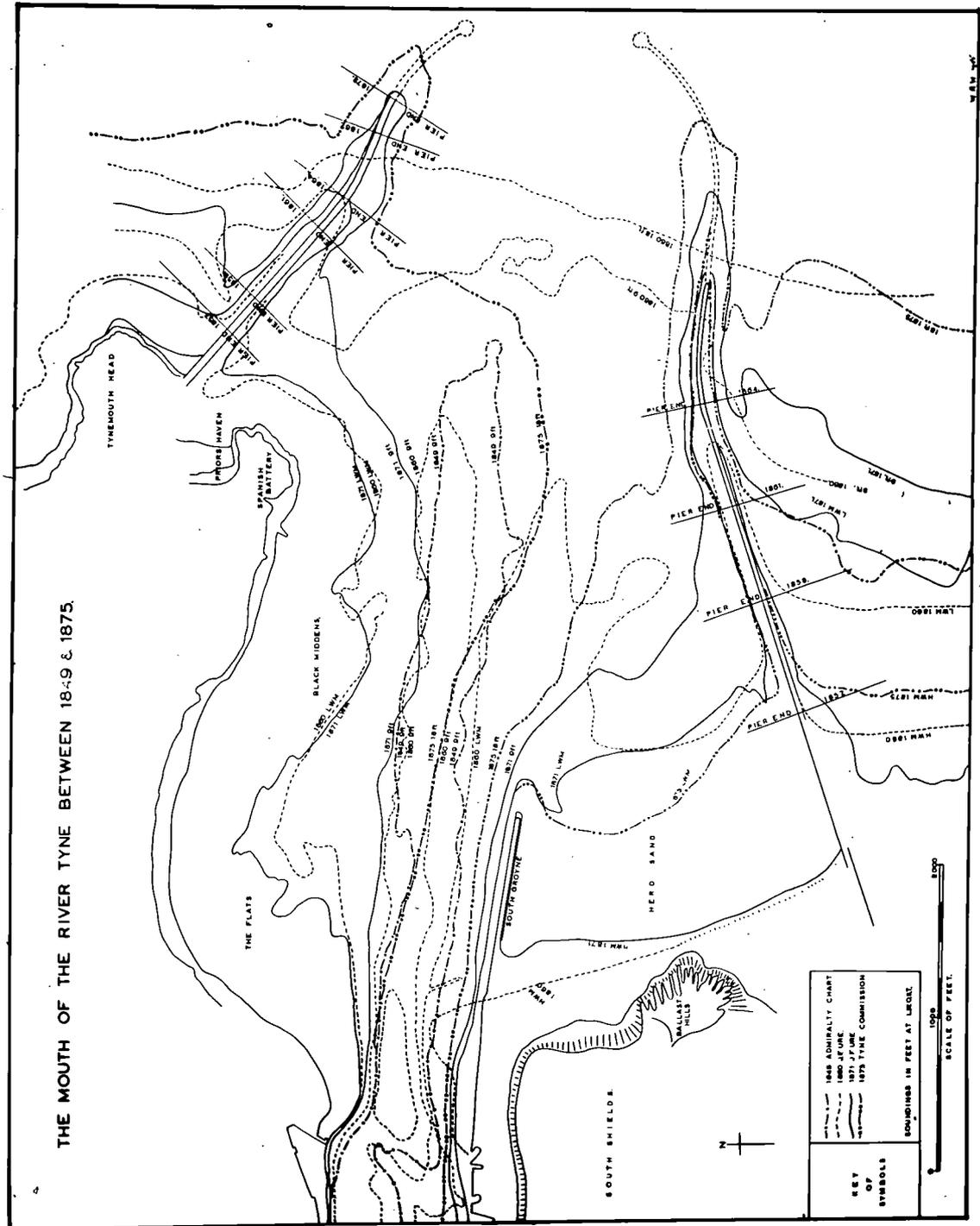






LONGITUDINAL SECTIONS ALONG THE CENTRE LINE OF THE RIVER TYNE.





THE MOUTH OF THE RIVER TYNE BETWEEN 1849 & 1875.

KEY  
 1848 ADIRALTY CHART  
 1860 J.C. COLE  
 1861 J.C. COLE  
 1875 THE COMMISSION  
 OF THE RIVER  
 1875 THE COMMISSION  
 OF THE RIVER

1000  
 2000  
 SCALE OF FEET.



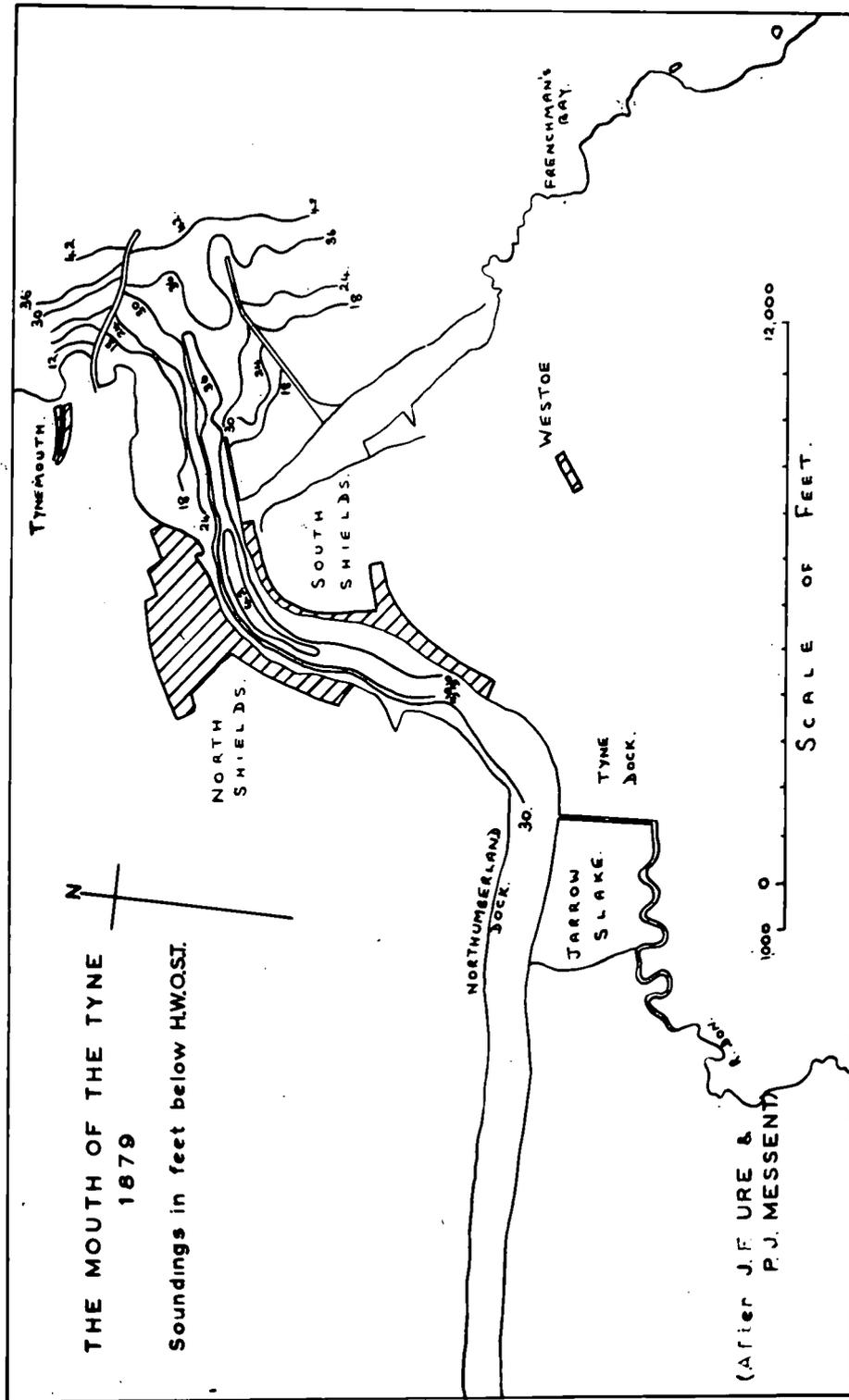
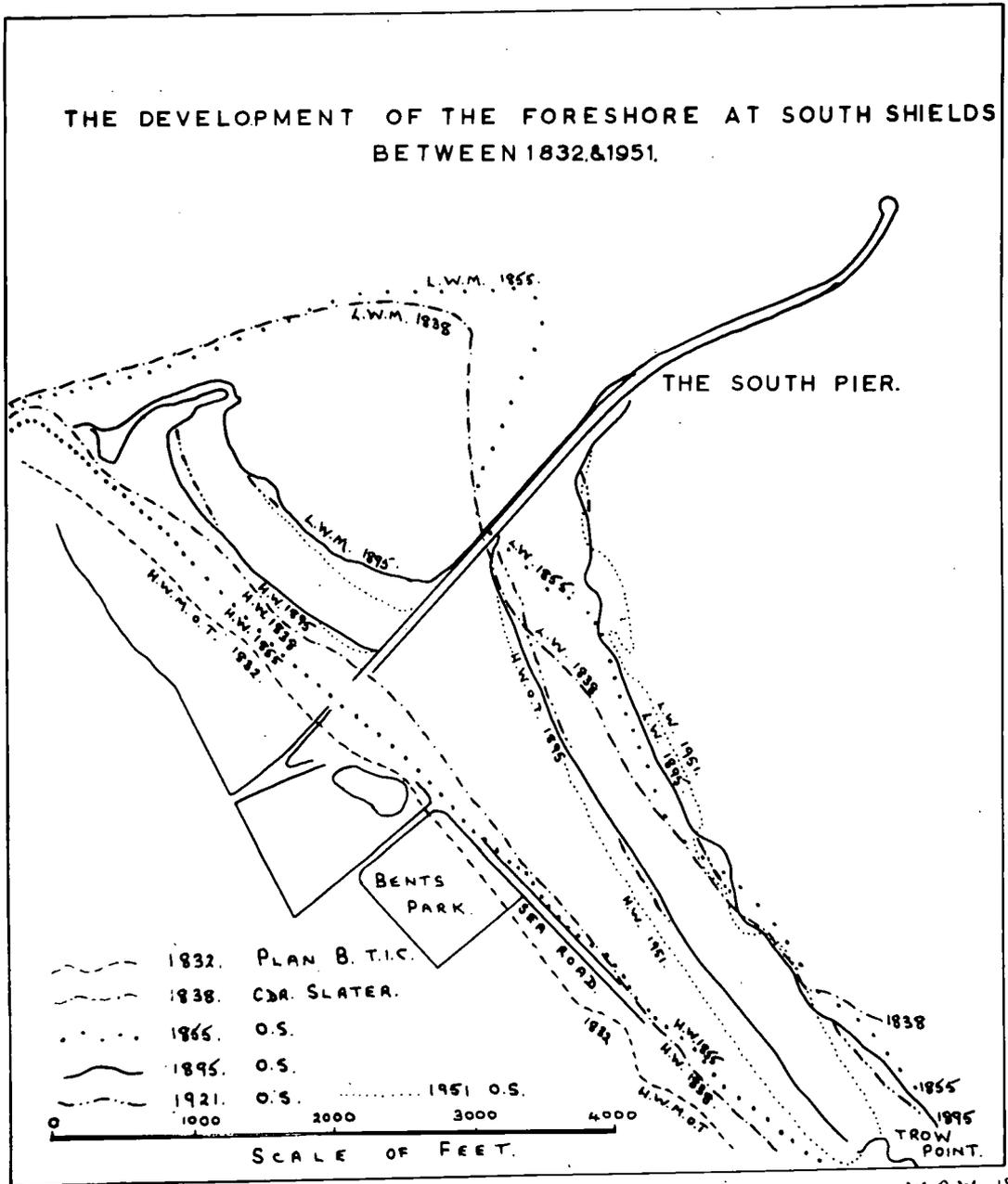


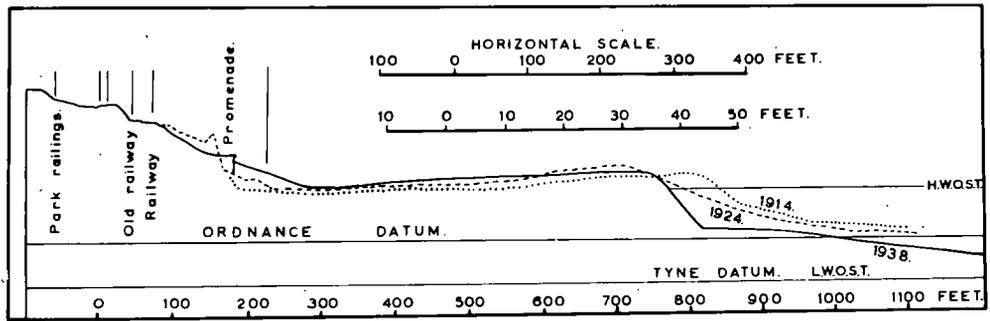
FIG. 49

THE DEVELOPMENT OF THE FORESHORE AT SOUTH SHIELDS BETWEEN 1832.&1951.



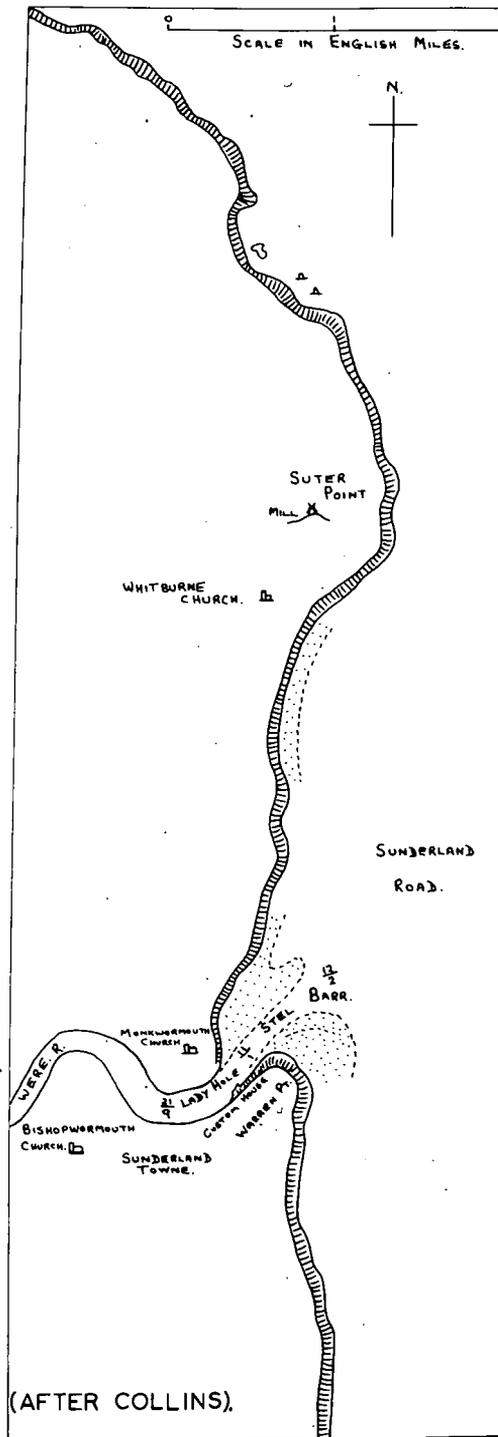
W.A.W. 1965.

FIG. 50



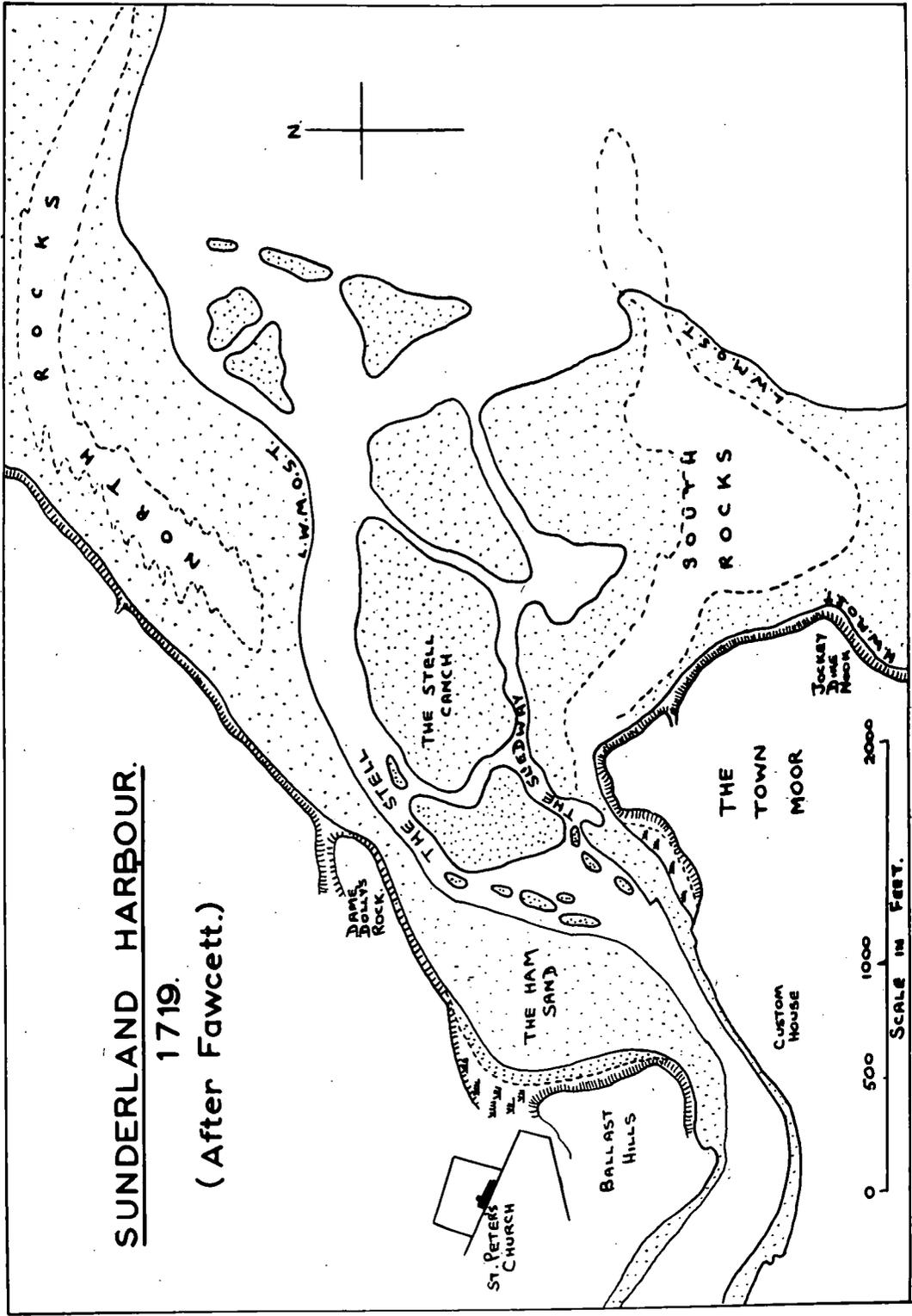
1913-1938. TYPICAL BEACH SECTIONS AT SOUTH SHIELDS.

FIG. 51



A PART OF THE COAST OF  
COUNTY DURHAM.

1693.



SUNDERLAND HARBOUR.  
1719.  
(After Fawcett.)

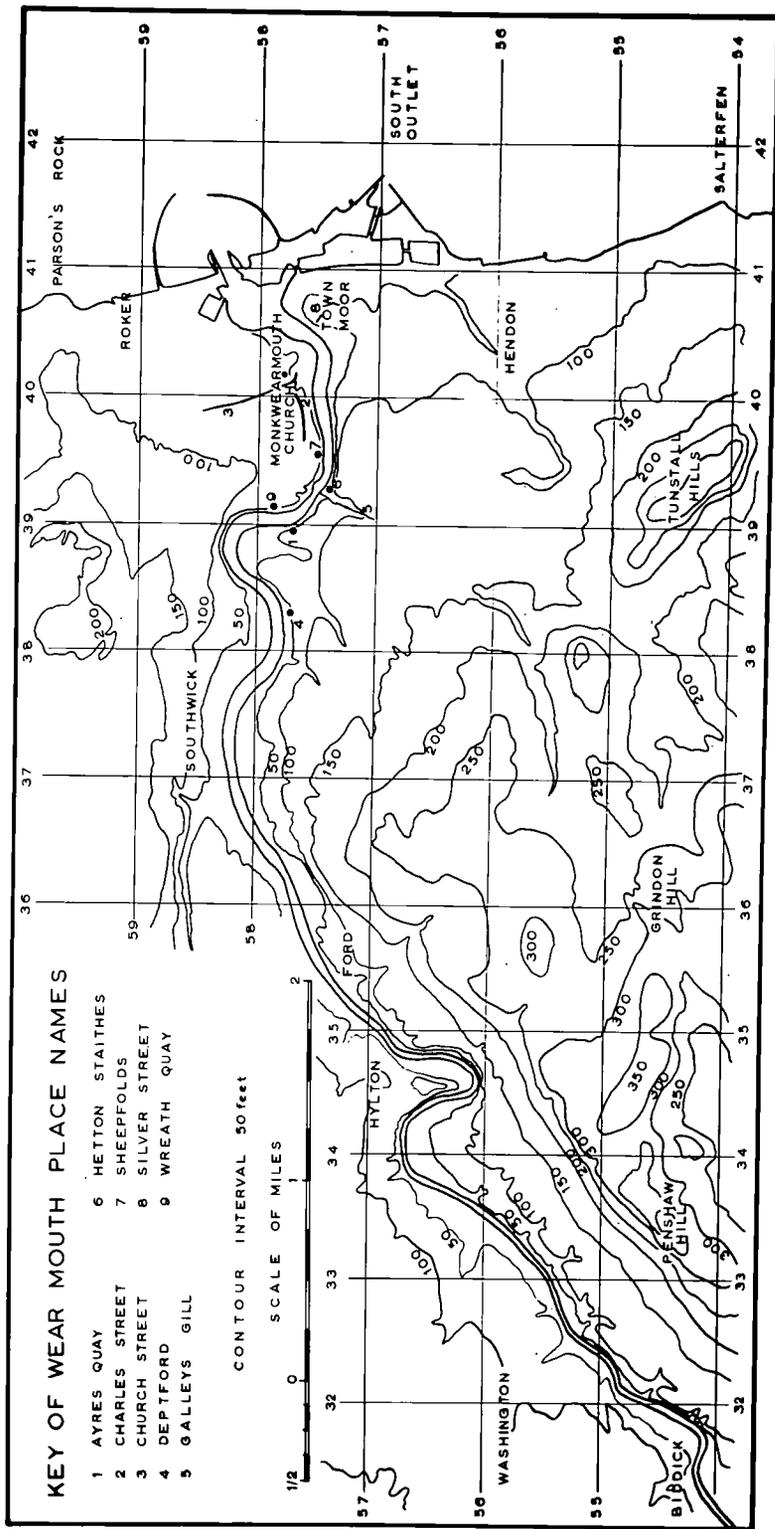
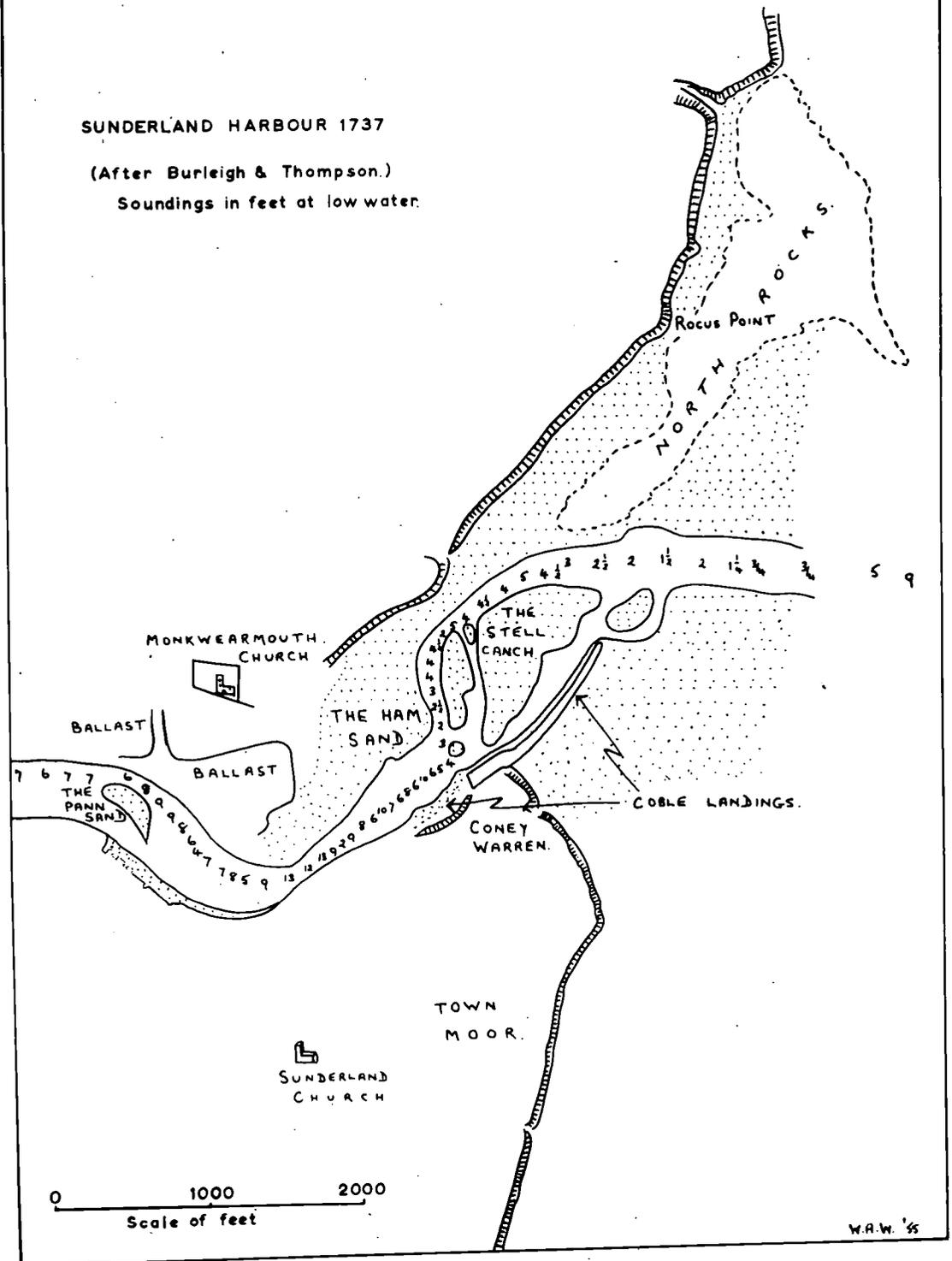


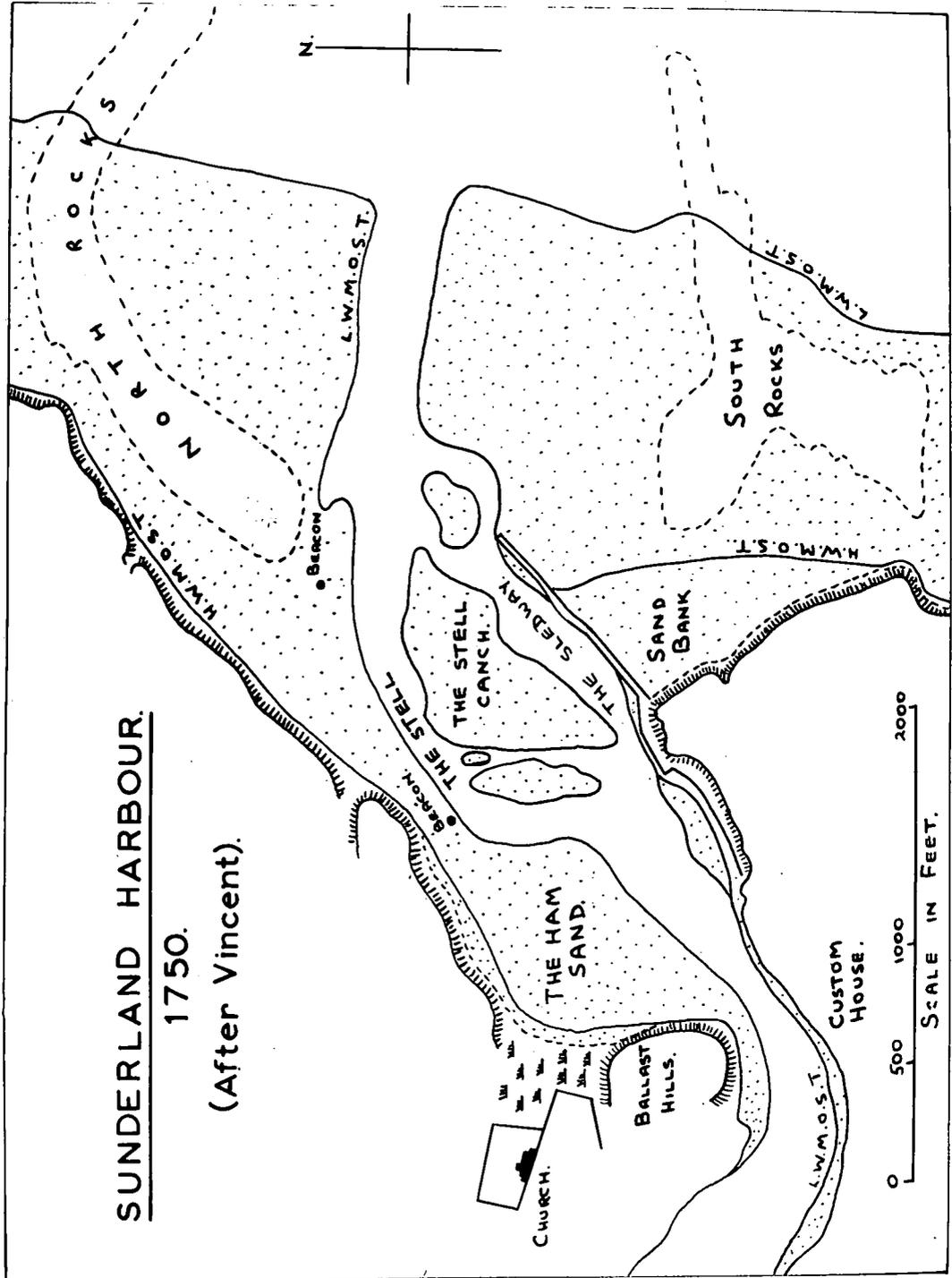
FIG. 54

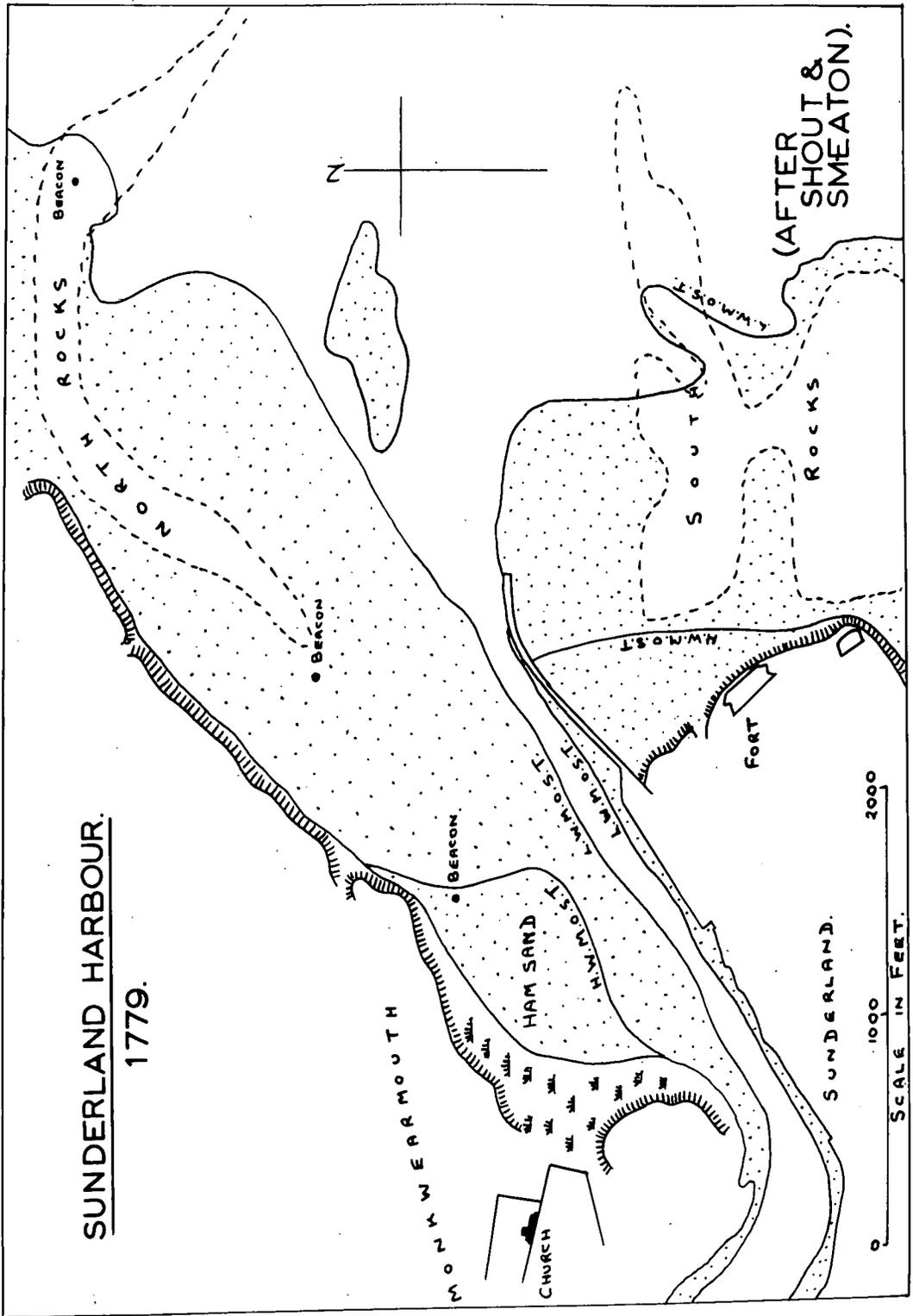
SUNDERLAND HARBOUR 1737

(After Burleigh & Thompson.)

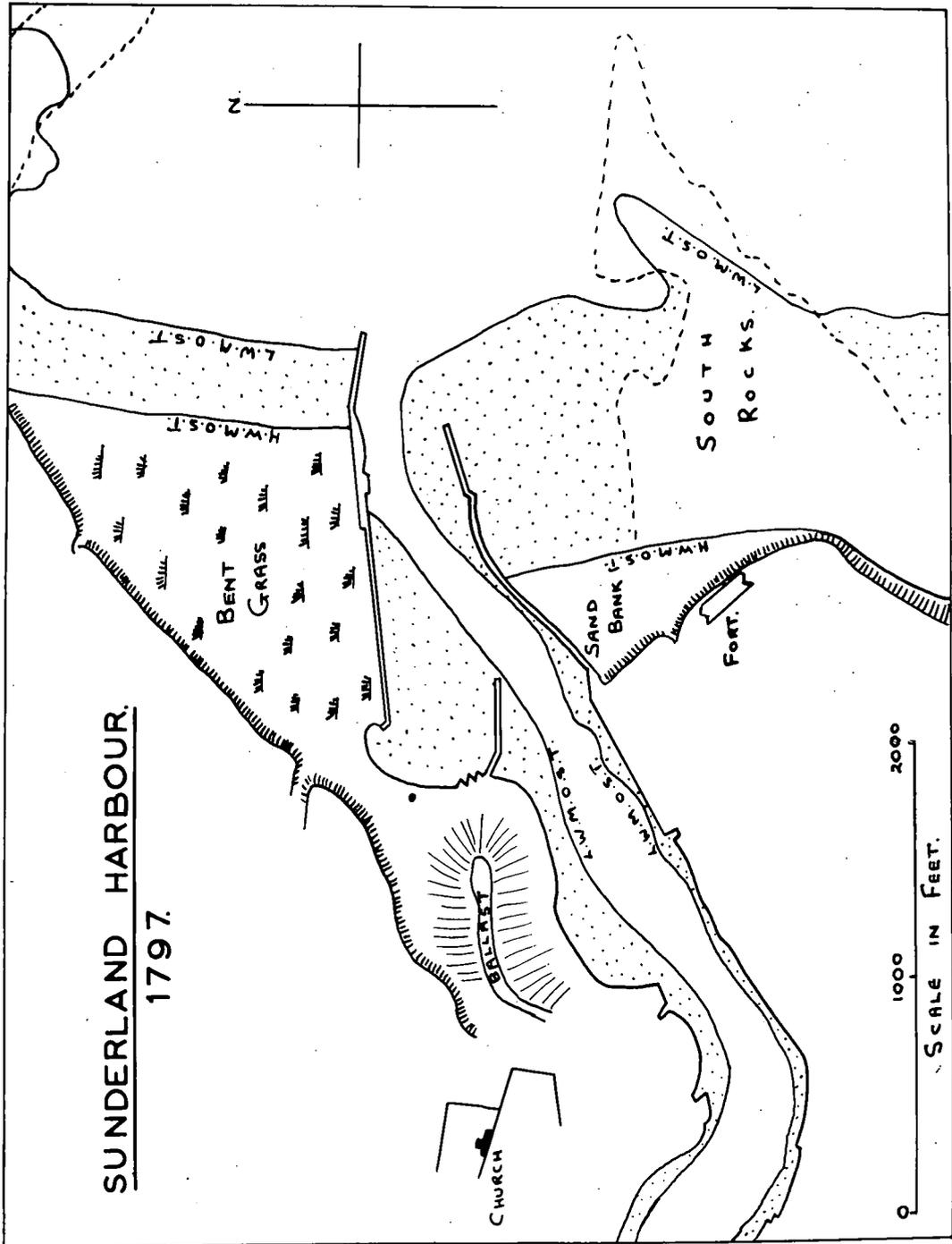
Soundings in feet at low water.

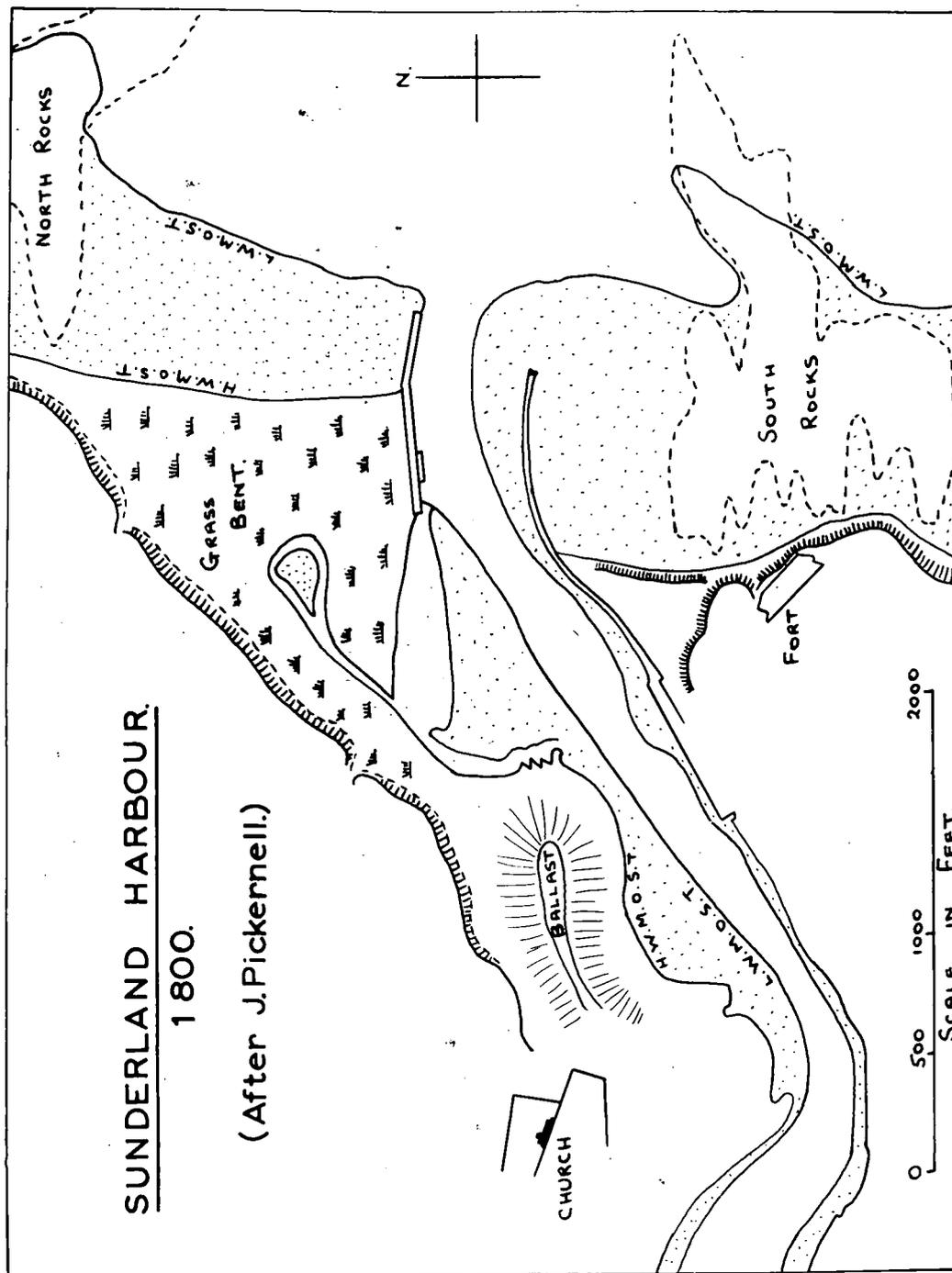






(AFTER SHOUT & SMEATON).

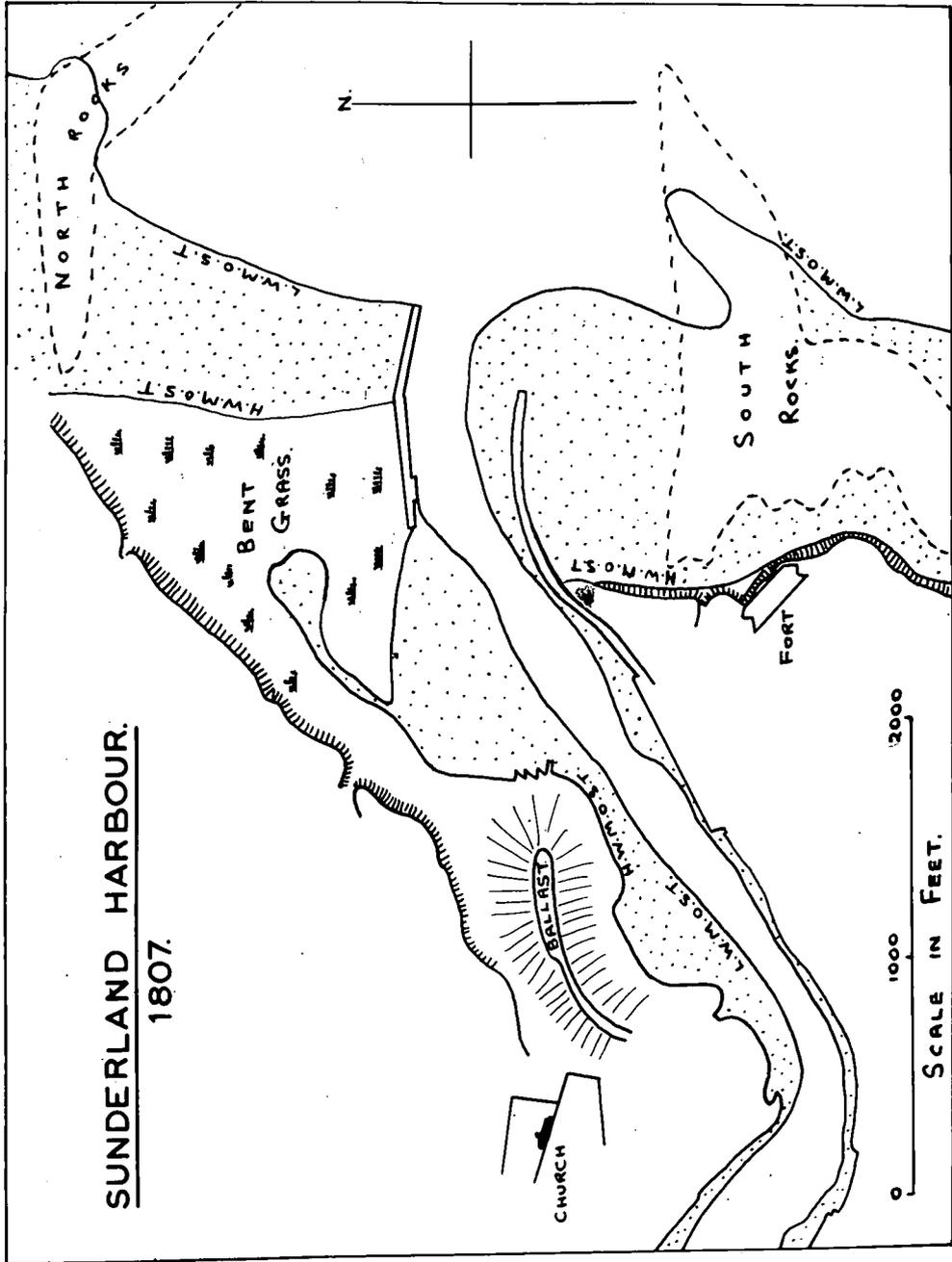


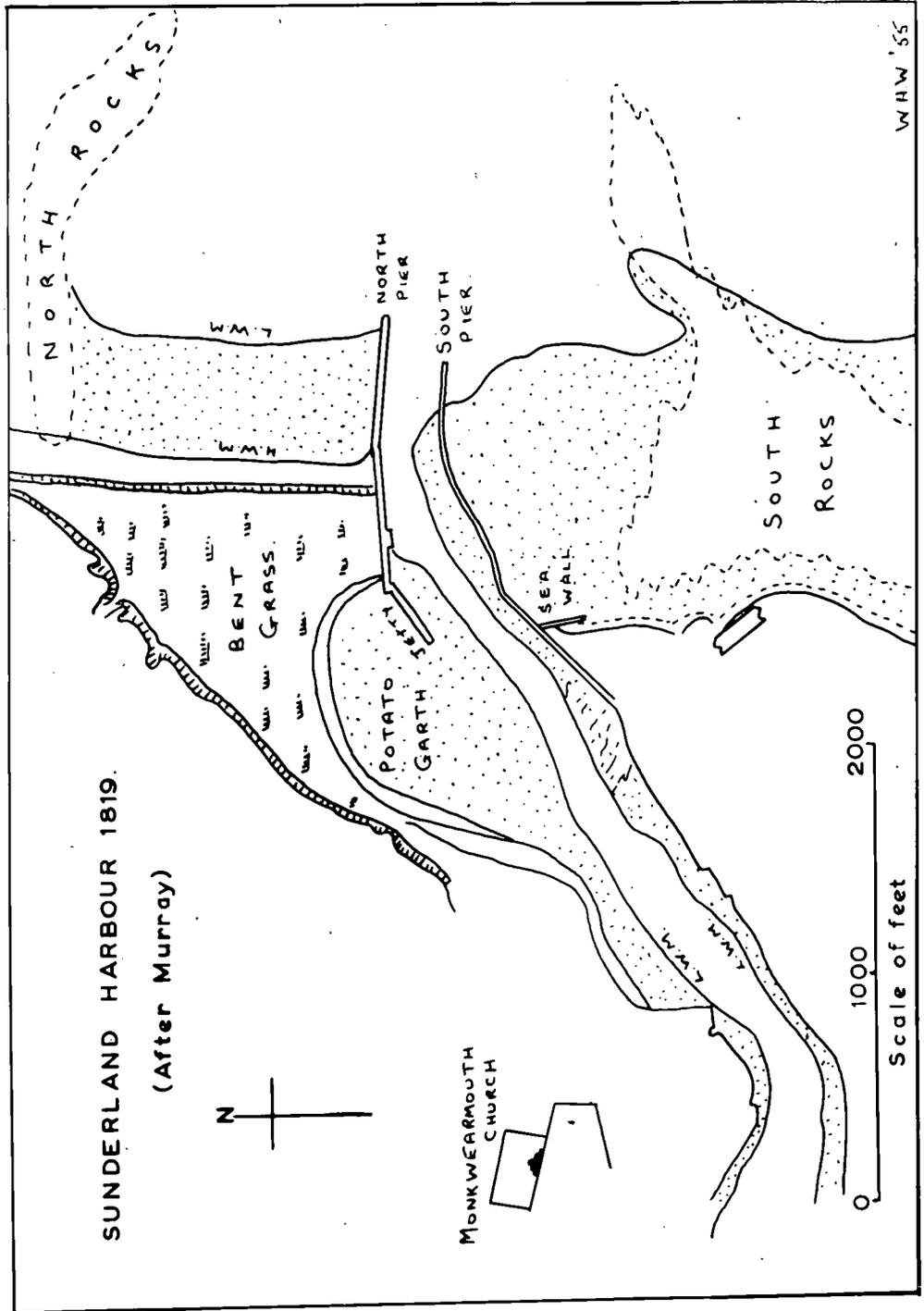


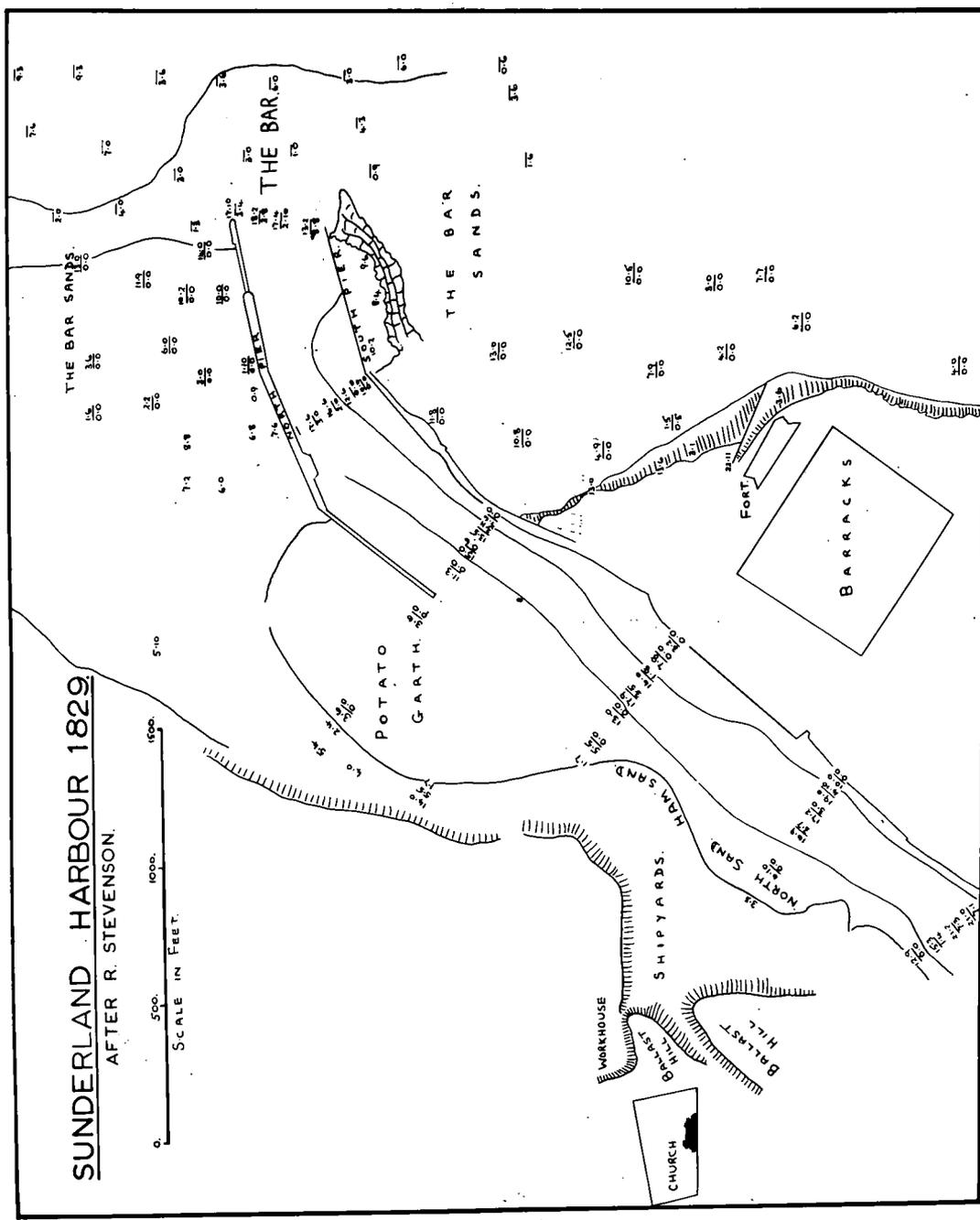
SUNDERLAND HARBOUR.

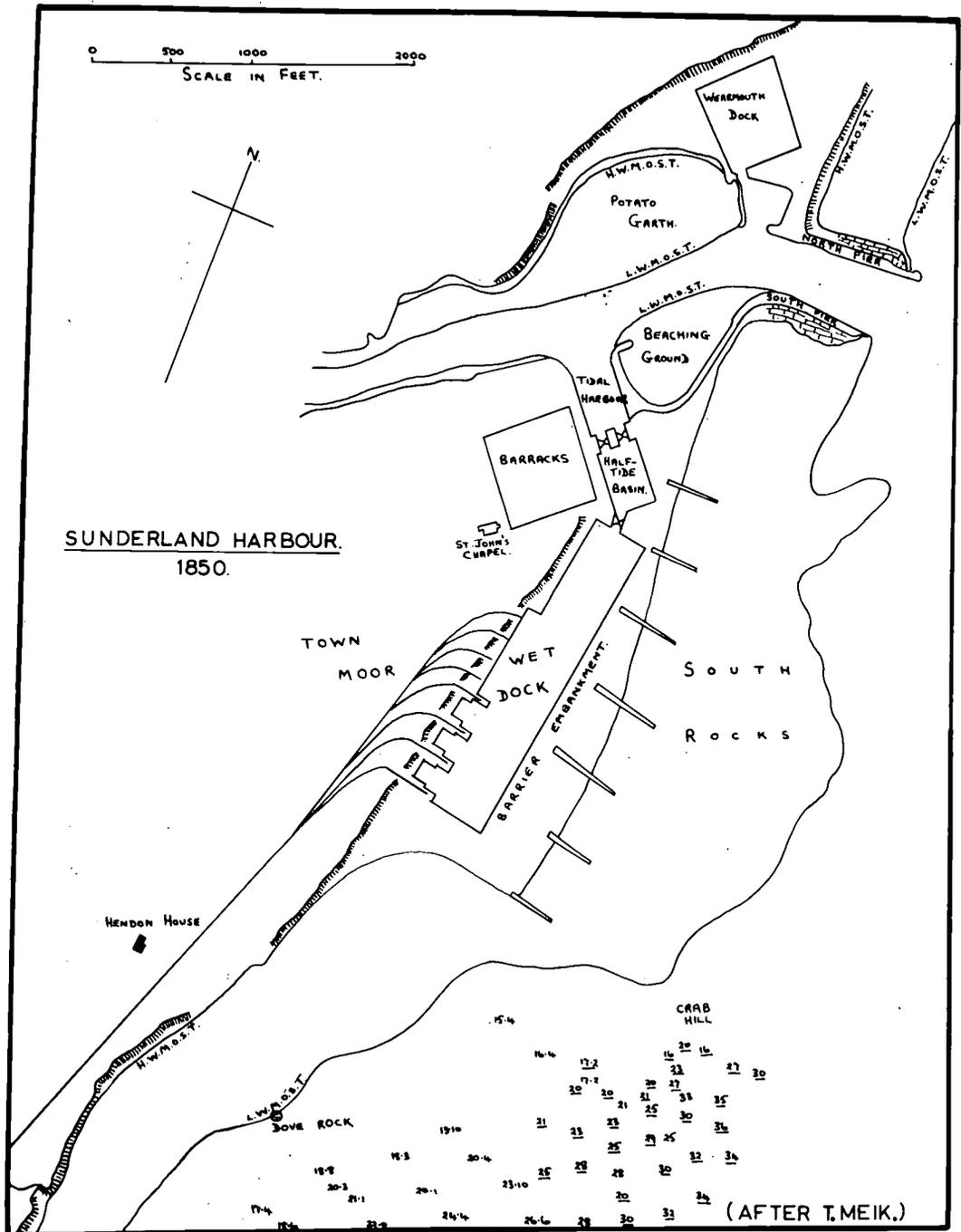
1800.

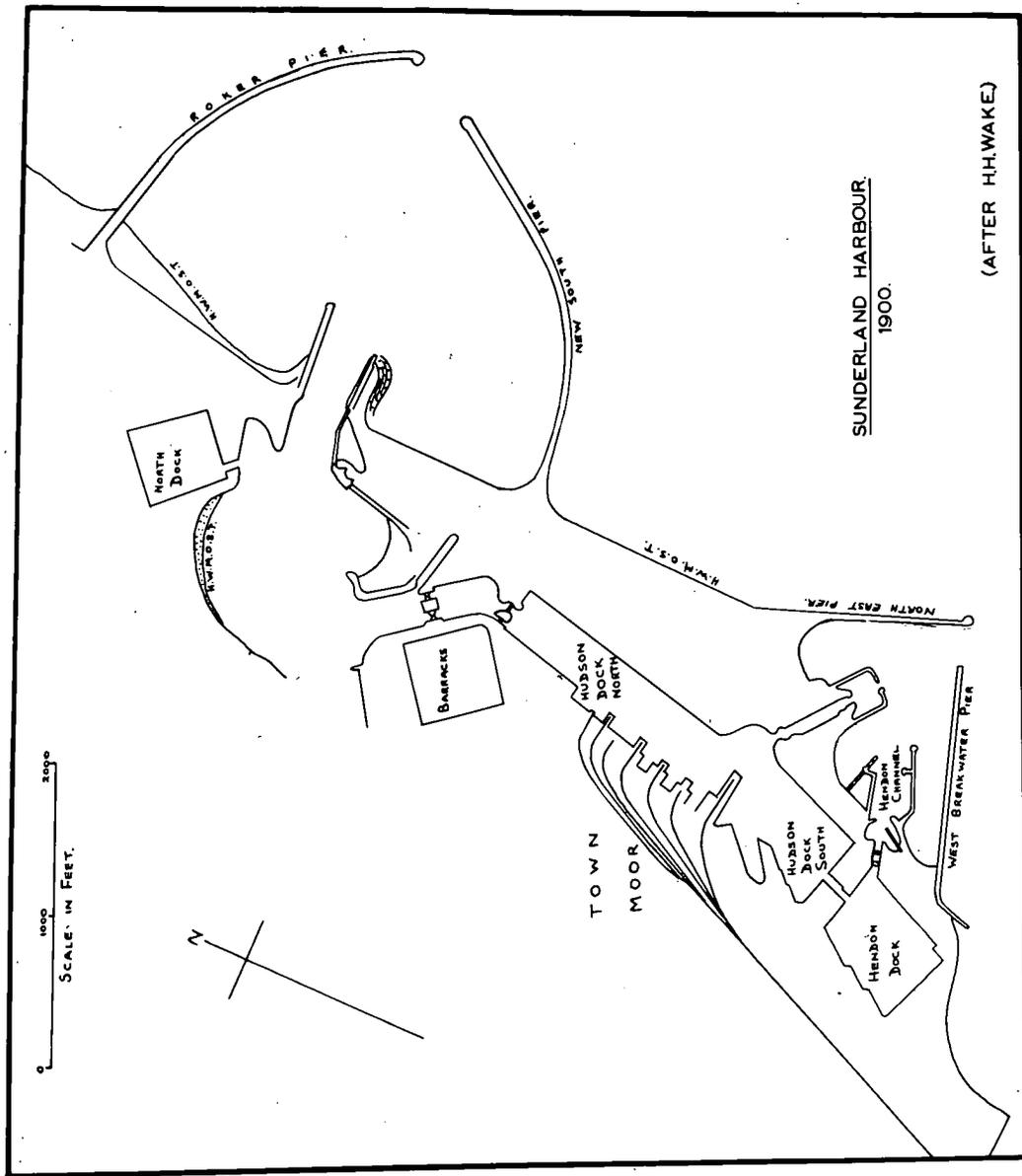
(After J. Pickernell.)





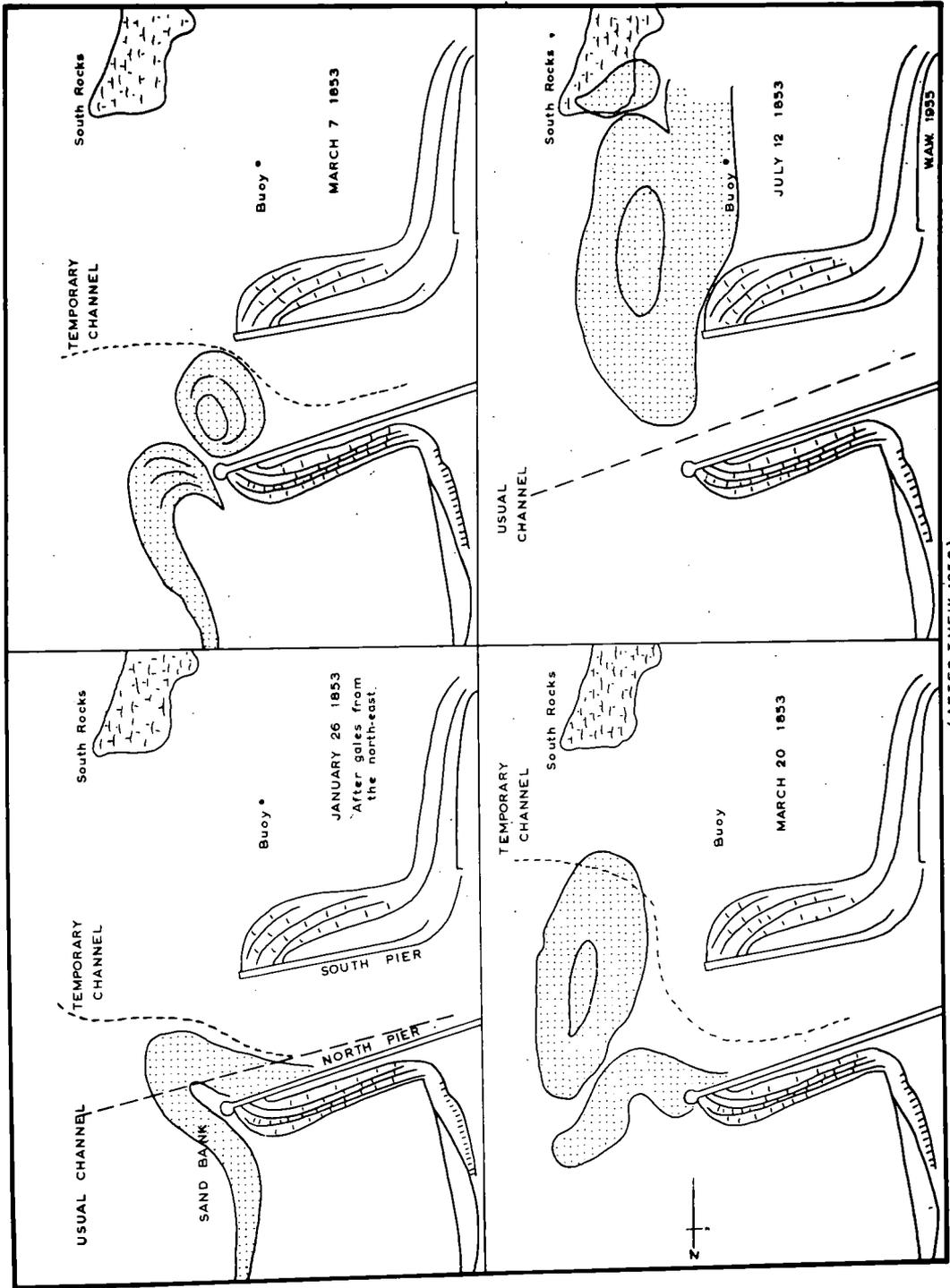




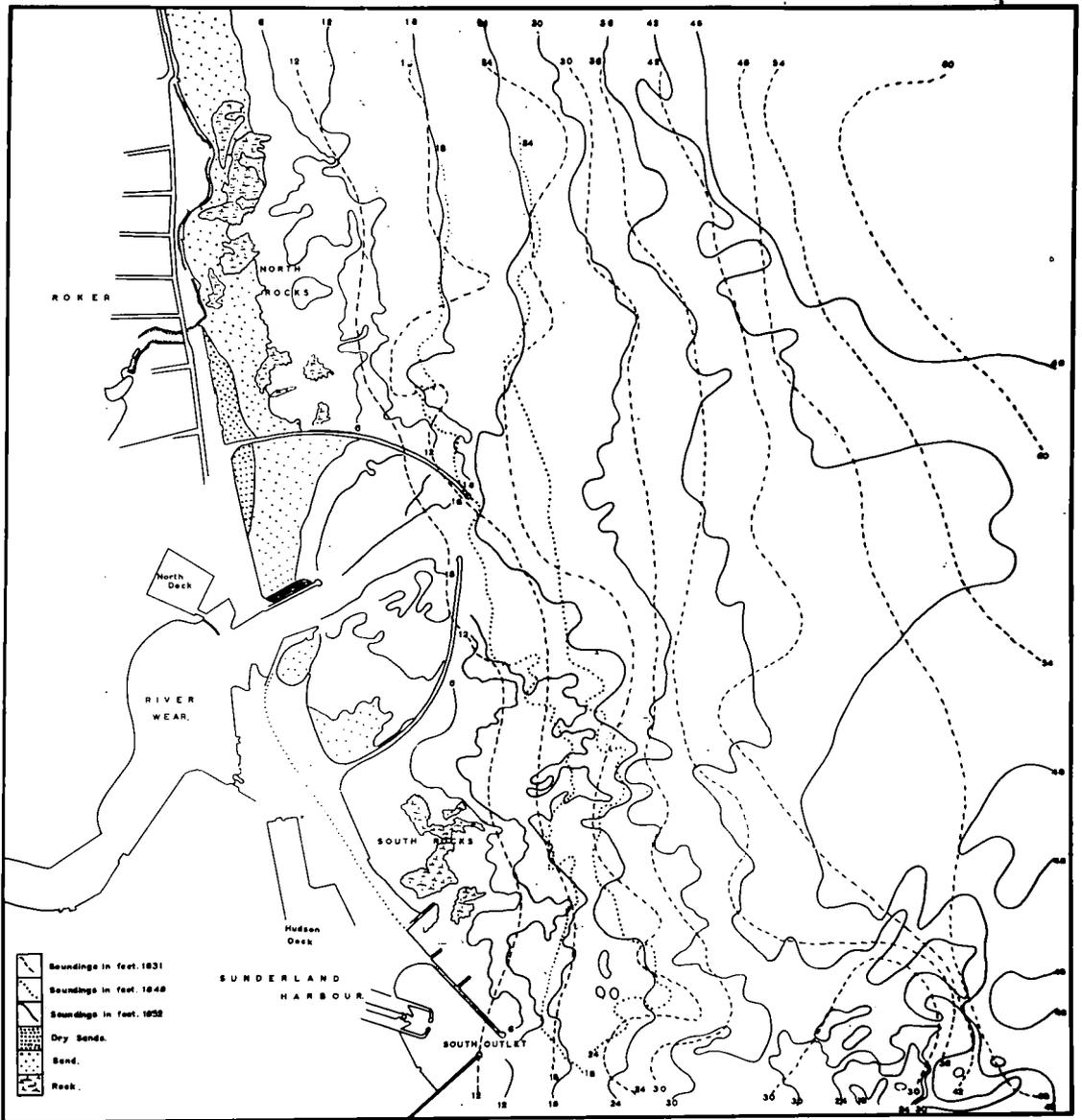


(AFTER H.H.WAKE)

The Reopening Of The North Channel (Sunderland) By Natural Means



(AFTER T. MEIK, 1858)

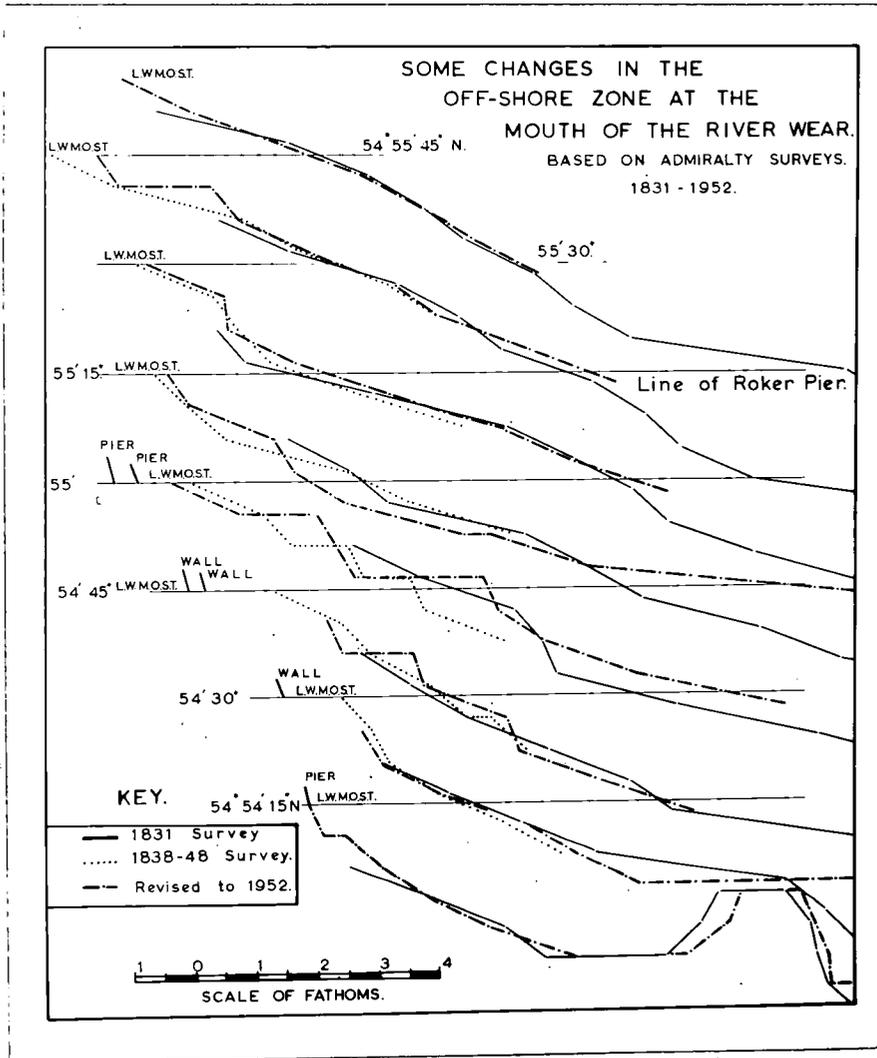


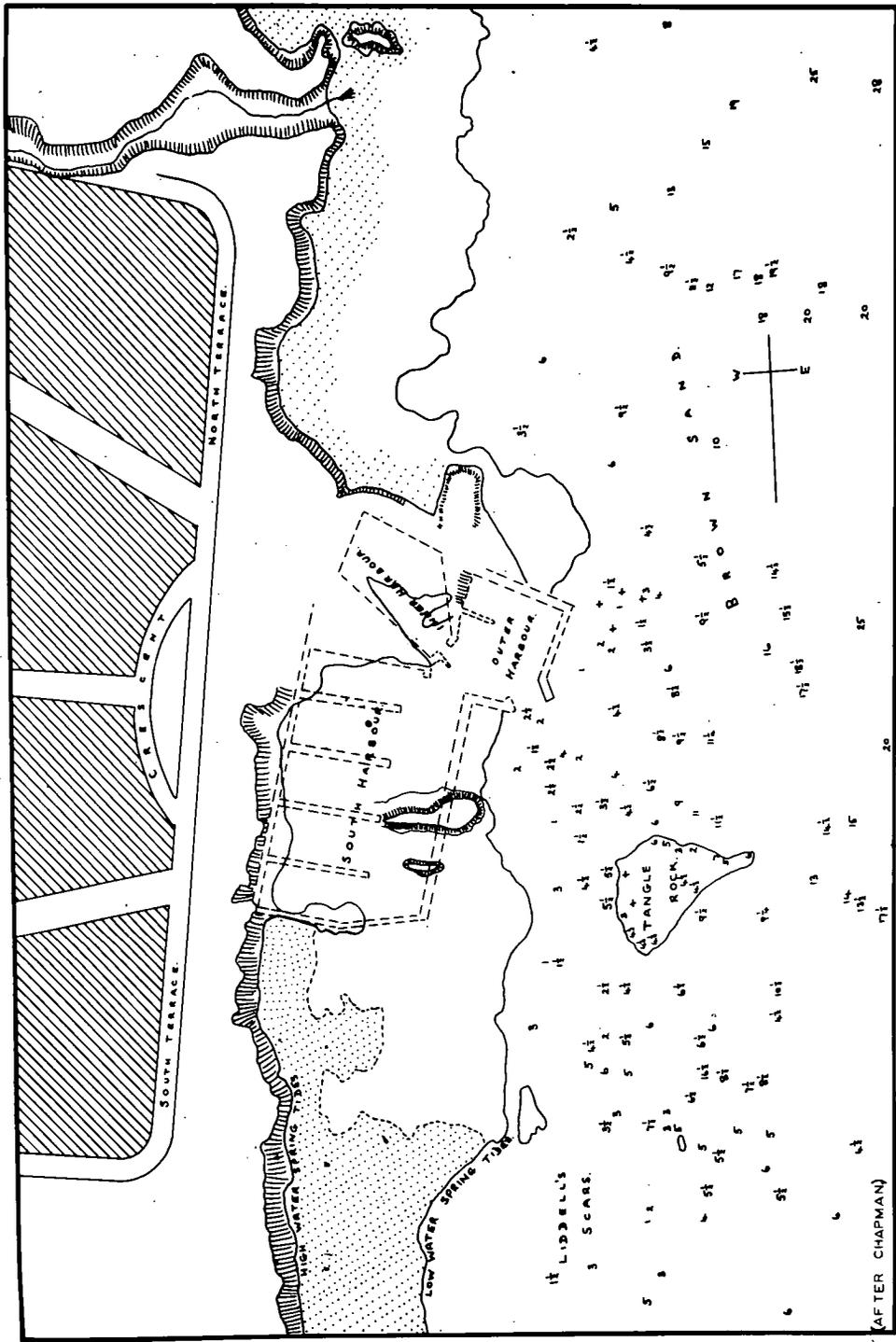
THE ENTRANCE OF SUNDERLAND HARBOUR IN 1831 & 1952

DATUM OF SOUNDINGS 07 FEET BELOW MEAN LOW WATER SPRINGS OR 7.03 FEET BELOW OD  
 BASED ON ADMIRALTY CHARTS



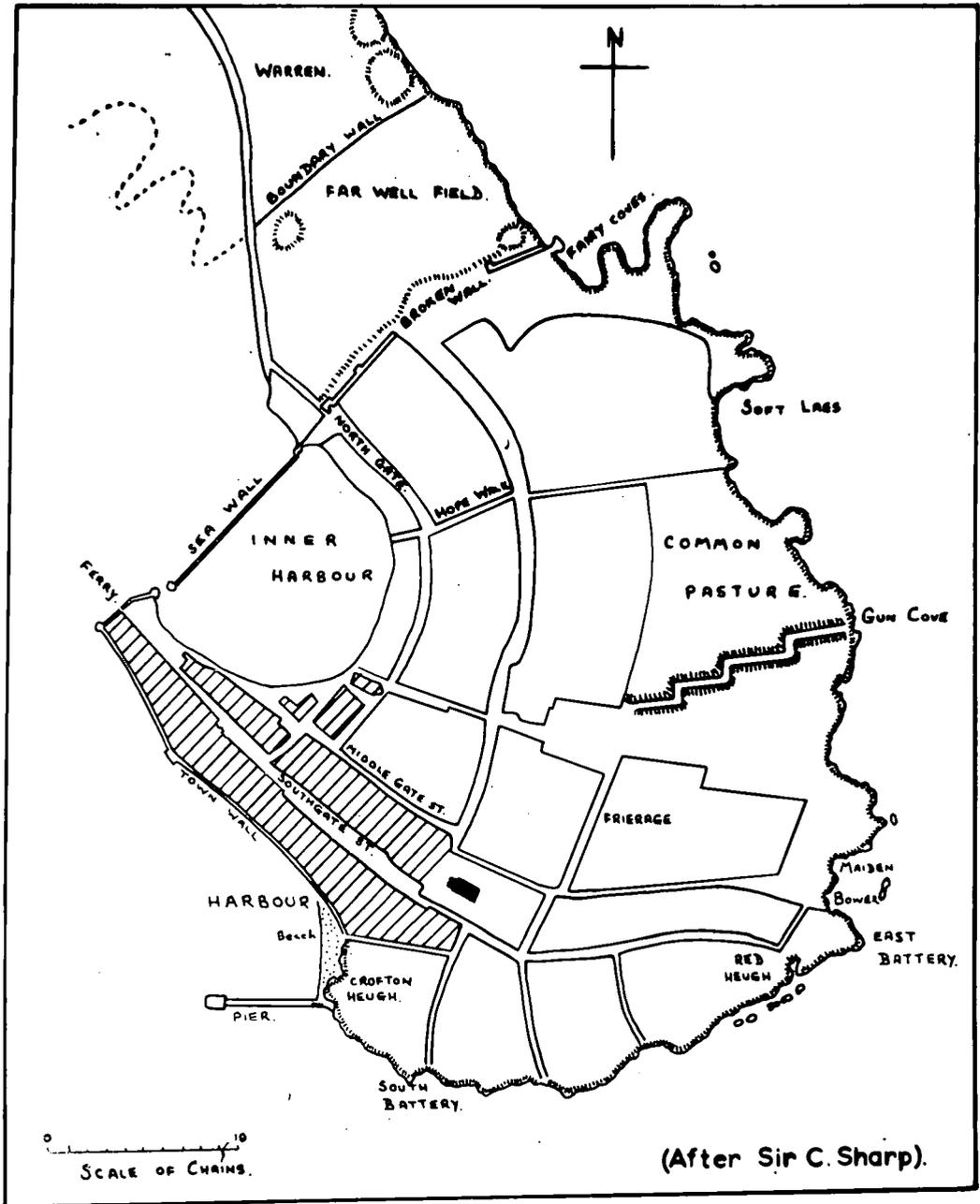
N.W.





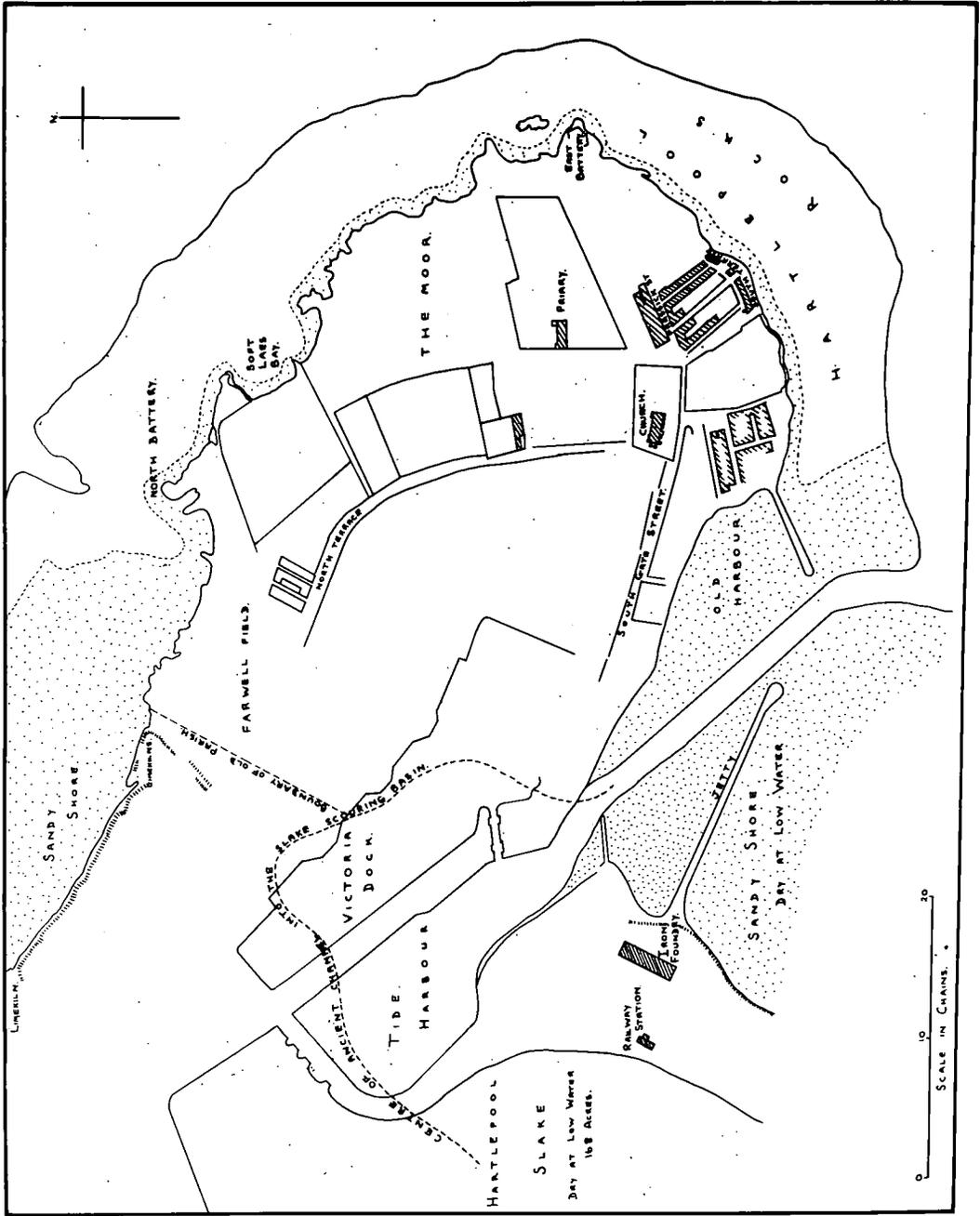
PLAN OF PROPOSED HARBOUR AT SEAHAM, 1830.

SOUNDINGS ARE IN FEET AT LOW WATER SPRING TIDE. EAST SEAHAM AFTER DOBSON 1830.



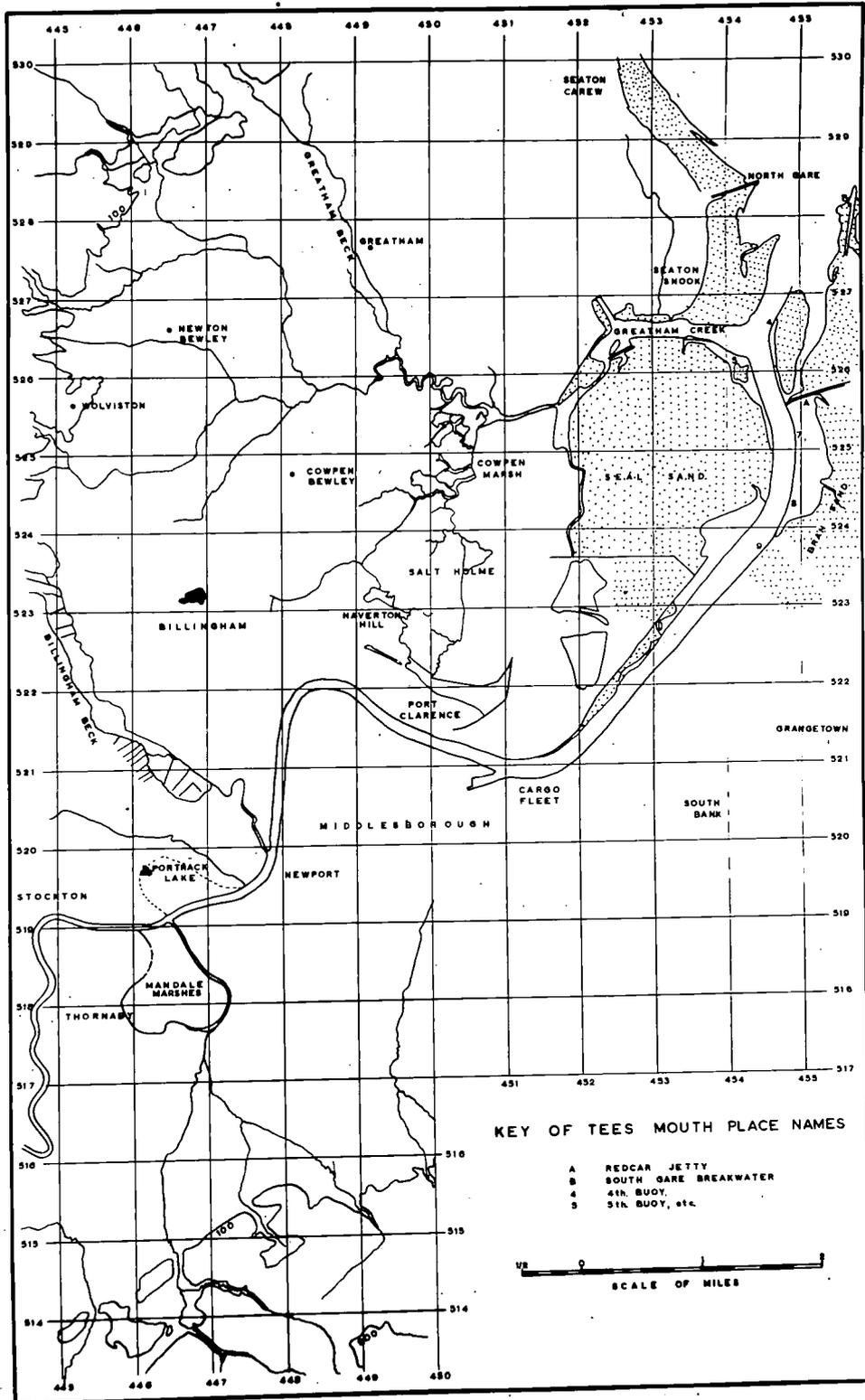
A PLAN OF HARTLEPOOL  
1816.

W.A.W. '56



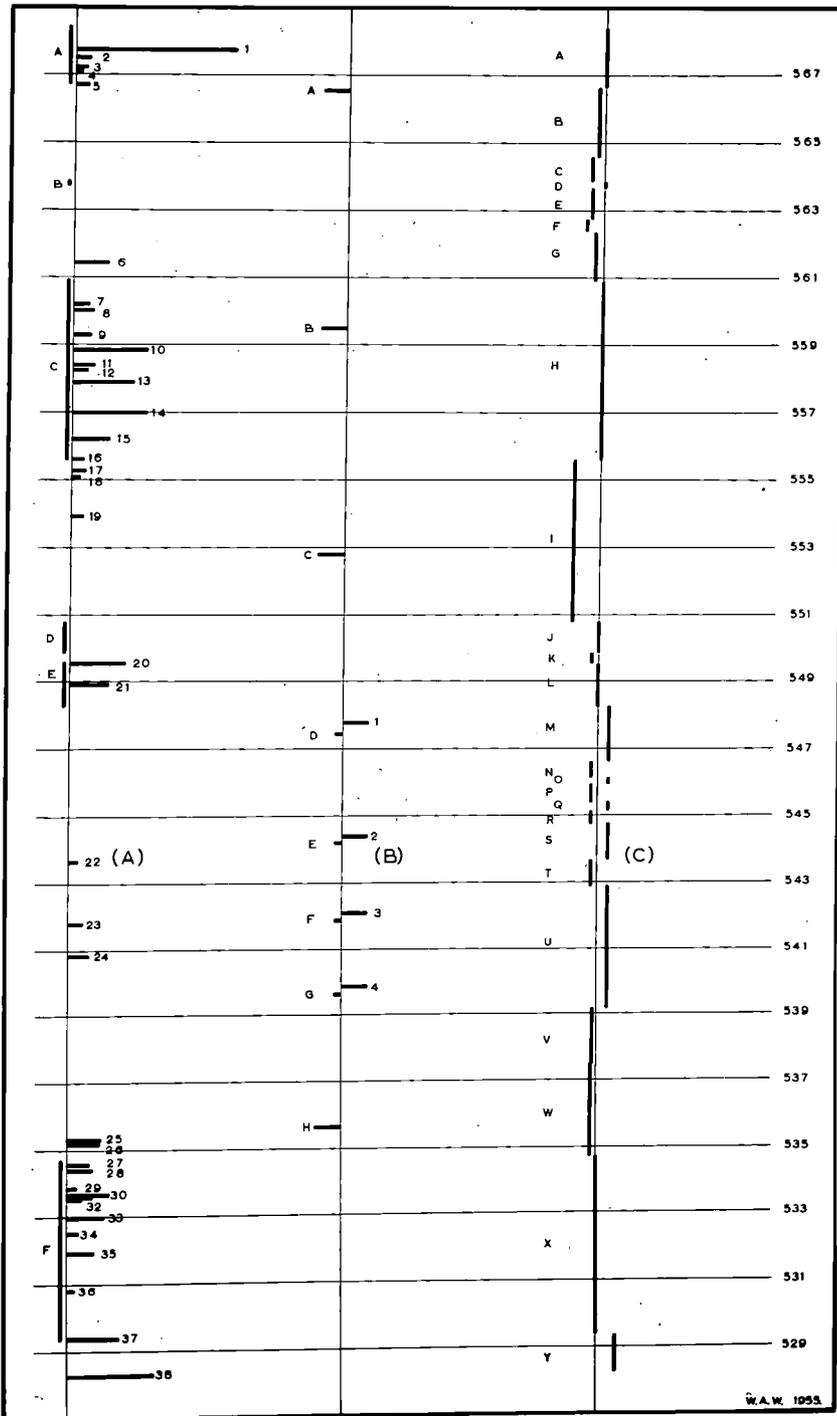
THE TOWN OF  
HARTLEPOOL.  
1841.

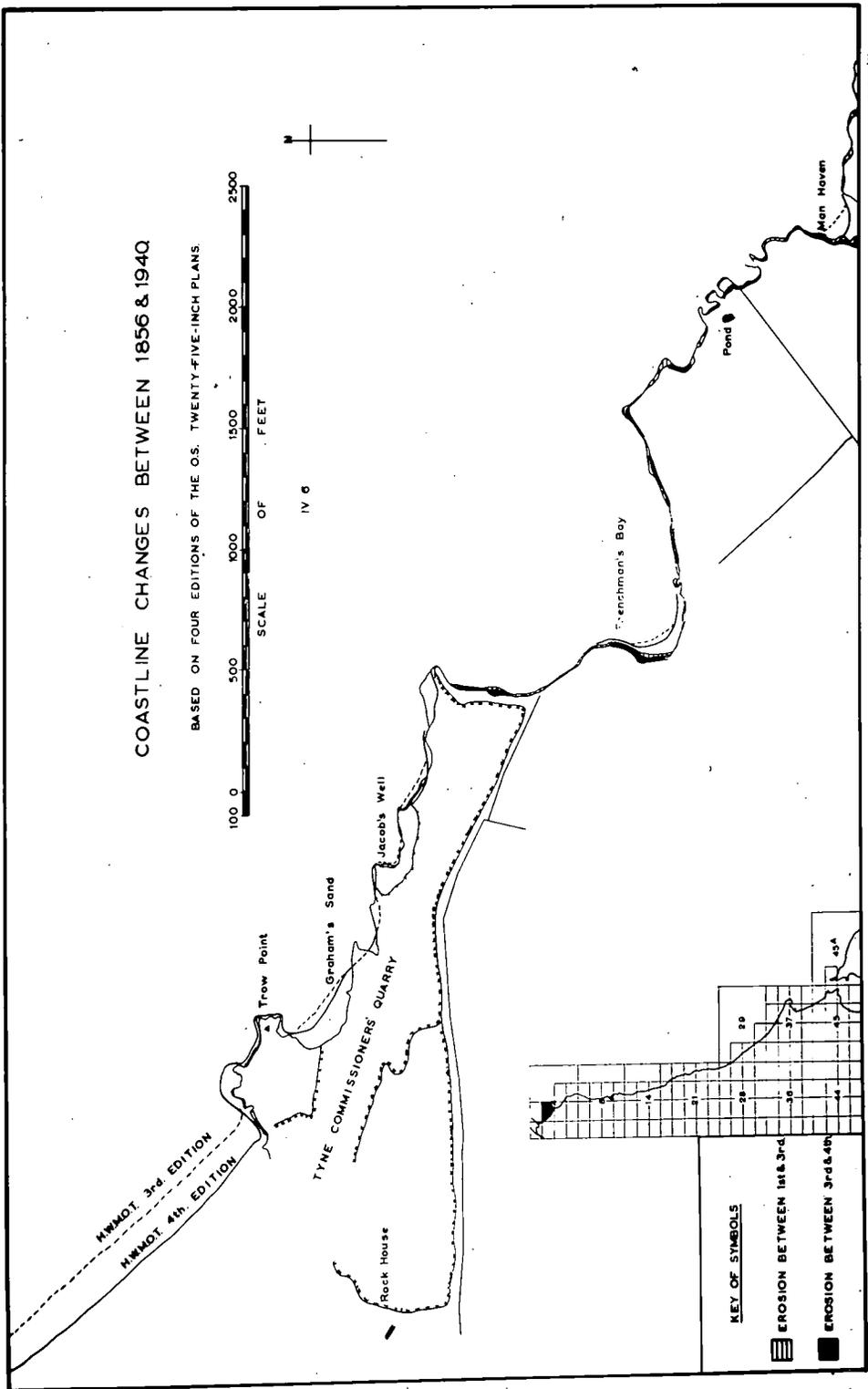
FROM A SURVEY BY,  
T. T. W. BELL,  
OF CASTLE EDEN.

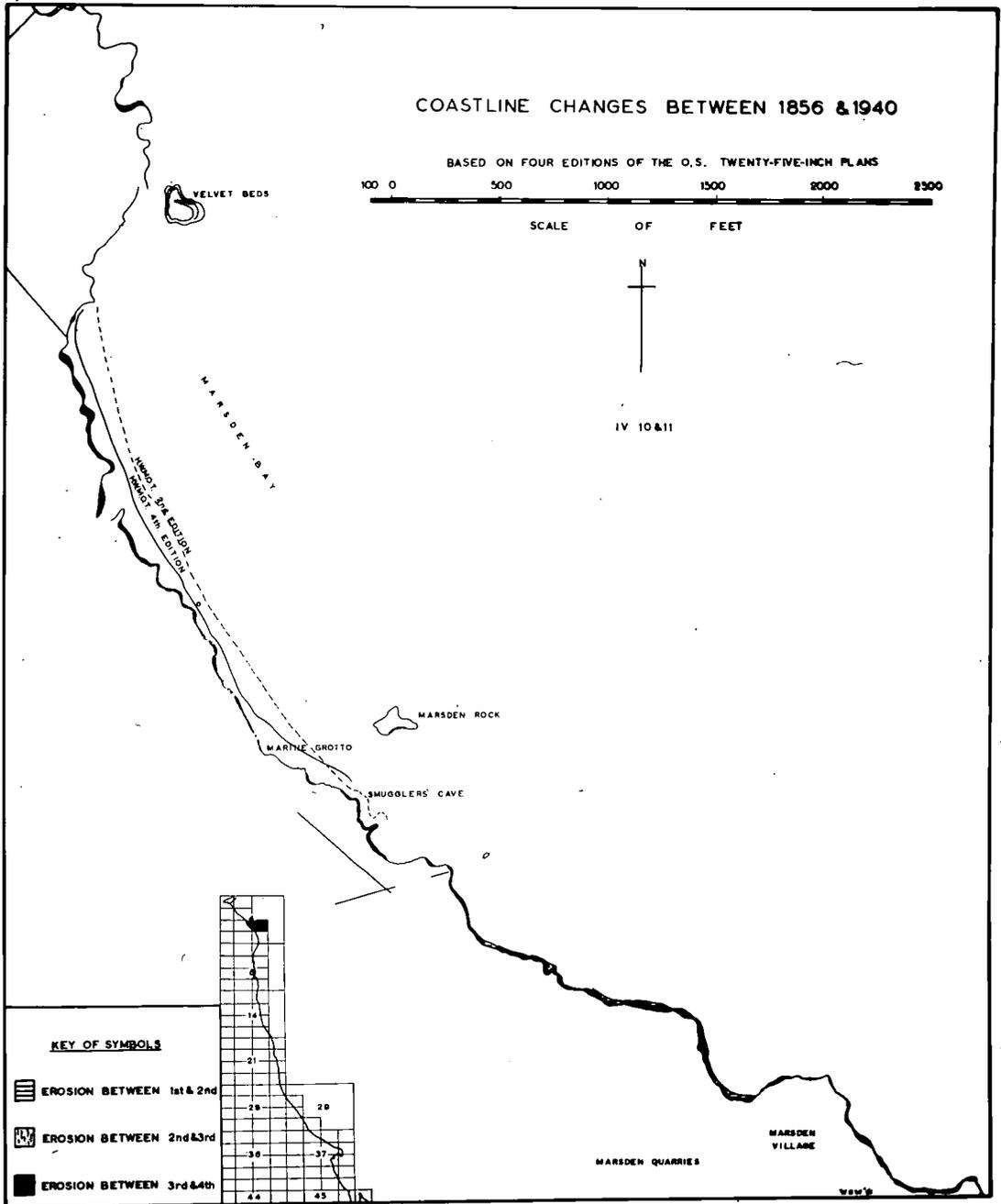


DIAGRAMS OF THE DURHAM COAST

PARTS A, B AND C.







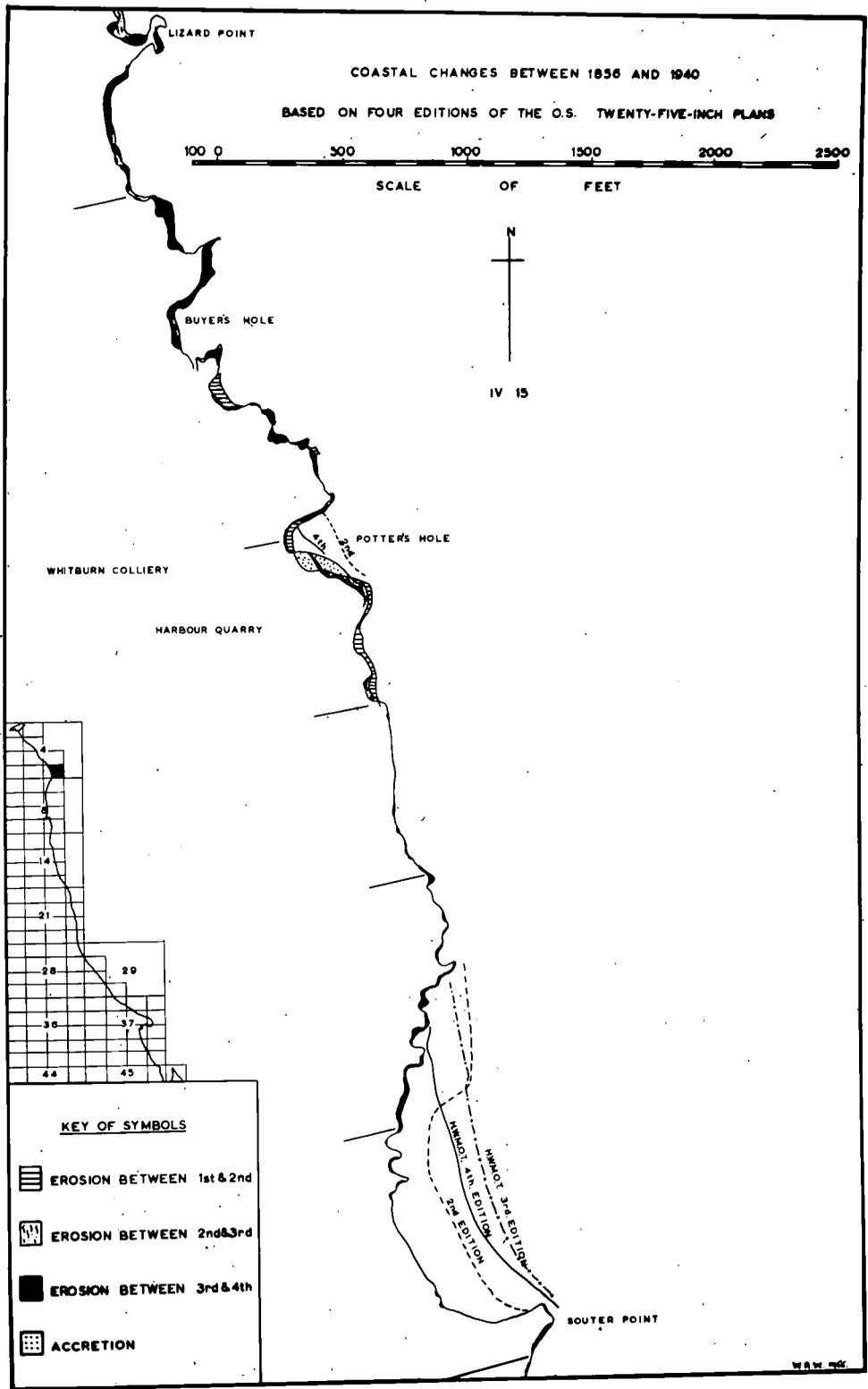
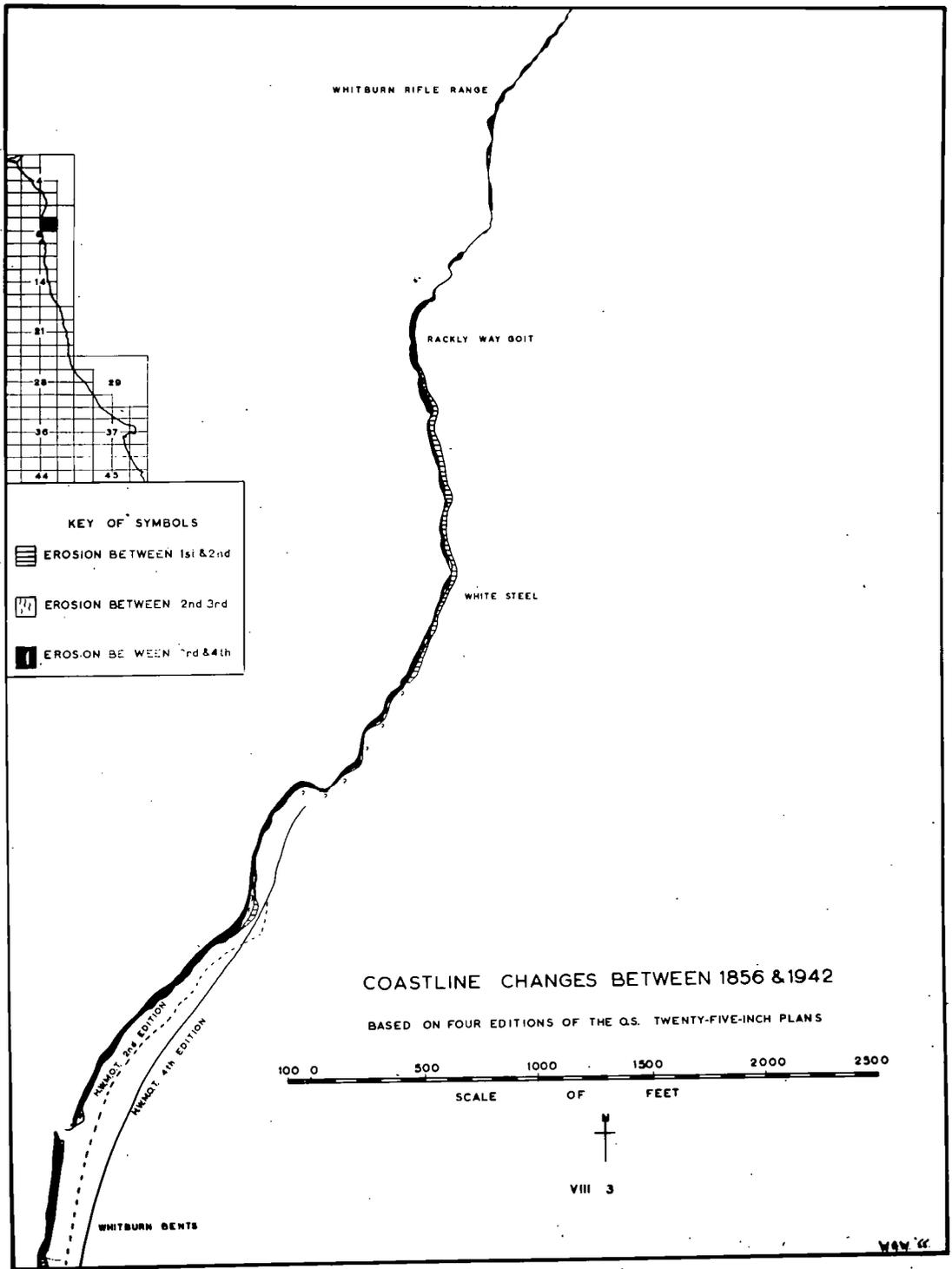
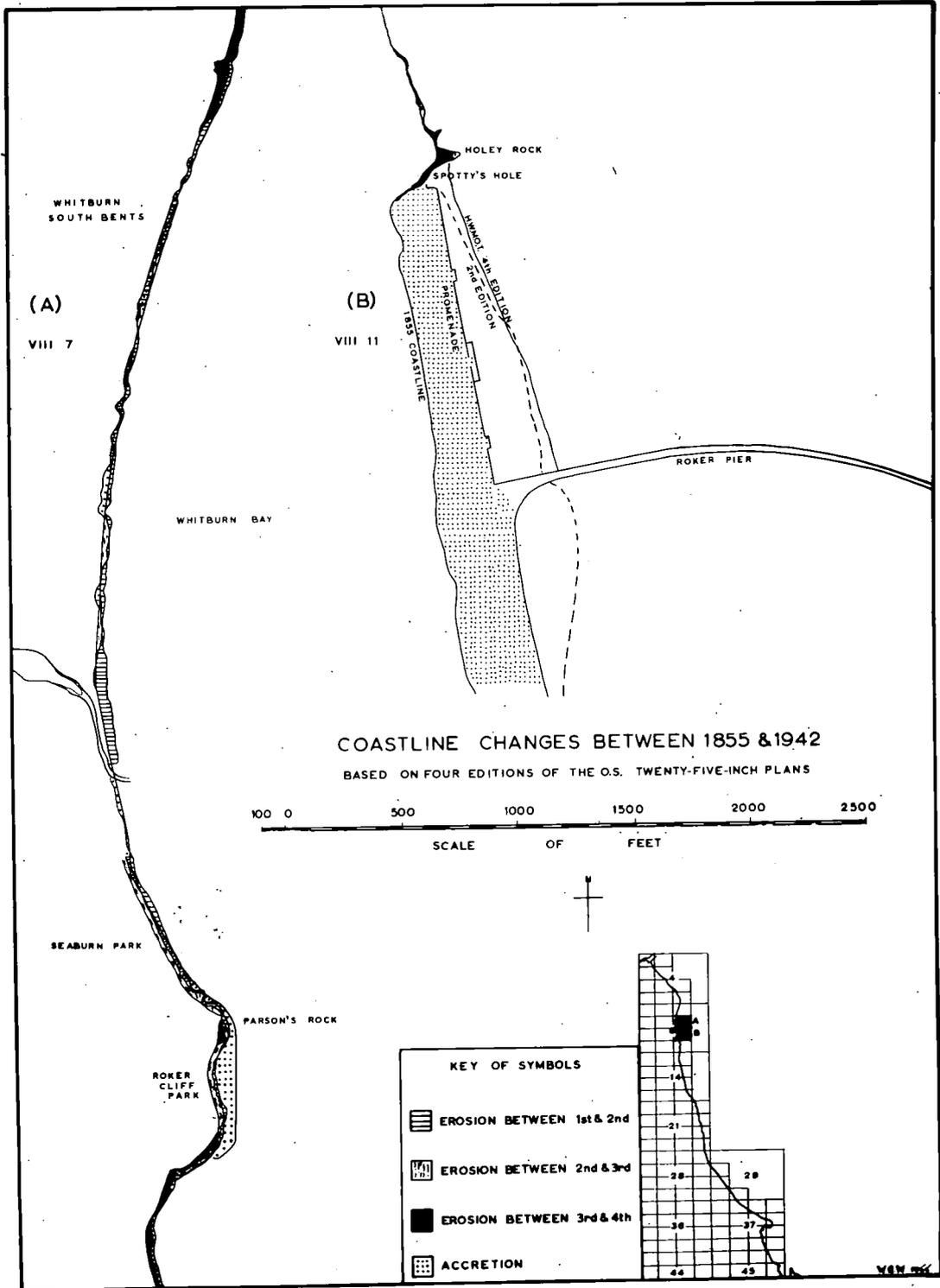
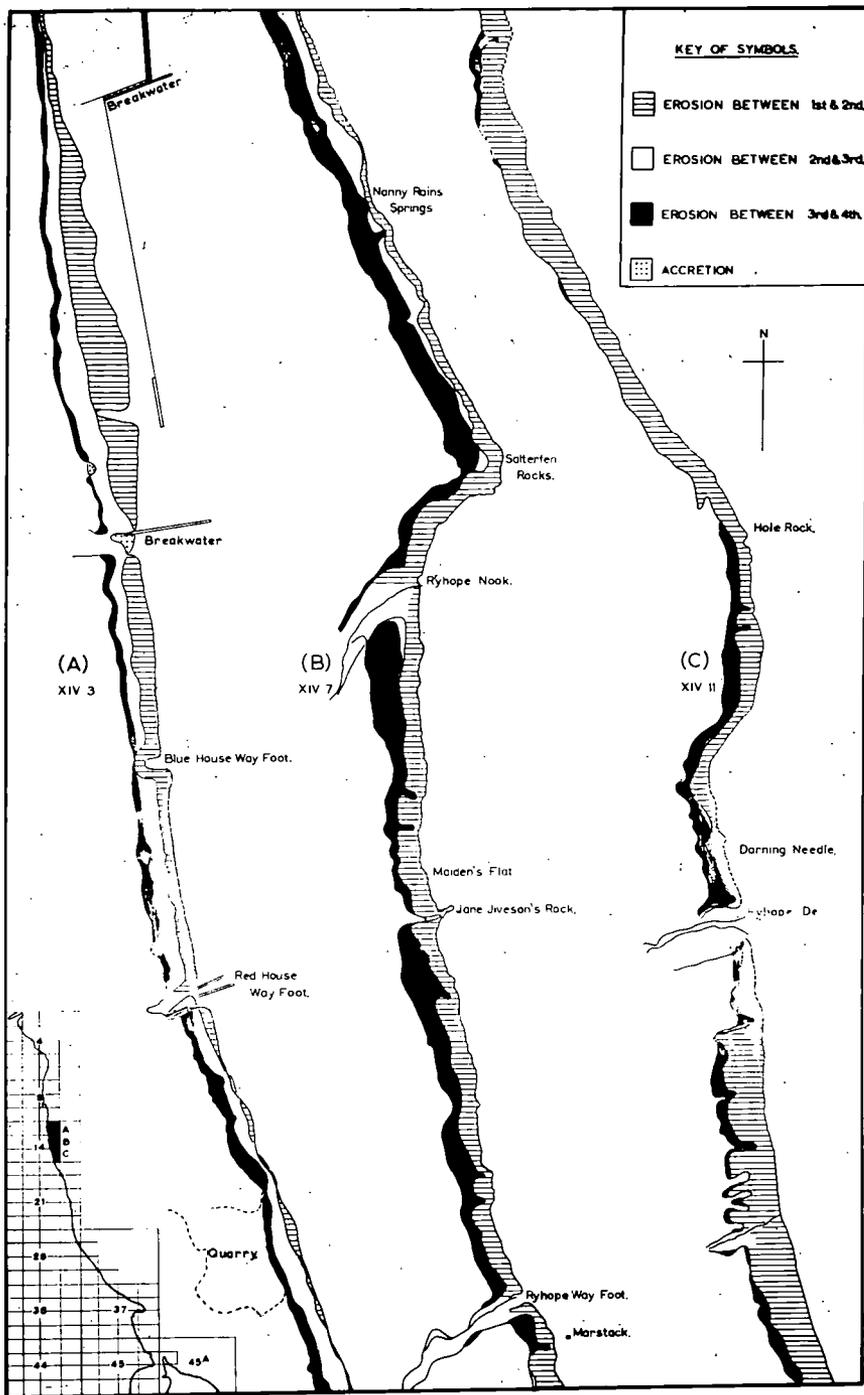
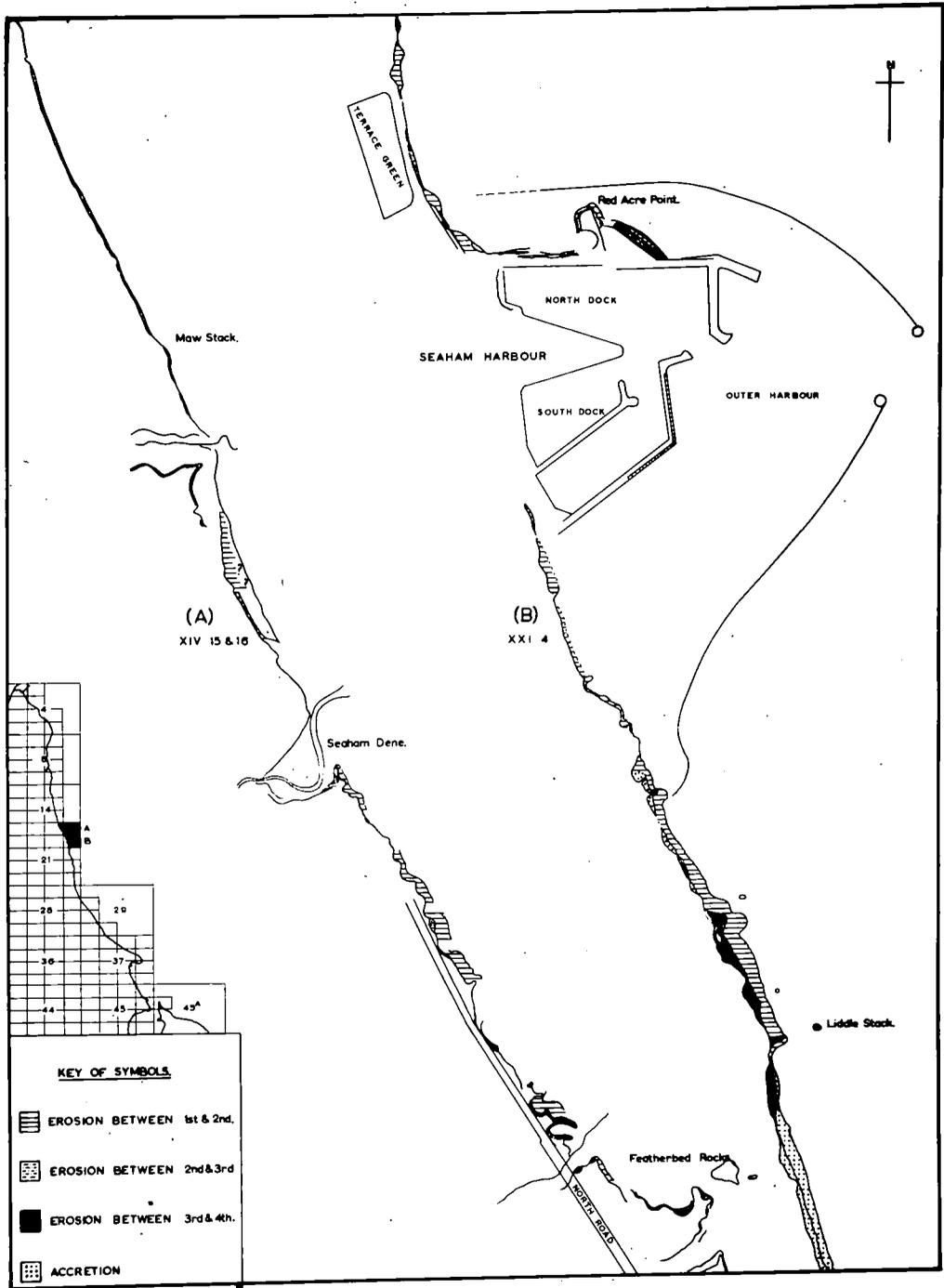


FIG. 75



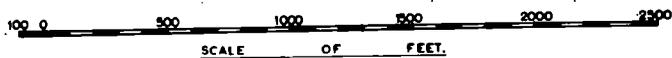


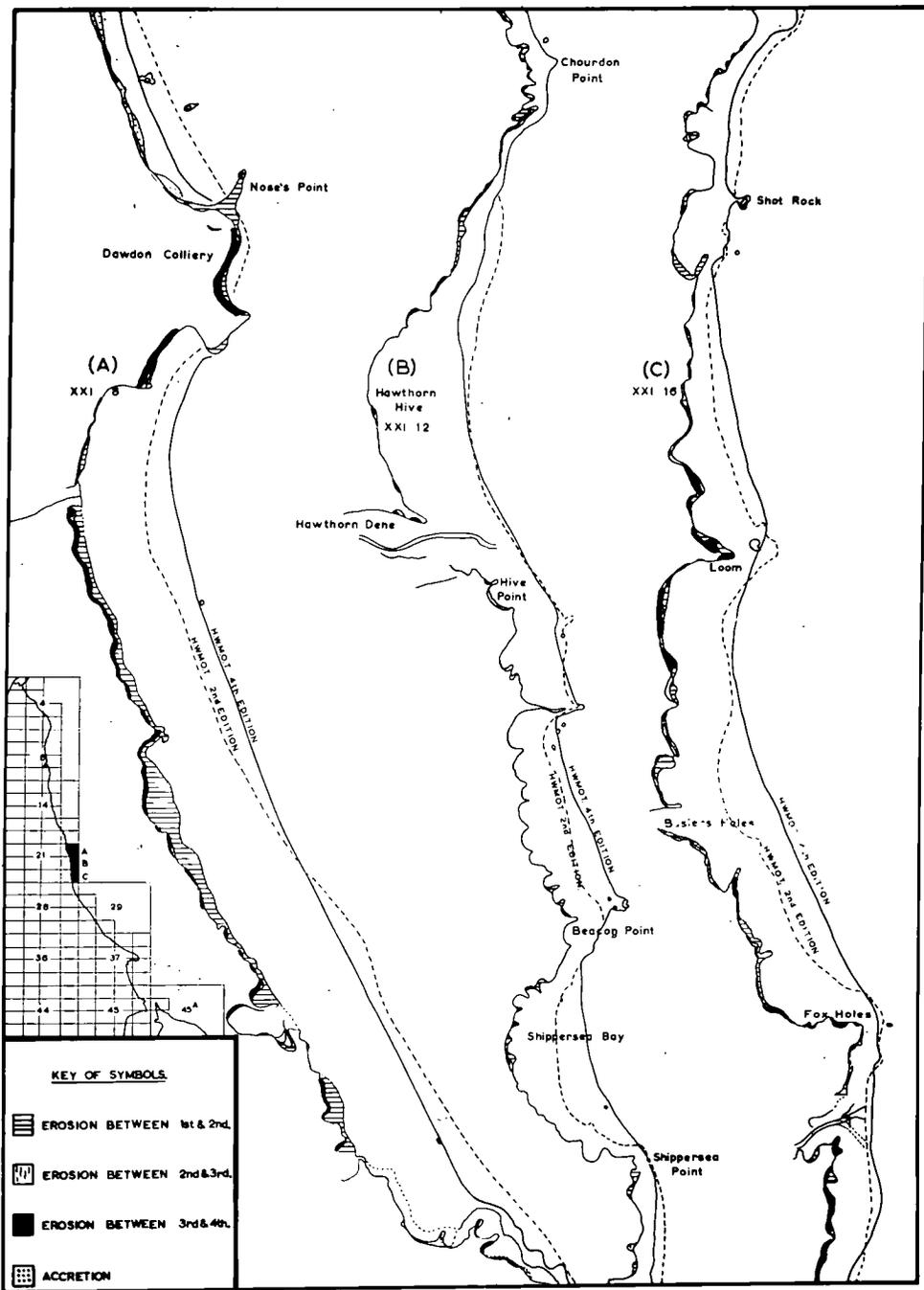




COASTLINE CHANGES BETWEEN 1856 & 1939

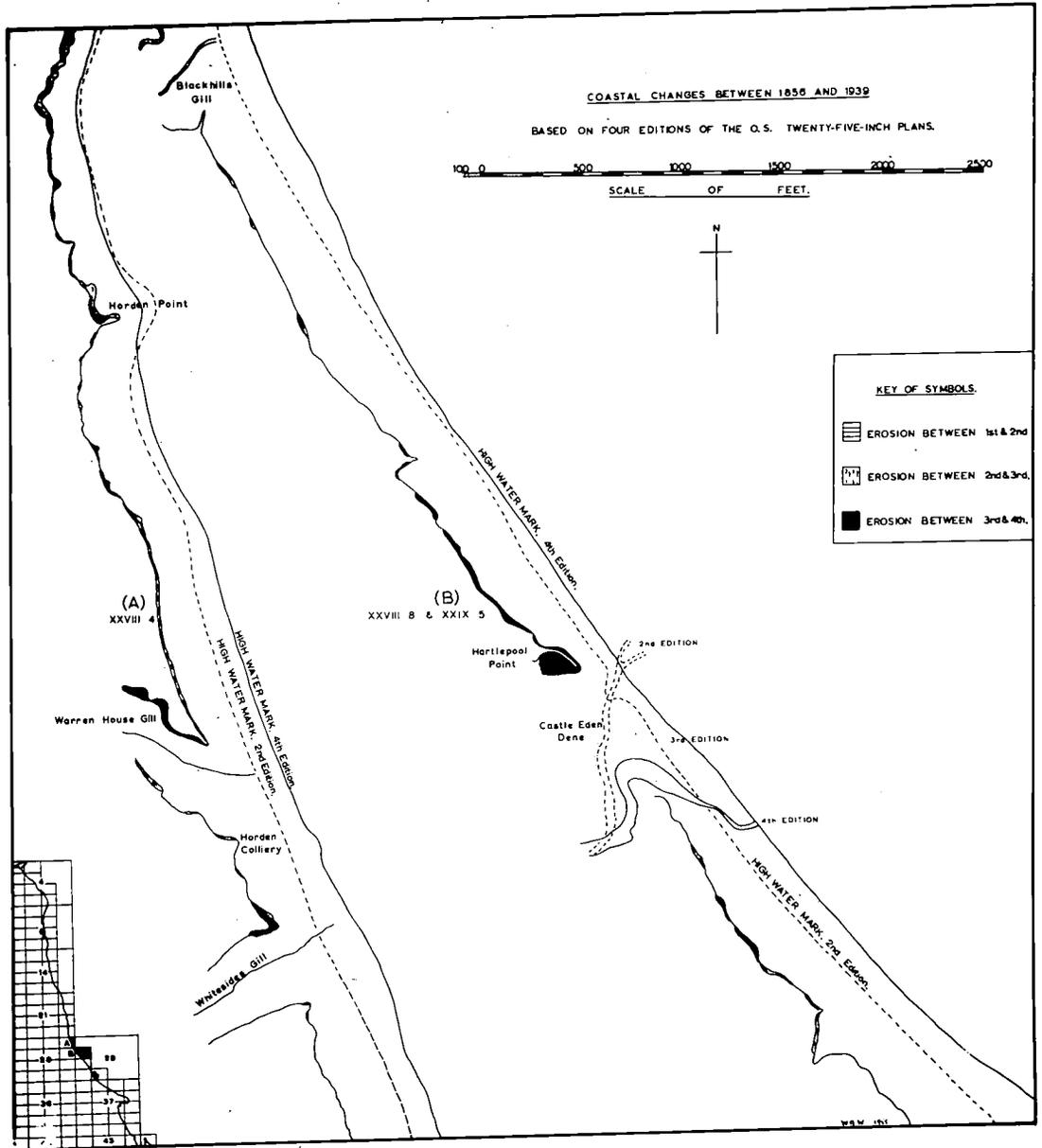
BASED ON FOUR EDITIONS OF THE U.S. TWENTY-FIVE-INCH PLANS.

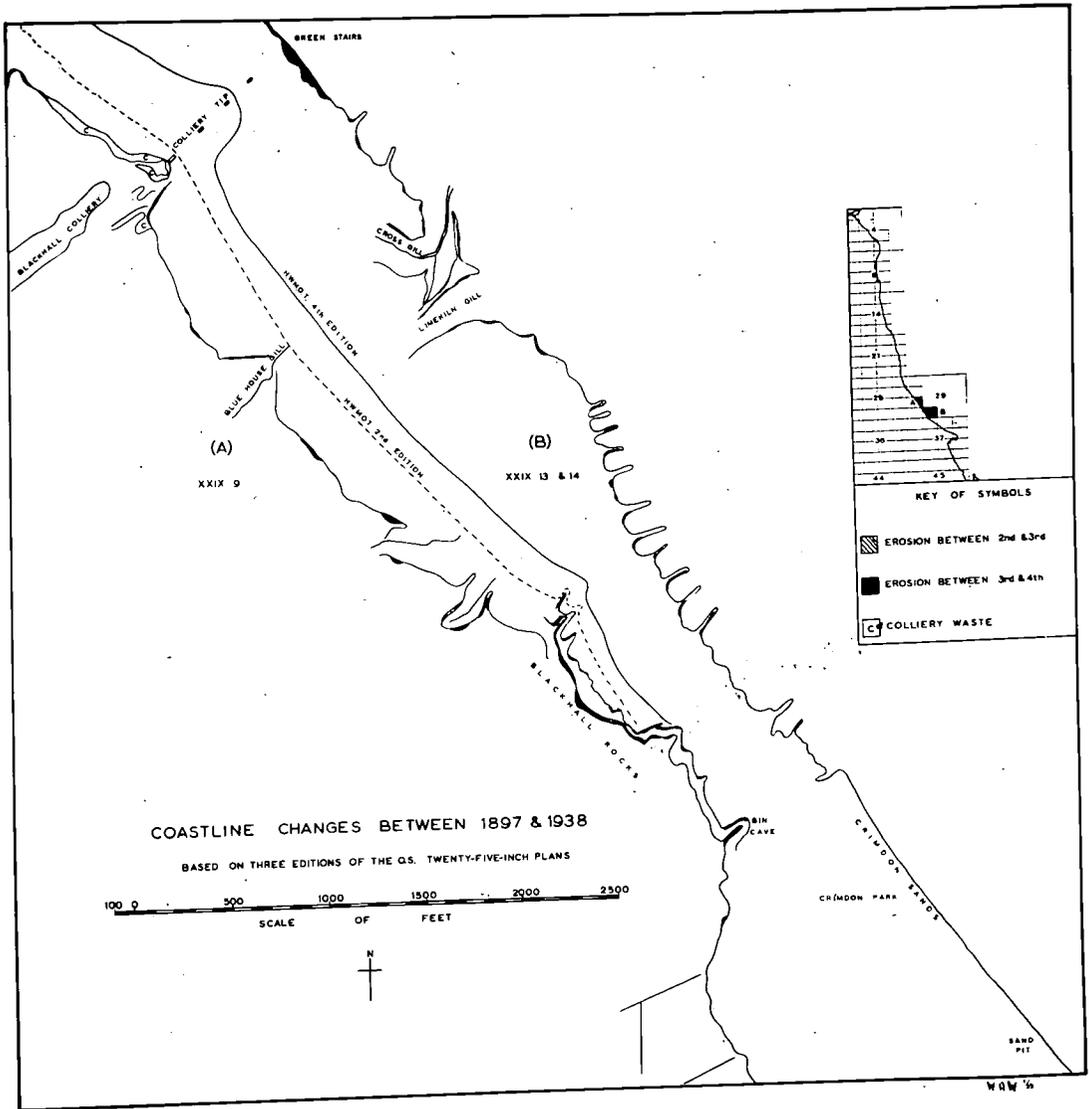


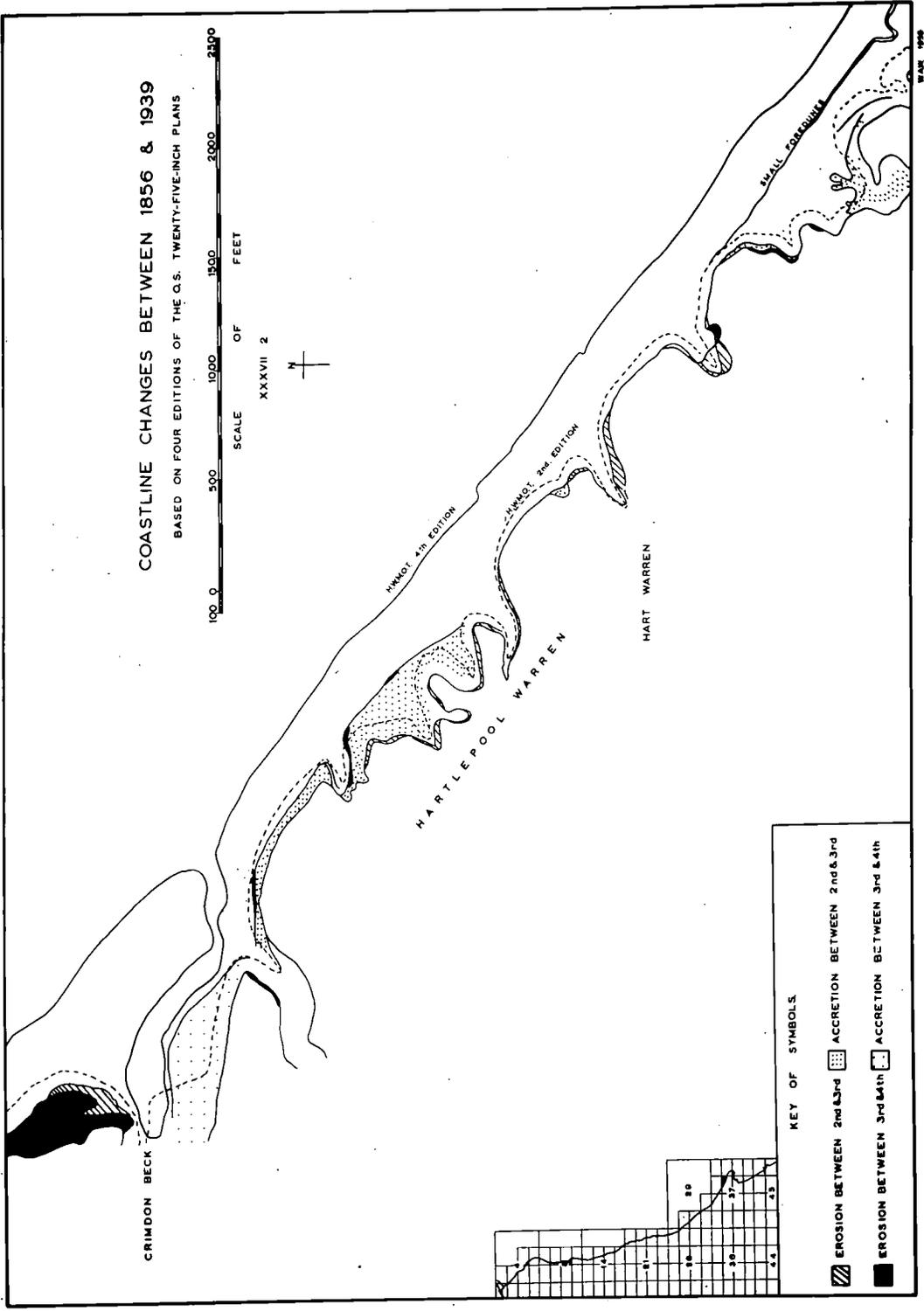


COASTLINE CHANGES BETWEEN 1856 & 1939.

BASED ON FOUR EDITIONS OF THE U.S. TWENTY-FIVE-INCH PLANS.







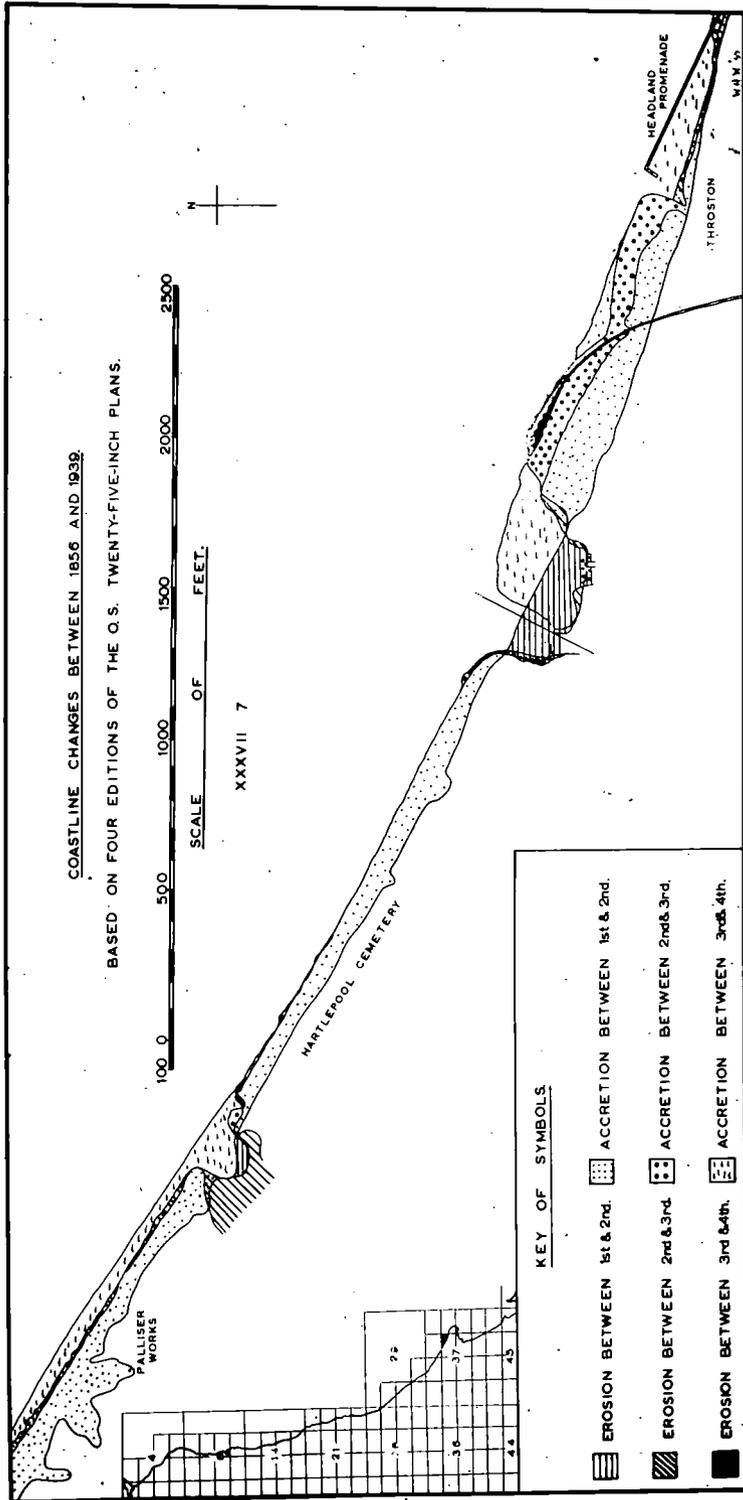




Plate I:

East of Cleadon Hills the coastal plain forms a marked feature of the landscape. There is an absence of surface drainage and bare outcrops of limestone are frequent. The piece of the plain shown is south of Frenchman's Bay, seen in the foreground.



Plate II:

Well bedded Lower Limestone with N-S fracturing forms the base of the cliffs south of Trow Point, and has occasionally been left standing as a stack on the floor of the Tyne Commissioner's Quarry.



Plate III: Spheroidal Concretionary Limestone resulting from the segregation of calcium carbonate.



Plate IV: Water-worn Cellular Limestone produced by the removal of magnesium carbonate.



Plate V: Bedded breccias on the east of the 'Shell Reef' often form the base of headlands. Local fracturing is sometimes well marked and forms lines of weakness.



Plate VI: South of Tunstall Hope the gravels and sands associated with the Tunstall overflow channel form an important part of the sea cliffs. These superficial deposits suffer from atmospheric as well as marine denudation. The large boulders fall when the supporting pebbles are washed away by rain wash, and they tend to accumulate on the top of the boulder clay.



Plate VII: The Easington 'Raised Beach' on the flanks of Beacon Hill has been considered marine by Woolacott, Lamplugh, Merrick and Trechmann, though they disagreed over its age.



Plate VIII: Bare surfaces of boulder clay are readily scoured by running water, and there is little chance of vegetation growing upon slopes which also suffer greatly from wind erosion.



Plate IX: Cliff top recession north of Tunstall Hope is rapid, owing to the lack of cohesion of the superficial deposits which readily fall on to the beach, and to the general shortage of beach material which allows the waves to attack the cliffs strongly.

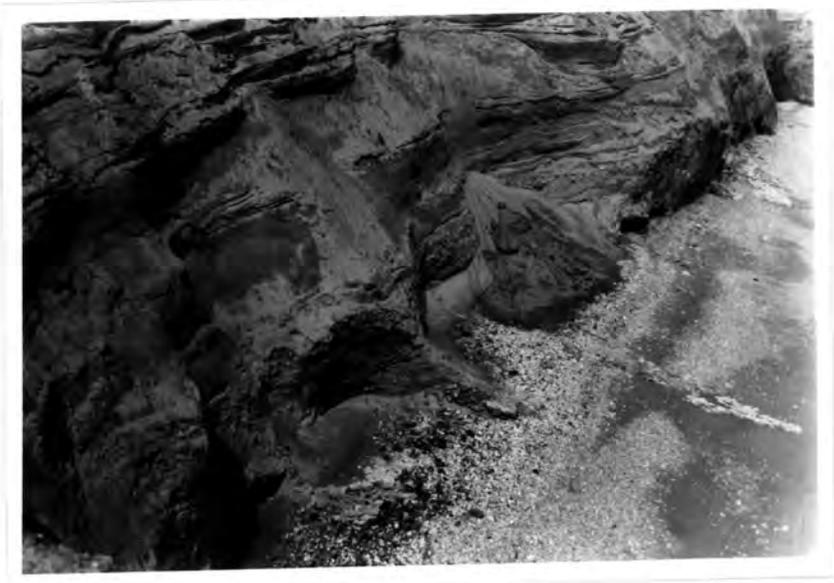


Plate X: Sandy Pleistocene deposits are very susceptible to movement when exposed in the cliff face, and north of Jane Jiveson's Rock almost the whole face is of such deposits. Slumping and wind erosion are quite pronounced, though clayey layers often stand out as more resistant bands.



Plate XI:

The development of the overlying glacial deposits south of Hendon is closely related to the erosion of the limestone 'foundation wall'. Where erosion is rapid, as in this instance, the boulder clay has a steep outer face, but where cliff foot recession is slow the less resistant boulder clay is eroded by atmospheric denuding agents to form a gentle slope, and 'slope over wall' profiles result.



Plate XII: The opening out of fractures by marine denudation is well seen at Trow Point, where the headland is cut by well developed N-S fractures. The fractures are frequently filled by beach shingle and sand.



Plate XIII: Breccias are found along many parts of the Durham coast, and many have been formed by limestone slumping down the seaward side of the 'Shell Reef'. The breccia resistance to denudation depends to a great extent on the character of the intervening unbrecciated fragments.



Plate XIV: Salterfen Point from the south. The resistant yellow bedded limestone is covered by a layer of less resistant boulder clay, which is covered by sandy deposits displaying bedding. Cliff top recession is rapid, and the footpath in the foreground has been partly washed away.



Plate XV: On the north side of Frenchman's Bay the well-bedded Lower Limestone is well developed and passes upwards into irregularly brecciated Middle Limestones.



Plate XVI: Souter Point Beach from the south. The old sea cliffs in front of the Rifle Range are quite secure from wave attack at present, and the beach deposits have become covered with vegetation.



Plate XVII: South of Dawdon Colliery the beach is very artificial, as the amount of beach material has been considerably increased by dumped material. The cliffs are safe from marine denudation and the beach has been completely ruined as an amenity.

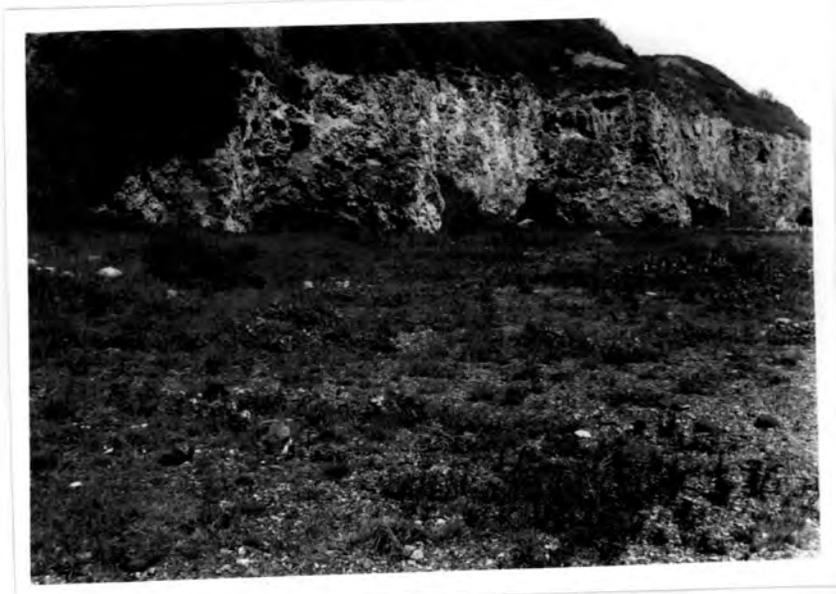


Plate XVIII: The cliffs at the head of Hawthorn Hive are secure from wave attack and the upper beach is covered with vegetation. The greater part of the accumulated beach material is derived from colliery tips.



Plate XIX: The construction of a new sewer outfall at Whitburn has resulted in much shingle and sand accumulating immediately to the north and a comparative shortage of such material to the south. In places the height difference between north and south beaches is about five feet.



Plate XX: The shortage of beach material at Ryhope resulting from the retaining of beach material by the Sunderland Harbour piers and breakwaters has been further aggravated by the daily removal of beach material for building purposes.

Plate XXI:

Field drainage is responsible for this notch cut in the cliffs near Jane Jiveson's Rock. This particular notch extends to beach level, but many smaller ones extend only a short distance into the limestone 'foundation wall'.



Plate XXII:

A stack of Lower Bedded Limestone topped with Middle Unbedded Limestone stands on the floor of the Tyne Commissioners' Quarry. The Lower Limestone is readily broken along its bedding planes, but the fossiliferous Middle Limestone is eroded by the picking out of the softer materials from the unbedded mass.



Plate XXIII: Trow Point from the south. The overlying glacial material has been eroded by rain wash to form a long seaward slope ending in a vertical face of limestone. Fracturing of the limestone has influenced the form of the headland, and a structurally guided break through of the headland is illustrated in the photograph.



Plate XXIV: Unbedded Middle Limestones stand out as bare rock features south of Frenchman's Bay. The coastal plain has a thin covering of boulder clay, but this is removed by rain wash and wind erosion near the cliff edge, and the bare limestone is exposed. The cave in the foreground of the photograph has been eroded in an anticlinal structure.



Plate XXV: North of Velvet Beds the Middle Limestones have been eroded into deep caves, and the roofs have often partially collapsed to form natural archways.



Plate XXVI: The importance of structure in guiding marine denudation cannot be overstressed, and the photograph shows slumped Middle Limestone being eroded along fracture planes to form arches and caves. The effect of the picking out of detail by the waves may be clearly noted.



Plate  
XXVII:

Despite the sheltering effect of Velvet Beds to the north-east, the soft white lime silts forming the cliff foot along much of the northern end of Marsden Bay have been rapidly washed away and the overlying more resistant limestone has been undermined.



Plate  
XXVIII:

Lithological and structural variations in the Marsden Rock area have led to the development of many caves and promontories, and there are many cases of resistant beds jutting out from the cliff profile. Fallen clay has often accumulated on these jutting rocks which later become covered by vegetation.



Plate XXIX:

The vertical cliffs of Concretionary Limestone near Marsden Village have an extremely variable composition. The cliffs are readily broken by waves and falls are almost continuous. There is only a thin covering of boulder clay.



Plate XXX:

Lizard Point has recently been broken through by the sea, and already a large gap has been formed between the stack and the mainland. Erosion has been severe in this area during the past century. In 1871 Souter Point Lighthouse was some 345 yards from the sea cliff, but that distance is now only 267 yards.



Plate XXXI: The bedded limestone cliffs around Potter's Hole are eroded into quite remarkable forms, and the bedding planes are all-important in the fashioning of local details.



Plate XXXII: South of Souter Point the shortage of beach material has allowed the waves to attack the broken Concretionary limestone and erosion has been rapid.



Plate XXXIII: Occasionally the broken Concretionary Limestone rests on an exposure of Bedded Limestone which is more resistant to denudation, and the cliff-line is more stable.



Plate XXXIV: Erosion at Hendon is very rapid, and results largely from wave attack across a poorly developed beach. The presence of fractures in the limestone is an important aid to the waves and many large falls occur from time to time.



Plate XXXV: Falls of limestone are quite commonly noted along the coast south from Sunderland, but the fallen rock is soon removed by the waves.



Plate XXXVI:

Coastal erosion south of Sunderland is so great that cliff top footpaths are frequently removed. The footpath shown in the foreground formerly extended towards the white tin placed in the middle-ground, but three months' erosion was sufficient to cut out the intervening boulder clay.



Plate XXXVII: Seaham Sea Wall has recently been completed, and the sea cliffs have been cut back to a  $45^{\circ}$  slope. Sand has tended to accumulate in front of the wall and this tendency will increase when the groynes are built.

