
OBSERVATIONS

ON THE

TEMPERATURE AND SALINITY OF THE SURFACE WATERS
OF THE NORTH SEA IN 1903,

BY

A. J. ROBERTSON, B.Sc.

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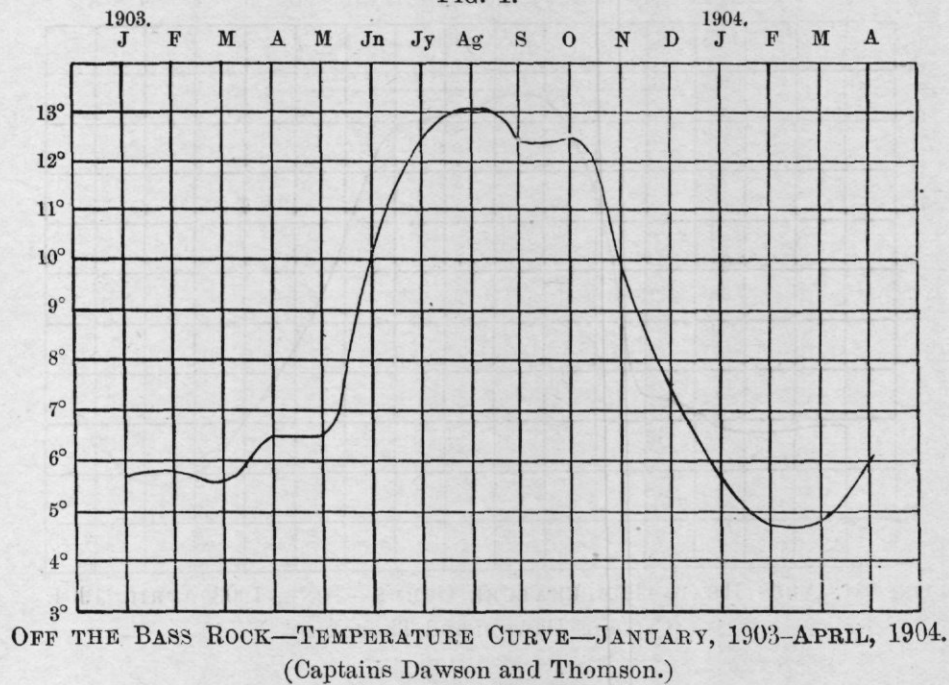
OBSERVATIONS
ON THE
TEMPERATURE AND SALINITY OF THE SURFACE WATERS OF THE
NORTH SEA IN THE YEAR 1903.

BY
A. J. ROBERTSON, B.Sc.

During the past year the captains of numerous passenger ships have co-operated with us by taking regular surface temperature readings, these having been since May, in some cases, supplemented by the collection of surface-water samples. The data thus supplied, taken in conjunction with the results obtained from the quarterly cruises, have proved of great service in interpreting the hydrographical changes occurring from season to season. These surface observations have also been extensively utilised in the construction of the seasonal charts by the International Bureau. There are in all about 20 captains taking part in this work, and the observations are carried on round the coast, along a network of routes across the North Sea, and also north to Shetland and Iceland. The coast work has been undertaken by Captains Collister and McNeill, Leith to Liverpool; Captains Dawson and Thomson, Leith to London; and Captains Cleary and Hetherington, Glasgow to London; while four observations daily have been taken at Abertay, North Carr, and Rattray Head lightships, the observers being Mr. Swadel, Mr. Kirkpatrick, and Mr. MacLeod respectively. On the cross routes good work has been done by Captain Stark, Leith to Copenhagen; Captains Browne and Grierson, Leith to Hamburg; Captains Miller and Sutherland, Leith to Harlingen; Captain Telford, Leith to Rotterdam; Captains Hansen and Oxholm, Newcastle to Bergen; and Captains Jones, Taylor, and Wright, Harwich to Hamburg. The observations taken by Captains Angus and Nisbet, Aberdeen to Shetland, and Captains Da Cunha, Jorgensen, Godtfredsen, and Syrdahl, Leith to Iceland, have proved of special interest, as these are carried on over the area assigned to Scotland in the international scheme of work. Captains Kerr, McDougall, and McTavish, sailing between Glasgow and Ireland, have also taken part in the work.

When this special branch of the work was started, the captains on the cross routes were asked to take only two sets of temperature observations each month, but in future continuous readings will be taken. Since May collections of water samples have been made once a month at short intervals over the more important routes, and this part of the work is being further extended throughout this year.

FIG. 1.



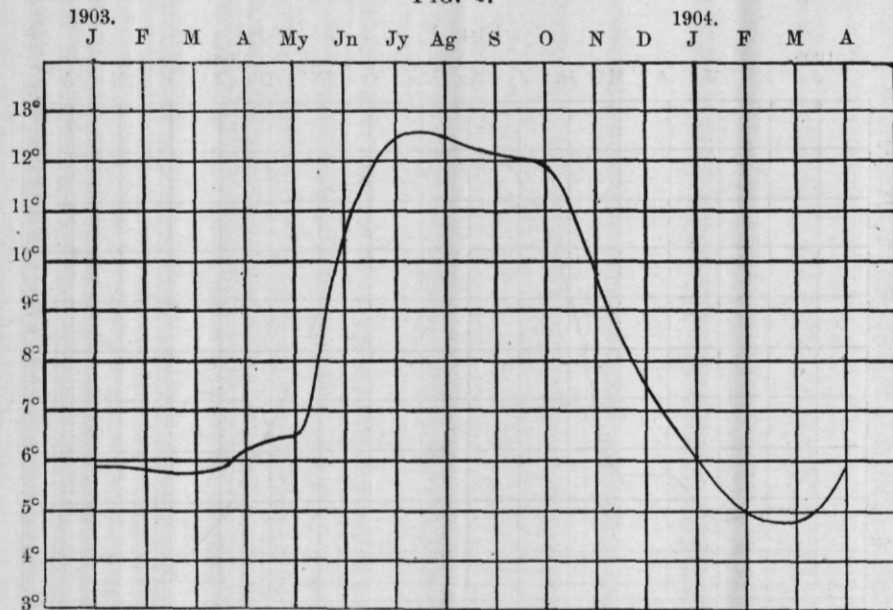
a. Unfortunately, our coast observations for the year are incomplete, especially those from Leith to Liverpool. A complete set of observations has been obtained along the route from Leith to London, and the following Table shows the mean monthly temperatures at various points along the coast. Most of these temperatures are the result of several sets of observations, so that the monthly averages are probably fairly correct :—

TABLE OF EAST COAST SURFACE TEMPERATURES, 1903.

—	Bass Rock.	St. Abbs.	Longstone.	Souter Point.	Flamboro Head.	Cromer.	Orfordness.
January	5·7	5·9	—	5·5	5·7	—	4·7
February	5·8	5·9	6·0	6·3	6·1	5·7	5·5
March	5·55	5·7	5·7	6·2	6·0	5·9	6·6
April	6·5	6·2	6·0	6·1	6·5	7·0	7·5
May... ..	6·5	6·4	6·7	6·95	7·35	8·3	9·3
June	9·65	10·45	9·9	10·55	10·25	11·25	12·4
July	12·45	12·50	11·4	12·1	12·40	14·0	14·65
August	13·00	12·50	11·8	11·9	12·5	15·15	16·5
September	12·45	12·10	—	—	13·0	15·45	17·2
October	12·45	11·95	11·6	11·55	13·25	13·5	15·7
November	9·75	9·75	9·95	9·75	9·85	10·5	11·15
December	7·60	7·60	—	7·3	7·20	6·7	7·0
Mean annual ...	8·95	8·90	—	—	9·15	—	10·68

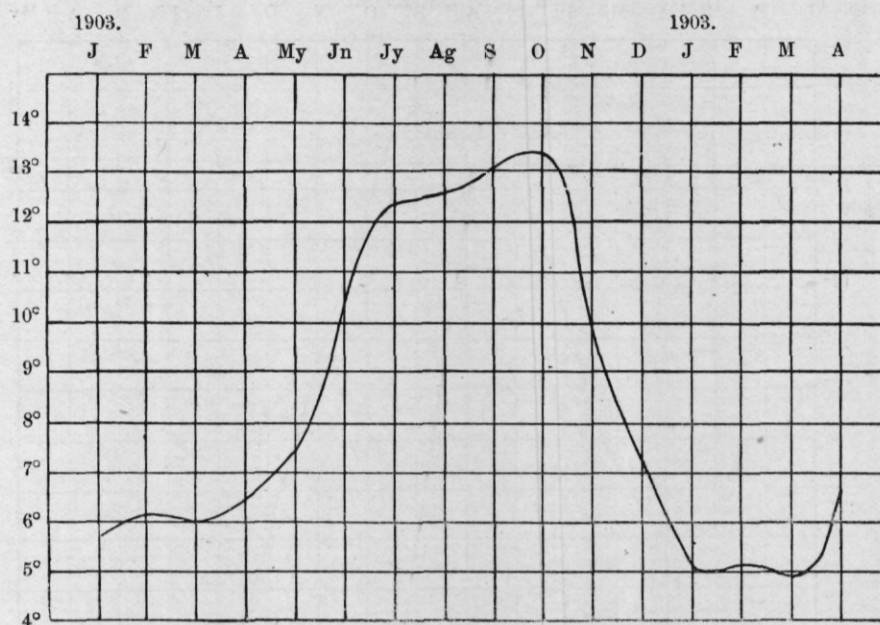
The sudden rise in temperature from May to June is very noticeable all along the coast. The maximum temperature was reached at the more northerly points in August, but not till September at Cromer and Orfordness. Temperature curves have been compiled from these monthly averages.

FIG. 2.



(OFF ST. ABBS HEAD—TEMPERATURE CURVE—JUNE, 1903—APRIL, 1904.
(Captains Dawson and Thomson.)

FIG. 3.



OFF FLAMBOROUGH HEAD—TEMPERATURE CURVE—JANUARY, 1903—APRIL, 1904.
(Captains Dawson and Thomson.)

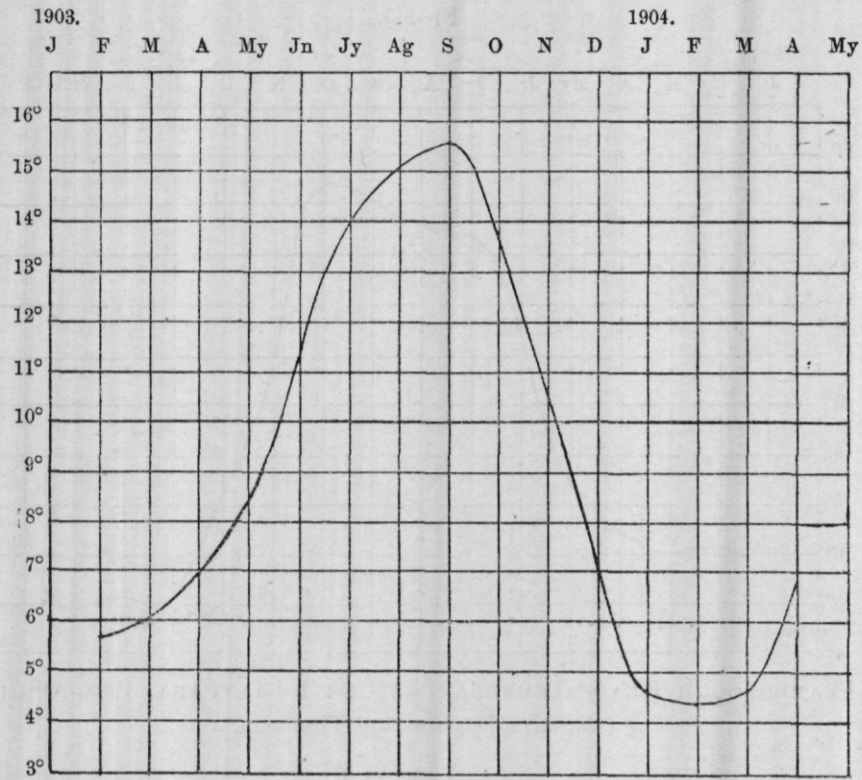
The observations from Leith to Liverpool round the north of Scotland are so incomplete that no Table can be given. On the route from London to Glasgow the work was not begun till March, so that observations for January and February are wanting. Included in the following Table of south coast temperatures are the observations taken at two points on the east coast of Ireland, *i.e.*, Codling light vessel and Tuskar :—

TABLE OF SOUTH COAST TEMPERATURES.

	Codling Light Vessel.	Tuskar.	Land's End.	Lizard.	Eddy-stone.	Start Point.	Isle of Wight.	Beachy Head.	Dun-ness.
March ...	8.1*	8.5**	9.4	9.7**	9.8**	9.4**	8.3**	8.4	—
April ...	7.8**	8.9**	9.5	9.7**	9.8**	9.7**	9.2**	8.8*	8.4*
May ...	8.9	10.1**	11.4**	11.6**	12.2**	11.7**	12.3	12.4	11.0
June ...	11.2*	11.6**	12.2	12.9**	14.0*	12.7	14.3	13.0*	12.5*
July ...	13.0	13.5	14.3*	—	14.9	14.3*	16.0*	—	—
August ...	13.5*	14.8	14.6	13.6	15.7*	14.7	16.4	16.9*	—
September ...	13.7	14.2	14.1*	13.6*	14.6*	15.1	16.0*	15.6*	—
October ...	12.5*	12.1	—	12.9*	—	13.6*	13.1	—	14.0*
November ...	—	12.2*	12.1*	12.9*	11.5*	—	12.0*	11.5*	11.5*
December ...	—	—	—	—	—	—	—	—	—

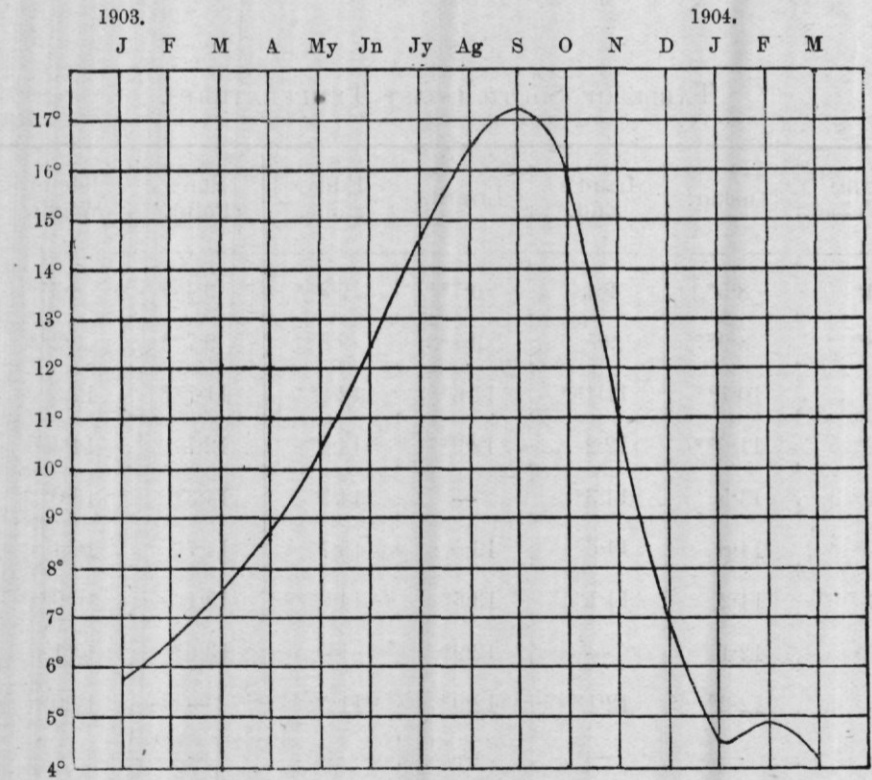
Temperatures marked * from one observation only ; those marked ** from more than three observations.

FIG. 4.



OFF CROMER—TEMPERATURE CURVE—JANUARY, 1903—APRIL, 1904.
(Captains Dawson and Thomson.)

FIG. 5.



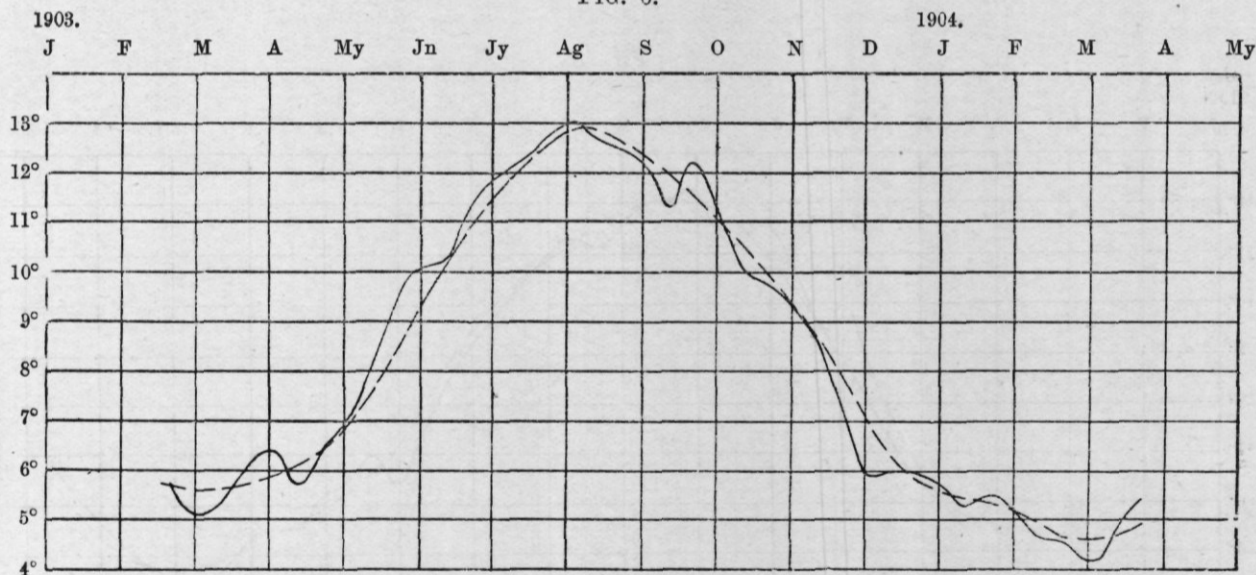
OFF ORFORDNESS—TEMPERATURE CURVE—JANUARY, 1903—APRIL, 1904.
(Captains Dawson and Thomson.)

The tables for Abertay and North Carr Lightships, and from Rattray Head Lighthouse, have been compiled from four observations daily from February to December, 1903* :—

TABLE OF SURFACE TEMPERATURES AT NORTH CARR LIGHTSHIP (56° 18' N., 2° 33' W.), ABERTAY LIGHTSHIP (56° 27' N., 2° 41' W.), and RATTRAY HEAD LIGHTHOUSE (57° 36' N., 1° 48' W.).

—	January.	February.	March.	April.	May.	June.
North Carr ...	— — —	— — —	5·5 5·5 5·7	6·1 5·7 5·1	6·7 7·4 8·9	10·4 10·5 10·6
Abertay ...	— — —	— — 5·8	5·1 5·3 6·05	6·45 5·7 6·4	7·0 8·0 9·2	10·1 10·2 11·3
Rattray Head	— — —	— — —	— 5·2 5·7	5·95 5·5 6·0	6·75 7·6 8·7	10·0 9·45 10·6
	July.	August.	September.	October.	November.	December.
North Carr ...	10·6 10·8 12·7	12·6 12·6 11·9	11·6 11·3 11·9	11·6 10·8 10·2	9·7 9·2 8·1	7·0 6·8 6·7
Abertay ...	11·9 12·05 12·6	13·0 12·7 12·5	12·2 11·3 12·2	11·3 10·1 9·75	9·4 8·6 7·2	5·9 6·0 5·9
Rattray Head	11·55 11·3 11·3	12·25 12·15 12·1	11·7 11·05 11·3	11·0 10·35 9·9	9·15 8·5 7·4	6·35 7·0 6·4

FIG. 6.



ABERTAY LIGHTSHIP—TEMPERATURE CURVE—FEBRUARY, 1903—MARCH, 1904.

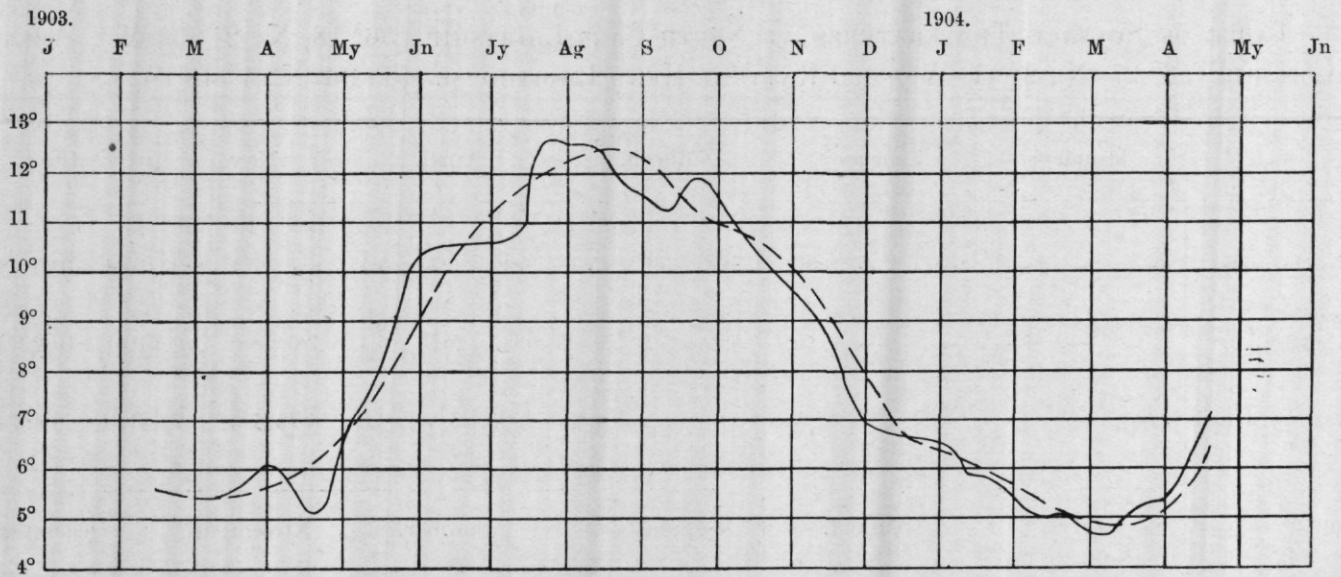
(Whole-line curve compiled from 10 day averages.)

(Broken-line curve compiled from monthly averages.)

(Mr. Swadel.)

* Cf. Dr. H. R. Mill, Ninth Annual Report of the Fishing Board for Scotland, Pt. III., p. 353, 1891.

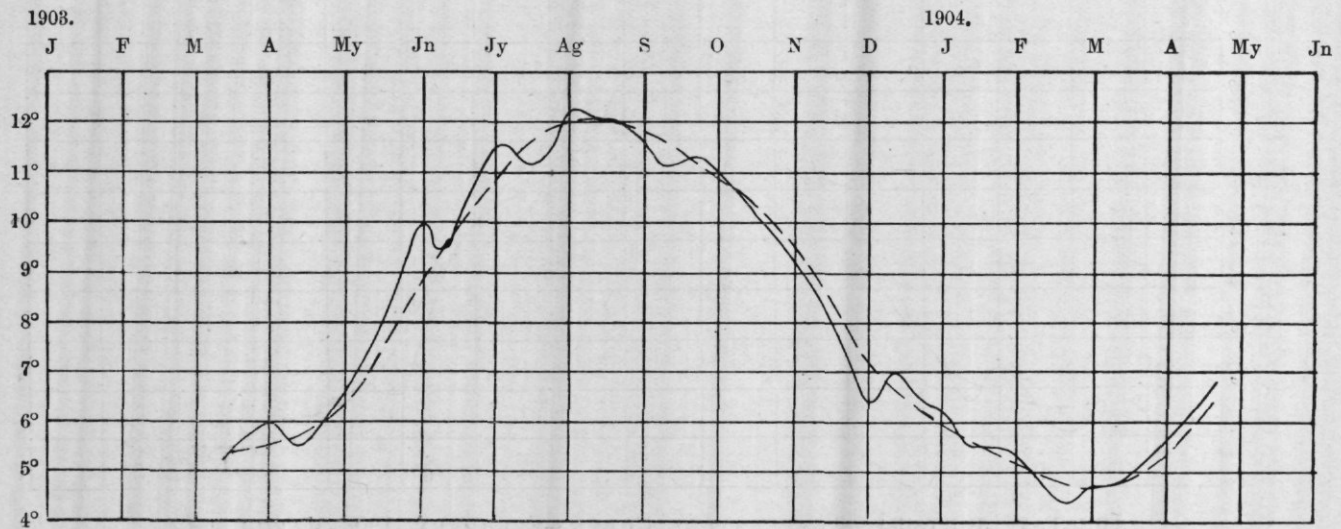
FIG. 7.



NORTH CARR LIGHTSHIP—TEMPERATURE CURVE—MARCH, 1903—APRIL 1904.

(Whole-line curve compiled from 10 day averages.)
 (Broken-line curve compiled from monthly averages.)
 (Mr. Kirkpatrick.)

FIG. 8.



RATTRAY HEAD LIGHTHOUSE—TEMPERATURE CURVE—MARCH, 1903—APRIL, 1904.

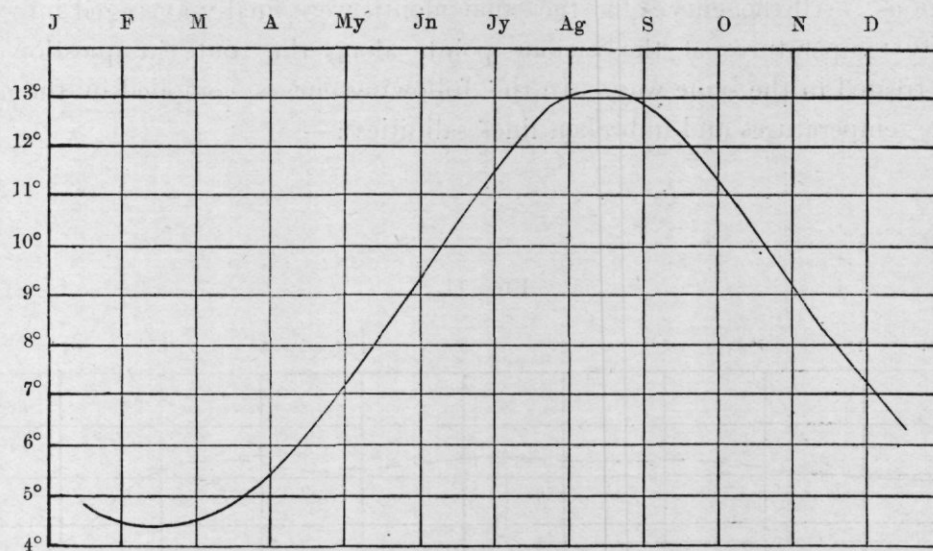
(Whole-line curve compiled from 10 day averages.)
 (Broken-line curve compiled from monthly averages.)
 (Mr. MacLeod.)

In the case of the lightship at Abertay, in the mouth of the estuary of the Tay, we have the advantage of a valuable series of observations taken regularly by Mr. Swadel during 10 out of the last 11 years :—

TABLE* SHOWING SURFACE TEMPERATURES AT ABERTAY, 1893-1903. (Mr. Swadel.)

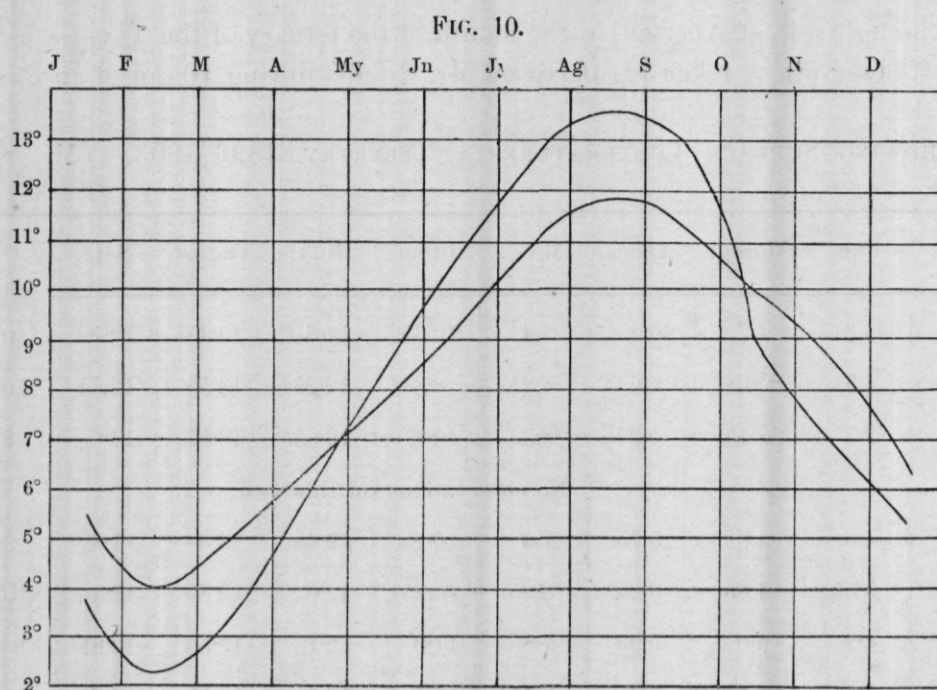
Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
1893	4.3	4.3	4.7	6.4	8.4	10.65	12.6	13.45	12.7	10.55	7.55	6.15
1894	4.65	4.5	5.0	6.6	8.25	9.8	12.25	13.55	12.65	10.55	8.95	7.65
1895	3.8	2.3	3.45	5.9	8.3	10.8	12.65	13.55	13.0	9.1	7.05	5.25
1896	No observations for this year.											
1897	4.15	4.0	4.8	5.75	7.5	10.25	12.65	13.3	11.3	9.45	8.85	5.85
1898	6.0	5.05	4.85	6.25	8.25	10.25	12.0	12.85	12.4	10.3	8.15	6.7
1899	4.6	4.2	5.0	5.95	7.85	11.0	12.7	13.55	12.65	10.2	8.45	6.3
1900	5.05	3.85	4.5	6.3	8.15	10.6	12.55	12.75	12.2	10.0	8.1	7.15
1901	5.9	4.3	4.85	5.9	9.15	10.75	13.5	13.55	12.85	10.85	8.35	6.1
1902	5.4	4.1	5.2	6.5	7.7	9.4	11.2	11.9	11.4	10.0	8.85	6.35
1903	—	5.85	5.75	6.2	8.3	10.6	12.3	12.75	11.9	10.2	8.45	5.95
Mean annual	4.87	4.24	4.81	6.17	8.16	10.41	12.44	13.12	12.30	10.12	8.22	6.34

FIG. 9.



ABERTAY LIGHTSHIP—TEMPERATURE CURVE—1893-1903.
(Compiled from monthly averages.)

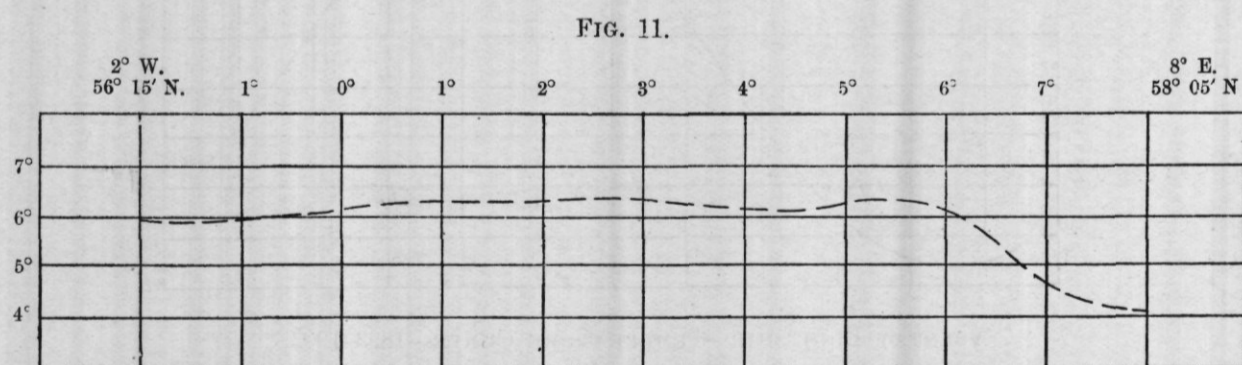
* Compiled from two observations daily.



ABERTAY LIGHTSHIP—TEMPERATURE CURVES—1895 and 1902.

(Compiled from monthly averages.)

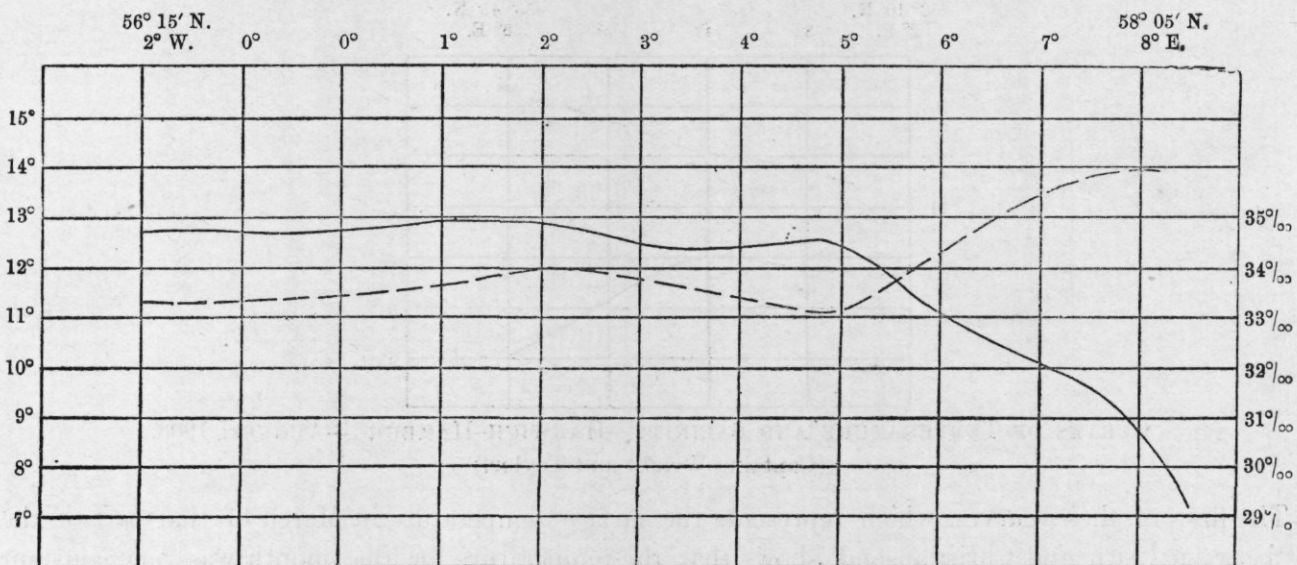
b. Cross-route Work.—Surface temperature observations have been taken throughout the whole year and surface water samples have been collected since May along the principal routes over the North Sea. In the working up of these results it has been found convenient to consider that the courses followed from month to month lie along straight lines connecting the ports of departure and arrival. As a rule they vary only very slightly from these lines. For each route the degrees of longitude were plotted horizontally at equal distances apart across a sheet of millimetre paper and a temperature curve was then drawn for each set of observations. All the curves for the same month were finally averaged into one, from which the average monthly temperatures at the various points along the route in question were got. The salinities have been treated in the same way. In the following curves, compiled in the manner described, broken lines indicate temperatures and unbroken lines salinities :—



CURVE OF SURFACE TEMPERATURE ALONG THE ROUTE LEITH—CHRISTIANSAND—MARCH, 1903.

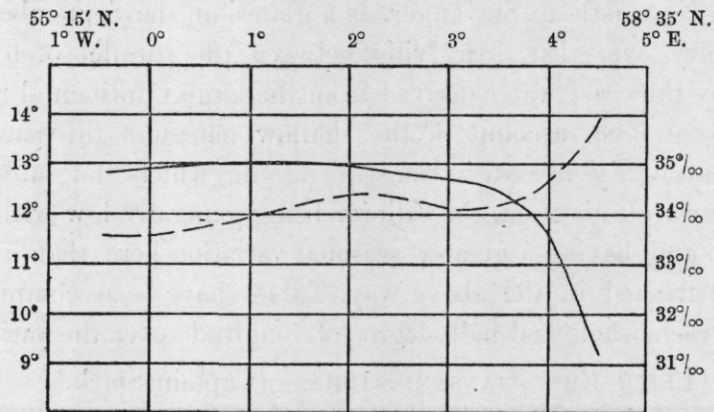
(Captain Stark.)

FIG. 12.



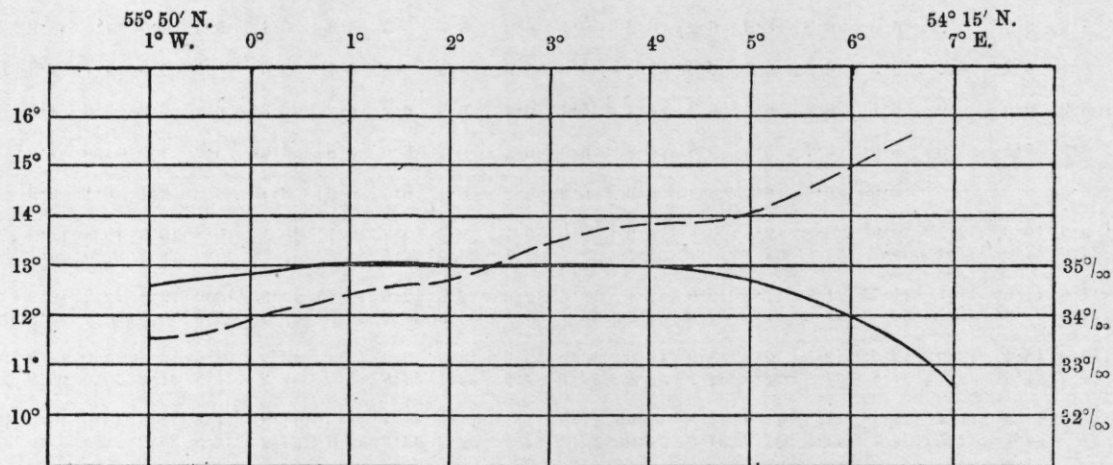
CURVES OF TEMPERATURE AND SALINITY—LEITH-CHRISTIANSAND—SEPTEMBER, 1903.
(Captain Stark.)
(Broken line indicates Temperature ; unbroken line Salinity.)

FIG. 13.

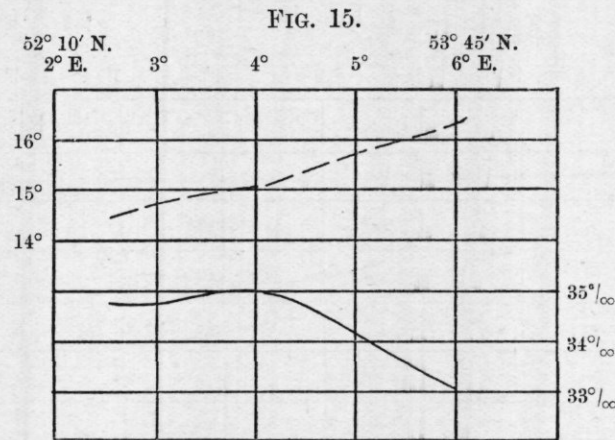


CURVES OF TEMPERATURE AND SALINITY—NEWCASTLE-STAVANGER—SEPTEMBER, 1903.
(Captain Oxholm.)

FIG. 14.



CURVES OF TEMPERATURE AND SALINITY—LEITH-HAMBURG—JULY, 1903.
(Captains Browne and Grierson.)



CURVES OF TEMPERATURE AND SALINITY—HARWICH—HAMBURG—AUGUST, 1903.
(Captains Wright and Taylor.)

The first of these curves, which represents the surface temperature in March of that part of the sea lying between Leith and Christiansand, shows that the temperature for that month was very constant till near the Norwegian coast, where the freshwater outflow from the Baltic, which at this season is colder than the North Sea into which it flows, caused a marked lowering of the temperature to 4° C. In September the Baltic stream made its presence felt at 5° East longitude on this route, a sudden rise in temperature and fall in salinity taking place at this point. The same characteristics were, in general, shown along the route from Newcastle to Stavanger, as a glance at the September curve at once indicates. The temperature and salinity over that area lying between the parallel of 6° East and the European coast are much influenced by the coast water derived from the large Continental rivers which flow into the sea along this part of the coast. On account of the shallow nature of this part of the sea the different kinds of water become thoroughly mixed, in consequence of which the salinity and temperature are remarkably constant from surface to bottom, the salinity being generally low with the temperature high in summer and low in winter, and having a greater seasonal variation here than in the centre of the North Sea. From the curves constructed in the above way, Tables have been compiled showing the monthly temperature and salinity at each whole and half degree of longitude over the various routes:—

LEITH—CHRISTIANSAND, 1903. (Captain Stark.)

N.	56° 15'																		58° 05'	N.		
	2°		1°		0°		1°		2°		3°		4°		5°		6°				7°	
January ...	5.7	5.9	6.0	5.9	6.0	6.3	6.3	6.25	6.2	6.1	6.0	5.7	5.3	5.3	5.4	5.3	5.0	4.5	3.9	3.5	3.4	
February	6.0	6.1	6.2	6.2	6.2	6.2	6.1	6.0	5.8	5.8	5.9	5.9	5.8	5.7	5.6	5.5	5.3	4.7	4.3	4.1	4.0	
March ...	6.0	5.9	6.0	6.0	6.1	6.2	6.3	6.3	6.4	6.4	6.4	6.3	6.2	6.2	6.3	6.4	6.2	5.6	4.8	4.3	4.1	
April ...	5.7	5.5	5.5	5.5	5.6	5.7	5.8	5.8	5.8	6.0	6.2	6.1	6.0	5.8	5.6	5.2	4.9	4.6	4.3	4.3	4.3	
May ...	6.6	6.5	6.5	6.5	6.6	6.6	6.55	6.4	6.3	6.2	6.2	6.4	6.5	6.5	6.4	6.2	6.1	6.1	6.3	6.5	6.7	
June ...	9.8	9.9	10.0	9.9	9.9	9.8	9.8	9.9	9.9	9.9	9.7	9.7	9.8	10.1	10.5	10.8	10.9	10.8	11.0	—	—	
	34.0	34.0	34.0	34.3	34.7	34.95	35.1	35.1	35.1	35.1	35.1	34.9	34.5	33.5	31.7	30.0	28.5	27.0	25.7	—	—	
July ...	11.6	11.6	11.6	11.7	11.75	11.7	11.8	12.0	12.4	12.6	12.65	12.5	12.6	12.75	12.95	13.0	12.8	12.2	10.9	9.8	—	
	34.4	34.5	34.65	34.75	34.8	34.8	34.8	34.9	35.1	35.1	35.1	35.0	34.2	32.9	31.8	30.8	30.0	30.2	31.1	32.6	—	
August ...	12.8	13.0	13.1	13.0	12.7	12.5	12.9	13.9	14.0	13.9	13.6	13.3	13.2	13.4	13.5	13.6	13.8	14.0	14.2	14.1	13.9	
	34.3	34.5	34.6	34.7	34.8	34.8	34.8	34.9	34.8	34.7	34.5	34.1	33.6	33.0	32.2	31.8	31.2	30.5	29.9	30.0	30.7	
September	11.2	11.2	11.3	11.4	11.4	11.5	11.6	11.8	11.95	11.9	11.7	11.6	11.4	11.3	11.2	11.6	12.3	13.0	13.5	13.9	14.0	
	34.7	34.7	34.7	34.7	34.7	34.8	34.9	34.9	34.9	34.7	34.5	34.4	34.5	34.6	34.4	33.8	33.0	32.5	32.0	31.7	30.8	
October ...	10.1	10.1	10.0	10.1	10.1	10.1	10.0	9.9	9.8	9.8	9.8	9.8	9.8	9.4	8.8	8.5	9.3	10.2	10.2	10.2	10.0	
	34.6	34.6	34.7	34.9	35.0	35.0	35.0	35.0	34.9	34.8	34.7	34.6	34.5	34.5	34.5	34.0	31.0	28.9	28.0	27.5	25.5	
November	9.5	10.0	10.3	10.5	10.5	10.3	10.0	9.7	9.5	9.5	9.5	9.5	9.5	9.5	9.4	9.4	9.5	9.9	10.2	10.1	9.9	
	33.0	34.0	34.7	35.0	35.1	35.1	35.1	35.0	35.0	35.0	35.0	34.9	34.7	34.3	33.1	30.0	30.1	32.0	33.9	33.5	32.0	
December	7.6	7.7	7.8	7.8	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.6	7.5	7.6	7.5	7.4	7.0	6.8	6.8	—	—	
	34.5	34.7	34.9	34.9	34.95	34.95	35.1	35.1	35.0	35.0	35.0	34.9	34.8	34.9	34.8	34.6	34.0	33.0	31.5	—	—	

LEITH-HAMBURG, 1903. (Captains Browne and Grierson.)

	N. 55° 50'																54° 15'	N.
	W. 1°		0°		1°		2°		3°		4°		5°		6°			
January ...	6.8	6.8	6.8	6.8	6.7	6.4	6.0	5.7	5.4	5.1	5.1	5.2	5.2	5.1	4.8	4.4	3.8	
February ...	6.3	6.5	6.5	6.4	6.4	6.3	6.3	6.2	5.9	5.5	5.2	5.1	5.0	5.0	4.9	4.5	3.8	
March ...	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.1	5.8	5.6	5.5	5.6	5.8	5.9	5.8	
April ...	5.8	5.9	6.0	6.1	6.0	6.0	6.0	6.0	6.1	6.15	6.1	6.0	5.9	6.2	6.4	6.4	6.3	
May ...	6.9	7.0	6.9	6.9	6.9	6.9	6.9	7.0	7.1	7.3	7.4	7.4	7.4	7.5	8.1	8.6	8.4	
June ...	10.2	10.2	10.4	10.7	10.8	10.9	11.0	11.1	11.2	11.2	11.4	11.7	12.2	12.4	12.5	12.6	12.7	
	34.7	34.7	34.7	34.8	34.9	35.0	35.1	35.1	35.1	35.0	34.9	34.8	34.6	34.2	33.6	33.0	32.0	
July ...	11.5	11.6	11.9	12.1	12.4	12.6	12.7	13.1	13.4	13.7	13.8	13.9	14.0	14.5	15.0	15.5	—	
	34.4	34.6	34.8	34.9	35.0	35.0	35.0	35.0	35.0	35.0	35.0	34.9	34.7	34.4	34.0	33.4	32.5	
August ...	12.2	12.3	12.5	12.6	12.7	12.7	12.6	12.8	13.3	13.7	13.7	13.6	13.8	14.3	15.0	15.7	15.8	
	34.7	34.7	34.7	34.75	34.8	34.8	34.85	34.9	35.0	35.0	35.0	34.8	34.7	34.7	34.8	34.8	34.3	
September	11.7	11.8	11.9	12.1	12.3	12.3	12.2	12.3	12.9	13.2	13.5	14.2	14.5	14.8	15.0	15.4	15.5	
	—	—	34.7	34.7	34.7	34.7	34.7	34.7	34.8	34.8	34.8	34.8	34.8	34.8	34.7	34.7	34.1	
October ...	11.0	10.8	10.8	11.0	11.4	11.9	12.4	12.6	12.8	12.9	13.2	13.6	14.0	14.3	14.4	14.5	14.5	
	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.9	34.9	34.7	34.6	34.5	34.4	34.2	34.2	
November	9.9	9.6	9.4	9.5	9.8	9.9	9.7	9.5	10.0	10.5	10.9	11.2	11.4	11.5	11.5	11.5	11.4	
	34.8	34.8	34.85	34.9	34.9	34.9	34.9	34.8	34.8	34.8	34.8	34.8	34.8	34.7	34.7	34.6	34.6	
December...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

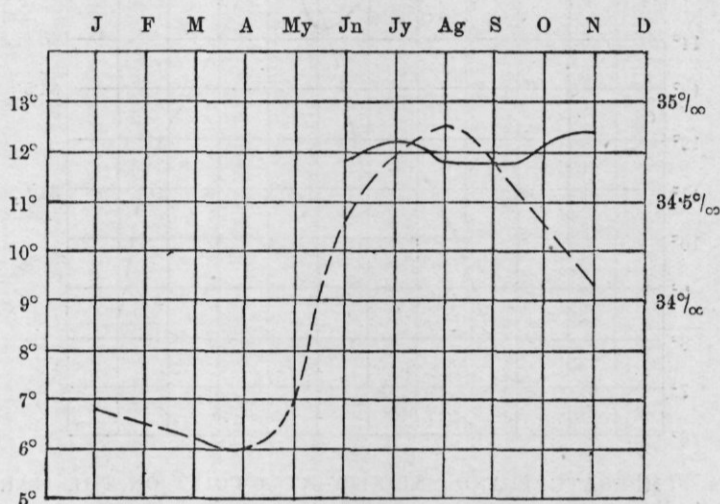
LEITH-ICELAND, 1903.

(From North of Orkney to Faeroe.) (Captains Godtfredsen, Da Cunha, Syrdahl, and Jørgensen.)

	W. 2°														8°	W.
	N. 59° 25'		3°		4°		5°		6°		7°		8°			
May ...	—	—	7.0	7.3	8.0	8.3	8.1	7.7	7.5	7.5	7.7	7.8	7.9			
June ...	—	9.4	9.5	9.7	9.8	9.7	9.0	8.1	8.5	8.7	8.2	7.7	7.7			
	—	35.1	35.2	35.4	35.4	35.4	35.35	35.3	35.3	35.3	35.25	35.2	35.2			
July ...	9.9	10.7	10.7	10.9	10.7	10.5	10.6	10.8	10.7	10.5	10.0	9.9	10.1			
	35.0	34.9	35.0	35.3	35.3	35.3	35.3	35.3	35.3	35.25	35.2	35.15	35.1			
August ...	—	—	11.0	11.2	11.3	11.2	10.9	10.9	11.0	10.8	10.7	10.7	10.6			
	—	—	35.1	35.2	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3			
September ...	11.3	11.3	11.3	11.3	11.1	10.7	10.2	9.5	9.5	9.5	9.5	9.5	9.5			
	35.0	35.2	35.2	35.1	35.1	35.15	35.25	35.25	35.25	35.25	35.3	35.3	35.25			
October ...	—	—	—	—	10.5	10.3	10.5	8.8	8.8	8.8	8.8	8.8	8.8			
	—	—	—	—	35.3	35.3	35.25	35.3	35.3	35.3	35.3	35.3	35.25			
November ...	—	—	—	—	10.0	10.0	9.6	8.2	8.0	8.0	8.1	8.4	8.7			
	—	—	—	—	38.1	35.2	35.35	35.3	35.2	35.2	35.2	35.25	35.3			

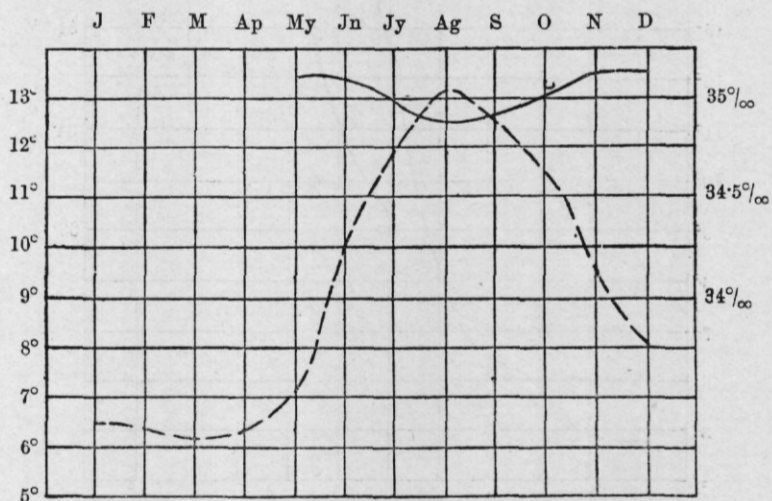
From the observations contained in these Tables curves may be drawn showing the monthly variation in temperature and salinity at any particular point along these routes. To illustrate this the following curves have been drawn :—

FIG. 16.



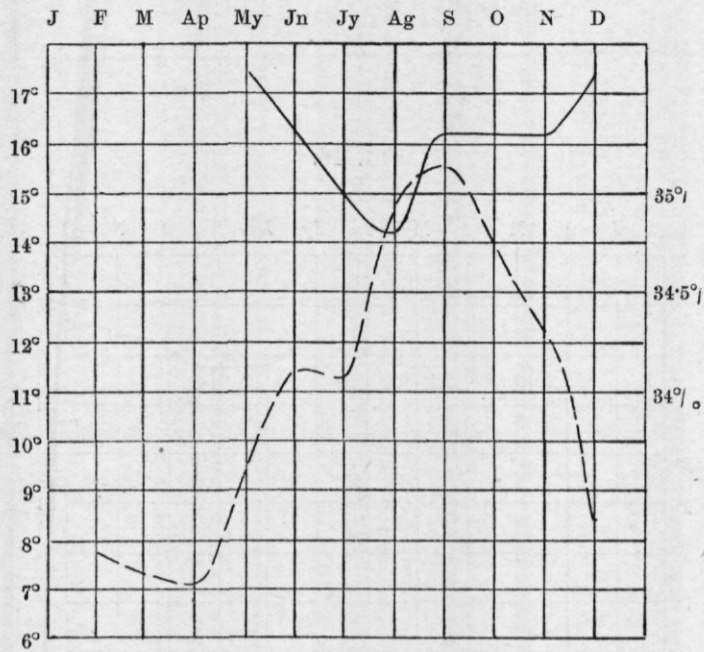
ANNUAL VARIATION IN TEMPERATURE AND SALINITY AT A POINT ON THE LEITH-HAMBURG ROUTE
(55° 40' N. Lat., 0° E. Long.)
(Captains Browne and Grierson.)

FIG. 17.



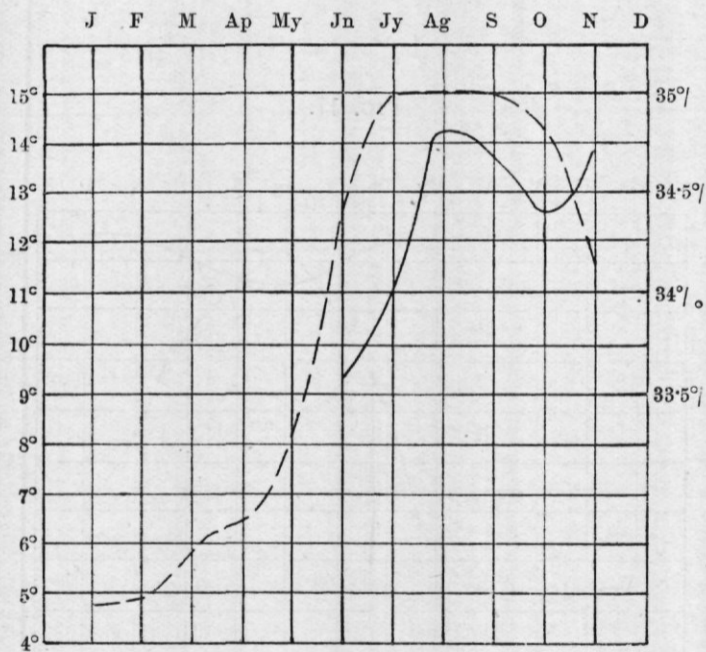
ANNUAL VARIATION IN TEMPERATURE AND SALINITY AT A POINT ON THE NEWCASTLE-STAVANGER ROUTE
(57° 15' N. Lat., 2° E. Long.).

FIG. 18.



ANNUAL VARIATION IN TEMPERATURE AND SALINITY AT A POINT ON THE HARWICH-HAMBURG ROUTE
(52° 40' N. Lat., 3° E. Long.).
(Captains Wright, Taylor, and Jones.)

FIG. 19.



ANNUAL VARIATION IN TEMPERATURE AND SALINITY AT A POINT ON THE LEITH-HAMBURG ROUTE
(54° 25' N. Lat., 6° E. Long.).
(Captains Browne and Grierson.)

From the Tables given above, the mean annual temperatures, and mean monthly salinities since May, can be found.

NEWCASTLE-STAVANGER, 1903.

—	1° W.	0°.	1° E.	2° E.	3° E.	4° E.
Mean annual temperature	8.85	9.03	9.08	9.11	9.06	9.09
Mean monthly salinity (Since May.)	34.65	34.88	35.00	35.00	34.75	33.1

LEITH-CHRISTIANSAND, 1903.

—	2° W.	1° W.	0°.	1° E.	2° E.	3° E.	4° E.	5° E.
Mean annual temperature ...	8.55	8.69	8.73	8.75	8.82	8.78	8.72	8.60
Mean monthly salinity ... (Since May.)	34.2	34.6	34.87	34.7	34.97	34.85	34.4	33.2

LEITH-HAMBURG, 1903.

—	1° W.	0°.	1° E.	2° E.	3° E.	4° E.	5° E.	6° E.
Mean annual temperature ...	8.85	8.9	9.15	9.18	9.35	9.5	9.75	10.15
Mean monthly salinity ... (Since May.)	34.68	34.77	34.88	34.91	34.91	34.91	34.7	34.36

HARWICH-HAMBURG, 1903.

—	3° E.	4° E.	5° E.	6° E.
Mean annual temperature	10.6	10.4	10.4	10.3
Mean monthly salinity (Since May.)	35.26	35.15	34.1	34.1

The surface salinity over the two most northerly of these routes seldom rises above 35 per mille, the maximum mean annual salinity being in both cases found between the parallels of 1° and 2° East longitude, this area evidently marking the downward flow of Atlantic water into the North Sea. The point 3° East on the Harwich-Hamburg route is evidently situated in the centre of the influx of warm salt Atlantic water through the English Channel, as is shown by the high mean temperature and salinity.

The salinity and temperature observations from Leith to Shetland are rather incomplete, and it is only possible to indicate the monthly temperatures and salinities for part of the year at a few points along this route.

TEMPERATURES AND SALINITIES FROM LEITH TO SHETLAND, 1903.

	6 miles E. of Inch Keith.		3 miles N.W. of Bell Rock.		6-10 miles N.E. of Kinnaird Head.		20-40 miles S. of Copinsha.		Auskerry.		8-12 miles S.W. of Sumburgh Head.	
	Temperature.	S.‰	Temperature.	S.‰	Temperature.	S.‰	Temperature.	S.‰	Temperature.	S.‰	Temperature.	S.‰
January	—	—	—	—	—	—	—	—	—	—	—	—
February	—	—	—	—	—	—	—	—	—	—	—	—
March	5.4	—	5.4	—	5.8	—	6.2	—	7.2	—	7.3	—
April	5.2	—	5.8	—	6.2	—	6.9	—	7.3	—	7.4	—
May	6.8	33.6	6.8	34.3	6.6	34.6	7.1	34.9	7.4	34.8	7.7	35.3
June	11.7	33.7	11.5	32.9	8.4	34.6	9.1	35.0	8.6	34.9	8.5	35.4
July	11.4	33.8	11.3	34.0	10.0	34.9	9.8	34.9	9.5	35.3	9.5	35.2
August	12.4	33.8	12.3	33.8	11.9	34.5	11.5	34.9	10.7	34.9	11.3	35.3
September	11.4	34.0	11.1	34.3	10.6	34.8	11.3	34.9	10.5	34.9	10.3	35.3
October	—	—	—	—	—	—	—	—	—	—	—	—
November	—	—	—	—	—	—	—	—	—	—	—	—
December	—	—	—	—	—	—	—	—	—	—	—	—

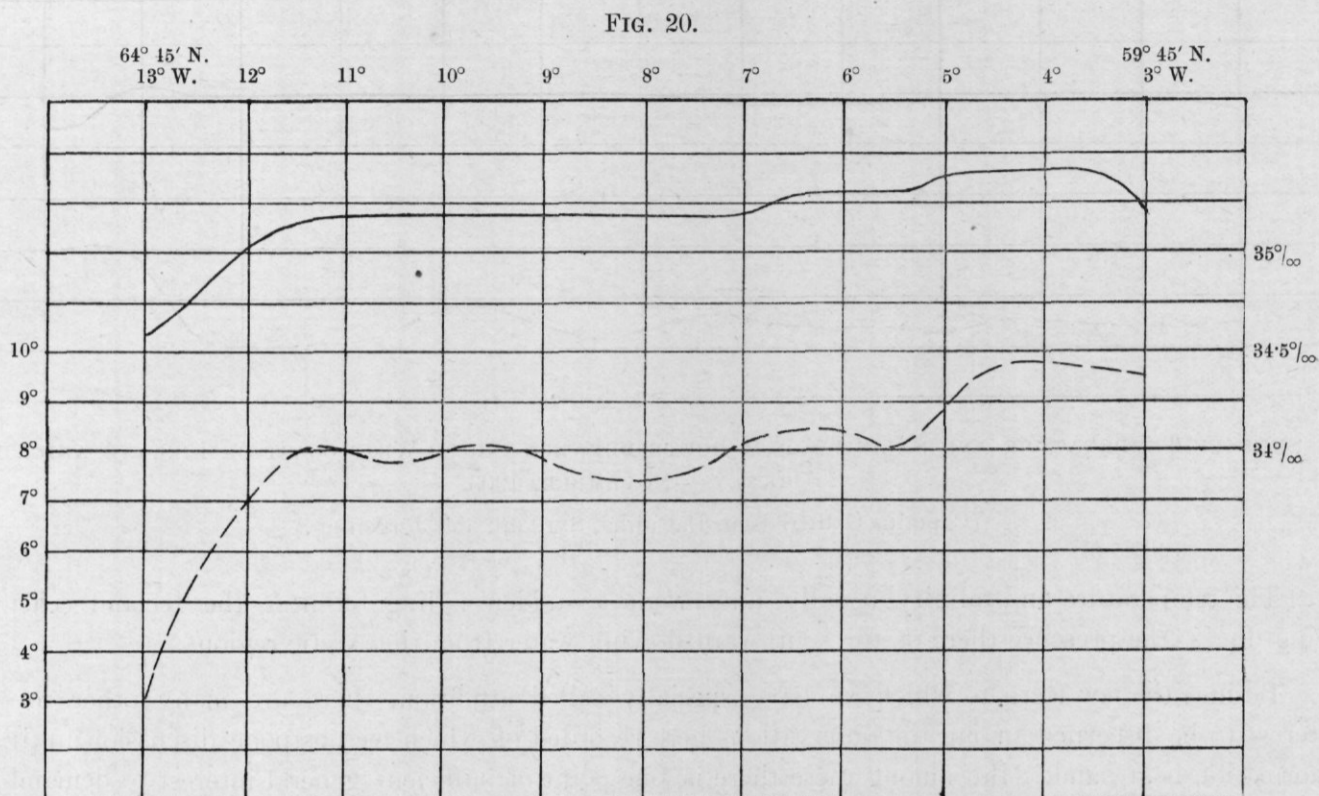
The mean monthly salinity along this route gradually increases from Inch Keith to Auskerry, the averages from May to September being :—

Inch Keith.	Bell Rock.	Kinnaird Head.	Copinsha.	Auskerry.
33.78 ‰	33.86 ‰	34.66 ‰	34.92 ‰	34.96 ‰

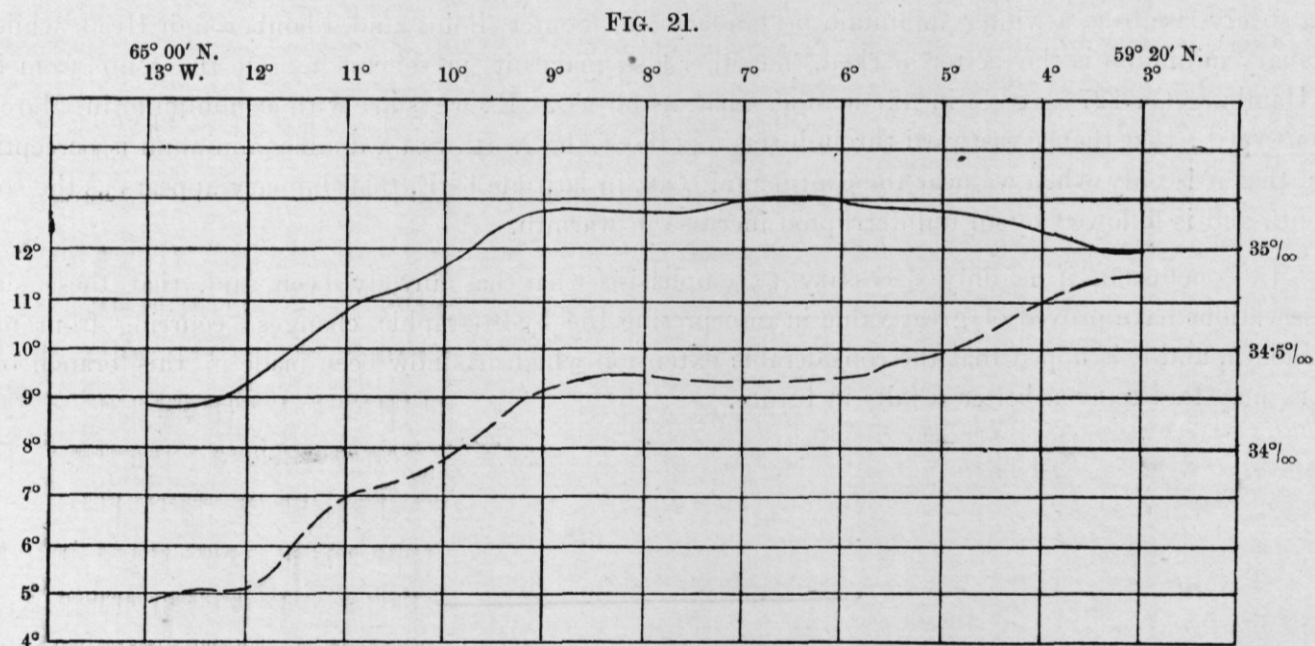
The average monthly salinity for the same period at Sumburgh Head is 35.3 ‰, showing that it is completely washed by Atlantic water. The temperature at Sumburgh Head has, moreover, a small monthly variation, that from March to August being only 3°·7 C., as compared with 6°·1 C. off Kinnaird Head.

The Leith to Iceland observations cannot be compiled in the form of a Table, because of the fact that the route followed by these boats varies from month to month over that part of the voyage beyond the Faeroes, some of them making for the south-east and others for the south-west coast of Iceland. During the first part of the voyage the same route is nearly always adhered to, *i.e.*, north beyond the Orkneys, and then north-west along the south of the Faeroe-Shetland Channel as far as the Faeroes.

A Table showing the temperature and salinity observations over this part of the course has already been given; a few curves illustrating the remarkable constancy of surface salinity in that part of the sea lying between Orkneys and Iceland will now be shown:—

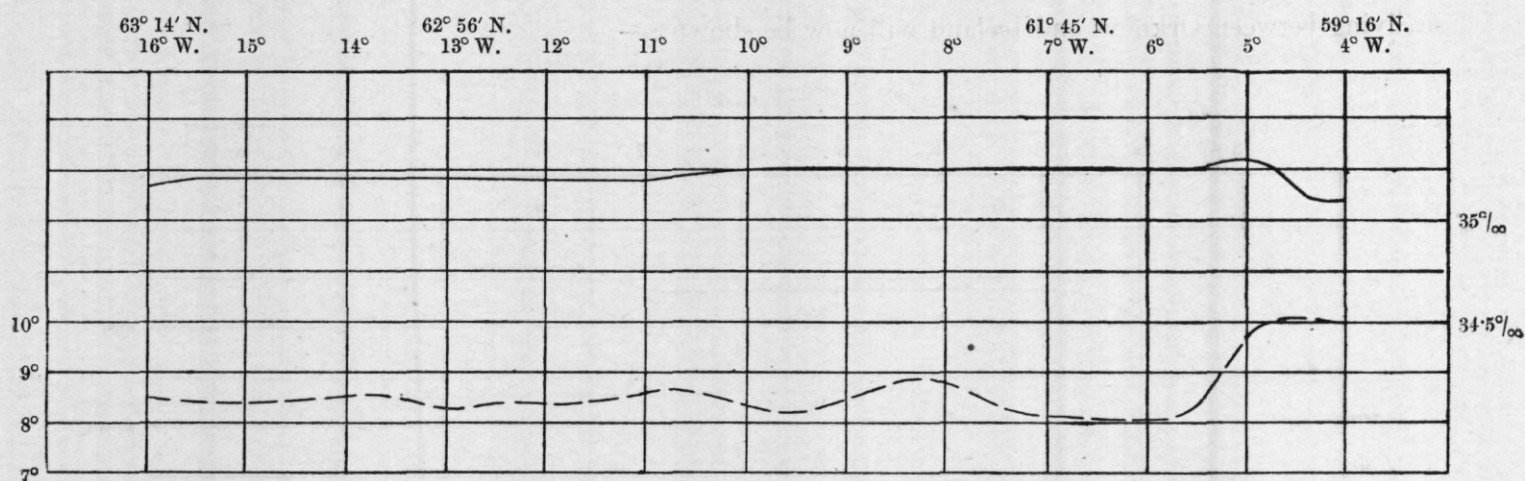


SURFACE TEMPERATURE AND SALINITY ON A ROUTE BETWEEN THE SOUTH-EAST COAST OF ICELAND AND THE ORKNEYS—JUNE, 1903.
(Captains Godtfredsen, DaCunha, Syrdahl, and Jörgensen.)



SURFACE TEMPERATURE AND SALINITY ON A ROUTE BETWEEN SOUTH-EAST COAST OF ICELAND AND THE ORKNEYS—SEPTEMBER, 1903
(Captains Godtfredsen, DaCunha, Syrdahl, and Jörgensen.)

FIG. 22.



SURFACE TEMPERATURE AND SALINITY ON A ROUTE BETWEEN SOUTH-WEST COAST OF ICELAND AND THE ORKNEYS—NOVEMBER, 1903.

(Captains Godtfredsen, DaCunha, Syrdahl, and Jörgensen.)

The temperature and salinity usually underwent a sudden falling off near the Iceland coast, this being due to the presence there of the southward-flowing water from the Arctic regions.

Besides the few facts to which we have specially called attention, there are many others of great interest to be discerned among the observations here recorded of which we postpone discussion until more information is at hand. But among these there is one point of sufficient general interest to demand brief notice meanwhile. This point is the remarkable difference between different parts of the North Sea in regard to the time of the *winter minimum*, or date at which the surface water is the coldest. It will be observed from the Table of East Coast Temperatures on page 117 that at the Bass Rock and St. Abbs' Head the minimum temperature is reached so late as March, while at Orfordness on the Essex Coast there is a steady rise from a winter minimum in January; at Souter Point and Flamborough Head, while the January minimum is the better marked, the other also makes its presence felt. On the route from Leith to Hamburg (p. 127) we see in like manner that, as far as 2° E., we start with a minimum in March, or even April; that thence eastward through the middle of the North Sea a double minimum is perceptible; and that it is only when we near the continental coast in latitude 6° E. that January appears as the coldest month and is followed by an uninterrupted increase in warmth.

In conclusion, it is only necessary to emphasise what has already been said, that these surface observations have proved of great value in interpreting the hydrographic changes occurring from month to month, and it is hoped that the considerable extension which has now been made in this branch of the work may lead to even better results in future.