A SUMMARY OF HYDROGRAPHICAL RESULTS OBTAINED DURING AN ARCTIC CRUISE IN 1929

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INTRODUCTION

During the summer of 1929 the R. Swedish Hydrographic Service had occasion to contribute to Arctic research by attaching one of its surveyors to a Swedish Expedition which was to make an oceanographical cruise along the ice-limit of the Atlantean Arctic under the leadership of Mr. J. W. SANDSTRÖM, a well-known Swedish climatologist. A more extensively report of the results of the expedition will appear in the publications of the Swedish Anthropological and Geographical Society (*), but it is believed that the following account by the astronomer and cartographer of the Expedition, Mr. P. COLLINDER, might be of some interest to the readers of the *Hydrographic Review*.

R. Hydrographic Service, Stockholm, June 1930.
Gustaf REINIUS,
Director.

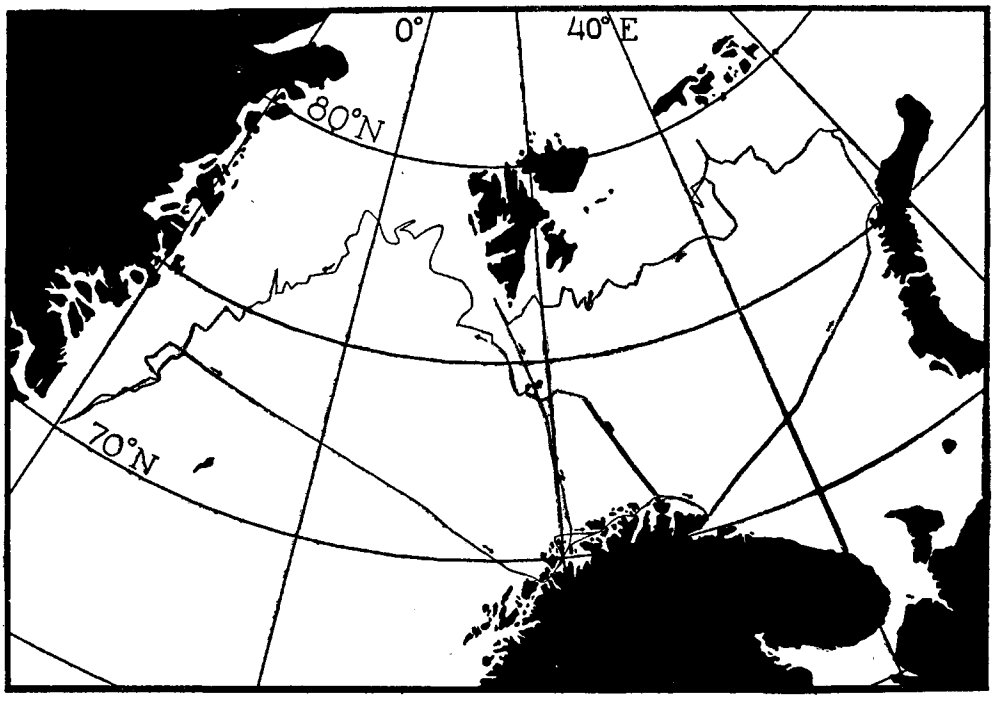
The prime importance of the Gulf Stream on European climate having been appreciated ever since the discovery of this warm current by Benjamin FRANKLIN, meteorologists have attempted more than once to state the correlation between the annual variations in the Gulf Stream and climatic changes in northern Europe. During the Swedish expedition for the rescue of NOBILE, Mr. J. W. SANDSTRÖM, Head of the Stockholm Meteorological Office, became persuaded that it was possible to make useful researches in this domain by means of a Norwegian sealing-cutter of about the same type as the *Gjöa*, on board of which Roald AMUNDSEN made the Northwest Passage. This plan was carried out during the summer of 1929 and it was made possible by the generous assistance of Swedish financial and shipping interests.

The vessel used was a ketch-rigged Norwegian sealing-cutter, about 20 metres (65ft 6 ins) in length, 6 metres (19ft 8 ins) beam and with a draught of 2 metres (6ft 6 ins). When the wind was not favourable, she was propelled at 5 knots by a 50 H. P. Swedish Bolinder motor.

The staff of the expedition consisted of four members viz., the Leader, a Hydrographic Surveyor, a Meteorologist and a Wireless Telegraphist.

The *oceanographical work* carried out was the determination of the temperature and salinity of the sea-water at certain stations every day from water-

(*) *Ymer*, 1930, pp. 75-117 (General and Climatological results). *Geografiska Annaler*, Stockholm 1930 (Hydrographical Results).



samples taken at the depths prescribed by international convention, down to 300 metres according to circumstances.

The *meteorological work* included the usual meteorological observations, which were communicated daily to the Tromsö Geophysical Institute. The meteorological code-telegrams were received and used for synoptic charts throughout the voyage.

The wireless set contained a receiving apparatus for long and short waves as well as a short-wave transmitter. Apart from occasional perturbations from atmospherics and continuous day-light, telegrams were sent and received regularly in all longitudes up to Latitude 79°30' N. The wireless set was constructed and set up by the *Svenska Radioaktiebolaget* of Stockholm. Short-wave broadcasts were often received with some difficulty, but even in Lat. 79° N. musical programmes were received faultlessly on 12 metres from the Philips station in Holland and on 26 metres from London. It may perhaps be said that our wireless communications were more successful than we had reason to expect.

As Hydrographical Surveyor and Astronomer the writer was responsible for the soundings and the charting of the ice-limit, which included also the astronomical observations. The shipmaster also took the noon meridian altitudes and occasionally also midnight meridian altitudes of the sun. As he had no chronometer, however, he could not determine longitude. This appears to be the rule, at least with sealing-vessels of this type. The cause, apart from economical considerations, seems to be that when proceeding through ice with such small vessels a chronometer is of very little use without frequent wireless checks. As is well known, irregularities often appear in the rate of chronometers on board smaller vessels, even in open waters.

The route of the vessel is shown on the accompanying chart.

Both the Barents and the Greenland Seas were to be circumnavigated in an anti-clockwise direction in order to avoid working against the arctic currents which generally follow the right shores of these seas.

The *Björnöy* sailed on 26th May and met the ice 60 nautical miles east of Bear Island. Passing south of this island, the vessel then proceeded northward, following the ice-limit west of Spitsbergen at a distance of from 30 to 60 nautical miles from the coast. After an unsuccessful attempt to push through open pack-ice to the northwestern corner of Spitsbergen she returned southward in about Latitude 78°30'. In a fresh attempt farther westward she again met close pack-ice in the same latitude.

Passing southward to 70° N. along the ice current east of Greenland, the *Björnöy* then returned to Tromsö at the beginning of July.

The second part of the voyage brought the expedition to Novaya Zemlya, from the northwestern coast of which the vessel steered north, on 25th July, towards Franz Joseph Land. This was not reached owing to a barrier of unbroken heavy ice, and the vessel turned southward in about 79°30' N., 44° E. Having attained the outer drift-ice limit with some difficulty, the expedition proceeded westward to the South Cape of Spitsbergen, calling at Hope Island. During the voyage from Novaya Zemlya to Spitsbergen fogs were very frequent, sometimes with fairly heavy swell but only faint winds. From Spitsbergen the expedition returned to Stockholm *via* Tromsö towards the end of August.

Owing to the very favourable weather and the skill of the Norwegian crew all branches of the work could be carried out according to programme. Gales were encountered only on two occasions, one in the beginning of June, when the vessel was anchored under the shelter of Bear Island, and the other in the latter part of June, when the *Björnöy* was brought to leeward of a tongue of drift-ice protruding from the Greenland ice-border. Fresh meat was obtained by bear and seal hunting nearly throughout the voyage.

THE ASTRONOMICAL WORK.

During almost the whole voyage, the sun was the only celestial body visible. Observations for altitude were taken with a PLATH micrometer sextant, generally three times a day. Clouds did not prove a very great obstacle to fixing position, even on days when the sky was completely overcast, for, after patiently waiting during some hours, the sun would eventually show through a thinner part of the clouds and a sight could be obtained.

Position-lines were calculated by the MARCQ ST. HILAIRE method without logarithms with the aid of Altitude and Azimuth Tables for all Latitudes published by the Swedish Navy.

THE BUBBLE SEXTANT.

A more serious difficulty was presented by fog and mists obscuring the horizon, especially during the late summer in the Barents Sea. For this purpose Commodore REINIUS, Director of the Hydrographic Service, had kindly placed at our disposal a PLATH micrometer sextant with bubble horizon.

The latter was of the type designed by the late Professor Edvard JÄDERIN of the Stockholm Technical High School for the ANDRÉE balloon Polar Expedition of 1897 (*). It was manufactured by Messrs LYTH, instrument-makers of Stockholm.

Of some 140 altitudes of the sun 17 were taken with the JÄDERIN sextant The results thereof were in good agreement with altitudes taken from the natural horizon.

When using bubble sextant altitudes, a series of five or more separate observations was always taken, and they were plotted against the times of observation on squared paper (**). This was necessary in order to be able to estimate the value of the results. A single observation was found liable to an error of from 3' to 10'. If the individual observations gave large discrepancies, a series of 15 to 25 values was observed, but if the agreement was good, about five observations were found sufficient to reduce the uncertainty of the results to 2' or 3'.

It is evidently not possible, from the restricted experience referred to above, to make any general statement as to the usefulness of the bubble sextant as a navigating instrument. The use of the bubble sextant on board the *Björnöy* however goes to prove that there is no danger in using such instrument and that when navigating in ice, it is often of considerable value.

If the vessel be unsteady, a greater number of observations are necessary of course, but if the sea is smooth, a small number suffices. By plotting the altitudes against the times the observer can estimate the reliability of the observations, and he uses a mean altitude for the mean time of observation, derived graphically or numerically. In all cases it must be of value to plot single observations according to some graphical method, in order always to make sure of the accuracy of the data used for calculating the line of position

Successful observation with the bubble sextant on board such a small vessel as the *Björnöy* seems to a considerable degree to be a matter of experience. Even to an observer well accustomed to the ordinary sextant, the use of the bubble is very difficult at first.

In a recent paper (***) Mr. H. COLDEWEY cites several series of observations made with a bubble sextant of somewhat more intricate design, constructed by himself. The observations, mainly made on board larger vessels, give deviations in individual altitudes up to 3' and occasionally more.

It may be of interest to compare the accuracy of the above results with that obtainable with a gyroscopic horizon. In the paper referred to above (****) Monsieur FAVÉ gives a very interesting survey of the theory, construction and use of the FLEURIAIS gyro-horizon, and the observational data seem to give

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(*) Kungl. Vetenskapsakademiens Oversikt 54, p. 493-506, Stockholm 1897.

(**) This method is described in the paper by M. FAVÉ mentioned below.

(***) *Annalen der Hydrographie und Maritimen Meteorologie*, 1925, p. 100-105. See also *Hydrographic Review*, Vol. V, N° 2 (November 1928), p. 173-175.

(****) *Le point sans l'horizon de la mer*, par M. L. FAVÉ, ingénieur hydrographe en chef de la Marine, Paris, Librairie CHAPELOT, 1910.

a mean error, in a single altitude, of about 2' (*). It should be remarked also that the FLEURIAIS observations were made under all kinds of conditions of sea and swell, whereas on board the *Björnöy* the bubble-sextant could not be used except in a calm or with very slight swell. The bubble observations on board larger vessels cited by Mr. COLDEWEY seem also to have been made in comparatively favourable weather.

However, the experience of the author of this article goes to prove that during navigation in ice, where fog and low mist is often prevalent, the bubble-sextant is a navigational instrument of considerable value even on board a vessel of the dimensions and type of the *Björnöy*. The navigator need not fear to be led into error, as the graphic method provides an easy means of testing the accuracy of the results.

According to extensive investigations of French navigators and astronomers such as Admiral FLEURIAIS, M. FAVÉ and others, as well as to long series of observations made on board French and Netherlands ships, the gyroscopic sextant is superior to the bubble sextant as regards accuracy and it should give useful service in conditions of sea or swell where the bubble sextant cannot be used. Thus it seems probable that the gyroscopic sextant should be a standard instrument, at least for Arctic and Antarctic expeditions or others frequenting fog-ridden waters.

It was a matter of regret that owing to the very short preparations, as well as to lack of funds, our expedition could not be equipped with a FLEURIAIS or other gyroscopic sextant.

THE CHARTING OF THE ICE-LIMIT.

The master of the vessel or the best member of the crew, when in the ice, kept continuous watch in the barrel or "crowsnest" in the mainmast. From there they kept the ice under constant survey and, after each watch, sketched in the approximate state of the ice on the chart. This was corrected afterwards in accordance with the next astronomical fix.

SOUNDING.

The depths in the Greerland Sea being oceanic, mostly between 2000 and 4000 metres, the "BEHMLOT" echo-sounder carried on board was found very valuable. The necessary funds had been raised from private donors by the Hydrographer, Commodore REINIUS, to whom the expedition is under a great obligation, and our thanks are due also to the courtesy of the maker of the apparatus, Dr. BEHM of Kiel.

The sounding apparatus was of the type called "BEHM-limnolot, Type VII". As this form has already been described in the *Hydrographic Review*, it may be sufficient to refer to the description given there.

In shoal water (down to 395 metres) the sound was emitted by strokes with a spear on a circular iron disc and in greater depths by an electrically fired cartridge.

(*) Loc. cit., p. 66.

In oceanic depths a somewhat different depth-recording method was used, *viz.*, the OHRLOT-Method (*).

As time and funds did not permit of building the emitter and receiver into the ship's sides, these accessories were submerged for every sounding from the stopped vessel. This was somewhat inconvenient, especially in the ice, when great care had to be taken to protect the receiver-cables from getting fouled by ice-blocks.

The apparatus was very simple in use, and the echos generally sharp and unmistakable. In all cases but one, where the echo was not quite sharp, a second or third sounding was taken. The one exception is the sounding of 3,750 metres in 78°23' N., 7° 02'E. (*see* chart). My first intention was to suppress this sounding, the echo being faint and the depth obtained unexpectedly large. Further northward there are however two previous soundings of about the same depth, and, as it seems possible that all three may indicate a long and narrow furrow running north and south, parallel to Prince Charles Foreland, I decided to publish my own sounding also though marking it as questionable. It would be of considerable interest to have this region investigated further.

A discovery of some interest which seems unquestionable was the broad submarine valley, at least two degrees of latitude in length, running parallel to the Greenland continental shelf north of Jan Mayen Island and with a "Thalweg" depth of about 3,000 metres. According to the previous sparse ocean soundings, depths of between 1700 and 2000 metres only were to be expected in this region. In other cases also large unsounded areas were crossed, but the depths generally agreed well with previous soundings.

Unfortunately it was not possible, in spite of two separate attempts, to attain a higher latitude than 78°30' in the Greenland Sea, and thus we could not, as we had hoped, check NANSEN'S theory, put forward on hydrological grounds, of a submarine ridge connecting northwestern Spitsbergen and northeastern Greenland.

In the Barents Sea, where depths generally do not exceed 300 metres, the soundings were taken by hand with wire and lead. The pack-ice did not permit us to pass over some larger unsounded areas, and in general our soundings agreed very well with the depths on the charts, perhaps remarkably well taking into consideration the fogs prevalent in these waters, which must have reduced the accuracy of the determinations of position of previous navigators as well as our own.

Owing to the smallness of the staff, the soundings, by echo or by hand, were always taken by the writer. It is to be regretted that this perforce put a limit to the density of the sounding; in unsounded areas the soundings were taken once in 3 hours, and when continued throughout some days and nights, together with the astronomical work, this was found to fill up one man's working-time fairly completely.

(*) *Hydrographic Review*, Volume VI, N° 2.

MISCELLANEOUS OBSERVATIONS.

During the visit to Novaya Zemlya some additions to the "Arctic Pilot" were noted. Coast views were drawn of the Liverpool coast of Greenland and of the Novaya Zemlya coast near Admiralty Peninsula, where they seem to have been lacking previously.

During the voyage from Novaya Zemlya and south of Franz Joseph Land rough compass azimuths of the sun were obtained which seem to confirm the statements of Norwegian sealers that the variation of the compass in these waters is very small, if any. The modern magnetic charts give a variation of 10° to 20° E, which values are probably much too large.

The results mentioned in this last paragraph have been communicated in greater detail to the British Admiralty and to the Editor of "Terrestrial Magnetism".

A list of the soundings has been communicated to the International Hydrographic Bureau.