THE MEASUREMENTS OF THE SURFACE WATER CURRENTS OF HORNSUND FJORD BY PHOTOGRAMMETRIC METHOD

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ABSTRACT

The necessity of a simultaneous measurements of the great water surfaces, was the reason why the photogrammetric method was used. From the altitude of several hundred metrs the water surface photos with floating bergy bits, ice floats and growlers were taken in the horizontal position of the axis sight and with the outher orientation of the camera exactly determined.
All the photos were taken in windless weather. On the base of the photogrammetric photos the maps of the ways and speeds of the bergy bits were elaborated. The statistic analysis of the results were done in order to find the relation between the speed and the movement of floating marks and the tidal cycle.

INTRODUCTION

In summer 1983 the measurements of the surface water currents of Hornsund Fjord in the region of the Polish Polar Station in Spitsbergen were carried out. For that purpose the land photogrammetric measuring photos were used. The adopted assumption as well as the way of the measurements execution allowed to make registration of water movements within the great area. The collected reach photographic material allowed to make thorough study of the occured changes in currents speed and directions during the whole tidal cycle.

The survey on merits of preparations of those measurements as well as on the later elaboration of the obtained results were carried out by Kazimierz Furmańczyk D.Sc. employee of the Expedition organizer - Gdańsk University.

The local measurements as well as the later elaboration of their results were made by one of this paper authors, employee of the Geodesy and Cartography Enterprise in Szczecin, Remote Sensing Department.

PRELIMINARY ASSUMPTIONS AND EXECUTIONS OF LOCAL WORKS

Choice of the surface water currents measurements method was decided after taking into consideration different factors.

First of all it was the necessity of limitation to the indispensable range, the local works as well as the members of the measuring team. The other factor that was conductive to make such choice it were the existing local conditions. Hornsund Fjord surrounded with several hundred meters mountains gave the favourable conditions for taking pictures of the examined area of water surface. Additionally the ice floats, bergy bits and growlers contrasting with water surface and coming from the Fjord interior made the very good possibility of registration of changes in their position on the taken photos and simultanously using them as the natural control marks.

- The photogrammetric registration of great water surfaces of the Fjord in rather short period of time, made in the best way possibility of founding eventual movements of the Fjord water.

In preliminary assumptions it was planned to execute stereophotogrammetric photos of the Fjord estuary fragment.
It was assumed, that the taken photos would allow to designate movements of the control marks on the basis of fundamental patterns of the land photogrammetry. The series of photos, which were taken successively, had to cover the whole tidal cycle.

Meteorogical and land conditions of Spitsbergen showed themselves to be less conductive to carry out the planned work than it was fireseen before. Sudden changes of weather repeated strong winds, low ceiling of clouds as well as the irregular flow of ice floats from the Fjord interior, forced the measuring team to act very operativelly in the existing local conditions. It was necessary to make usage of all short periods at time when there were favourable conditions for carrying out the measurements. Additionally great difficulties in movements in the area as well as troubles with precise synchronization of taking photos finally decided of the executing photogrammetric registration carried out only from one measuring stand. The quite high altitude of the measuring stand allowed to have good sight even on the far fragments of the Fjord water surface. The preliminary analisis had proved that there were possibilities for determining positions of the floating control marks on the base of the image coordinates obtained only from one measuring photo.

The additional argument for carrying out registration of the changes, only from one measuring stand, were great difficulties,in obtaining the stereoscoping model from the photos of ice floats floating on the water surface. It was suggesting that the great effort put into obtaining the stereoscopic photos will be compensated only in very little rate in the effect of the better and more simple way of elaborating the required results. Moreover the simple measuring stand was making easier to carry out the photogrammetric photos really very remarkably.

Resignation of the stereoscopic elaboration of the photos was effected with some small decrease of accuracy in determining at the control marks displacement. Still the measuring error did not exceed 10 % of the determined values for the most unfavourable case.

Such solution was admited to be quite proper not only because it was easier for execution but because of the considerably increasing the area covered with the carried out measurements.
Very short periods of time of favourable meteorological conditions suitable for carrying out the required measurements made necessary in the beginning stage, to take photos of the Fjord waters in short periods covering the seperate fragments of the tidal cycle. It was planned to make such their arrangement which could allow to obtain with the measurements covering the whole tidal cycle.

Later it turned out that it was quite possible to use, with success, the longer periods of the stabile weather for registration the whole tidal cycle and it was made two times - once for the western part of the Fjord together with its estuary and the next time for the middle and eastern part of the Fjord.

The areas and dates where and when the photos were made against the background of the tidal cycle, according to Longyearbeen's tidal table, has been illustrated on the figure No.1.

The stands of the measuring cameras were marked with circles, the first one on Ariekammen ridge, the second at the base of Treskeloden peninsula. Ranges of the seperate series of photos were marked with radial lines coming from the measuring stands. Over the measuring stands there are placed the symbols and dates of the executed registration against the background of the tidal cycle graph. Besides the photogrammetric photos the necessary range of geodetic measurements was carried out for determining the measuring stands position in the Gauss-Krüger coordinates scheme, and on the topographic map of Spitsbergen. Directions from the stands of photogrammetric camera to the control points were measured as well. For the control points were used the natural situational details clearly projecting, on the measuring photos.

The successive in time, conformable one to another, measuring photos were made in keeping the identical outer orientation. The ground coordinates of control points, being in background of the water area, were confirmation of the existing situation. All the photos were taken in the horizontal position of the phototheodolite axis sight.

CALCULATIONS AND ELABORATION OT THE FINAL RESULTS

The base for calculations of the control marks ground coordinates were their image coordinates on the successive, measuring photos as well as on the known elements of the photos outer orientation. Very essential over here was the regular nearly flat shape of the water surface with the floating control marks.

Preliminary, before completing calculations the image coordinates were corrected taking into consideration influence at the outer orientations errors. Those corrections were done on the basis at the photographed control points in their background arrangement.

As a rule the orientation errors did not exceed 0.1 grade. Additionally the image coordinates were taken into consideration to include influence of atmospheric refraction and earth curvatur - what was making deformation of the water surface. In the later calculations the change in water surface level was taken into consideration as well.

The measurements of image coordinates was carried out using Zeiss Stecometer. For assuring the proper identification of control marks, simultanously two, successive in time, photos, corresponding one to another with their orientation, were being measured.

The stereoscope observation of control marks increased measurements accuracy and assured identification of control marks through comparison of their shapes, position against the existing background as well as their mutual configuration. Each photo as well as each of the examined control marks were measured independently two times. Such way of the carried out measurements allowed to make estimation of its accuracy and had influence on accuracy of the final calculations. The calculations were carried out partly with usage ot the programmable calculating machine HP - 41C, and partly using "ODRA 1305 Computer". Results of the calculations referring each pair of the photos were charted on the seperate maps to scale 1:50 000. The full line was used on the maps to represent ways of the control marks in the period of time exposition of the both photos. After plotting one onto another the successive maps as well as drawing the successive movements of the control marks, the map of the control marks driftage was completed.

The decreased drawing of the above mentioned map in shown on Figure No.2 and No.3. Additionally driftage vectors regarding the seperate phases of the tidal cycle were calculated and their maps was plotted.

All the maps were made at the Regional Geodesy and Cartography Enterprise in Szczecin with usage of automatic drawing table. It required to put into memory of the plotter controlling computer all the controlling marks coordinates. It assured possibility of optional processing of included in them informations as well as the wide statistic analysis of the obtained results.

The average inner error of determining the control marks position was calculated as well as its dependence from the position in relation to the used measuring stand. Its value forms only a little percentage in relation to the used measuring stand. Its value forms only a little percentage in relation to the determined movements and practically it is contained in the range of the graphic accuracy of the figure.

The statistic analysis was carried out for finding the existing interdependence between direction of water movement and the tidal cycle phase in the Fjord. Fig.4.

SUMMARY

The maps and prints elaborated on the base of the obtainèd calculations allow to confirm the satisfactory accuracy of the method in question. Slightly less accuracy in comparison with the stereoscopic elaboration has been recompensated remarkably well by simplification of the field marks as well as the less quantity of the required photos.

The talked over and presented here materials refers to the Hornsund Fjord western part only, they were elaborated on the basis of the photos made in the period of time of two days August 16 th and 17 th, 1983.

The photos covering the Fjord eastern and middle parts have not been elaborated yet.

The same photos,allow to elaborate the similar maps for the smaller chosen fragments of the Fjord neibouring to the measuring stands but to the greater scale and with the greater accuracy as well.

The talked over way of registration and elaboration can be successivelly applied for registration all series of nature phenomenons connected with different water reservoir surfaces as well as for phenomenons existing on the other flat or regular areas.

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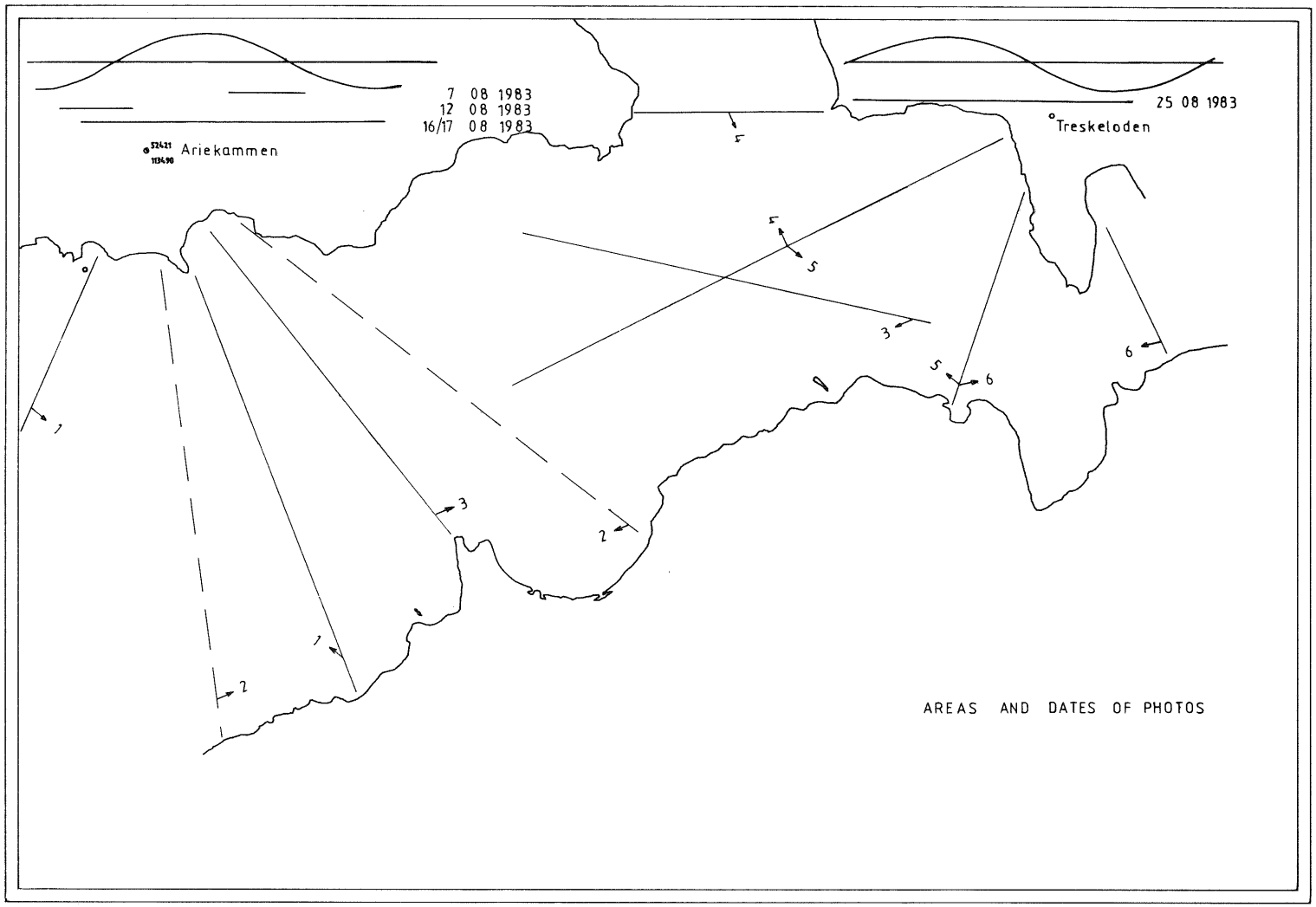
7 08 1983
12 08 1983
16/17 08 1983
Ariekammen
25 08 1983
Treskeloden
AREAS AND DATES OF PHOTOS

Fig. 1

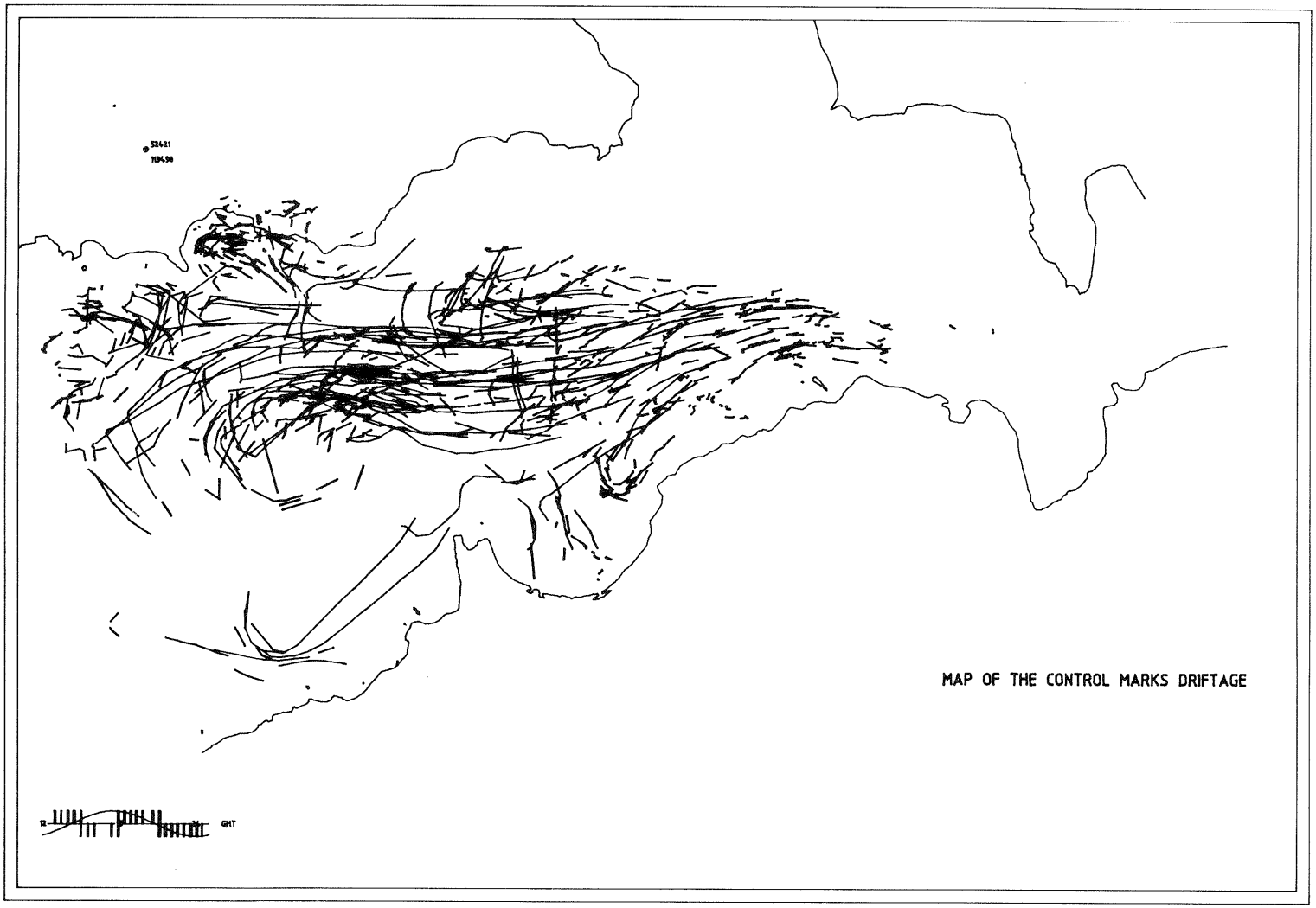

Fig. 2

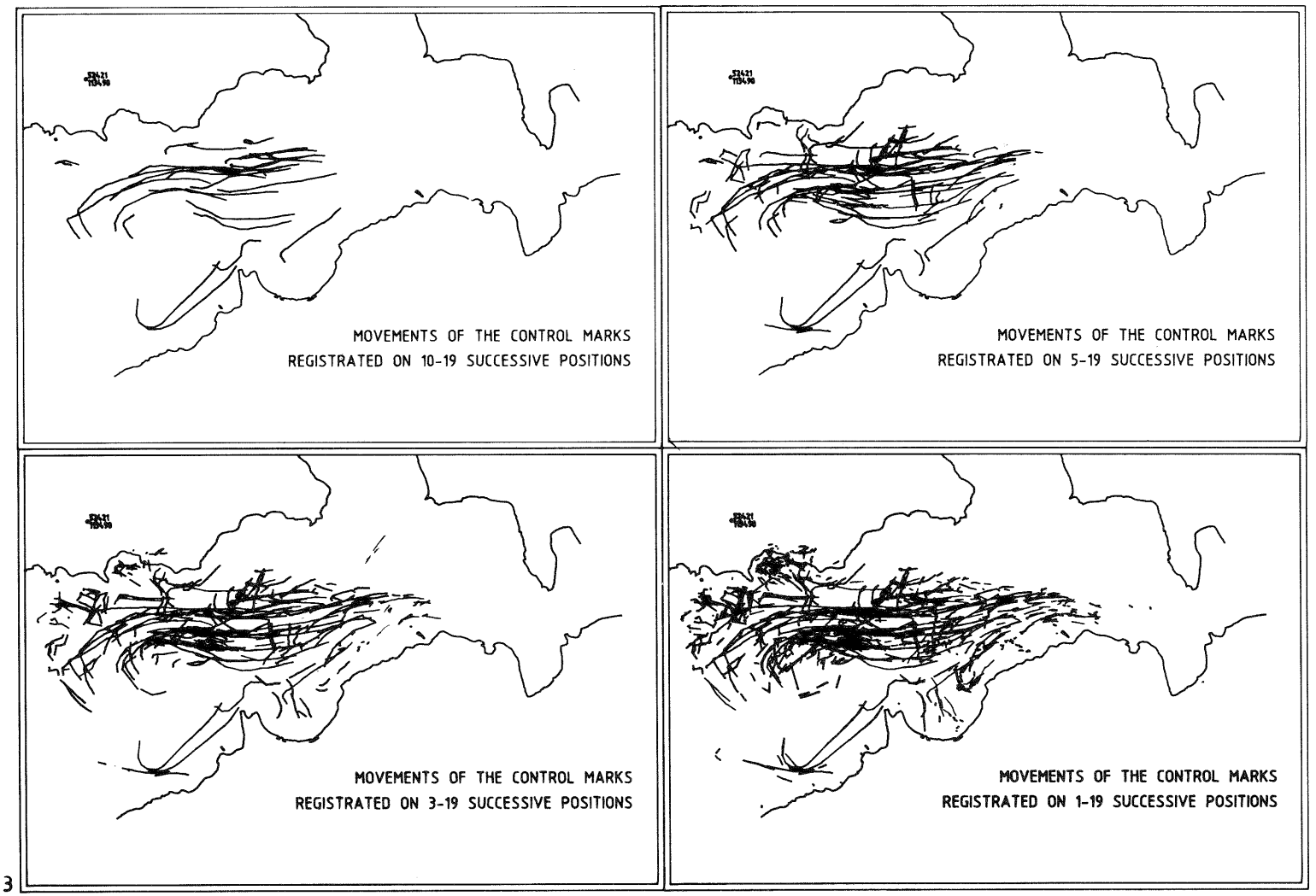
MOVEMENTS OF THE CONTROL MARKS
REGISTRATED ON 10-19 SUCCESSIVE POSITIONS
MOVEMENTS OF THE CONTROL MARKS
REGISTRATED ON 5-19 SUCCESSIVE POSITIONS
MOVEMENTS OF THE CONTROL MARKS
REGISTRATED ON 3-19 SUCCESSIVE POSITIONS
MOVEMENTS OF THE CONTROL MARKS
REGISTRATED ON 1-19 SUCCESSIVE POSITIONS

Fig. 3

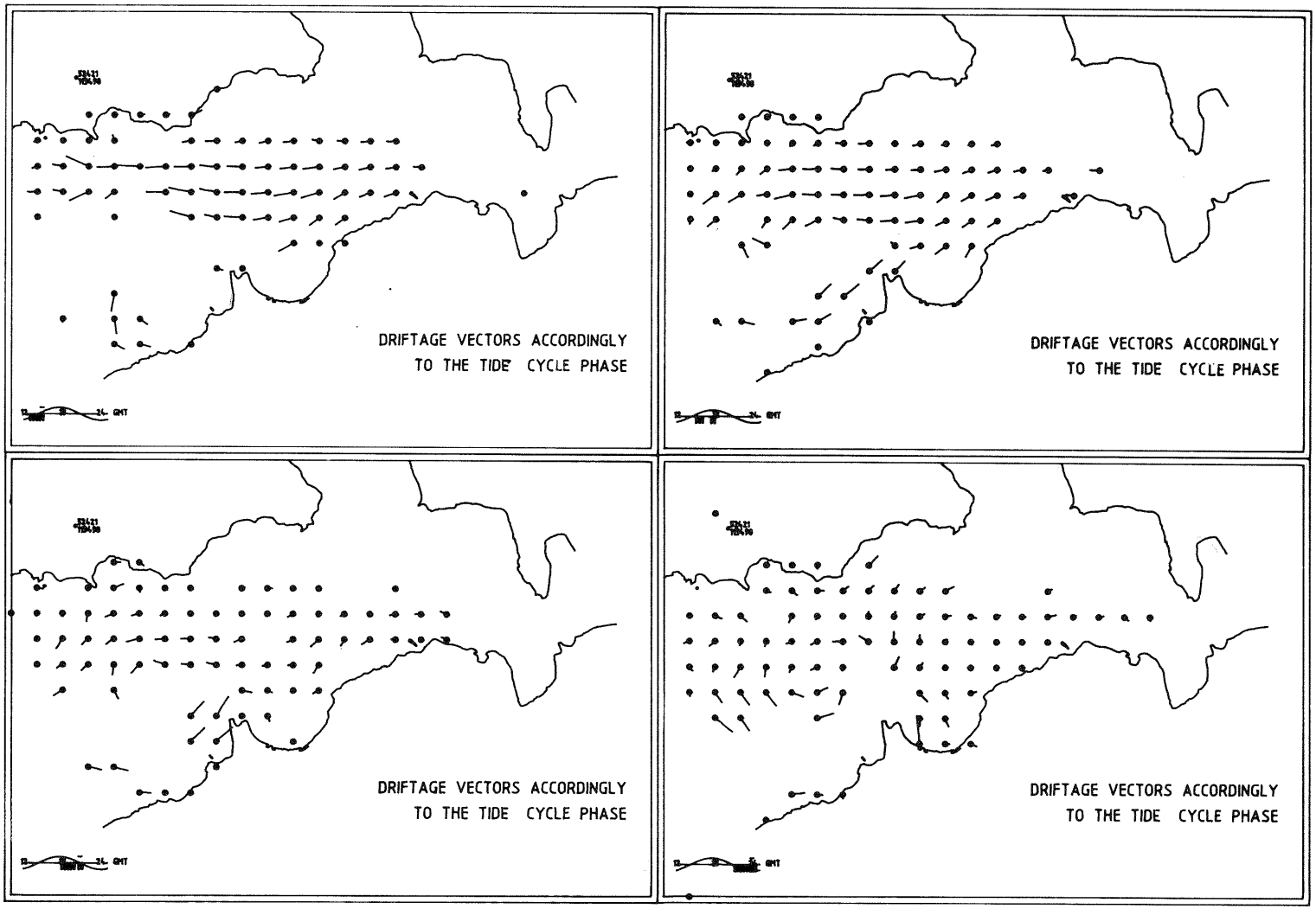
DRIFTAGE VECTORS ACCORDINGLY
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Fig. 4