CHAPTER 59

Giant and Mega Ripples in the German Bight and Studies of their Migration in a Testing Area (Lister Tief)

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Abstract

In a lot of regions the bottom of the North Sea is covered with large ripple fields, especially in the estuaries and in the tidal channels. A great number of echo sounding profiles (29.500 n.m.) were evaluated to determine the boundaries of these areas and to describe the dimension of patterns. Special investigations of the hydrographic situation, the distribution of deposits and the migration of ripples under the influence of tidal currents only, were carried out in a testing area in the Lister Tief on 11 cruises since 1971.

General Distribution of Ripples

There are several comprehensive descriptions of the distribution of deposits of the German Bight. But these maps don't show the processes of permanent transposing of movable material. Transversal current ripples can be considered especially

suitable as qualitative indicators of sediment transport processes on the sea floor. Thus an attempt has been made to schedule all areas of the south-eastern North Sea where the bottom shows such ripples. It is impossible to carry out a synoptical survey of the bottom of this large region of the North Sea. Therefore 29.500 n.m. of echo soundings obtained by numerous institutions of coastal research from 1964 to 1971 have been evaluated for characteristic patterns. The results have been presented on 22 sheets on the scale 1:100 000 (J. ULRICH, 1973). A comprehensive map of all sheets is shown in Fig. 1. From comparative investigations of several years it is shown that most of the ripple fields changed their boundaries only a little. The sounding tracks do not always run normal to the ripple crests because the surveys were predominantly carried out for nautical purposes and, therefore, the mapping can give only qualitative information. The largest ripple fields can be found in estuaries of the rivers Ems, Weser and Elbe as well as in the tidal channels between the islands and the large tidal flats which are characteristic of the coasts of the German Bight. Regions of larger patterns with heights of 2.0 to 10 m. can be found between 6 and 20 m. depth in the areas with sand of coarse and partly medium grain size, whereas the medium and fine sand areas of the tidal channels, the edges of the estuaries and, frequently, even the slopes of sandbanks, reefs and bars are characterized by smaller patterns less than 2 m. height. The areas of the tidal flats shallower than mean low spring tide are not investigated by this mapping. It must be considered that in this region, which partly falls dry at low tide, large fields of small ripples could be found.

Testing Area

Patterns of remarkable variety in shape and dimension are in the zone of the German-Danish frontier - in the Lister Deep (location see Fig. 1). During every tide through this tidal

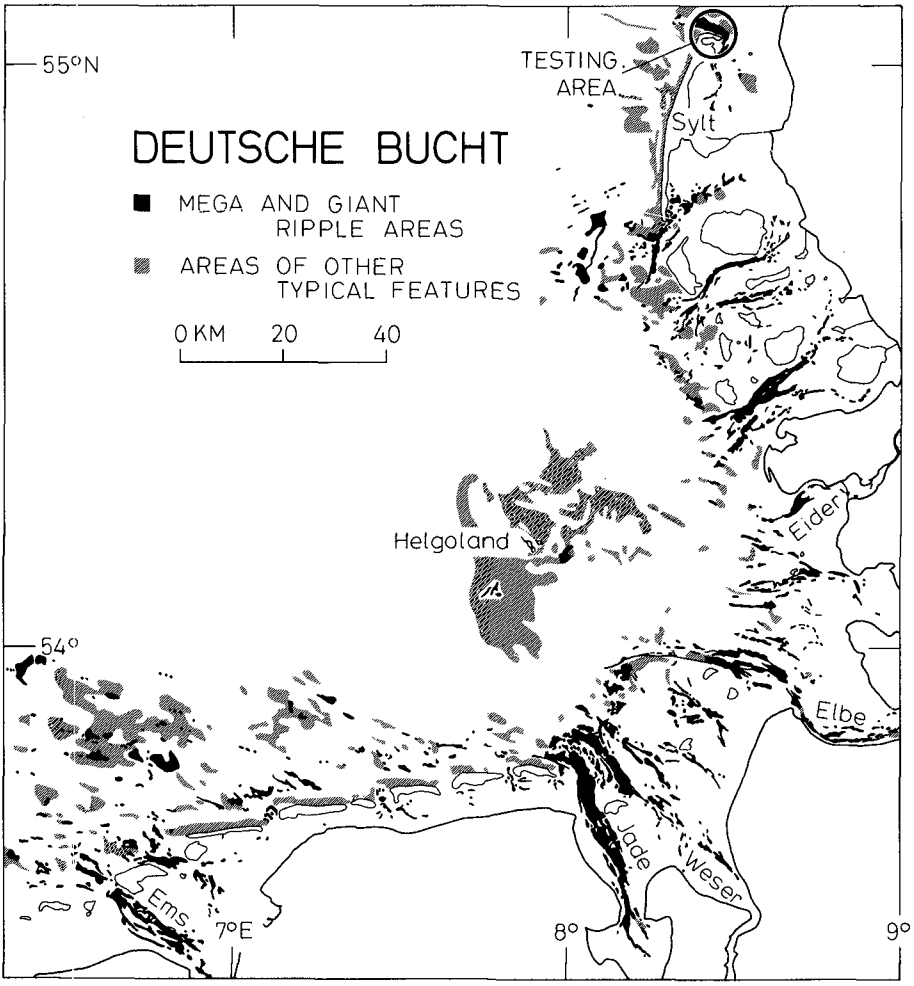

Fig. 1 Ripple areas in the German Bight

channel about 520 Mio m^3 of water streams into the Bight closed by two dams which connect the island Rømø and the island Sylt with the mainland. There is no remarkable fresh

water flow - so the bottom of the channel is formed by tidal streams only. During 11 cruises in a testing area on fixed tracks narrow echo soundings were made since 1971. The employed navigation system Hydrodist NRB 201 with a deviation of $\pm$ 1 m. gives a sufficient accuracy of bearings even for detailed analysis. Fig. 2 shows the boundaries of the testing area, the

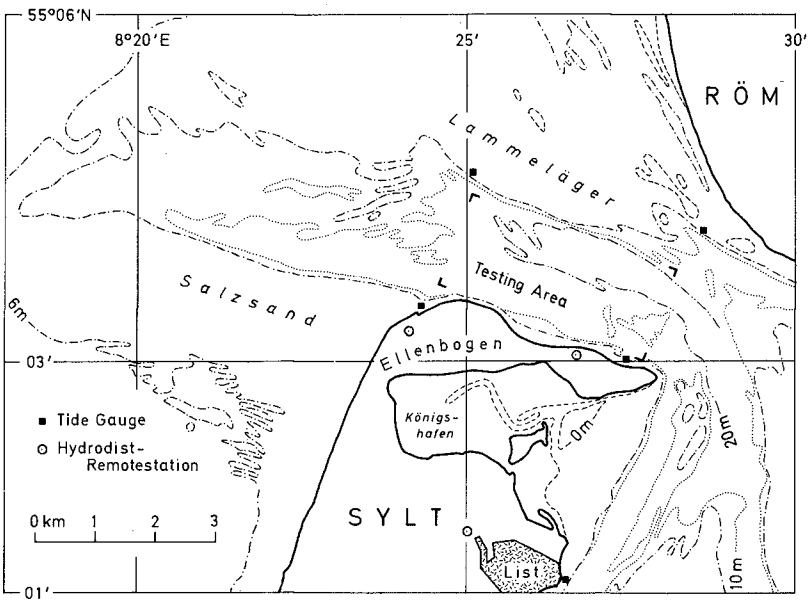

Fig. 2 Testing area in the Lister Tief

positions of the remote-stations of the Hydrodist-System and apart from that, the positions of the tidal gauges additionally established for this investigation for the correction of echo soundings. The testing area extends from 1.6 km to 3.6 km, the water depths range from 10 m. to 40 m. The tidal range determined by the mean of ten years is 1.71 m. Numerous current measurements from anchored ships yielded that even 15 minutes

past low water the current reaches the opposing direction and 25 minutes later velocities of more than 1.00 m/sec have occurred in general. Such measurements will be completed by the application of floats. Fig. 3 shows the great spatial and temporal variability of currents during ebb and flood.

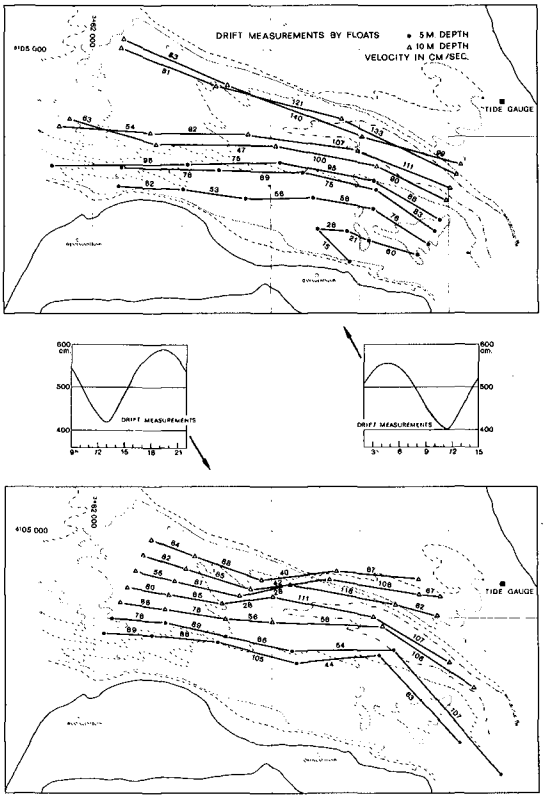

Fig. 3 Drift measurements by floats. The values at the trajectories are calculated means in cm/sec between the positions taken by means of Hydrodist.

Bathymetry

As mentioned above soundings were taken on fixed tracks. They run parallel to the axis of the channel in a lateral distance of 50 m, if possible in the given time for our explorations, in addition to that in a distance of 25 m.

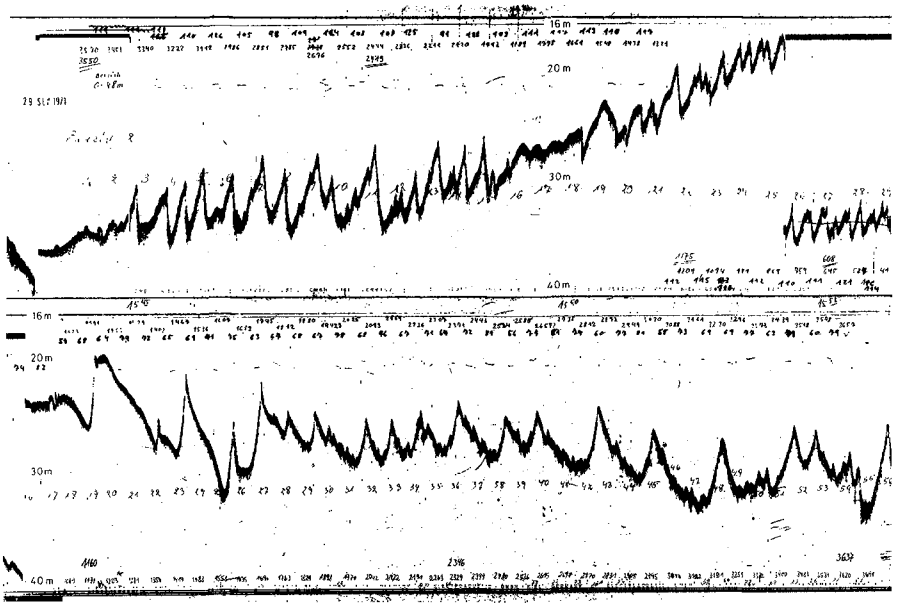

Fig. 4 Echo soundings of giant and mega ripples in the Lister Tief area

Fig. 4 shows two sections of the original copies of echo soundings. After the correction referring to the tide gauge level the whole system of tracks is drawn enlarged five-times and gives a quasi-spatial impression (Fig. 5). A system of giant ripples with heights up to 11 m. and wave lengths of

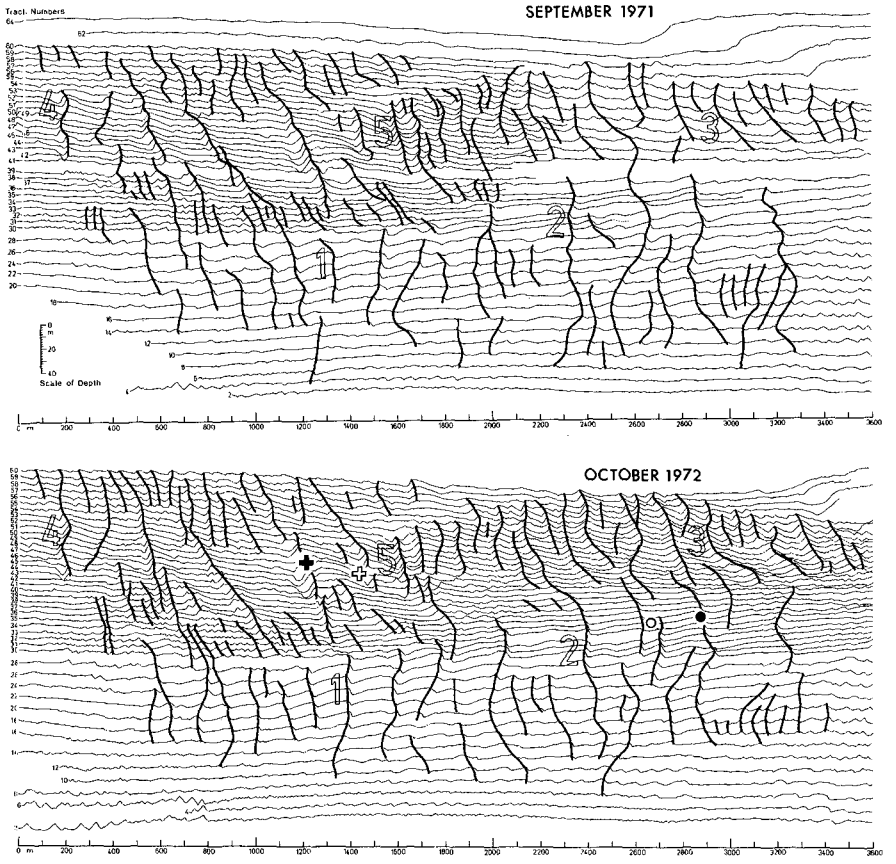

Fig. 5 Series of corrected sounding numbers: see text
cross and dots: positions of bottom samples described in Fig. 7

more than 300 m is overshaped in a lot of regions by mega ripples which can have heights of 2 m. On the other hand, Side-Scan-Sonar recordings have shown these two systems

but especially on so called luff slopes, is covered with extensive regions of small ripples in the max. dimension of some ten of centimeters which can not be detected by vertical echo sounding because of physical and technical reasons.

Migration of Ripples

As to the asymetrical shape and the observed migration of ripples the Lister Tief can be devided into two areas: In the northern part, we find westward moving ebb-orientated patterns, in the southern part, on the contrary, eastward moving flood-orientated ones. The highest ripples can be found in the northwestern part of the area. From additional analysis of the geometrical parameters of the giant ripples as height, wave length and depth of water no significant relations to the rate of migration could be deduced.

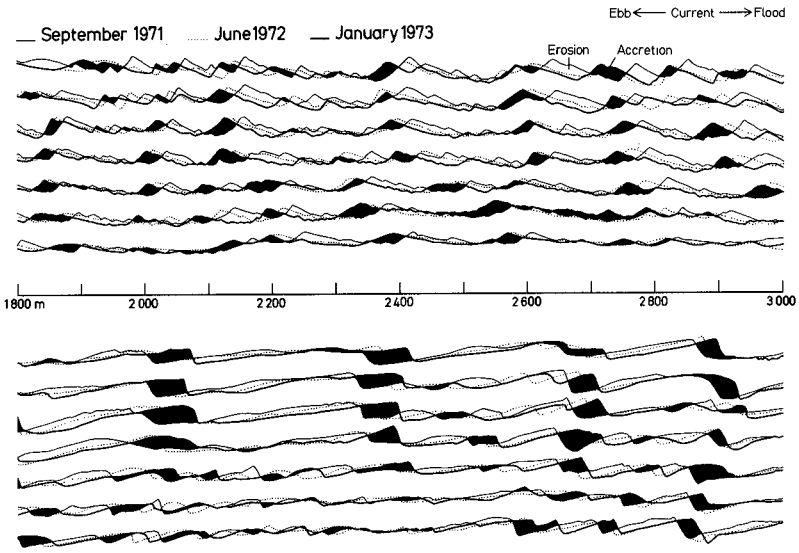

Fig. 6 Flood- and ebb-orientated ripples

The amount of migration is shown in Fig. 6 which represents a section of the northern part the ripples of which are shifting westward mainly and in a distance of five 50 m.-tracks of the southern part that is ripples which are shifting eastward on the whole. Even reverse motion of ripples in contrast to the general direction of migration can be observed. From a calculation of transport of sediments with the help of transposition of shape results - for the northern part - a transport amount of about 5 t. p 10 m. cross-section of the channel, and for the southern part sometimes even more than double of the amount. But this need not be the real amount of transported material, for the main transport of sediment even seems to occur in suspension because of the high velocity of the currents - that is more than 1.0 m/sec in the mean. The highest value measured on the surface was about 1.0 m/sec.

Sediments

By comparison of a great number of bottom samples a sorting by the influence of currents can be seen. In general, finer sediments occur in the eastern flood-orientated part and more coarse sediments in the western ebb-orientated part of the Lister Tief. Finer deposits can be found in the ripple troughs, which we already know from many investigations in several other regions. The Md-value of fractions varies between 200 m. and 1000 m. For example on the crest of the ebb-orientated ripple marked in Fig. 5 we found out an Md-value of 850 μm. and for the luffward trough of 640 μm. On the other hand in the region of flood-orientated ripples we find values of about 570 μ m. on the crest and 290 μm. in the adjacent trough respectively. These values are means of several samples (Fig. 7).*

*The numerous samples are analyzed thoroughly for interpretation by Dr. Lüneburg, Institut für Meeresforschung, Bremerhaven.

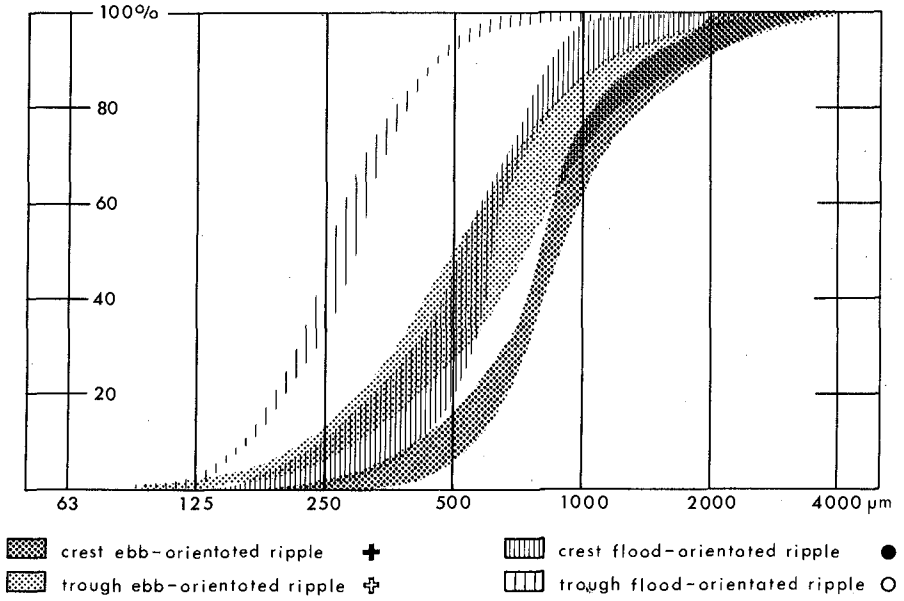

Fig. 7 Cumulative curves of fractions found at the positions marked in Fig. 5

Looked at more closely some remarkable phenomena are to discern in Fig. 5. As a help we have marked the courses of ripple crests whereever the profiles were to be correlated clearly. Considerable shift velocities appear in several areas. As examples for this fact we have the patterns signified with number 1 (about 60 m/year) or with number 2 (of the same value) in the flood-orientated part, and the same with number 3 in the ebb-orientated part. There may be relationships between the speed of ripple migration (in this case patterns > 2 m) and the current velocities. Obviously the difference of in- and outflow is of great importance. In several places we found values of more than 20 m/sec difference. The travel-

ling direction is determined by the direction of higher flow (A. H. STRIDE, 1963). On the other hand some ripples remain in their position for a long time only with small oscillations from a position of rest like the patterns with number 4 and 5. Remarkable are the depressions adjacent to the lee slopes with a maximum depth of 2 m. and a width about 50 m., they may be moulded by strong eroding eddies. The analyses have not been finished yet, but the preliminary results give hope for the assumption that from this model in full scale some new facts about the kind of sediment transport under the influence of tides can be deduced.

Acknowledgements

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References

STRIDE, A. H., 1963: Current-swept sea floors near the southern half of Great Britain. Quart. J. Geol. Soc. London, 119.

ULRICH, J., 1973: Die Verbreitung submariner Riesen- und Großrippeln in der Deutschen Bucht. Ergänzungsheft zur Deutsch. Hydrogr. Zeitschr. Reihe B, 14.

ULRICH, J. und H. PASENAU, 1973: Morphologische Untersuchungen zum Problem der tidebedingten Sandbewegung im Lister Tief. Die Küste, 22.