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VARIATIONS IN CONCENTRATION OF SUSPENDED MATTER IN THE SCHELDT ESTUARY

BY

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ABSTRACT

An overall picture of the concentration of suspended matter in the section of the Scheldt estuary between the Rupel mouth and the Ballastplaat is given. The evolution from hour to hour of the concentration of suspended matter during one tide is discussed with the help of 12 figures.

RESUME

Un aperçu général des concentrations en matières en suspension dans l'estuaire de l'Escaut entre l'embouchure du Rupel et le Ballastplaat est donné. L'évolution d'heure en heure de la concentration en matières en suspension pendant une marée est discutée à base de 12 graphiques.

INTRODUCTION

One of the most important sections of the estuary of the Scheldt (Schelde) is located between the confluence Scheldt - Rupel (hereafter indicated as Rupel mouth) and the Ballastplaat at the Belgian - Dutch frontier (fig. 1). Indeed measurements by M. DELLA FAILLE (1961), S. WARTEL (1967) and N. DE PAUW (1971) clearly demonstrate that this section can be characterized by an annual up- and downstream migration of the boundary between river water and sea water. In figure 2 a salinity distribution along the estuary is given for a summer- and a winterperiod.

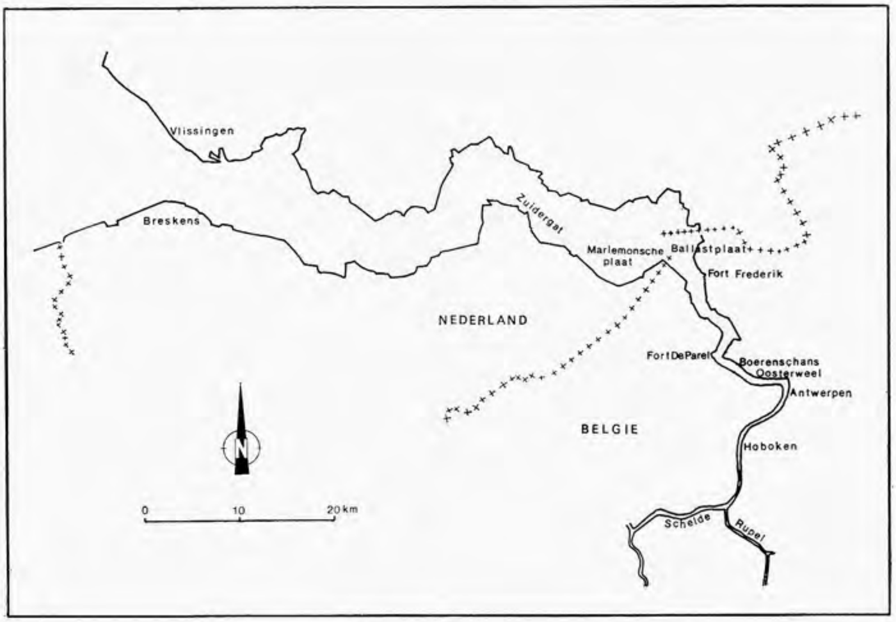
Vlissingen
Breskens
Zuidergat
Marlemonsche plaat
Ballastplaat
Fort Frederik
NEDERLAND
Fort De Parel
Boerenschans
Oosterweel
Antwerpen
BELGIE
Hoboken
Schelde
Rupel
N
0
10
20 km

Fig. 1.

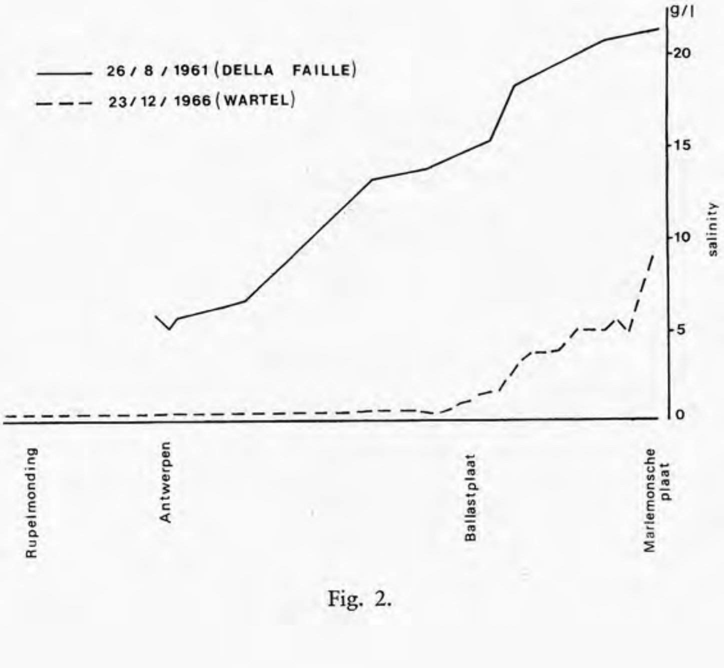
26 / 8 / 1961 (DELLA FAILLE)
23 / 12 / 1966 (WARTEL)
g/l
20
15
10
5
0
salinity
Rupelmonding
Antwerpen
Ballastplaat
Marlemonsche plaat

Fig. 2.

Moreover C. MIGNIOT (1968) indicated that estuarine water with a salt content of 5 g/l has a maximum effect on flocculation of fine suspended sediments.

The above mentioned section may thus be an ideal environment for deposition of these fine sediments. This is also in good agreement with several studies on bottom sediments of the Scheldt. Unpublished maps based on measurements by the ANTWERPSE ZEEDIENSTEN (1956 - 1960) and by A. BASTIN (1963 - 1966) show clearly the rather large amount of mud and muddy sediments deposited between Antwerp (Antwerpen) and Fort De Parel. It is important to observe that these mud concentrations are found in the more downstream part (beyond Antwerp) of the section, whereas the upstream part shows coarser sediments (S. WARTEL, 1972a). This can be explained by a considerably higher supply of suspended matter during periods when the fresh-salt water boundary is situated downstream of Antwerp (winter period; see also M. DELLA FAILLE, 1961, who showed that the concentration of suspended matter is higher during this period).

From 1967 until 1969 a great number of suspended matter concentration (indicated hereafter as s.m.c.) measurements were carried out in this section of the estuary, in order to obtain a better insight into the sediment transport. In this paper an attempt is made to summarize schematically the concentration variation of suspended matter based on measurements along the estuary and during a whole tide (fig. 3 to 14).

The diagrams of figures 3 to 14 are not to be considered as representing absolute data. Indeed they only give an approximate idea of the distribution of suspended sediment as measured along this section of the estuary.

METHOD AND GRAPHIC PRESENTATION

All measurements were made in situ with a Davall siltmeter based on the principle of light extinction. They extended over periods of 13 hours in order to cover, for each station, the variation during a whole tide, but they only relate to summer periods (July - September).

On the top of each diagram of s.m.c. the average velocity of waterflow and the discharge at that moment are represented. They are based on data obtained between 1949 and 1959 (E. VALCKE *et al.*, 1966) and do not represent actual data at the moment of the s.m.c. measurement.

The reference time (0 hour) for each diagram is the time of high water at Flushing (Vlissingen).

OBSERVATIONS

The lowest values of s.m.c. (maximum 300 mg/l) occur at 3 hour (reference time) (fig. 3). At this time high water is registered at Antwerp. One hour later (4 hour, fig. 4) a considerable increase of suspended matter in the lowest water layers is measured between the Rupel mouth and Hoboken (more than 1.000 mg/l), while further downstream s.m.c. values are lower than 500 mg/l. An increase of s.m.c. (1.000 mg/l and more) downstream of Hoboken is measured at 5 hour (fig. 5). At this time, the values upstream from Hoboken are diminishing somewhat. From 6 until 8 hour, after high water at Flushing, no important changes are registered (fig. 6 to 8). But at 9 hour (fig. 9) a decrease in the s.m.c. occurs upstream from Antwerp and at 10 hour (low water at Antwerp) the s.m.c. values drop below 500 mg/l nearly everywhere in the section (fig. 10). At this time however higher s.m.c. values at Fort Frederick already indicate the effect of the rising flood waters.

During the following flood the s.m.c. rises again, although in the region between the Rupel mouth and Antwerp it remains somewhat lower than during the corresponding ebb period (fig. 11 and 12).

During ebb as well as during flood, the s.m.c. remains low downstream of the Ballastplaat.

On the upstream side of Antwerp changes in concentration with tide are important. The start of the ebb period is here characterized by an increase of s.m.c. (fig. 4). This zone of higher suspension values gradually drifts in a dowstream direction. During the flood on the contrary, this high concentration zone, which is first generated in the neighbourhood of Fort Frederik, does not reach far upstream from Antwerp. It is easy to see that the section between Antwerp and the Ballastplaat can be characterized not only by its high s.m.c. but also by important variations related to tide.

Furthermore the more important variations in s.m.c. are situated in the lower water layers. This is most probably due to effects of erosion, whereby recently deposited or older muds are brought into suspension again. The shear velocities calculated for this part of the estuary are sufficiently high for the erosion of important quantities of mud (S. WARTEL, 1972a and 1972b).

CONCLUSIONS

The suspension concentrations between the confluence of the Scheldt and the Rupel and the Ballastplaat are distinctly higher than these occurring further downstream. This zone of high s.m.c. corresponds to a zone of muddy deposits in the main channel of the river on one hand and an annual up- and downstream migrating boundary between fresh and salt water on the other hand. It is clear that a relationship between these three factors exists. The contact of fresh water containing a high degree of fine suspended sediment with salt water causes flocculation of the suspended sediment, followed by an active sedimentation and the formation of mud deposits. The suspension concentration in this section of the estuary also shows variations with tide. High s.m.c. alternates with

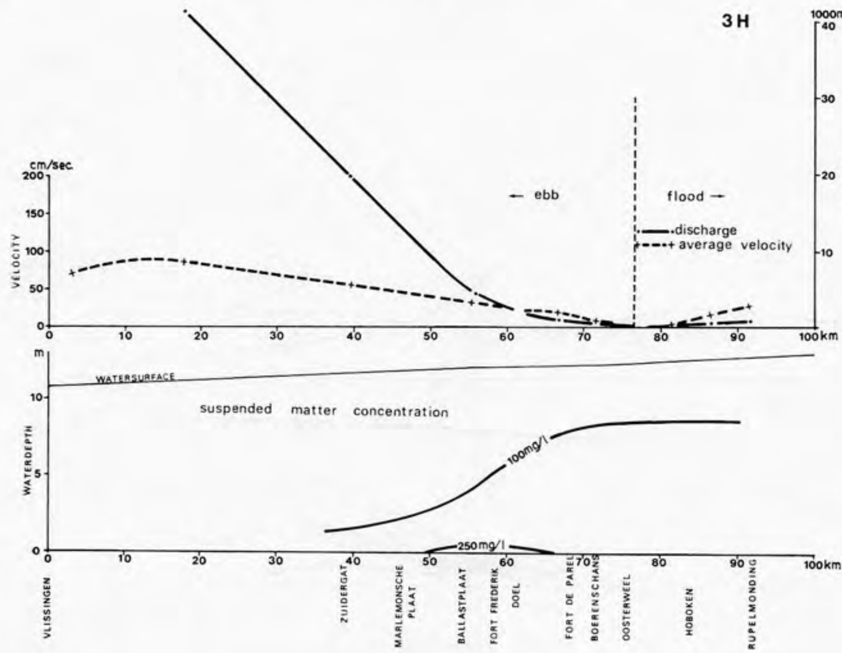

Fig. 3.

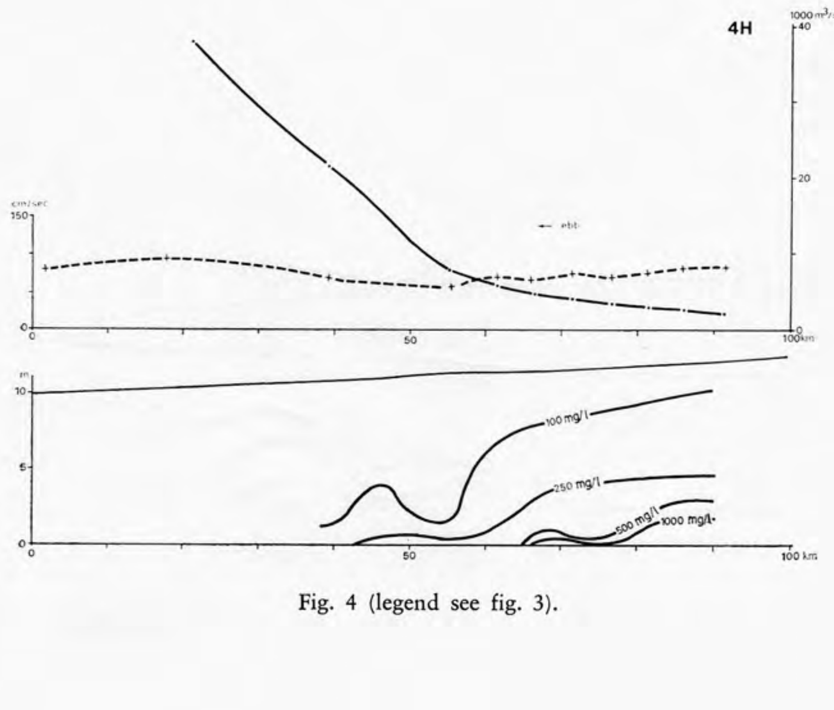

Fig. 4 (legend see fig. 3).

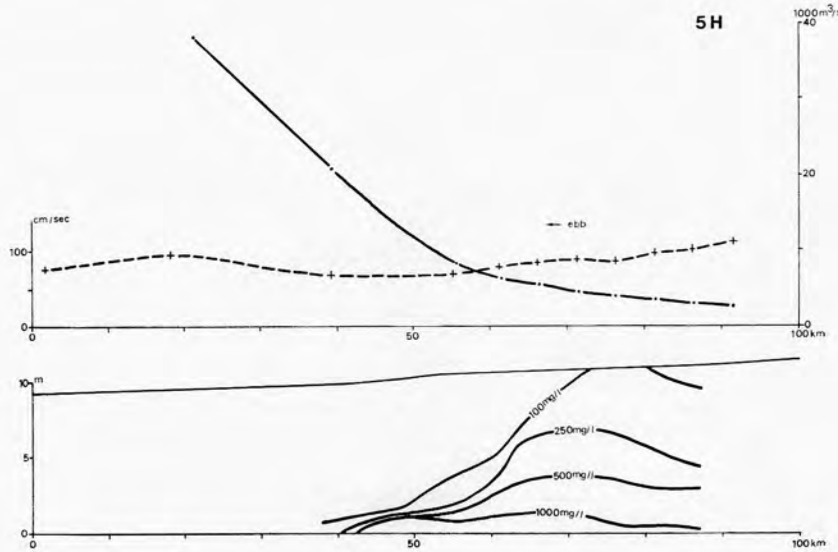

Fig. 5 (legend see fig. 3).

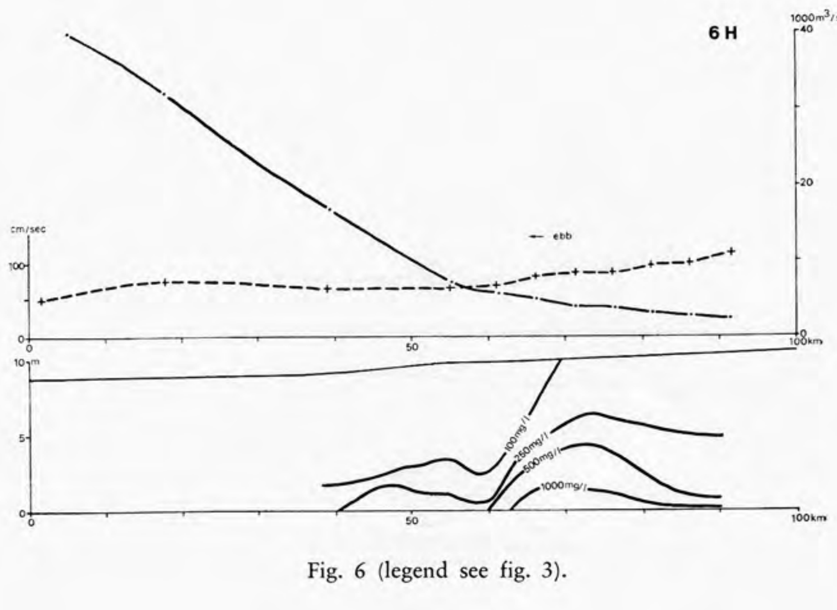

Fig. 6 (legend see fig. 3).

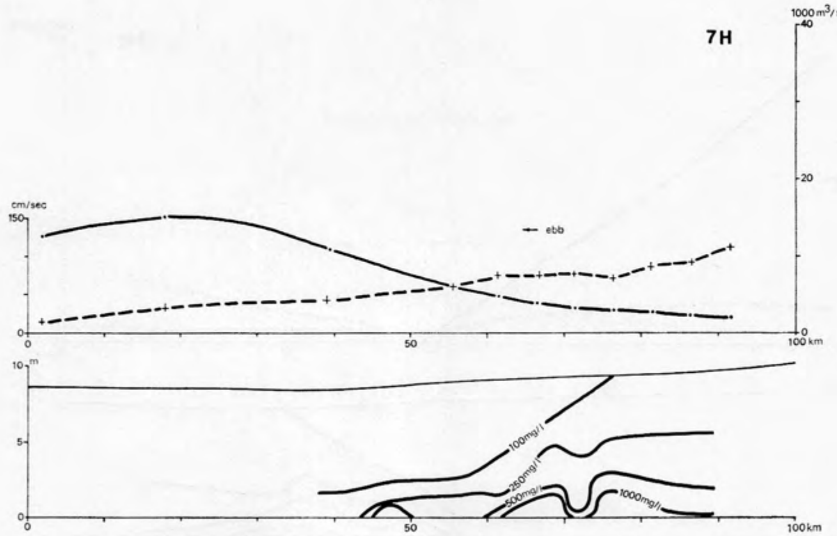

Fig. 7 (legend see fig. 3).

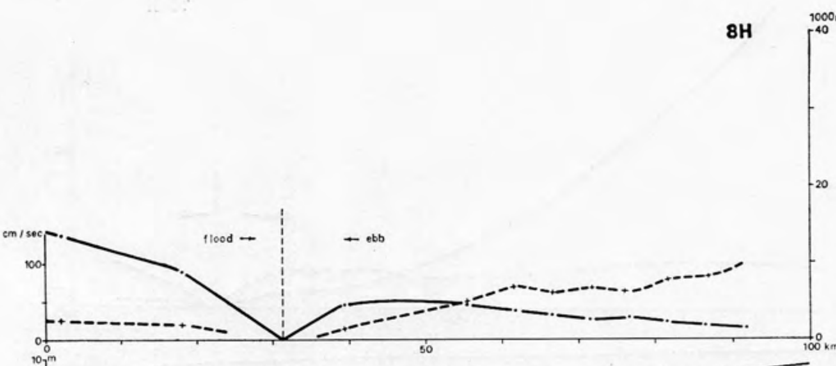

Fig. 8 (legend see fig. 3).

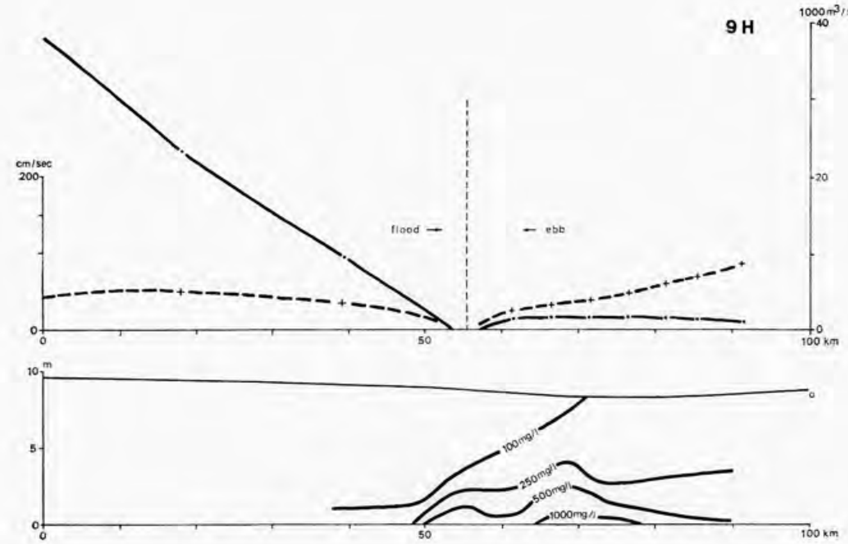

Fig. 9 (legend see fig. 3).

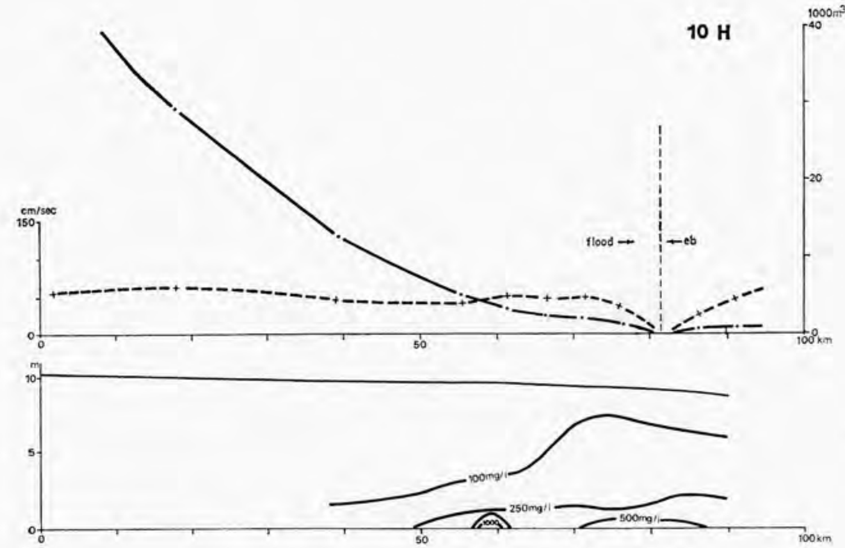

Fig. 10 (legend see fig. 3).

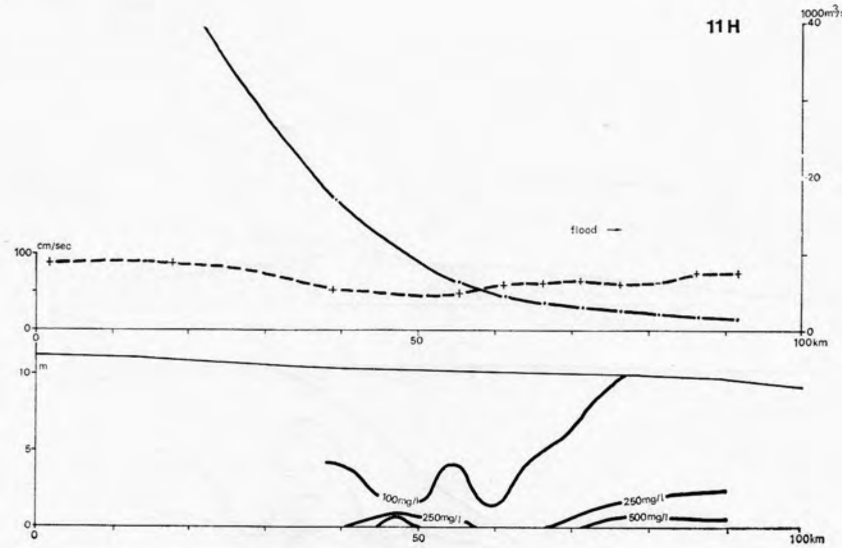

Fig. 11 (legend see fig. 3).

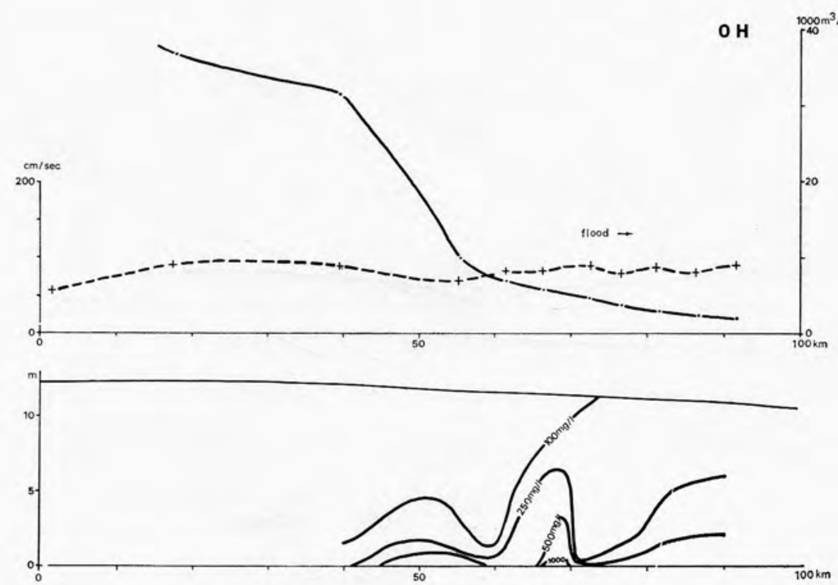

Fig. 12 (legend see fig. 3).

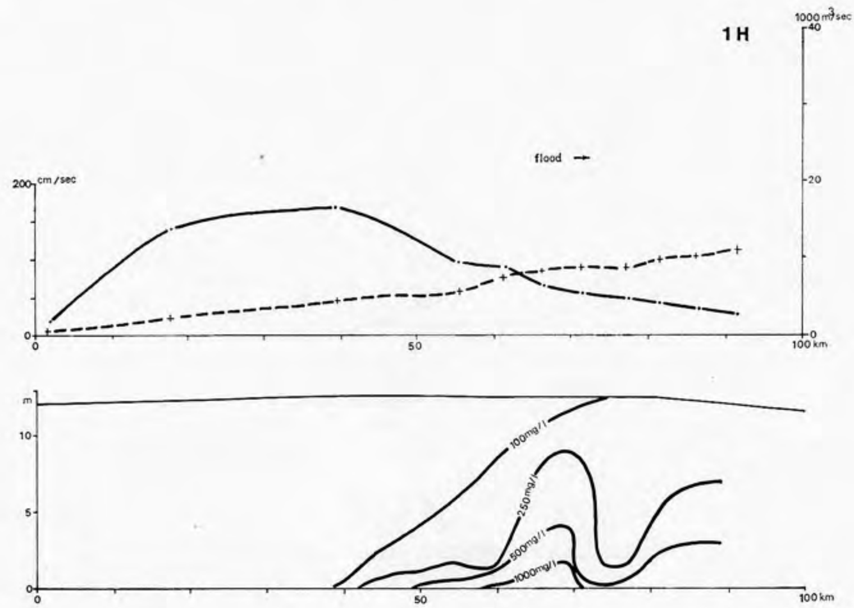

Fig. 13 (legend see fig. 3).

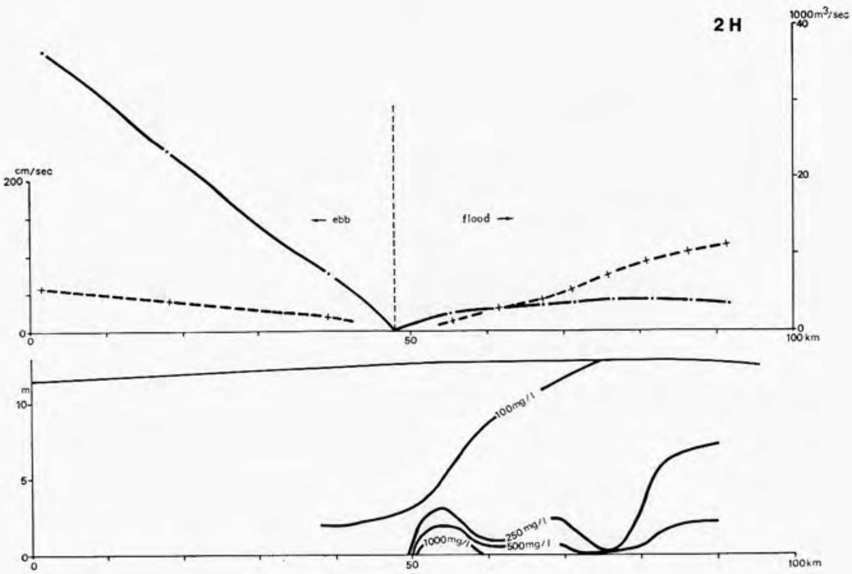

Fig. 14 (legend see fig. 3).

two moments of very low values respectively at high (fig. 3) and low water at Antwerp.

The migration of the zone of high s.m.c. in a downstream direction during ebb (fig. 4 and 5) indicates the transport of mud in this direction.

The highest sediment concentrations, occurring in the lowest water layers, are also due to the erosion of earlier accumulated and flocculated mud deposits. The erosional velocity of the water is sufficiently high to erode even important quantities of these fine sediments. The bulk of the mud deposits is located downstream of Antwerp. It is obvious that these deposits are formed during periods of highest sediment discharge and this occurs at the time when the boundary between fresh and salt water is located downstream of Antwerp.

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