Study of the movement of the principal fairway on the River Scheldt between Terneuzen and Hansweert by means of old river charts.

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Key words: Hydrography, River Scheldt, Sandbanks

SUMMARY

Between 1955 and 1965 the fairway "Middelgat" leading ships from Terneuzen to Hansweert on the right river bank silted up in favour of the "Overloop van Hansweert" lying on the left river bank.

This alteration occurred spontaneously without any human interference. A study of the position of this fairway and the silting up was carried out based on old river charts. These charts where obtained in the digital city archive of Antwerp. The oldest used chart dates from 1799 followed by different charts on various dates until today.

All those charts are based on different reference systems, for instance, the meridian of Amsterdam instead of Greenwich, making direct comparing impossible. To solve this problem the scanned charts were georeferenced with a geo-information program based on the position of the various church towers showed on these charts, giving positions in the world geodetic 84 system.

After georeferencing, the charts could be placed on top of each other and the fairway and the river borders could be compared in time, allowing us to make a study of the movement of the depth contours and the river bank.

When comparing the positions of the church towers, it was also possible to compare the precision of the old charts with the newer charts. These differences proved to be acceptable.

The soundings on the charts are also based on different horizontal reference planes. The older charts are based on a mean tidal level and the newer charts are based on Lowest Astronomical Tide value. Before we can compare the different depths on the charts they must be transferred to the same reference plane. This will be done using known reference points.

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1. Introduction

The port of Antwerp is located at the shore of the river Scheldt and is linked to the North Sea by the Westerschelde estuary. The port has played a major role in the history of Antwerp and still today it is one of the biggest ports in the world. The river consists of flood and ebb channels with a total tidal difference in height of about 5.50 m in Antwerp. Along the Scheldt that connects the North Sea to the port of Antwerp, there is a small region between Terneuzen and Hansweert where the flood channel is formed by the *Gat van Ossenisse* and the ebb channel by the *Middelgat*. This region is shown in Fig. 1. Before 1955-1965, the *Middelgat* was the main fairway in that region but from 1955-1965 onwards the *Gat van Ossenisse* became the main fairway. This alteration occurred spontaneously without any human interference. It is not exactly known what has caused this sudden change. It is the intention of this contribution to study the evolution of the principle fairway, position of the river banks and river borders in order to understand the causes for this sudden change.

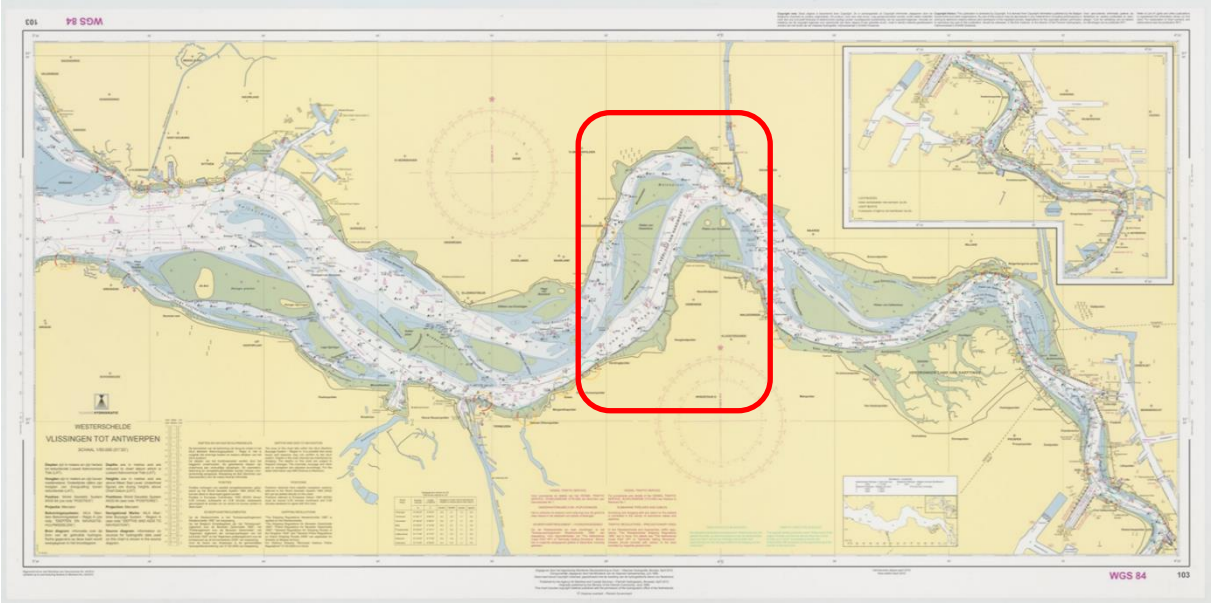

Fig. 1: Overview of the River Scheldt between the Westerschelde estuary and the city of Antwerp and the region where the fairway has suddenly changed; Indicated on chart 103 made by the Flemish Hydrigraphic Service in 2010

2. Working method

The study is done by comparing navigation charts of the river made in different years. Some charts were already a long time in my possession but other chart where obtained in a raster format at the digital City Archive of Antwerp. As this are raster charts is was only possible to make a visual comparison.

The chart 103 from the Flemish Hydrography of 2010 made in WGS 84 is used as a reference chart. On top of that chart, a grid was built using latitude and longitude lines. The position of still existing historical church towers was determined in that grid. Since the same church towers are shown on the historical charts, the same grid could be applied on the older charts.

3. Results

The evolution of the principal fairway can be reconstructed by considering the historical charts as snap shots of a process. For that reason, the results extracted from these charts will be presented in a chronological way.

3.1. Chart of Beautemps-Beaupré published in 1799

The chart is the first known navigational chart of the river with markings of the depths and dangers in the river. It has been made by Charles-François Beautemps-Beaupré (1766-1854), as commissioned by Napeleon. He worked at the age of 10 by his cousin Nicolas Bouache, a geographer, in Paris. In 1791 he was a member of the expedition of admiral d'Entrecasteaux in search of the lost expedition of La Pérouse during which he learned the art of chartmaking and invented a new chart making method descripted in his later works. Returned in France he was nominated deputy conservator of the French depot of maritime charts and maps. He was send to the Dutch country in 1799 to make a hydrographic study of the River Scheldt from Antwerp to Flushing and the North Sea coast. Resulting in a navigation map of the river.

The characteristics of this chart are summarized in Table I. The chart itself is shown in Fig. 2. There are no latitude of longitude marks on this charts. Places falling dry at low water are indicated with a dotted line and sandbanks remaining dry at high water are indicated with a bold dotted line. The depths on the chart are expressed in French feets, (32,4 cm) and are reduced to the low water level during the equinox. It is not marked which equinox but in lower left corner on the chart it is noted that the chart is marked "*Thermidor et Fructidor an VII, Vendémiaire et Brumair an VIII"* translated as July to November 1799, so we can assume that the mentioned equinox is this of the 23rd of September 1799. As there is no direct reference height for the tidal level on this chart, the comparison of depth with newer chart is very difficult. The names of the passes on this chart are written in French.

The *Middelgat (Passe du milieu)* is at that time the more pronounced fairway on the North side of the banks in the middle of the river. The pass of Ossenisse is only useable for small vessels with a very narrow paasageway at the site of Terneuzen. The Middelbank is indicated as staying dry at high water and more to the North is the *Capellebank* indicated as partially lying above high water level with the *Middelgat* passing between them. North of the *Capellebank* is the *Passe de Capelle.* On the map the waterway connection to the city of Hulst is visible.

TABLE I: Summary of characteristics of the chart of Beautemps-Beaupré

Chart maker	Charles-François Beautemps-Beaupré (1766-1854)
Publication date	1799
Chart scale	1/42000
Depth Units	The depths on the chart are expressed in French feet (32,4 cm)
Projection type	Unknown
Reference longitude	Not marked
Reference height	low water level at the equinox of 23rd September 1799
Remarkable items	The dates on the chart are given with the French Republican calendar introduced after the revolution and used between 1793 and 1806.

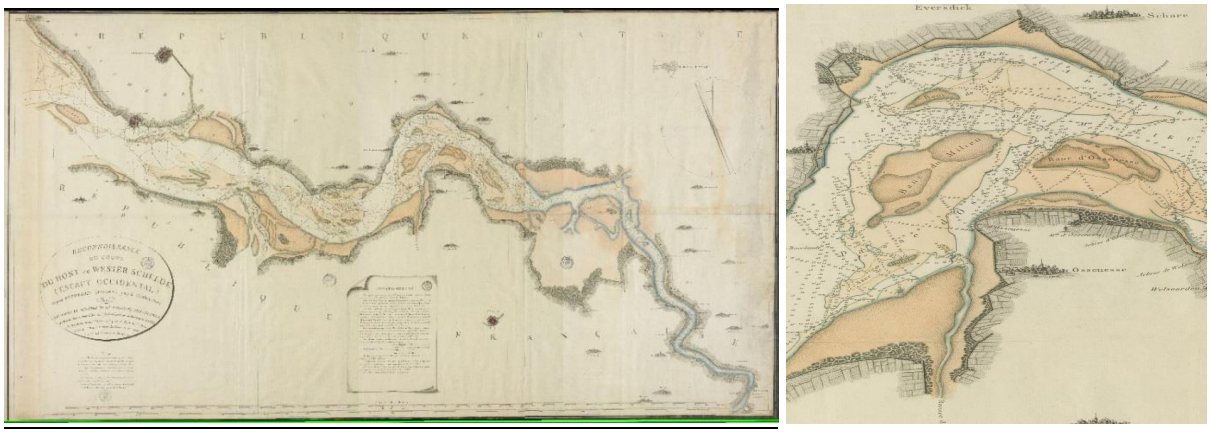

Fig. 2: Overview of the chart of Beautemps-Beaupré made in 1799 and a detail of the bend where the fairway has been changed.

3.2.Chart of Blommendal published in 1867

The map shown in Fig. 3 with its characteristics given in Table II is made by A.R. Blommendal who was a Dutch navy officer and chief of the Dutch hydrographic service. Unfortunately, the region that is the topic of this study has been divided over 2 charts, hampering a precise study of the depths. The depth contours are not equal so by placing the two charts against each other we notice some jumps in the contours. At the same time, the positions of the different church towers are given in latitude and longitude allowing a comparison in the differences in position between the WGS 84 positons and the local projection.

On the western chart we still see the waterway connection to Hulst. The main fairway is also the *Middelgat* lying between *Kapellenbank* and *Middelbank/Plaat van Ossenisse*. To the North of the *Kapellenbank* is the *Bogt van Kapelle*. The *Pas van Ossenisse* is not marked on this chart, there is only a small entrance South of the *Plaat van Hulst*, lying more to the South as on the chart of 1799.

TABLE II: Summary of characteristics of the chart of Blommendal published in 1867

Chart maker	A.R. Blommendal
Publication date	measurements are done in the summer of 1860 but published in 1867
Chart scale	1/25000
Depth Units	Dutch palms (10 cm)
Projection type	Cylindrical projection with 51°23' as middle latitude
Reference longitude	The meridian of Amsterdam
Reference height	The mean low water in the ports of Flushing, Terneuzen and Liefkenshoek during the period of the observations
Remarkable items	The unit for sounding is the Dutch Palm is rarely used. Occasional some buoys are marked on the chart.

Fig. 3: Overview of the chart of Blommendal published in 1867 and a detail of the bend where the fairway has been changed.

3.3. Chart of August Stessel published in 1869

Once Belgium had claimed its independence from the Netherlands in 1830, the treaty of the Scheldt determined that the river should remain accessible to ships heading for Belgian ports. Nevertheless, the Dutch government would demand a toll from passing vessels until 16 July 1863. It is probably in this context that one should read the first Belgian chart of the Scheldt. The chart was made by August Stessel who remained director of the Belgian hydrographic service until 1885.

According to the chart shown in Fig. 4, the tidal curves for different ports are shown in this chart. The chart does not contain much details to chartered depths but the deep contours are well marked at 2,5 – 5 and 8 meter above low water.

The main fairway passes close to Terneuzen and then going North to the *Middelgat*. There is only a small opening between the *Passe de Neuzen* and the *Middelgat* West of the *Middelbank*, named *Ossenisse bank* on this chart. There is no indication of a fairway South of the *Middelbank* and the connection to Hulst is sanded and not more accessible.

This is the first chart were the fairway is completely marked with buoys.

TABLE II: Summary of characteristics of the chart of Blommendal published in 1867

Chart maker	August Stessel
Publication date	1869
Chart scale	Not marked
Units	meter
Projection type	Not mentioned
Reference longitude	Markings relative to Greenwich
Reference height	The zero level in Ostend
Remarkable items	The notifications on the chart are in French. First chart with buoys.

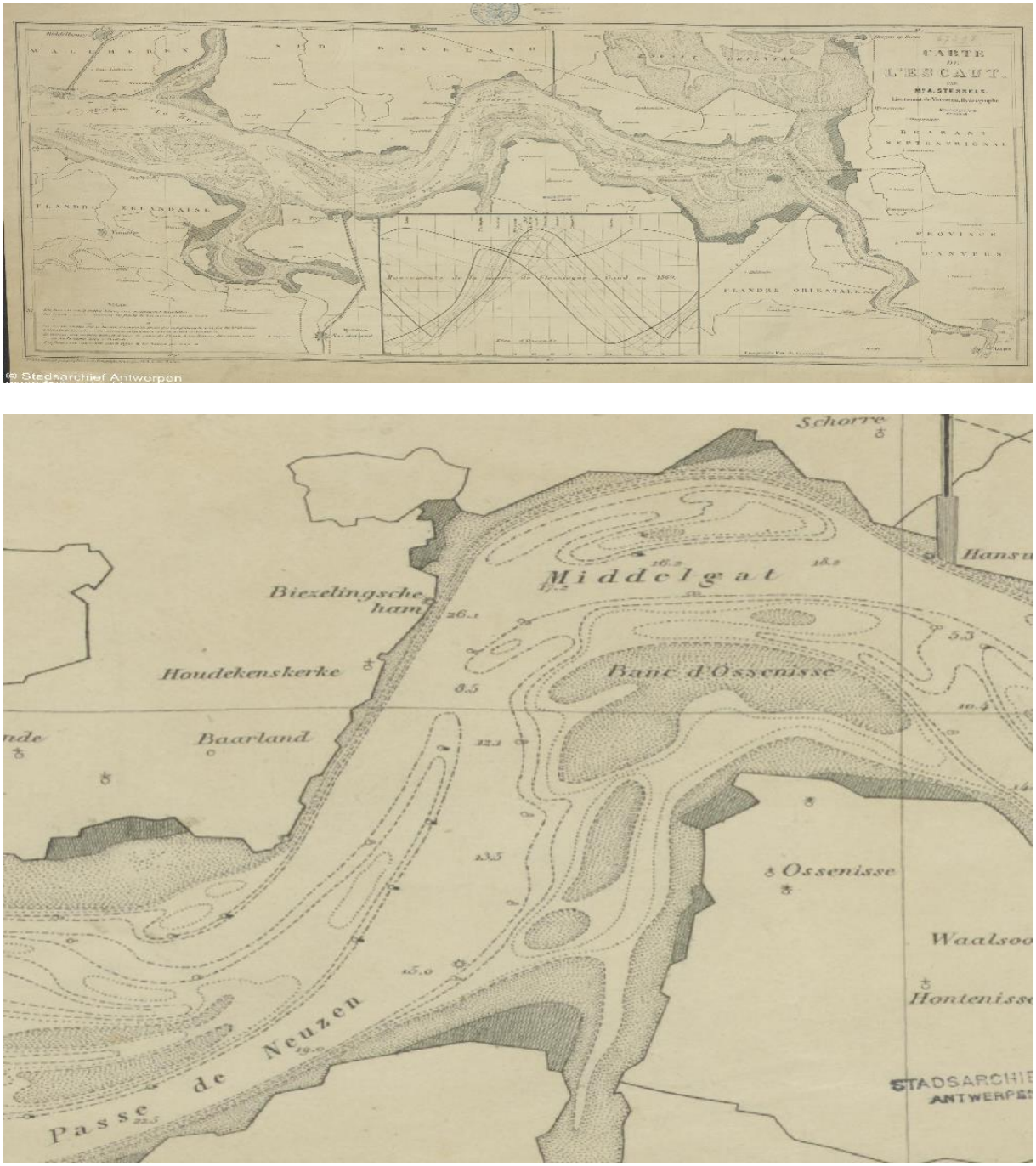

Fig.4: Overview of the chart of August Stessel published in 1869 and a detail of the bend where the fairway has been changed.

3.4. Charts of 1880 and 1882

The chart of 1880 is a Belgian Chart and the chart of 1882 is a Dutch chart. Both charts gives approximately the same information.

According to the charts, there is no fairway South of the *Middelbank* and there is only a small passage coming from Terneuzen to the *Middelgat*. This passage is marked by buoys. The *Kapellenbank* became small with a minor fairway North of the Banc.

TABLE III: Summary of characteristics of the Belgian chart published in 1880.

Chart maker	Belgian Ministry of Public Works - L. Petit and E. Rochet
Publication date	1880
Chart scale	1/20000
Depth Units	meter
Projection type	Not mentioned
Reference longitude	Meridian of Brussels
Reference height	Zero reference level of Belgium
Remarkable items	

TABLE IV: Summary of characteristics of the Dutch chart published in 1882.

Chart maker	Dutch Maritime Ministry T.E. de Brauw and M.C. van Doorn
Publication date	1882
Chart scale	1/50000
Depth Units	decimeter
Projection type	Not mentioned
Reference longitude	Meridian of Greenwich
Reference height	Mean low water level Amstedam
Remarkable items	The water depths in the table on this chart are referenced to the Amsterdams Peil,

3.5. Belgian charts of 1936 to 1953

From 1895 onwards, dredging did occur on the Westerschelde estuary and later in other locations in the river Scheldt. This is needed to assure a minimum depth and minimum width. This will affect the charts in the following decades. From this period onwards, the characteristics of the charts did not change substantially and is very similar to Table III.

On these charts, the *Middelgat* is a large fairway lying on the North site of the river. The *Middelplaat* is not marked any more on the charts and the *Middelgat* is turning around the *Platen van Ossenisse*, *Brouwersplaat* and *Molenplaat*. A new fairway is forming South of the *Platen van Ossenisse* but at the moment the fairway is ending in the middle of the sandbanks.
The *Kapellenbank* has disappeared

TABLE V: Summary of characteristics of the Belgian charts published between 1936 and 1956

Chart maker	Belgian Kingdom – Antwerp Seaways
Publication date	1936 – 1938 - 1946 – 1953 - 1956
Chart scale	1/50000
Depth Units	decimeter
Projection type	Mercator
Reference longitude	Meridian of Greenwich
Reference height	Zero reference level of Belgium (appr; mean low water spring)
Remarkable items	

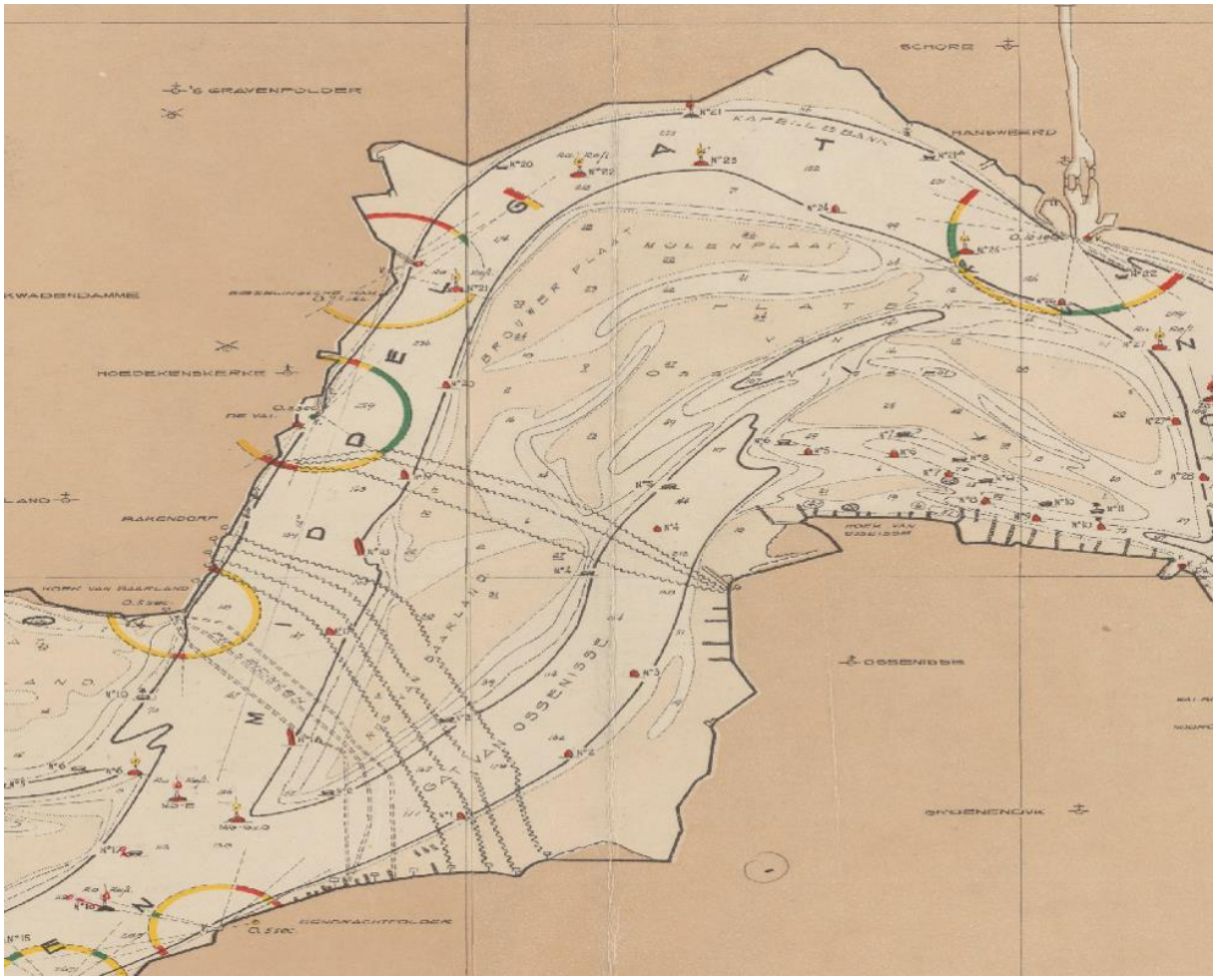

Fig. 5: Detail of the chart published in 1953.

3.6.Charts published between 1956 and 2010

In this period, 7 Belgian charts have been used with a frequency of 5 to 11 years. This gives a fairly good image about the evolution in this period. The following observations could be made:

- **Chart of 1956:** The *Middelgat* remains unchanged while the *Gat van Ossenisse* is forming more and more and makes nearly a complete short cut for vessel coming from Terneuzen and going to Antwerp. The fairway is completely marked by buoys and useable for small vessels. This can be seen in Fig. 7a;
- **Chart of 1962:** The *Middelgat* still stays at the same place but the *Gat van Ossenisse* is becoming a shorter and faster fairway to Antwerp. With dredging works this fairway is from this moment kept at navigational depths. A detail of this area can be seen in Fig. 7b;
- **Charts of 1967, 1978 and 1983:** The *Gat van Ossenisse* is the main fairway and is now renamed as *Overloop van Hansweert*. The *Middelgat* is narrowing and becomes filled up with

sand, especially the entrance at the South side which became very narrow and dangerous for big vessels. The chart of 1983 can be seen in Fig. 7c.

– **Charts of 1996 and 2010:** The southern entrance of the *Middelgat* is completely filled up and no more useable. All traffic is now using the *Overloop van Hansweert.*

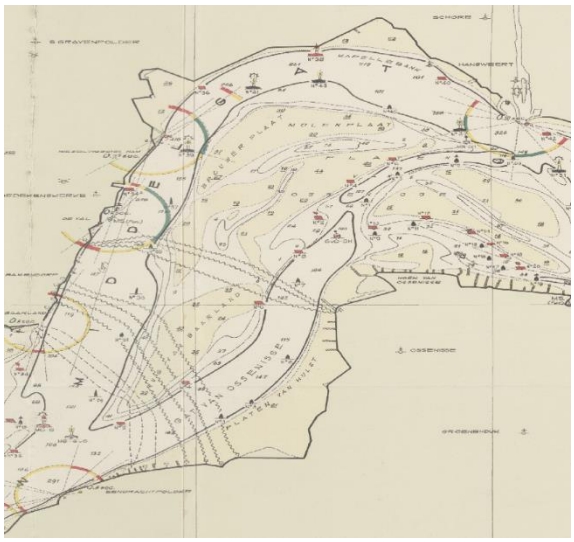

Fig. 6a: Chart of 1956

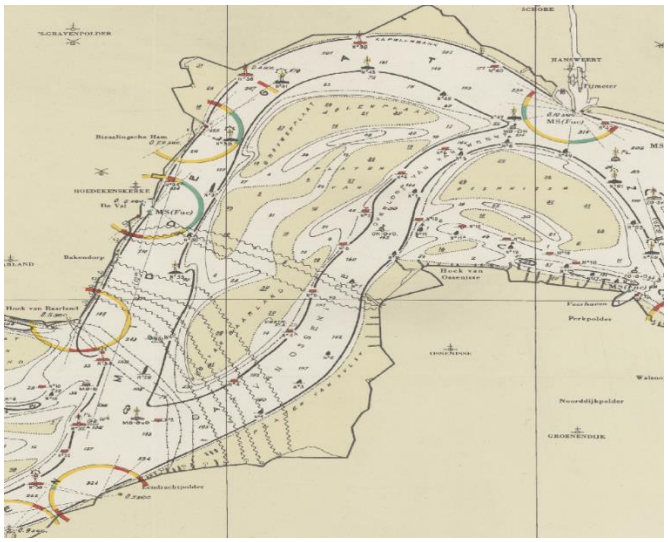

Fig. 6b: Chart of 1962

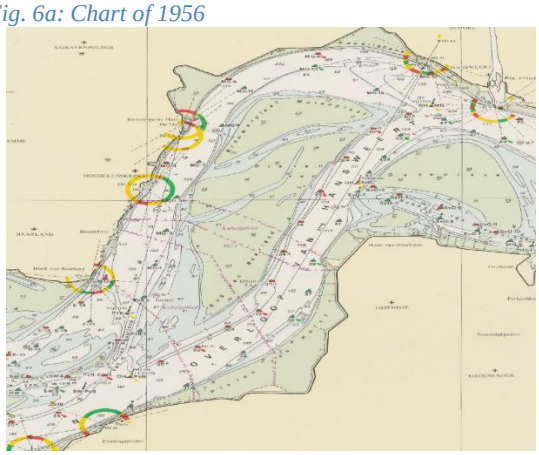

Fig. 6c: Map of 1983

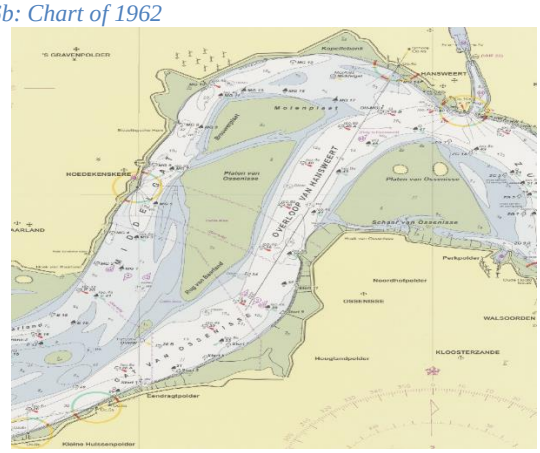

Fig. 6d: Map of 2010

TABLE VI: Summary of characteristics of the Belgian Charts published between 1962 - 1983

Chart maker	Belgian Kingdom – Antwerp Seaways
Publication date	1962 – 1967 – 1978 – 1983
Chart scale	1/50000
Depth Units	decimeter
Projection type	Mercator
Reference longitude	Meridian of Greenwich
Reference height	Local Mean low low water spring
Remarkable items	

TABLE VII: Summary of characteristics of the Flemish Chart nr 103 published in 1996

Chart maker	Flemish community – Flemish Hydrography – chart nr. 103
Publication date	1996
Chart scale	1/50000
Depth Units	decimeter
Projection type	Mercator
Reference longitude	Meridian of Greenwich
Reference height	Local Mean low low water spring
Remarkable items	

TABLE VIII: Summary of characteristics of the Belgian Charts published in 2010

Chart maker	Flemish community – Flemish Hydrography – chart nr. 103
Publication date	2010
Chart scale	1/50000
Depth Units	decimeter
Projection type	Mercator – WGS 84
Reference longitude	Meridian of Greenwich
Reference height	Lowest Astronomical Tide
Remarkable items	

4. Results

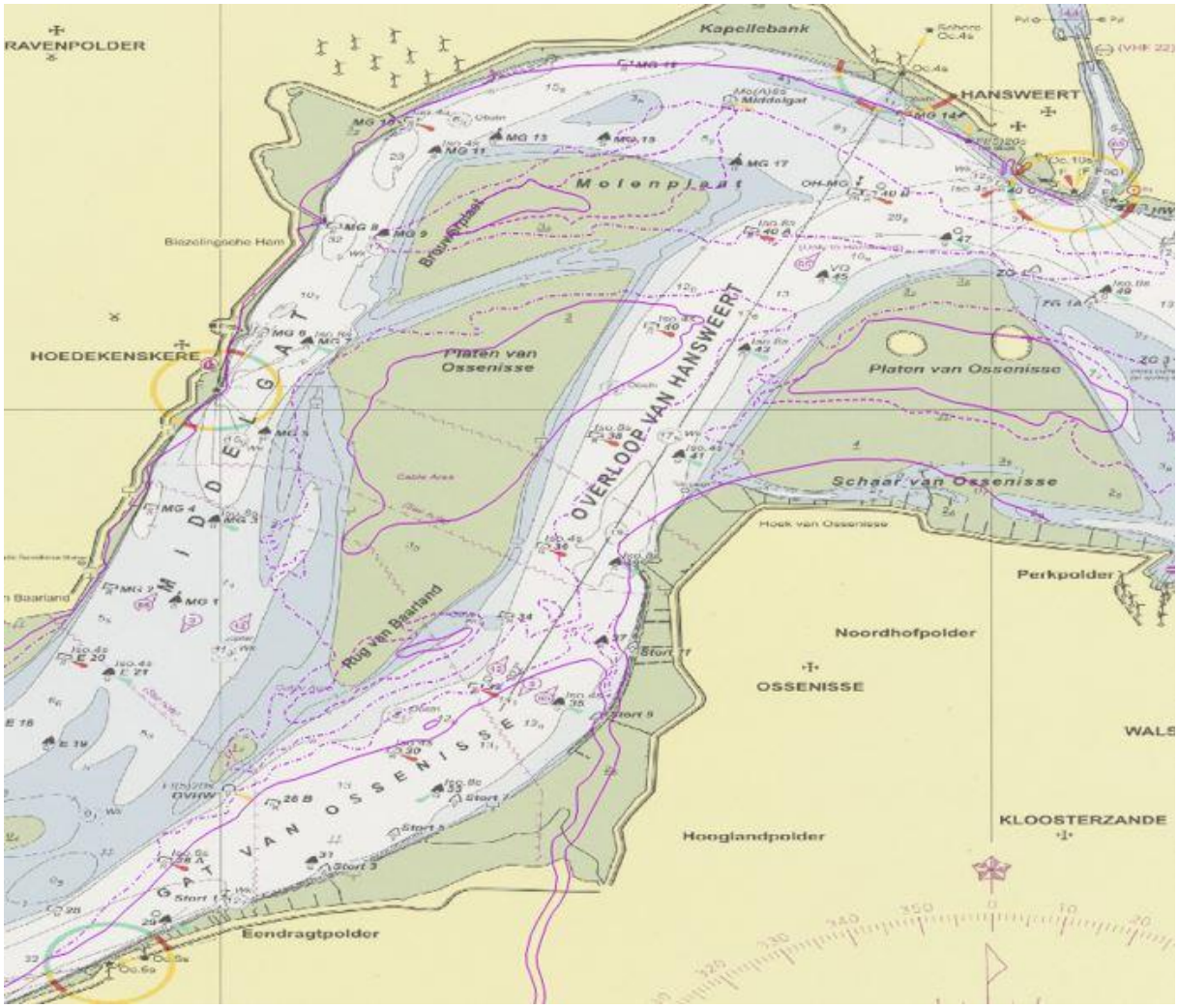

Fig. 7:Reference chart 103 ed. 2010 with the contour lines of the chart of 1799 of Beautemps-Beauprez..

Fig. 7 shows the depth contours of the chart of 1799 in relation with the reference chart 103 edition 2010. The actual position of the *Overloop van Hansweert* was not useable in 1799 and covered with sandbanks. At the original position of the *Middelgat* is now a small connection between the actual *Middelgat* and the *Overloop van Hansweert*. The *Middelgat* moved completely to the North and is now lying against the riverbanks.

After georeferencing the old chart of 1799 and lying her over the actual chart it is noticeable that the riverbank at the Northside is nearly identical as the riverbank on the reference chart of 2010. At the

South side of the river a large amount of sand disappeared and the connection to Hulst completely sanded up.

5. HORIZONTAL REFERENCE PLANE

It is very difficult to establish a common horizontal reference plane as the depths on most of the charts have another reference plane, some without any known points. For instance Beautemps-Beaupré referenced his chart to the low tidal level during the equinox at the moment of the observations. There is no reference point to do an exact comparison with the actual tidal level.

The horizontal reference plane on the Belgian changed from the old Belgian Zero Level. This corresponded with the mean low spring tide at the port of Ostend. This level was later changed to the common reference plane named *Tweede Algemene Waterpassing (TAW)* the reference plane still used today in Belgian for terrestrial geometry. As with most nautical charts the reference plane used between 1962 and 1996 was the local mean low low water spring. This was the mean of the lowest tidal levels measured during spring tide. This level was later replaced by the Lowest Astronomical Tide. This is the lowest tidal level that could be calculated and predicted by using the harmonic constants found after years of tidal observations.

On the Dutch chart of 1882 the reference plane is de mean tidal level of Amsterdam, later transformed to the *Normaal Amsterdam Peil (NAP)*. An horizontal level still used in many European countries. This level is 2m33 higher than the Belgian TAW.

The horizontal referencing still needs to be done in this study. It will be possible by comparing the tidal informations found on most of the chart with tidal heights in most ports on the charts. With this the differences in levels can be found and the depth soundings on the chart can then be adjusted to a common horizontal level.

6. CONCLUSION

This study demonstrated that it is possible to study the moving of sandbanks and fairways over time. This is illustrated for the area between Terneuzen and Hansweert. The depths in the river are nowadays maintained with dredging works and by placing sand at will at determined places in order to keep the sandbanks into position. However, in the past, the principal fairway has changed in the period 1955-1965. At that moment there were none notifications of dredging works in de mentioned area.

The mean reason for this changings are still unknown and there are many possible reasons to mention. One of them is the general flooding of The Netherlands and Belgium in 1953 enabling the river to change his riverbed. Another possible reason is that due to dredging works in other parts of the stream intensities changed and created new sandbanks and gullies.

Acknowledgements

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