Interrelationship between hydrography, sedimentology and modelling .

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Introduction

Hydrography may be defined as the science of measuring and depicting the parameters, necessary to describe the precise nature and configuration of the seabed, its geographical relationship to landmass and the caracteristics and dynamics of the sea [1].
Those parameters encompass different disciplines such as bathymetry, the knowledge of the horizontal and vertical tides, waves, the physical properties of the seawater (mainly temperature and salinity), geology, geophysics.
The major benefits, gained from the modern hydrographic surveying, are the abilility to compile detailed and quality controlled graphic documents (sea charts) and to set up the "ECDIS" (Electronic Chart Display and Information Systems); this information is mainly used by the mariners but also by other people, concerned with the marine environment, such as hydraulic engineers, oceanographers, marine geologists, sedimentologists, modellists and environmental scientists.
Another important application of the hydrographic know-how, since many years, is its use in the planning of the marine resources, i.e. the exploration and the exploitation of the seabottom.

EVOLUTION OF HYDROGRAPHIC SURVEYING FROM 1800 TILL NOW

1. The first very simple but rather reliable hydrographic techniques for the areas of the lower countries (Belgium and Holland) started in Napoleon's time, namely from 1799 till 1811, when the French hydrographer Charles-François Beautemps Beaupré (1766-1854) surveyed the coasts of Flanders (Belgium), the river Scheldt and the southern part of The Netherlands.
In those areas for the first time, the positionning was carried out by observing the two angles between three marks on land by sextants; the station pointer was used for mapping the intersection of the two angles.
This sort of positionning provided sea charts, on which only the general shapes of the channels and the banks could be recognised.
At that time, for the depth measurements, the hand lead was still the common practise. If such a lead line or later on, for deeper bottoms, a mechanical sounding gear was used, there was quite an interval between consecutive soundings, dependant on the personal factor and/or the efficiency of the machine. This means that, as a matter of fact, only a limited amount of soundings could be gathered; so, a complicated bottom configuration, such as the sandwaves on the sandbanks and in the channels, could not be identified.
Nevertheless, from this time on (the beginning of the 19th century), these data already could be used for the monitoring of the general shapes of the channels and the sandbanks [2 and 3], not only in the mouth of the river Scheldt but also for the area of the so called Flemish Banks. By doing this, the stringent condition was that the available charts had to be converted to the same horizontal and vertical standards (i.e. the European Datum 50 as projection system and local mean lowlowwaterspring as chart datum).
The Belgian engineer Ir. P. De Mey was in fact the first explorer, who used some older charts for making comparisons (but without introducing any sort of correction on the horizontal and vertical standards) [4].
Many years later, the Dutch engineer J. van Veen did the same, but he extended the area of the Flemish banks more westwards to Dover Street; at the same time, he recognised the typical patterns of the ebb- and flood channels in the area of the Flemish Banks [5].

2. As, some years before Worldwar II, the first versions of the single beamed echosounder became operational, the same van Veen examined - for the first time - the sandwave structures of some banks in the Dover Street and the southern North Sea [5].
He tried to explain the general shape and the direction of these features, but, as the information of an echosounder is limited to one single track, no doubt, it was very difficult for him to extend his study to some other areas and to make more detailed conclusions concerning these configurations.
Positionning by sextant angles was only possible to approximately 12 km from the coast line; for the areas beyond that distance, buoys were used and, after World War II, the Decca Navigator, as the first radio positionning system for shipping and surveying.

As the last system was not very adequate for hydrographic suveying, in the late sixties, positionning systems, more adapted for the needs of hydrography, became operational.
In this manner, the accuracies on the planimetric coordinates considerably increased, mainly for the remote areas and fortunately the dependence on the terrestrial visibility was no longer existent.
The use of the side scan sonar in the seventies was also, among other applications, a big improvement for the determination of the direction of the sandwave crests.
Also in the early sixties the existence of moving crests of sandwaves in the deep draft routes, situated in the southern part of the North Sea, was a big concern for the hydrographers of the national hydrographic services of France, UK and The Netherlands.
Therefore, from that time on, for the safety of navigation, some critical areas were resurveyed periodically and the tasks were shared by the three hydrographic services concerned.
This sort of international cooperation was adopted on the first meeting of the North Sea Hydrographic Commission (NSHC) at The Hague (The Netherlands) in October 1962.
Later, on the 15th Meeting of the NSHC at Antwerp (Belgium) in September 1984, the periodical monitoring of the so called boxes in the Trafic Separation area at the southern part of the North Sea was adopted, which led to the Four Nations Agreement of 1984 (meanwhile Belgium was also involved). These check surveys delineated areas of national responsability, having survey intervals, varying from 1 to 5 years.
In 1998, the Agreement of 1984 was subject to a revision; France, on a meeting of the 4 nations involved, presented a report (in French), where, for 4 boxes in Dover Strait and for 4 boxes at the southern entrance of the North Sea, some important movements of sand dunes were identified during the period from 1984/1985 till 1990/1992.

3. For the time being, the single beam measurements with a hydrographic echosounder and with a side scan sonar provide still always valuable records. The earlier shore-based positionning systems are now replaced by the allround - code based - Differential Global Positionning System(DGPS), increasing considerably the reliability and the accuracy of the hydrographic surveying.
Further, with the venue of the multi-beam systems, it is possible - specially in complicated areas- to make evidence of all features, such as the sand dunes and even of the smaller hazards on the sea floor.
The “oldies” in hydrography must emphasize also the ever growing possibilities of the computer techniques, which allow the hydrographers to store big quantities of data and to process and represent them as well.
The Belgian Coastal Hydrographic Service, Oostende, participated in the EC programme STARFISH (“Sediment transport and bedform mobility in a sandy shelf environment”), as a part of MAST II, which was set up to run over more than 3 years (from January 1993 to the end of April 1996).
Part of Task 1 of this project dealed with “the chronosequential multibeam echosounding by vessel: recording and processing”. The overall task was related to the assessment of the volumetric and the morphological evolution trends of the Middelkerke Bank; this is a large sand bank, off the Belgian coast, belonging to the area of the Flemish Bank complex.
As it was practically impossible to resurvey the entire bank at the desired frequency of at least 3 times a year, two smaller areas, R2 and R4, were chosen as best reflecting the behaviour of local bedforms.
These two areas are not the shallowest parts of the bank, but do contain a number of identifiable sandwaves.
The multi-beam sounding tracks were spaced 40 to 50 metres, depending on the local depths.
Nevertheless, during the summer and autumn of 1995, the Coastal Hydrographic Service was able to survey the whole of the Middelkerke Bank simultaneously by means of the common vertical echosouder and by the EM 950 swath sounding system of KONGSBERG SIMRAD.
The details of this study are given in the References 7 and 8; the general conclusions were:

- the surface layers of the shallower R2 box only were found shifted with some 20 metres after a stormy period, but, later on, this shift reversed gradually towards its original situation;
- the deeper R4 box gave evidence of a large stability, mainly in the tranversal direction of the bank;
- once more, the high degree of an overall stability in the Flemish Bank area, found by the earlier comparisons of the older hydrographic maps [3], has been identified;
- however, later re-surveys of the 2 boxes on suitable occasions took place and the continuation of those for the future is also highly desirable.

4. Finally, as I already tried in an earlier paper [9], we could venture upon predictions about possible future developments in the hydrographic surveying.
First, I think that very soon the DGPS, based on OTF-techniques, will come into common use in hydrography; in this manner, the necessary tidal corrections and the attitude parameters of the survey vessel (roll, heave and pitch) may be determined at the same time.
Further, considering that I am NOT a sailor myself and probably, as a matter of fact, not influenced, biased or prejudiced by any sea navigational concerns or feelings, I think that hydrographic surveying by ships or similar

vehicles remains a - sea-state dependent - business; it is also a time consuming process for the data collection, due to the lower speeds of the survey vessels.
Sea surveying from planes and helicopters with laser technology is already a quick and adequate possibility in clear coastal waters.
Satellite derived data may provide a cheap (less time consuming) method for mapping large near-shore areas. The imagery from satellites can be either passive (optical or micowave) or active (radar) [10]. In the last system, the return radar pulse provides us with sea surface details, such as surface roughness and current information. These data are influenced by the bathymetry in shallow waters, so that, by tide en current modelling, they can be used to derive the sea bed topography.
For our less transparant coastal waters, in the lower countries, we already did some trials with the last remote sensing techniques
A contract with the European Space Agency (ESA) allowed the three contrac-tors (Argoss BV, Vollenhove, The Netherlands – the University of Ghent, Belgium - the Coastal Hydrographic Service, Oostende, Belgium) to make a - one year - study of the Kwinte- and the Middelkerke Bank (for 1998). Here, the Dutch spin-off firm Argoss BV was the manufacturer of the system.
For this study, the information, coming from the ERS II-satellites, was taken into account, providing pixel-sizes of 25x25 metres; basicly airborne data can also be used, where pixel-sizes of 3x3 metres can be obtained [11].
So far, the results were satisfactory as far as only small-scale comparisons between the BAS records and the CARIS electronic chart-files of the concerned area occur. By comparing mid-scaled (e.g. 1/20.000)- and large-scaled charts (1/5.000) sometimes the differences are still too high; the histogram of the frequency distribution (where 6893 values were taken int consideration) indicated also skewness to the right. This means that the frequencies of the differences of +1 dm and more (i.e. the conventionnal measurements being deeper than the BAS ones) are much higher and also more spreaded over the higher positive differences than at the other side; a further detailed examination gave evidence that, in the shallower part (areas, less than 10 metres), the differences were the highest; here also the spreading of the positive differences was bigger, which means that the system is less accurate on the shoals...
An explanation for this phenomenon of the skewness cannot be given.
These first, perhaps unsatisfactory, results do not mean the end of further endeavours, because the continuation of the system is assured with the start of a new ESA contract.
Perhaps in a not to far future, better results with a modified system, perhaps airborne installed, could provide us with better results, allowing to reduce considerably the need for the classical sea surveying.

CONCLUSIONS

The complicated configurations of the sea bottom worry the hydrographers since quite a lot of time.
Their periodic hydrographic activities in the channels, covered with sand dunes, mainly were and are still always intended for the safety of navigation.
A further concern is coastal management (coastal protection, harbour and dredging works, etc;) sedimentological knowledge of the movements of the channels and banks is also needed; this knowledge can only can be enhanced by obtaining more detailed and reliable bathymetric information.
As the standards of precision increased, specially during the last 10 years, this information is also more and more applicable for scientific sedimentological studies and morphological modelling.
We explained that the use of ships is time consuming and thus expensive and that in the future – let us hope - still more complicated and reliable systems, will reduce or eliminate this usage of ships, providing us, at least, the same details in a shorter period of time.
This possibility would also be interesting for a faster monitoring of the situation in critical or – scientificly interesting – areas.
In ancient times, the Greeks made the following statement: “παντα ρει“ or “everything changes as the time is passing by”.
Let us hope this proverb also applies to the future positive developments in hydrography!

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