SOUNDINGS ...

We promised to publish comments received following our short article under the heading of "SOUNDINGS" in edition 60 of LIGHTHOUSE. You may recall the article was related to "What is Bottom".

Following are several comments we received.

"I am responding to your column "SOUNDINGS" in edition 60 of Lighthouse (Fall/Winter 2001) which arrived 3 January 2002.

Preamble

I am amazed as well as disappointed that you are not aware of the developments that have taken place during the last 30 years regarding the determination of depths in areas with fluid mud and silt. Admittedly most of these developments took place in Europe. However the paper "Definition of the Seabed in Navigation Routes through Mud Areas" was presented in Canada as early as May 1979 at the 1st International Hydrographic Technical Conference held in Ottawa (details of this paper and other relevant publications are listed at the end of my letter). The reason for my amazement and disappointment is that I always admired the CHS for taking the lead in research and development and in implementing new technologies (and I was proud to be part of that organisation) so I expected it to stay abreast of developments elsewhere. If there is a lack of awareness amongst Canadian hydrographers I think it would have been caused by their unwillingness to become members of the Hydrographic Society and/or a lack of access to suitable journals (the latter was certainly the case when I was in the CHS).

The Establishment of Nautical Depth

After leaving the CHS in 1978 I worked at the Maritime Research Institute Netherlands in Rotterdam and in 1981/82 became quite involved in research on navigable depth as an expert witness in a court case. The depth that is really available for ship traffic then began to be called "Nautical Depth". It is defined as the depth measured from the water surface to the point where the water density reaches a specified value. In the Rotterdam Waterway for instance Nautical Depth is the depth at which the density reaches 1.2 tm^{-3}. If part of the ship's hull were to move through "muddy water" with a density greater than 1.2 tm^{-3} it was assumed the manoeuvrability of the ship would be affected too much for safe navigation. Density is unfortunately not the only criterion that determines the effect it has on ship behaviour. Therefore it cannot be assumed that what is acceptable for Rotterdam is acceptable elsewhere. The shear strength of the material, be it mud, sawdust or any other soft material and whether it is in suspension or more or less consolidated, as well as the presence or absence of gas in it also significantly influences the manoeuvring characteristics of a vessel.

The Influence of Nautical Depth on Ship Admission Policy

Around 1981 it was determined in tank tests at the Netherlands Ship Model Basin as well as with a real VLCC entering the Rotterdam Waterway that, provided the density was no more than 1.2 tm^{-3}, the vessel could proceed safely and behaved like any other vessel subjected to very shallow water conditions. Note that the ship's keel in these circumstances is in muddy water with a density of less than 1.2 tm^{-3} due to the minimum Under Keel Clearance (UKC) the Rotterdam Port Authority requires. At that time it was not known how much more and in what way manoeuvrability would be affected if the ship's keel is immersed below the Nautical Depth density of 1.2 tm^{-3}.

The Rotterdam Port Authority provided the pilots of all vessels that could be constrained by these conditions with up-to-date chartlets. These showed density contours together with the soundings. On the basis of these chartlets the pilot could then determine whether the ship could proceed. This was possible whenever the depth on the chartlet was less than the required depth and its associated density was less than

1.2 tm^{-3}. The method may well have changed, as it is now 20 years since this approach was first used. Since that time newer methods have been devised in determining density and more research has been carried out on the behaviour of floating mud and its influence on ship behaviour. For instance the Oceano Report (see list of literature) describes a French density meter introduced in 1986, which was an improvement on earlier models. Furthermore the information may well be shown differently or perhaps only nautical depth is shown now that the pilots are experienced in making use of it. There must be pilots currently employed that have never piloted vessels before the implementation of Nautical Depth. These pilots would feel completely at home navigating ships through areas that more than 20 years ago would have been considered too shallow and would first have been dredged to the design depth of the channel.

The Influence of Density on Depth Measurement

My own research, based on fieldwork carried out by others as well as personal experience, showed that an ordinary lead will always indicate the greatest depth. An electric hand lead shows less depth than an ordinary lead, while an echo sounder with a 210 kHz transducer indicates the least depth. The variation in measured depth between these three methods depends also on the degree of consolidation of the silt. What was most significant however was that in the tests done, the echo sounder (a Krupp Atlas) always indicated a depth where the density was 1.06 tm^{-3}, while the electric hand lead indicated a depth where the density was around 1.3 tm^{-3}. This was so regardless of the degree of consolidation of the silt. From this it can be seen that a standard lead will not detect the presence of mud until the density is well in excess of 1.3 tm^{-3}.

If the riverbed has been disturbed, either by a sudden influx of silt / mud or a ship with very little UKC moved through it, the density profile will be distorted. Any depths measured right after this event would be significantly shallower than those measured a few days or weeks later.

It was also discovered that 30 kHz transducers were much less consistent than the 210 kHz transducer in showing an echo at a constant density level. However it always showed the “seabed” at a depth where the density exceeded 1.2 tm^{-3}. In other words it could not be trusted to provide correct depth information in areas with silt or soft mud.

A striking example of this was experienced in Stony Lake on the Trent-Severn Survey in 1968. The Kelvin Hughes 26A echo sounders then in use by the CHS employed a frequency of about 30 kHz. For a number of days in the main body of the lake the greatest depths obtained were in the order of 90 feet halfway between shores. One day however one of the hydrographers, who had not been out in that area before, for some reason had cranked up the gain control. When his sounding roll was scaled we suddenly noticed a faint bottom appearing at less than half the depths obtained previously. Not only that, it was flat and at a fairly constant depth right across, whereas the previously measured depths plunged right down the moment the launch started its sounding line (it was common to touch a rock with the bow and measure 60 feet on the sounder). Upon investigation this faint bottom turned out to be soft mud and the whole area had to be sounded again. Ironically this happened a year after the Rotterdam Port Authority had already carried out its tests with the various frequencies and lead line leading to the results I quoted above. If only we had been informed then !

Developments after 1983

Since my move to Australia in 1983 I began to lose touch with the further technological developments. However I am sure this concept of nautical depth and its use by port authorities must be reasonably widespread. For instance I gave a paper on this topic at a symposium held at the Australian Maritime College in 1985 and received many inquiries from pilots and harbourmasters for several years after that. A number of papers have been produced over the years although I am not sure in what journals or at what symposia and when. If you wish to find out more I suggest you consult the (mostly quite old) publications listed below (there are many more but unfortunately they are in Dutch). Newer articles should be looked for

in maritime oriented journals and PIANC proceedings. I have scanned the Hydrographic Journals from 1979 onwards and included in my list any relevant articles.

Summary

Summarising the answers to your questions: Yes, for the past twenty years we have been able to measure the density and the height of the mud / silt layer and we have known how dense the muddy water may become, before it unduly affects the ship's manoeuvring behaviour.

I take this opportunity to wish you and all my former colleagues a healthy and prosperous 2002 and a safe field season for those not yet retired.

Best Regards,
George H. Goldsteen
Lecturer in Hydrography (retired)
Lecturer in Navigation (not quite retired)"

Partial List of papers on Nautical Depth and Related Topic:

Bakker, D.J., "Density measurements in conjunction with echosounding", The Hydrographic Journal No. 14,
April 1979.

Goldsteen, G.H., H. van Donselaar, "Hydrographic and hydrodynamic analysis of the 'Spring Odessa' incident",
Maritime Research Institute Netherlands, Rotterdam, 1982 (this paper was used in a court case and thus confidential at the time and was not published. It taught a great lesson to the port authority concerned about proper surveying procedures, dredging, ship manoeuvring, and of course nautical depth. It led to a seminar on Nautical Depth, which I organised as Chairman of the Netherlands Branch of the Hydrographic Society in April 1982).

Granboulan, J., C. Fourcassies, Chaumet Lagrange, "Measuring the navigable depth in a muddy channel",
2nd International Hydrographic Technical Conference, Plymouth, UK, 1984

Hellema, J.A., "New techniques lead to savings in maintenance of shipping channels and ports", Dock and Harbour Authority, January 1981 (I am not sure the article's title is correct. I only have the Dutch version).

Kerckaert, P., B. Malherbe, A. Bastin, "Navigation in muddy areas – The Zeebrugge experience", PIANC 1984/85

Kirby, R., W.R. Parker, W.H.A. van Oostrum, "Definition of the sea bed in navigation routes through mud areas", 1st International Hydrographic Technical Conference, May 1979, Ottawa, Canada (also in the Hydrographic Review, Monaco, January 1980).

Mundy, M., "Getting the measure of fluid mud", Port Construction International, No. 2/3, 1984.

Nederlof, L., G. van Bochove, "Manoeuvring behaviour of ships in muddy canals and harbours", Dock and Harbour Authority, May 1981.

Oceano Instruments, "Report of the Demonstration of the SD 105 Acoustic Sediment Densitometer", March 1986, (Oceano Instruments, 4 Avenue Henri Poincare, 92160 Antony, France).

Os, P.J. van, et al, "New survey techniques for silt density measurement systems", Proceedings of HYDRO '96
"Port & Coastal Hydrography", S.P. No. 36, Rotterdam, September 1996

Paske, R., "The towed silt density gauge: A new system for measuring navigable depth", The Hydrographic Journal No. 35, January 1985.

PIANC Working Group 3-a, "Navigation in muddy areas", Permanent Technical Committee II, Bulletin No. 43, PIANC, 1982/83

Sellmeyer, R., G. van Oortmerssen, "The effect of mud on tanker manoeuvres", RINA Spring Meeting 1983.

Woerden, J.A. van, J.A. Hellema, M. Tielman, "Hydrographic echosounding combined with sub-bottom

profiling and nuclear density measurements", The Hydrographic Journal No. 50, October 1988.

Another note received via e-mail:

"Earl Brown certainly hasn't lost it when he posed the above question in the Fall/Winter 2001 edition of Lighthouse page 14.
This is by no means a new problem and I believe that there was a paper presented on the subject at a hydrographic conference in the late 70's. From memory the paper dealt with experiences at Europort, a large port on the Rhine estuary in the Netherlands, where the water contained a significant amount of suspended sediment. Conventional echosounders were unable to resolve the issue of where bottom was. As a result samples of the water and sediment mix were retrieved from various depths and bottom was defined at the point when the density exceeded a certain value.

Regards,
John Brigden CLS, President
Brigden Survey Consulting Inc."

Editor's Comment:

We appreciate the comments and our thanks go out to George Goldsteen and John Brigden. George's comments are, as expected, very detailed and well thought out.

It is also of interest that both George and John make reference to a paper presented over 20 years ago. How have those responsible for charting responded to this concern raised two decades ago?