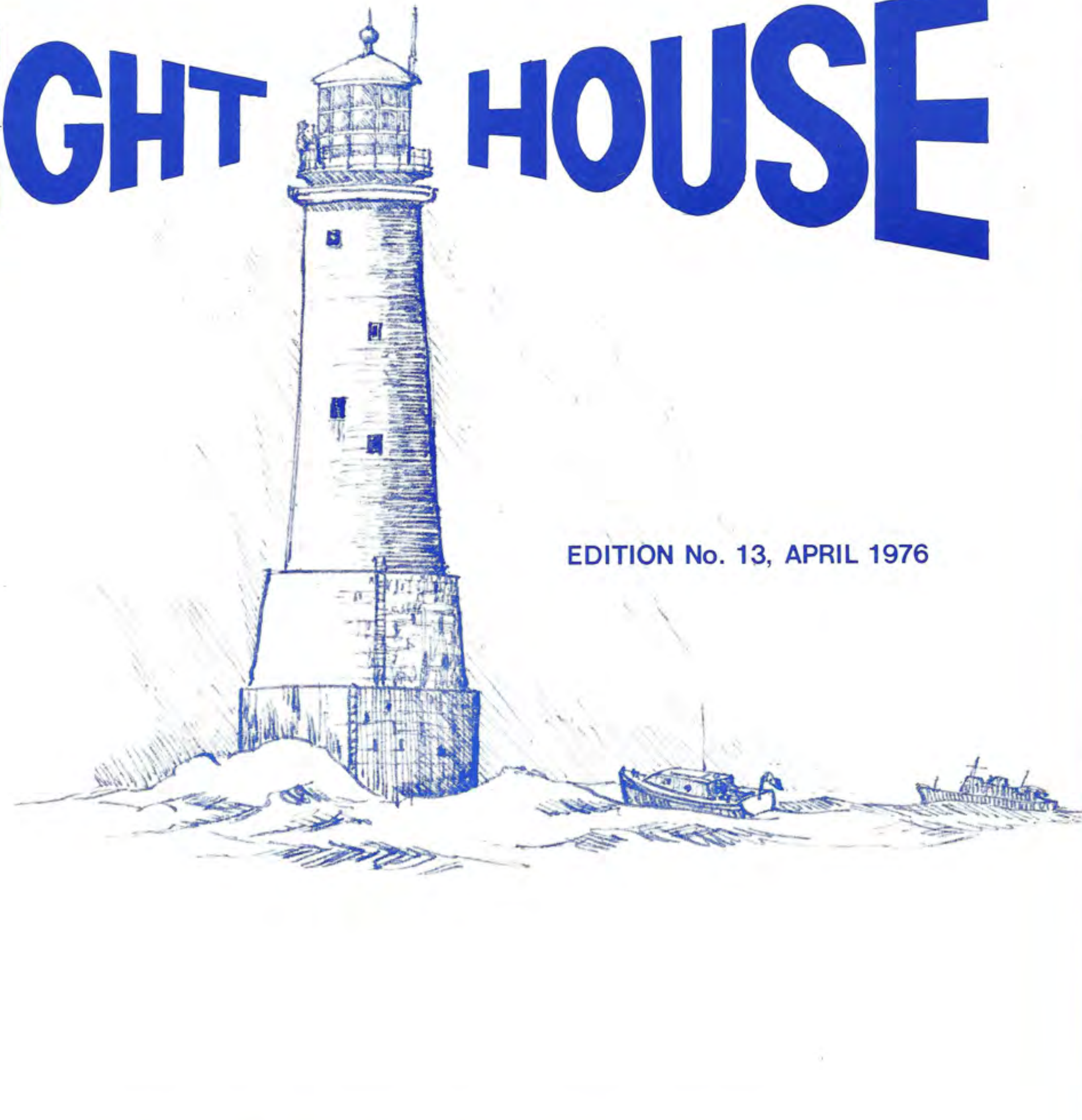
LIGHTHOUSE



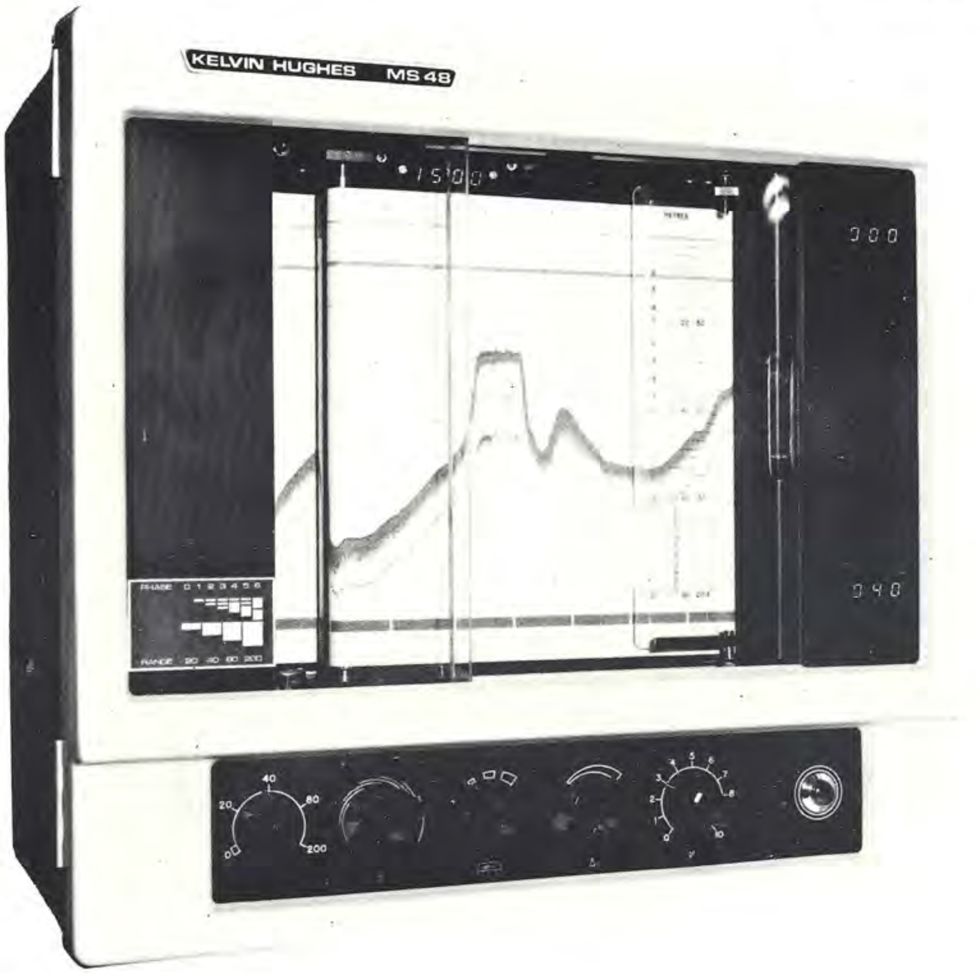
EDITION No. 13, APRIL 1976

Journal of the Canadian Hydrographers' Association

Introducing,

THE MOST ADVANCED, COMPREHENSIVE, PRECISION ECHO SOUNDER FOR HYDROGRAPHERS

KELVIN HUGHES MS48



AN ENTIRELY NEW DIGITAL ELECTRONIC UNIT HAS BEEN DESIGNED TO OPERATE IN CONJUNCTION WITH THE MS48 TO PROVIDE DEPTH RESULTS FOR USE INTO A COMPUTER AND ASSOCIATED PRINT-OUT EQUIPMENT AS DESIRED.

The MS48 has been designed to meet the latest requirements for precision surveying in shallow and medium depths. Prior to its launch it successfully completed extensive sea trials for the Hydrographer of the Royal Navy and it is intended to fit it in all classes of RN survey vessels in place of the Type 771 and Type 772.

The MS48 has four depth scales, 0-20m, 0-40m, 0-80m and 0-200m. Each can be phased in six steps to maximum depths of 80m, 160m, 320m and 800m respectively. A unique feature is that the scale and phase in use are automatically shown on the record by coding marks. Another innovation is that the minimum and maximum depths which can be recorded with the range and phase in use are visually indicated. The recorder employs 10" wide paper with straight line recording.

A highly stable but variable speed motor drive system has been developed to enable the surveyor to set the stylus speed to correspond to the prevailing velocity of sound; this velocity is clearly displayed on a digital read-out. A separate digital equipment has also been developed as a compatible unit.

Changes in depth range are made by altering the frequency of the motor supply, thus avoiding the use of a change speed gearbox. The paper is driven by a separate motor, unaffected by adjustment of stylus speed.

EDITION No. 13 **LIGHTHOUSE** APRIL, 1976

JOURNAL OF THE CANADIAN HYDROGRAPHERS ASSOCIATION

Editorial Staff

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Introduction

Perhaps superstition should run in the publication of journals as it does in the construction of multistorey buildings; however, here we are with Edition 13 of LIGHTHOUSE. Arcticles presented in this edition cover a variety of topics ranging from chart scales to a geoscientist's views of hydrographic surveys. They should give each of our readers something of interest and, hopefully, an opportunity for discussion and comment. If this is the case and you would like to make your views known then please express them in a "Letter to the Editor".

A few changes and additions have, as you will no doubt notice, been made to this edition of LIGHTHOUSE, all aimed at improving the overall quality of the journal. The layout and production techniques have been changed and, for the first time, advertising space has been sold. This latter move seems to have been well received. Three columns - News from Industry, News from C.H.S., and C.H.A. Personal Notes - have been added, admittedly with a sparcity of copy. However, we hope that their very existence will generate contributions for future editions. We intend to solicit material for these columns but please don't feel that you must wait to hear from us. No doubt the scope of this "news" section will broaden to include international, conference and other aspects of hydrographic activities.

Edition 12 of LIGHTHOUSE seems to have been well received. We hope that you are even more pleased with Edition 13.

EDITORIAL

Three major Canadian government initiatives have lately caused some concern in the chart making business. The first of these has been metric conversion and the second has been bilingualism. The third has been the anti-inflation initiatives which somewhat ironically, have made it difficult, if not impossible, to carry out the first two.

In responding to a government's initiatives, a hydrographic office will often be required to develop good justification in order to obtain funds to carry out these policies. In the case of metric conversion, there are some interesting arguments. One such argument is that conversion must be all done at once or else the navigator will fall off the end of his fathom chart and land with a solid thump - or will it be a splash? - on his metric chart. It is supposed that this argument is given support by Sweden which changed from driving on the left-hand side to the right-hand side in one night. But navigators for years, at least in Canada, have blithely stepped from fathom chart to feet chart and back again. So is the change from one set of units to another really a cause for concern? One must argue that the hydrographer must minimize any possible cause of error that may endanger the navigator.

Being such an advanced hydrographic country!!!, Canada had already gone to buff for land tint when metric conversion came along and so could not, as some other nations have done, use the change of colour from black and white to warn mariners that they had a metric chart in their hands. Instead Canadian metric charts state METRIC/METRIQUE in magenta - or is it nautical purple now, along the border.

Which brings me to an issue which has virtually kept the International Hydrographic Organization going for all these years - the matter of language. If every navigator understood Esperanto there would be no problem but that is not the case and navigators seem to prefer to work in their own language. If though, they "go foreign", they are obliged to use a chart from one of the countries that chart on a world-wide basis. Even then they have quite a choice - English, French, German, and, I believe, Japanese and Russian if they can get the charts. Canadian hydrographers, along with the hydrographers from South Africa, have a particular problem, they must show two languages on their charts. According to the law of the land the travelling public may receive service in either of the country's official languages.

It is true that two sets of charts could be produced, one in English and one in French, but at double the cost of charts in one language - double the initial production and double the maintenance. Instead Canada chooses to produce bilingual charts, although Sailing Directions are produced in each language (one wonders with a rather anglophone bias, whether there is much sale on the French editions outside of Quebec). The matter for discussion is whether the navigator is best served by the bilingual chart with respect to safety. At present, a debate rages in Canada over whether control operators at airports should carry out their work in both languages. Major disasters are prophesied if the control language is not always English. Certainly there are reports of misunderstandings aboard ships caused by language differences. On going some years ago to survey an area of the St. Lawrence just by the pilot station at Les Escoumins, the first thing I saw was a fine white ship - high and dry on the rocks. Local gossip had it that what should have been "gauche" was taken as starboard by a Spanish quartermaster! For those in touch with the Canadian maritime scene, that ship was later named "ANSWER" and in her capacity as a runaway ship caused some red faces in Canadian government circles.

One of the most important aspects of the cartographers skills is that of presenting data clearly. Hydrographic data is by itself very detailed and it is the work of an expert to present this clearly so that the navigator in fair weather and foul, under dim lights and beneath coffee stains can see "where the rocks ain't"! Add to this another language, so that *depths in feet* are doubled as *profondeurs en pieds* and *mouillage interdit* is doubled as *prohibited anchorage*, and the question stands out - "Is the safety of the majority of mariners being jeopardized in order to satisfy the requirements of a few?"

"Range Holes" and what to do about them.

THOMAS P. GILB and
GARTH F.C. WEEDON, P.Eng.
Motorola

While using a microwave positioning system for hydrographic surveying, have you ever experienced a situation in which an otherwise perfect survey suddenly went "bad" because of loss of signal from one of the reference stations? After checking all batteries and the equipment, and confirming you are within the system's range capability, you find you are still in trouble. However, subsequent change in boat location causes everything to return to normal. You have probably experienced a "range hole".

What happened?

A range hole is caused by interference between the direct signal arriving at a receiver and a signal reflected from the water's surface or some other object. The phenomenon, usually referred to as multipath, is common to all radio systems (radios, radars, positioning systems, etc.) that operate at frequencies where the primary propagation mode is line-of-sight.

In hydrographic applications, the primary source of reflected signals that cause range holes is the water's surface.

In analyzing reflection from the water's surface, only one reflection path needs to be considered because of the property that radio waves must leave a reflecting surface at an angle equal to one at which they arrived. For given heights of the measuring station and reference stations above the reflecting surface and measuring station to reference station separation, only one point (area) on the surface will satisfy the equal angle condition. The point at which the equal angle condition is satisfied is called the reflection point. The situation is illustrated in Figure 1.

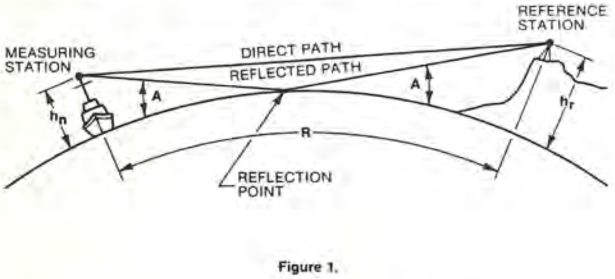

Figure 1.

It will be convenient for discussion purposes to assume a transmitter is located at the measuring station and a receiver located at the reference station. This will not affect the results because radio waves will travel the same paths independent of the direction of travel.

The effective signal seen at the receiver will be a composite signal whose strength depends on the strength and phase relationship of the direct and reflected signals at the receiver.

The strength of the reflected signal is primarily determined by the angle at which the signal arrives at the reflecting surface (the smaller the angle, the better the reflection) and by the physical and electrical properties of the reflecting surface. A good reflecting surface is one that is smooth and has a dielectric constant significantly different than that of the atmosphere. Water (whether choppy or not) is a very good reflecting surface at angles of 2° or less, a condition that is met in most hydrographic applications. Another factor affecting the strength of the reflected signal is the attenuation due to the additional distance travelled by the reflected signal; however, for signals reflected from the water, this factor is normally negligible. The distance travelled is usually only slightly longer than the direct path; often the extra distance can be measured in centimetres.

For a low angle reflection from a water surface, it is normal to assume that the reflected and direct signals will arrive at the receiver with nearly equal strength.

The difference in phase at the receiver is caused by two factors; the two signals have travelled slightly different distances to the receiver thus arriving at different times, and the reflected signal undergoes a phase change at the reflections point. At the small reflection angles common in hydrographic applications, the phase change occurring at the reflection point is very close to 180°. Assuming the phase change at the reflection point to be a constant, then the relative phase of the two signals at the receiver will be a function of the extra distance travelled by the reflected signal. Under these conditions, destructive interference will occur when the path length difference between the direct and reflected paths is a multiple of the system's wave length. (Note: Wavelength (λ) is equal to the speed of light (c) divided by the system's frequency of operation (f)). That is, destructive interference will occur when the distance travelled by the reflected signal minus the distance travelled by the direct signal equals $k\lambda$ where $k = 0, 1, 2, 3, \ldots$. As the path length difference changes from an exact multiple of the system's wavelength, less interference will occur; indeed as the path length difference approaches an odd number of half-wavelengths ($1/2\lambda$, $1\text{-}1/2\lambda$, $2\text{-}1/2\lambda, \ldots$) the reflected signal will reinforce the direct signal and the resulting signal will be stronger than the direct signal alone.

Figure 2 represents a pictorial summary of the effective pattern of an omni antenna in the presence of reflected signal from the water's surface at a reasonable distance from the station. The dashed line represents the coverage that would be obtained in the absence of reflection signal. The overall effect of the reflected signal interference is to break up the original antenna pattern into a vertical lobe structure.

At ranges and altitudes where the reflected signal reinforces the signal, the system range is increased. Theoretically, it can be doubled at the peak of a lobe where both signals are in phase; at the

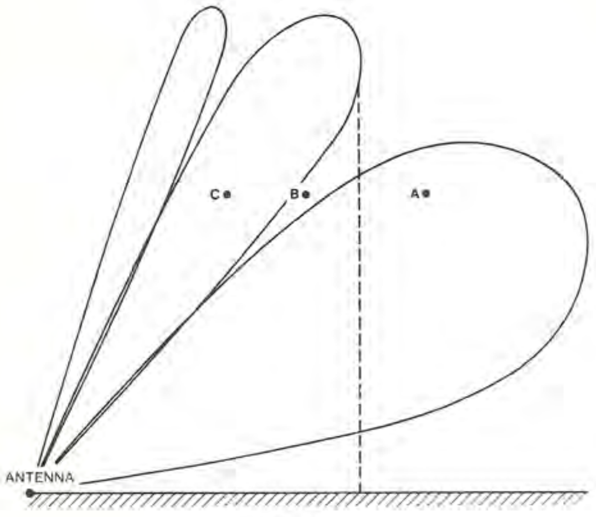

Figure 2.

ranges where the direct and reflected signals tend to cancel, the system's range is reduced. A signal loss--range hole--will occur when the signal level is reduced below the sensitivity of the system. If an omni antenna is assumed to be located on the measuring station and a reference station is assumed to be located at the range and elevation indicated by point A in Figure 2, then the system could be expected to obtain data at a range in excess of the system specification. If the measuring station begins to move closer to the reference station, it would be expected to lose data from the reference station near the point marked B, where destructive interference from the reflected wave would reduce the signal below the system's sensitivity. If the range continued to close, then the data would again become available as the system moved into the second area of signal reinforcement.

A second point to be noted from Figure 2 is that first lobe of reflection signal modified antenna pattern is tilted upward, leaving an area of reduced signal level near the surface. This is a direct result of the 180° phase shift that occurs at or near the reflecting surface, causing a signal cancellation required to occur near the reflecting surface. This tilting will require stations (required to be used at maximum range) to be raised higher than the line-of-sight would require.

What can be done about range holes?

There are four basic techniques that can be used to minimize or eliminate the detrimental effects of range holes.

The first is to select reference station locations and elevations that prevent range holes from occurring in the work area. This technique is a lot easier to describe than to implement. In a field station, the availability of suitable reference sites is normally severely limited by accessibility, line-of-sight, and suitable geometry considerations. The height of these stations can, however, sometimes be controlled. Often an elevation difference of 2 to 4 metres can make the difference between holes or no holes in a work area. This approach requires an ability to predict the location of range holes.

In some instances, the manufacturers of the positioning system can provide range hole charts for a particular system installation. A sample chart as provided by Motorola for the Mini-Ranger III™ position determining system is shown in Figure 3.

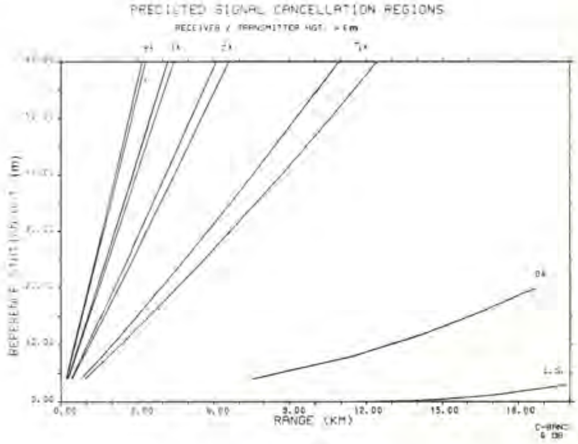

Figure 3.

The chart is drawn assuming the measuring station antenna fixed--in this case at six metres above the water's surface as would be the case for a small survey boat. Heights of the reference stations are shown on the vertical axis in metres, the horizontal axis is range in kilometres. Heights shown are measured from a reference line through the reflection point (assumed to be the on the water's surface). The effects of curvature of the earth and the refraction coefficient of a standard atmosphere have been included in the construction of the chart.

The areas on the chart where destructive interference can occur are identified by the path length difference that caused them (0λ, 1λ, 2λ, etc.). The width of an actual "hole" in the field will depend upon many factors, including the range between measuring station and reference station, the transmitter output power, and the receiver sensitivity to name some of the most important. The width shown on the chart was arbitrarily selected as the point where cancellation would reduce the system's maximum range by 1/2 (a signal strength reduction of 6 dB) assuming perfect reflection from the water's surface.

Normally only the 0λ, 1λ, and 2λ areas need concern the system user. The higher order holes occur at close range where the system will normally have very strong signal, and the reflection angle is getting significant, reducing the amplitude of the reflected signal. The holes, if they exist, will be very narrow.

For situations where range hole charts are not available, the following two formulas that assume a flat earth can be used to estimate the approximate locations of the centre of range holes and the centre of lines of maximum signal strength:

1. Lines of minimum signal

$$h_1 = \frac{n\lambda R}{2h_2}$$

2. Lines of maximum signal

$$h_1 = \frac{(2n + 1)\lambda R}{4h_2}$$

Where: h_1 = height of one station in metres

h_2 = height of other station in metres

λ = wavelength of system as defined above in metres

R = range between station in metres

n = integer identifying holes (1, 2, 3 ...).

Figure 4 shows a comparison between the centre of range holes computed from formula 1 and the values determined by a computer for a curved earth for the same conditions used for Figure 3, where:

h_2 = height of measuring station = 5 metres

λ = 5.4 centimetres (f = 5500 MHz).

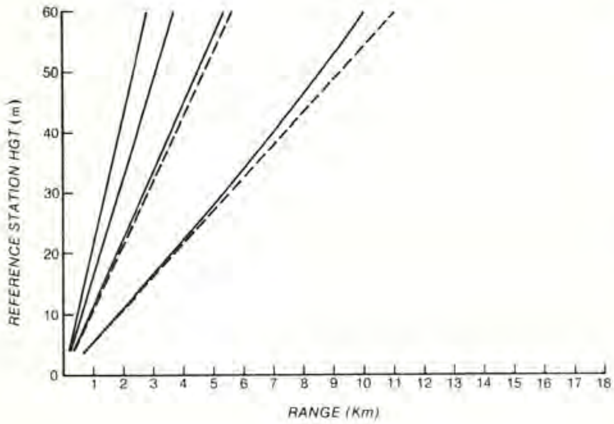

Figure 4.

One other consideration needs to be discussed in the prediction of the location of range holes. An inspection of Figure 3 indicates that the location of range holes move significantly depending on the height of the system's antennas above the reflection surface. The measuring station is normally located on a boat in hydrographic surveying applications and the height of its antenna off the water is usually reasonably fixed. The reference stations, however, are normally established on shore reference points and their height above the water's surface will vary with the state of the tide. This will cause range holes to appear to move around as the tide changes and is the reason why many times a vessel can operate in an area without trouble and come back later and be totally unable to function. A similar situation also can exist with vessels, such as hopper dredges, that have large changes in draught during an operation.

With these factors in mind, let's consider some other approaches for dealing with range holes.

A second approach that can be used with positioning systems that permit multiple reference stations, such as the Mini-Ranger III (up to 16 reference stations), is to select multiple reference sites that will allow one set of stations to cover the range holes in the other. This solution also suffers in practice from the lack of availability of suitable reference station sites. However, a successful variation of this scheme is to establish two reference stations on the same site at different elevations.

A third approach that can be used with systems that have small antenna units that can be readily moved is to mount the unit on a moveable track on the mast so that it can be raised or lowered to take advantage of the range holes sensitivity to height. This technique has been successfully used with the Mini-Ranger III where an occasional adjustment will eliminate a range hole problem. Typical applications include survey vessels that required occasional height changes to account for tide changes or for a coring or bottom-sampling vessel that requires position fixes separated by reasonable intervals of time.
None of the above solutions are really satisfactory for a modern hydrographic vessel that uses computer-processed position data in real time to control the survey. Such a vessel is capable of rapidly covering a large area in a short time and then moving to a new area.

A fourth approach to solving the range hole problem is an automatic "space diversity" system. This technique has been implemented as a field-installed option on Mini-Ranger III positioning systems to meet the needs of this type of vessel. The approach is an adaptation of a technique long used in the microwave communications field. The system, as implemented by Motorola, consists of placing two antennas (receiver/transmitter assemblies - R/Ts) on the vessel's mast at different heights to take advantage of the range holes sensitivity to antenna height. Both units continually monitor received signal strength from the reference stations. These outputs are compared and the R/T with the strongest signal is used to interrogate the reference station for range.

Analysis of range hole charts and field experience has shown that a vertical separation of about 5 metres is adequate to virtually eliminate the range hole problem. The technique has been successfully applied for several years on a number of automatic hydrographic systems.

A note on other sources of reflected signals

Signals reflected from sources other than the water's surface can cause range holes; e.g., bridges, ships, and oil tanks. The mechanism causing the range hole (that is, destructive interference between the direct and reflected signal) is the same as with the water surface reflections. However, the antenna lobes are primarily horizontally spaced instead of vertically spaced as with the water reflection. Vertical space diversity techniques are ineffective for these types of range holes. Fortunately, the path-length difference from these sources is generally much greater than the path length difference of the reflections from the water's surface. These greater path-length differences allow positioning systems that utilize the pulse time-of-arrival methods for determining range, such as Mini-Ranger III, to discriminate against reflections from these sources because of the later time of arrival of the reflected signals. This equipment is unaffected by reflected signals with path-length differences greater than 100 metres. Other techniques that can be used to minimize the effects of reflected signals from these sources are careful selection of reference station sites and the use of directional antennas on the reference stations.

Conclusion

The existence of range holes covered by signal reflections from the water's surface can seriously affect the operation of hydrographic surveyors using accurate line-of-sight positioning equipments. However, techniques for identifying and eliminating the detrimental effects of range holes do exist. In particular the automatic space diversity system has the capability of reducing this problem from a major headache to a very occasional minor annoyance.

Modern Hydrography as seen by a Geoscientist

Comments on the occasion of the Canadian Hydrographic Service Planning Meeting, Ottawa, October 30, 1973.

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Catapulted by the engagements of the last global wars, the world has moved rapidly towards an increasingly complex interdependence. This process has been accelerating during the past ten years and its significance and implications are penetrating public consciousness. We are all aware of global nuclear strategies of the superpowers. The artificial satellites have bound the world communication into one vast communication network. The population pressures have transcended national and regional boundaries and have become everybody's problem. The availability of resources and the equality of standards of living have become factors in one global economic equation. The world is becoming an integrated system.

The increasing complexities of global interactions are a large scale manifestation of the progress of human evolution. As the organisms evolve they become more complex, more sophisticated, more sensitive and more interdependent; their activities follow a parallel course. Societies are also governed by the laws of evolution. As a result we are now entering a phase in which simple, straightforward answers are becoming nearly impossible. Is it desirable to develop hydrocarbon resources of the Arctic? Should we build superports? Should we allow winter shipping in the Gulf of St. Lawrence? Should we allow offshore drilling in the Beaufort Sea? In the Straits of Georgia? No group working within a single technical or scientific discipline can provide substantial answers to questions like these. We have to seek partial answers from related disciplines and have to learn to assemble these partial answers so that decisions for action can be made.

Relationships between Hydrography and Geoscience are so close that there is a question whether we are talking about two related disciplines or about two aspects of the same discipline. Traditionally, the two have been separated along organizational lines (as is the case in Canada today) or according to the type of personnel engaged (civilian versus military). It is therefore necessary, from time to time, to remind ourselves just how close these connections are.

From a traditional point of view Hydrography is a branch of science concerned with the safety of navigation of ships at sea, in coastal waters, in harbour approaches and in rivers and lakes. It is thus concerned with all the factors affecting a ship's passage: The weather (strong winds, visibility in fog); the sea (tides, currents, waves) and the sea bottom (geomorphology).

The third of these concerns, the depth and shape of the sea floor, have greatly overshadowed the other two, primarily because for a long time the hydrographers have had a responsibility for publication of navigational charts depicting the sea floor. Describing the sea floor is a common ground for both hydrography and geoscience.

Our main tool for describing the sea floor is still an echo sounder, a device to measure the travel time of a pulse of sound energy from a surface vessel to the bottom and back. This gives a "spot" sounding, the size of the spot depending on various geological factors, like depth, nature of the bottom, reflectivity, etc. If the vessel is travelling on a track, then quick succession of spot soundings will give a continuous line of soundings which will give a two-dimensional representation of the bottom along the profiles traversed. If a three-dimensional (aerial) representation is required, then the adjoining tracks should be so close that the acoustic illumination cones overlap - a task which is impractical. In actual operations tracks have to be spaced some distance apart and the nature of the bottom between tracks inferred by interpretation. This last step cannot be carried out without an application of geological knowledge.

Because the shape of the sea bottom is not a random phenomenon we can use the track sounding to describe it provided we understand the geological processes which have moulded its present shape. Before undertaking any hydrographic survey, the first step should be to review the knowledge of surrounding geology in order to prepare meaningful survey specifications. As the survey progresses the new data will increase and modify geological knowledge, which in turn might dictate changing survey specifications. During the initial review of geology we can learn about the nature, age and depth of basement rocks; about the nature and distribution of the overlying sedimentary rocks; and about the thickness and character of the surficial sediments. The structural considerations should indicate the presence of faults, horsts and grabens; from tectonic considerations we could assess the long-term stability of the area, and the likelihood of local seismicity and volcanism.

This preliminary study is required in order to choose properly the spacing and the orientation of the survey lines. At this point we must consider operational constraints such as navigational control grid, requirements for port calls and refuelling, weather and ice conditions, etc. The final operational plan will be a compromise, but this compromise must be based on a sound evaluation of all the survey design factors.

Until now, satisfactory hydrographic surveys had to be carried out using only echosounders. Technology has advanced however and the new tools now available must be seriously considered and evaluated. The first of these is a side-scan sonar, a tool directly related to the primary mission of the hydrographer. With this tool an area of the sea floor centered along the ship's track can be swept. The records give a great deal of information about the nature of the sea floor and about the pinacles and other obstructions located between the tracks. But to interpret the records and to utilize and understand all the information contained in them,a considerable 'feeling' for geology is required, and thus geologist and hydrographer must work together.

Today's responsibilities of hydrographers go beyond the provision of data and charts necessary to ensure safety of navigation. Increasingly, hydrographers are called upon to advise resource and development agencies regarding the engineering properties of the sea floor and problems that might be encountered in connection with pipeline crossings, erection of offshore structures, and constructions on the sea floor. They are required to advise the environmental protection agencies on potential or actual pollution threats due to dumping of materials on the sea floor; due to removal of material by dredging; and due to the accumulation of toxic materials in areas of rapid sedimentation or low circulation. Hydrographers are frequently consulted by fishermen engaged in bottom trawling and by defence authorities who have a variety of problems associated with shape, composition and other characteristics of the sea floor. Finally, there are growing numbers of recreational activities moving farther offshore and generating their own set of questions.

The net result of this broad spectrum of demands is that hydrographers must learn a great deal more about the sea floor in addition to the least safe depth. This knowledge must be based on intensive use of high resolution seismic profilers and the systematic study of surficial samples. The result will be the information on nature, size and distribution of sediments; the knowledge of engineering properties of sediments, for example, bearing strength; and eventually a better understanding of geochemical processes at the water-sediment interface. The information will be used to guide dredging, trenching and construction activities and will be helpful when dealing with erosion problems.

Most of the scientific basis for the above problems will be provided by marine geologists specializing in surficial studies. Geologists and hydrographers approach to the common problems must not be separated since each has so much to contribute to the efforts of the other. If there is any validity to the concept of synergism this is surely one case where it must apply.

The common basis for achieving objectives of surficial geologists and hydrographers was recognized only recently. The common interest of hydrographers and geophysicists on the other hand has been recognized for almost three centuries. It is well known that the first multiparameter hydrographic survey was on board HMS PINK PARAMOUR in 1698-1700 when Haley measured the declination of the Earth's magnetic field in North and South Atlantic (my dictionary says that 'paramour' is one who loves or is loved illicitly. This love affair between hydrography and geophysics continues to the present day).

The knowledge of the magnetic field declination (or 'variation' as the mariners call it) had been essential until the advent of gyro compass. Even today the navigators of smaller craft must understand this correction and must rely on their charts for up-to-date information on this slowly changing geophysical phenomena. Until very recently every naval hydrographic expedition to distant parts of the world carried out magnetic observations. Last century's Royal Navy exploration of the Canadian Arctic was motivated by the need to map the location of the magnetic pole as much as by the desire to find a shorter route to Cathay. Such scientific establishments as the Greenwich Observatory and the worldwide network of magnetic observatories were initially supported because of the needs to improve navigational capability of mariners.

The basis for hydrographic work is surveying, or determination of the geometrical relationship between two points on the Earth. Before this relationship can be worked out, a base map must be constructed using the geodetic approximation to the true shape of the Earth. When determining the geoid, the knowledge of the Earth's gravity field is essential. Consequently, hydrographers have been concerned with gravity measurements since the time of Newton. Again, the Arctic expeditions illustrate this concern. In spite of instrumental difficulties (and poor accuracy of results) early explorers have often taken pendulums to inaccessible places in order to measure the force of gravity. Today, with the advent of rocket and space travel, there is a further need to refine the maps of the Earth's gravity field.

Modern instrument developments make it possible to measure a number of parameters while the ship is engaged in offshore hydrographic surveys. This logistic convenience has resulted in the development over the past fifteen years of the technologically advanced marine survey systems. The benefits of reducing the cost per parameter have been recognized by all responsible for these surveys. The main rationale for the implementation of the multiparameter surveys has been the requirement for a more efficient use of ships. It is equally important to recognize that there is a strong functional relationship between hydrography and geoscience and that there is a substantial overlap of interest and responsibilities between the two activities. We are learning today that global problems require unreserved coordination and cooperation throughout the spectrum of human activities. Geoscientists and hydrographers occupy adjoining sections of this spectrum and must develop a common approach to solving common problems.

Datum Transformations

DAVE WELLS

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One of the most misunderstood aspects of using satellite navigation (Navsat) is the matter of datum transformations. The problem arises because the coordinates of most control points are referred to a different kind of coordinate system (which we call a *local geodetic datum*) than are the coordinates we get from Navsat. First let us find out why this is so, and then look at what we can do about it.

The motion of an artificial near-earth satellite depends almost entirely on the effect of the earth's gravity field. Therefore, by tracking a satellite or satellites from several points on the earth's surface (*terrain points*), we can obtain enough data to locate the earth's centre of gravity (the *geocentre*) within a few metres relative both to terrain points and satellite orbit. A significant aspect of using satellites is that they are a link which can be used to connect observations from different continents and thus establish one world-wide coordinate system.

Local geodetic datums, on the other hand, were established long before the dawn of the satellite age. Lacking satellites to locate the geocentre, the stars were used. In the earliest and crudest method, arcs on the terrain were accurately surveyed to find their lengths, and precise astronomic observations were made to find the angles the arcs subtended at the geocentre. The size (*semi-major axis a*) and shape (*semi-minor axis b*, or *flattening* $f = (a - b)/a$) of a *reference ellipsoid (see Figure 1)* could then be computed by comparing the linear and angular lengths of two or more meridian arcs at different latitudes. A reference ellipsoid was chosen because it is the simplest figure which reasonably approximates the shape of the mean sea level surface (which we call the *geoid*). Having chosen an ellipsoid, it was positioned relative to the earth by specifying the geodetic coordinates (latitude ϕ, longitude λ, and height h) of a single terrain point and an initial azimuth to a second terrain point. It was then assumed that the centre of the ellipsoid coincided with the geocentre, whereas in fact the difference was usually several hundred metres. More sophisticated techniques of choosing the ellipsoid size and shape, and positioning it relative to the earth, have been developed but the primary limitation (lacking satellites) is that only data from interconnected geodetic networks, that is from a single continent, can be used for each such determination. As a consequence, each continent, and in some cases each country, presently has its own local geodetic datum, reference ellipsoid and implied geocentre location. Table 1 lists the ellipsoid sizes and shapes used with several local geodetic datums, together with the coordinates of the ellipsoid centres expressed in a particular geocentric (satellite) coordinate system called WGS72 (Sepplin, 1974). These *datum translation components*, as they are called, are Cartesian coordinates in a right handed coordinate system whose Z-axis passes through the north pole and X-axis passes through the intersection of the equator and the Greenwich meridian. (The actual definition of this coordinate system uses more precise language.) Figure 2 shows the relationships between the XYZ and $\phi\lambda h$ coordinate systems, exaggerated for clarity.

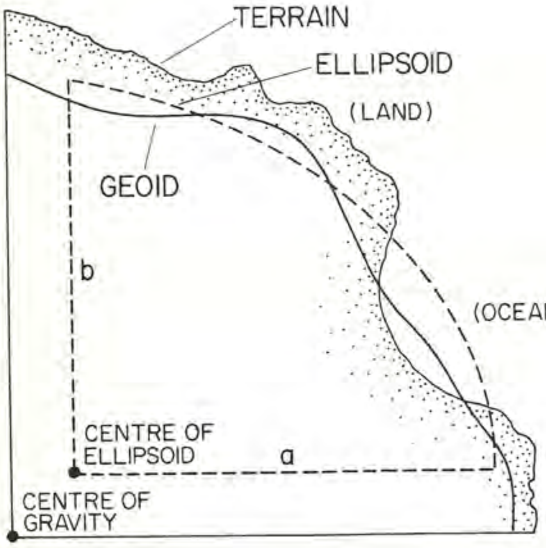


FIGURE 1

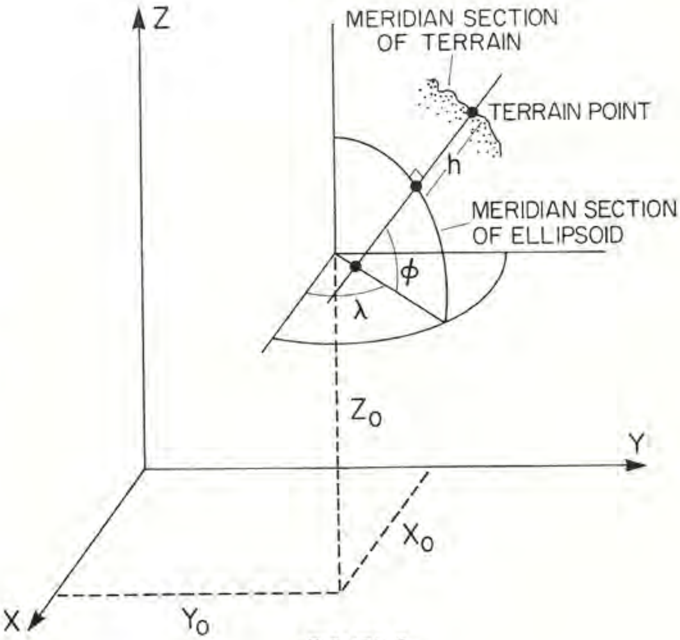


FIGURE 2

TABLE 1

SOME COMMON DATUM PARAMETERS

LOCAL GEODETIC DATUM	REFERENCE ELLIPSOID		DATUM TRANSLATION COMPONENTS		
	a(m)	f	x_o(m)	y_o(m)	z_o(m)
Australian Geodetic	6378160	1/298.25	-122	-41	146
European	6378388	1/297	-84	-103	-127
North American 1927	6378206.4	1/294.9786982	-22	157	176
South American 1969	6378160	1/298.25	-77	3	-45

TABLE 2

THE MOST COMMON NAVSAT REFERENCE ELLIPSOID

a	f	x_o	y_o	z_o
6378144	1/298.23	0	0	0

Given the local geodetic coordinates of a terrain point, and values for a, f, x_o, y_o, z_o such as from Table 1, the geocentric Cartesian coordinates of the terrain point can be computed from:

$$X = x_o + (N + h)\cos\phi\cos\lambda,$$
$$Y = y_o + (N + h)\cos\phi\sin\lambda, \qquad (1)$$
$$Z = z_o + (N(1-f)^2+h)\sin\phi,$$

where the prime vertical radius of curvature is,

$$N = a(\sin^2\phi + (1-f)^2\cos^2\phi)^{-\frac{1}{2}} \qquad (2).$$

Unfortunately, given XYZ it is not so easy to invert equations (1) to obtain $\phi\lambda h$. However, there are three ways of doing this; the direct method (Paul, 1973); the differential method (Heiskanen and Moritz, 1967): and the iterative method, which I shall now describe.

Given X, Y, Z, x_o, y_o, z_o, a, and f we first compute, in order,

$$x = X - x_o$$
$$y = Y - y_o$$
$$z = Z - z_o$$
$$\lambda = \arctan(\frac{y}{x})$$
$$p = (x^2 + y^2)^{\frac{1}{2}}$$
$$N_o = a$$
$$h_o = (x^2+y^2+z^2)^{\frac{1}{2}} - a\ (1-f)^{\frac{1}{2}}$$
$$\phi_o = \arctan\left[\frac{z}{p}\cdot\frac{N_o + h_o}{N_o(1-f)^2+h_o}\right]$$

Then for the iterations i = 1, 2, 3... we compute, in order,

$$\left.\begin{aligned} N_i &= a\left[\cos^2\phi_{i-1} + (1-f)^2\sin^2\phi_{i-1}\right]^{-\frac{1}{2}} \\ h_i &= \frac{p}{\cos\phi_{i-1}} - N_i \\ \phi_i &= \arctan\left[\frac{z}{p}\cdot\frac{N_i + h_i}{N_i(1-f)^2 + h_i}\right] \end{aligned}\right\}(3)$$

until $\left|h_i - h_{i-1}\right| < a\varepsilon$

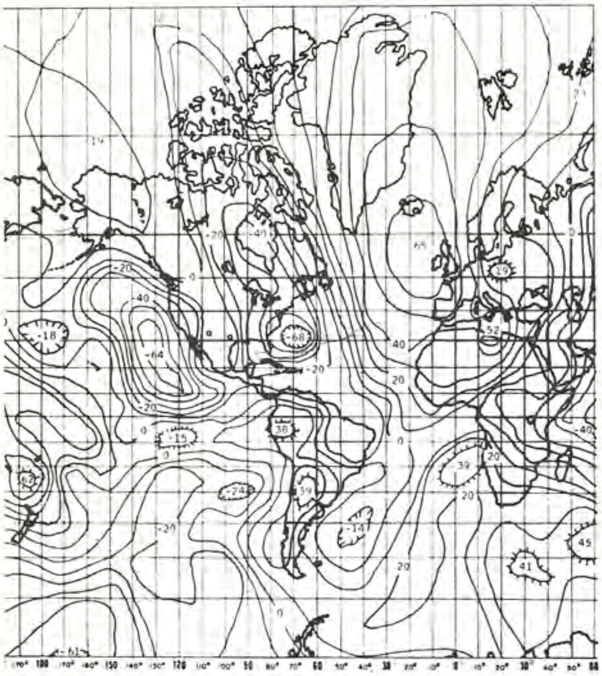
and $\left|\phi_i = \phi_{i-1}\right| < \varepsilon$

for some appropriately chosen value of ε (for example $\varepsilon = 10^{-7}$ radians for convergence to one metre or less).

Note that in both equations (1) and (3) the third geodetic coordinate h is the height of the terrain point above the *reference ellipsoid*, not the height above sea level. Therefore, we need two maps showing the height of mean sea level (the geoid) above the ellipsoid used for Navsat computations, and above the local geodetic datum.

Maps of geoid heights above the Navsat reference ellipsoid are usually supplied with computer software. The most commonly used Navsat reference ellipsoid has the values shown in Table 2. A map of geoid heights above this reference ellipsoid, taken from Moffett (1973), is shown in Figure 3.

Maps of geoid heights above local geodetic datums are computed from *deflection of the vertical measurements*. One such map for North America,



CONTOUR MAP OF GEOIDAL HEIGHT (METRES)

FIGURE 3

U.N.B. 73
ASTROGEODETIC GEOID IN NORTH AMERICA
North American 1927 Datum
Contour Interval 2 metres
64 Coefficients

FIGURE 4

taken from Vanicek and Merry (1973), is shown in Figure 4. Note that the geoid contours in Figures 3 and 4, while based on different measurements and plotted with respect to different ellipsoids, still are similar in gross detail. In fact all we really need is the same geoid information plotted on both the reference ellipsoid used in the Navsat computation program and on the local geodetic datum. Some Navsat computation programs are flexible enough so that we can specify the reference ellipsoid we want to use. In that case, the problem of datum transformations can be avoided by specifying the a, f, x_o, y_o, z_o, for the local geodetic datum we are interested in. This is equivalent to having equations (1) and (3) built into the Navsat computer program.

Returning to the problem at hand, in the case where the Navsat computer program uses the geocentric reference ellipsoid of Table 2, the steps required to obtain a Navsat position referred to a local geodetic datum are:

1) Find the correct geoid height from Figure 3, add it to the height of the antenna above sea level to get h_s, which is fed manually into the Navsat Computer program.

2) After a Navsat computed position fix (ϕ_s, λ_s), convert ϕ_s, λ_s, h_s to geocentric XYZ using

$$X = (N + h_s)\cos\lambda_s \cos\phi_s$$

$$Y = (N + h_s)\sin\lambda_s \cos\phi_s$$

$$Z = (N(1-f)^2 + h_s)\sin\phi_s$$

where

$$N = a(\sin^2\phi_s + (1-f)^2\cos^2\phi_s)^{-\frac{1}{2}}$$

and where the Table 2 a and f values are used.

3) Select the local geodetic datum values for a, f, x_o, y_o, z_o from Table 1.

4) Convert the geocentric XYZ to local geodetic ϕ_G, λ_G, h_G, using equations 3.

5) Subtract the geoid height from Figure 4 from h_G to get the height above sea level.

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The General Bathymetric Chart of the Oceans, 5th Edition

by RONALD SAUCIER and RONALD E. GAUTHIER

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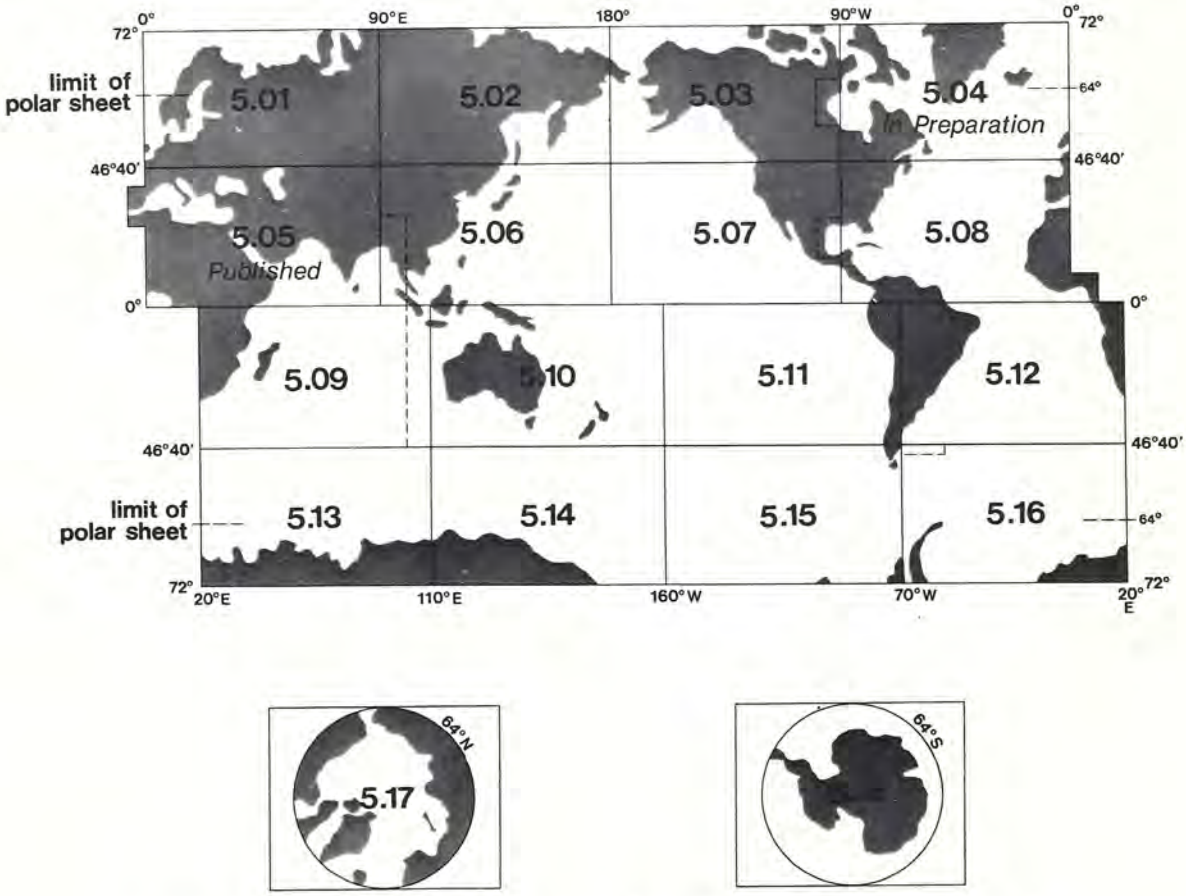
By the turn of the century, several bathymetric charts of the world oceans had already been produced at various small scales. At the VIIth International Geographical Congress held in Berlin in 1899, it was decided that a series of 24 abutting sheets at a scale of 1:10,000,000 at the Equator would provide world wide coverage of the oceans on a sufficiently large scale. The General Bathymetric Chart of the Oceans (GEBCO) was endorsed by the Stockholm International Congress in 1899 and by the Second International Conference of Christiania (Oslo) in 1901. H.S.H. Prince Albert I of Monaco, and his scientific cabinet undertook the preparation of the first GEBCO edition. The series was completed January 11, 1904. The first edition of GEBCO contained approximately 18,400 spot depths.

The GEBCO series was updated and three other editions printed during the next seventy years. The methods of compilation of the four editions remained basically the same. The content of each sheet had always been measured in terms of the number of selected soundings with emphasis on maximum and minimum depths. The purpose of contours was to outline the general shape of the ocean floor features. The main criticism of the GEBCO, therefore, was its lack of specific scientific content. Several meetings and discussions were held with the purpose of improving the GEBCO, but none were as successful as the meeting of the Scientific Committee on Oceanographic Research (SCOR) Working Group 41 in April 1973,

> "The Working Group agreed that there was a need for a world bathymetric chart series at a scale of 1:10,000,000 but none of the existing charts fulfilled the needs of scientists who require accurately produced charts prepared with due regard to the existing state of knowledge of sea floor morphology and of the geological and geophysical processes active on the sea floor." (IHO).

At the GEBCO Committee meeting held in June, 1973, the recommendations of the SCOR Working Group 41



Assembly Diagram for GEBCO Sheets (5th Edition) were endorsed. It was also recommended that the existing GEBCO Committee be dissolved and be replaced by a Guiding Committee. This Committee was charged with the task of determining the needs of the scientific community, educational institutions and other users of the GEBCO, and to produce, based on these needs, new specifications for the preparation and production of the fifth edition. Canada was represented on the guiding committee by Mr. G. N. Ewing.

In April 1974, the first meeting of the GEBCO Guiding Committee was held in Paris. New specifications were discussed and adopted for the fifth edition. The format of the GEBCO did not change except that the limit of sheets 5.04, 5.05, 5.08 and 5.12 (see figure) were extended to include ocean basins or ocean floor features. As with the previous editions the scale would remain 1:10,000,000 at the Equator on Mercator's projection. All data would be in metres, corrected for the varying velocity of sound in sea water using Matthew's Tables.

The most significant departure from previous editions is in the content of the chart. Depth data are represented as contours rather than selected spot soundings. This method of presentation will ensure:

a) that all the morphological detail of a systematic survey or a single profile is portrayed;
b) clarity by eliminating thousands of spot depths;
c) detailed portrayal of the shape of ocean floor features by adding intermediate isobaths; and
d) rapid visual identification of major and minor ocean floor features by the use of distinct colour tints to define depth ranges.

Credibility of the contours is substantiated by the inclusion of the sources from which the isobaths were interpreted. Three different types of source data are represented:

a) boxed areas which enclose comprehensive surveys;
b) solid lines which represent profiles;
c) dots which represent spot soundings.

This source information not only indicates the density of data from which isobaths were interpreted, but also clearly identifies areas in which little or no data exists.

A tentative production program for the GEBCO fifth edition was adopted at the April 1974 meeting of the GEBCO Guiding Committee. Rather than one organization having the responsibility for the compilation, scribing and printing of all GEBCO sheets, (as was done with the fourth edition) a flexible, decentralized scheme was introduced. Individual marine geologists and geoscientists volunteered to co-ordinate the scientific content of specific GEBCO sheets. Dr. A. S. Laughton of the Institute of Oceanographic Science, United Kingdom, offered to co-ordinate Sheet 5.05 (Northern Indian Ocean and Mediterranean Sea). Canada, represented by Mr. G. N. Ewing, volunteered to scribe and print GEBCO Sheet 5.04 (the Northern Atlantic) and Sheet 5.05.

In April 1975, GEBCO Sheet 5.05 was published by the Geoscience Mapping Section of the Canadian Hydrographic Service and displayed at the United Nations Law of the Sea meetings in Geneva and at the second meeting of the GEBCO Guiding Committee held that same month. At this meeting, Canada accepted the responsibility of drawing and printing two more sheets in the series and is the only Member State of the International Hydrographic Organization to offer this service. At present, Canada is preparing eleven of its seventeen 1:1,000,000 plotting sheets for the publication of GEBCO Sheet 5.04. It will be drawn and published by the Geoscience Mapping Section of the Canadian Hydrographic Service in early 1976.

Reference

International Hydrographic Organization, *International Hydrographic Bulletin*, June 1973, No. VI, page 193.

Chart User Survey

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Introduction

Between January 30 and October 15, 1975 a survey of chart users was undertaken by the Canadian Hydrographic Service. The purpose of this survey was to obtain chart user comments, and reactions to, three prototype Canadian metric charts.

Two of these charts are of the 'Approaches to Vancouver Harbour': Chart H-3481 is a Direct Conversion; and Chart M-3481 is Contour Style. These two prototype charts are compared with the standard chart of the same area, No. 3481.

A Direct Conversion chart, is conversion of the imperial unit chart directly to metric units, this includes retaining the old fathom contour lines but relabelling them with the metric equivalent. As a result the contour lines have odd metric values. The Contour Style is a radical departure from our Standard Style chart. Bathymetric contours are used extensively, and soundings are limited for specific purposes.

The third prototype chart, 'Quebec To Donnacona', Chart 1310, is produced in bilingual format, and designed as a strip chart with askew orientation. The sounding information on the prototype is presented in the standard style. This chart presented navigation light information in an abbreviated form, plus the light list number.

Results received from this survey were used to help decide the future style of Canadian charts.

Survey Procedure

The major portion of the survey was carried out by mailing the prototype charts, together with a questionnaire, to all known interested groups. These prototype charts and questionnaires were also advertised in 'Notice to Mariners'.

Because prototype chart 1310, 'Quebec to Donnacona' raised issues other than style of bathymetric presentation, it was mailed separately with a special questionnaire.

In addition to direct mail, interviews and group discussions were held with chart users in Victoria, Vancouver, Montreal, Halifax, St. John's and London (U.K.). A total of 19 meetings were held with a representative of the Canadian Hydrographic Service present to answer questions on the chart styles, and the metric conversion program. Several other meetings were held both in Canada and abroad, these meetings resulted in group opinions being forwarded to the Canadian Hydrographic Service.

SURVEY RESULTS

Strip Chart

The total replies from chart users on the strip chart are given in Table No. 1, and are subdivided into user groups. The first column gives the total number of completed questionnaires received, and the second column shows the quantity of users which these completed questionnaires represent. In some instances one completed reply represents the views of several users. The return from this questionnaire was 34,2%.

The strong supporters for strip charts as can be seen from Table No. 1, are home trade mariners, Coast Guard, pleasure craft, Laurentian Pilotage, and shore based mariners. Pilots in areas other than the Laurentian District are evenly divided, but international shipping and naval officers generally oppose it. The objections to it are generally on the grounds of safety, and possible confusion when in congested waters.

A total of 86 written comments were submitted on the strip chart and are fairly consistent in their suggestions for improvements required on strip charts in order to make them effective navigational instruments. A summary of these suggestions are:

1. A strong north indicator is required.
2. Meridians should not be broken in order to position notes.
3. Meridians should be visually distinguishable from parallels.
4. Subdivisions for plotting should be available in water areas.
5. The compass roses should be placed closer.
6. With the chart printed on a narrow strip of paper parallel rules frequently run off the edge, especially the roller type. Printing two together on a normal A.O. size paper will overcome this last problem.

It would appear that although chart 1310 is a great improvement over our small craft charts, it still requires further improvements in design to fully satisfy the chart user.

Removal of Light Information

The removal of light information is the next question dealt with on the questionnaire for chart 1310. The replies to this are tabulated in columns 7 and 8 of Table No. 1. A total of 112 users or 36.7% approved of the removal of light information from charts, 186 or 61% objected to removing light information, 7 or 2.3% expressed no opinion. A total of 47 written comments about the removal of light information were also received.

The rather large number of users 36.7% supporting removal of light information from the charts is at first rather surprising, particularly considering the open hostility expressed, at all meetings, to the removal of light information. However, examining the users by interest groups, a consistent pattern can be seen.

First there is a rather large group of pleasure craft operators who never sail at night, some of their written comments confirm this. Secondly, the home trade and coast guard officers are fairly evenly split, divided between purely local traffic which know all the lights, and those who roam further afield. Pilots are evenly split, they have the local knowledge and it would be in their best interest to remove light information from charts. Naval Officers are evenly split on this issue, but naval vessels are far better manned than merchant vessels and can afford the manpower to make the necessary pencil notations on the charts when required. Other chart users who support removal of light information never use this information.

Bilingual Charts

The bilingual aspect of this chart was not controversial, we only received nine written comments, and it was not discussed or commented on extensively at any meetings.

Chart Styles

The next question to be dealt with is chart styles, and the results from this questionnaire are given in Table No. 2. The first column of this table gives the total number of completed questionnaires received, and the second column shows the quantity of users which these completed questionnaires represent.

A total of 60 written comments dealing with chart styles were also received.

The returns show that 23% prefer the Standard Style, 67% prefer the Contour Style and 8% prefer Direct Conversion. A surprising number 32.8% consider that the Standard Style is not acceptable. After this trend was noticed several chart users were approached a second time to see if this was precisely what they intended to say. Generally the reply was yes, and the reason given, "because we feel that the Contour Style is a better chart, and we always expect the hydrographic service to produce only the best, therefore second best is not acceptable."

An examination of preferences by interest groups reveals preference for the contour style is evenly divided in all groups except marine schools, and tow boats on the east coast. The home trade mariners are evenly split three ways in their preference.

The largest groups which state that the contour style is not acceptable comes from the 'College of Fisheries', St. John's, Newfoundland, and the 18 replies from this source are unanimous in preference for the Standard Style. The objections to the contour style from these 18 replies are that it will be very confusing and cluttered when overlayed with Decca, or Loran, plus notice to mariners corrections.

During discussions in St. John's at a later date this question was discussed in greater detail. The chart which had previously been used by this group as a practical test for the contour style had been chart 4016. They state that labelling of the contours on this chart is poor, and contour lines are virtually useless without the aid of many soundings. The Vancouver prototype chart, it was agreed, is adequately labelled but it was questioned if an equivalent job could be achieved in Placentia Bay. This group is not yet fully convinced that bathymetric contour lines and lattices can be superimposed on the same chart without causing confusion in areas such as Placentia Bay.

The only strong support for direct conversion came from the home trade, where 34.6% prefer it. Many of these users supported direct conversion because it is a rapid method for converting an entire block of charts into metric units.

International shipping generally supported the Contour Style and noted that it has advantages, e.g. safe passing distances are more readily obvious and contours give an indication of currents and tidal streams.

Meetings

The meetings and discussions brought to light several items of concern to the users which did not stand out clearly in the completed questionnaires. The first and most important issue at all meetings was the need to identify clearly all metric charts. The labelling 'Depths in Metres' as is portrayed on the prototype charts was generally felt to be inadequate. The labels along the border of charts are often covered by paperweights.

A second major concern was that a systematic, not piecemeal approach be taken when converting charts into metric units. The general feeling was that an entire route should be completed at one go, and certainly not to commence conversion in the centre of a route.

Summary

The written comments from users are voluminous, and are contained in an 81 page appendix to the main report. The comments not only deal with the questions asked on the questionnaires, but touch on many aspects of the navigation chart. Many comments are of course repetitious, but for the cartographer who wishes to understand the users' needs they make interesting reading.

The strip chart with askew orientation is popular with many users. The numerous comments indicate that improvements in design are required. The survey also indicates that in areas of dense traffic such as the St. Lawrence River, it is wise to avoid producing askew oriented charts because of the safety factor. The removal of light information from charts is opposed by the major users of lights.

In chart styles the preference is clearly in favour of the Contour Style. However, the concern expressed in Newfoundland about confusion when lattices are superimposed over the contours must be carefully considered. In addition, the adequate labelling of contours is an important issue which was raised. All users felt that Chart M-3481 met the required standard.

Conclusion

The response to this survey has demonstrated that chart users are keenly interested in, and constructively critical of the navigational charts which we produce.

The results show that chart users are not afraid of change. They have examined the various options, discussed them, and given us the benefit of their experience. With this help the Cartographer can now proceed with the challenging and demanding task of designing a nautical chart to meet the changing needs of the user.

TABLE No. 1

Strip Chart with Askew Orientation and Deletion of Light Information

Total to October 15th, 1975

				STRIP CHART				REMOVE LIGHT INFO	
	QUESTIONNAIRE	REPLIES	%	P	A	NA	D	APPROVE	REJECT
Ship Surveyors - Port Wardens	10	15	4.9	13	0	2	1	2	13
Other Govt. Employees	8	8	2.6	6	0	2	0	4	4
Canadian Shipping Co.	10	10	3.3	7	1	2	1	5	5
Foreign Shipping Co.	14	14	4.6	5	7	2	1	2	8
Organizations	5	5	1.7	3	2	0	0	2	3
Marine Schools	11	19	6.2	14	1	4	1	3	16
Naval Officers	19	19	6.2	7	1	11	8	9	10
Mariners (International)	6	68	22.3	7	0	61	60	0	68
Mariners (Coastal)	22	22	7.3	16	3	3	1	15	7
Mariners Coast Guard	29	29	9.5	18	1	10	4	14	15
Tow Boats (West Coast)	1	5	1.6	5	0	0	0	0	5
Tow Boats	7	7	2.4	2	0	5	0	5	2
Pilots (Laurentian)	10	10	3.3	9	0	1	0	7	3
Pilots (Other areas)	10	10	3.3	5	1	4	1	5	5
Offshore Services	1	1	0.3	0	0	1	0	0	1
Vessel Traffic Management	7	7	2.4	7	0	0	0	5	2
Harbour and River Works	7	7	2.4	6	0	0	0	5	2
Pleasure Craft	36	36	11.4	30	1	5	1	19	15
Police	8	8	2.6	4	1	2	0	5	2
Others	1	5	1.7	5	0	0	0	5	0
TOTAL	222	305	100.0	173	19	115	79	112	186

189 replies in English; 33 in French.

P - Prefer
A - Acceptable
NA - Not acceptable
D - Dangerous

Initial Mailing - 550 Copies
Subsequent Mailing - 341 Copies
Total Mailing - 891 Copies
Total Replies - 305
Response - 34.2%

TABLE No. 2

Chart Styles

Standard, Contour and Direct Conversion

Total to October 15th, 1975

				STANDARD			CONTOUR			DIRECT CONVERSION		
	QUESTIONNAIRE	REPLIES	%	P	A	NA	P	A	NA	P	A	NA
Ship Surveyors - Port Wardens	16	16	6.9	2	7	6	13	1	2	1	1	12
Other Govt. Marine Employees	4	4	1.7	0	2	2	3	1	0	1	0	3
Canadian Shipping Co's	9	9	3.9	3	3	1	3	2	3	2	1	4
Foreign Shipping Co's	14	14	6.0	2	3	7	9	3	2	1	3	7
Marine Schools	7	29	12.6	21	2	1	2	1	19	2	1	20
Naval Officers	2	2	0.9	1	1	0	1	1	0	0	0	1
Mariners (International)	9	71	29.3	1	19	45	69	1	1	1	1	63
Mariners (Coastal)	26	26	11.2	8	12	3	9	4	9	9	7	8
Tow Boats (West Coast)	18	18	7.7	0	7	9	18	0	0	1	0	15
Tow Boats (East Coast)	6	6	2.5	6	0	0	0	5	0	0	0	5
Pilots	13	16	6.9	3	6	1	12	1	2	1	3	5
Offshore Services	2	2	0.8	1	1	0	1	0	1	0	2	0
Vessel Traffic Management	1	1	0.4	0	1	0	1	0	0	0	0	1
Harbour and River Works	3	3	1.2	0	2	0	2	0	0	0	1	1
Pleasure Craft	10	10	4.4	3	5	2	7	1	1	0	3	7
Police	2	2	0.9	1	1	0	1	1	0	0	0	0
Others	2	6	2.6	0	1	0	6	0	0	0	1	5
TOTAL	144	235	100.0%	54	73	77	157	22	40	19	24	157

8 Replies in French; 136 in English.

P - Prefer
A - Acceptable
NA - Not Acceptable

Initial Mailing - 550 Copies
Subsequent Mailing - 39 Copies
Total Mailing - 589 Copies
Total Replies - 235
Response - 39.9%

Let's Discuss Hydrographic Chart Scales

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"The Chart Schemer's Theme Song", a novelty poem which appeared in the last issue of LIGHTHOUSE, has generated some discussion, particularly with reference to chart scales. Perhaps this topic is worthy of elaboration.

Hydrographic charts in Canada consist of a large variety of seemingly inconsistent scales. Where did they originate? Why were they selected? Why can't all charts be at the same scale or, at most, at two or three different scales?

The Canadian waters of the Great Lakes are presently charted at about 30 different scales (not including harbours and insets). There are just as many paper sizes. In many cases, these scales originated decades ago, and I am sure that the exact reason for their selection is unknown to the hydrographer or cartographer of today. It is possible that, in some instances, a scale compatible with the original survey was chosen, the original survey having been conducted for a purpose other than marine charting. Also, many of the odd scales are a reflection of the imperial system of measurements where the following criteria were used.

Scale	Reasoning
1:72,960	1 inch = 1 nautical mile (6080 ft.)
1:63,360	1 inch = 1 statute mile (5280 ft.)
1:12,000	1 inch = 1000 feet
1:97,280	3/4 inch = 1 nautical mile at latitude $47^{\circ}30'$N.

The conversion to the metric system of measurements will eliminate the above arguments for odd scales.

However, in selecting scales for a new scheme of charts in conjunction with metric conversion, the following basic guidelines will have to be followed:

1) the scale will be large enough to adequately portray the degree of irregularity of the seafloor and the intricacy of the coast so as to enable safe passage past any dangers,

2) the closer a navigator must approach land, whether it be under or above the water, the larger must be the scale. Areas of restriction or complexity will require large scale charting. A rule of thumb which seems to have developed is that the narrowest portion of a tricky channel should be 1 to 2 cm wide at the scale of the chart. (O'Shea).

   A more traditional "rule of thumb" advises that, whatever chart he is using, a mariner should not approach nearer to charted dangers than the width of his own thumb. (Oudet).

3) overlapping charts must contain sufficient common features for a transfer of vessel position,

4) navigational aids and/or conspicuous features which together are required for positioning or guiding the vessel must appear on the same chart,

5) charts designed for recreational use will require more detail, both for the information and pleasure of the user,

6) metrication will call for scales that are a multiple of 10,000 or a factor thereof, e.g., 1:1,000, 1:5,000, 1:10,000, 1:20,000, ... 1:100,000, etc.,

7) it is desirable to maintain one scale for each series of charts,

8) an adequate ratio should exist between one series of charts and the next smaller (between 1:3 and 1:4),

9) scales of existing charts and their present acceptance by the user might be influential.

These factors must be balanced against the need for a chart to cover an area which is convenient to the mariner and which can be printed on a sheet of paper of manageable size. It is expected that charts will soon be printed on one standard size of paper, although there may still be some flexibility in the neatline (border) size.

From the above basic guidelines we can see that chart scales will never be restricted to a few standard ones, as are topographical map scales. There are just too many influencing factors. But the variance of scales can and most likely will be reduced. With the introduction of metrication - a more workable system of measurement - we can expect to see the scales of charts to be nearly always a multiple of 1,000, to be greatly reduced in number, and to be uniform in size with some limited flexibility in the border dimensions.

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The Survival of Hydrography

R.W. SANDILANDS
Canadian Hydrographic Service
Victoria, B.C.

In Canada, we are at present experiencing financial and man-year cuts in Government and there are indications that these will be of a long term nature.

It may therefore be of some interest to review the British experience of budget cuts as they have affected hydrography.

In view of cuts in defence expenditures the British Hydrographic Service is facing a crisis.

The Hydrographic Office of the Admiralty, as a part of the Royal Navy, was established in 1795 and was founded at a time when the Navy's losses through shipwrecks were greater than from enemy action.

The Board of Admiralty Minute establishing the office contained the following paragraphs:

> "The inconvenience especially when ordered abroad felt by Officers commanding His Majesty's ships respecting the navigation, has led us to consider the best means of furnishing such information, and preventing the difficulty and danger to which His Majesty's fleet must be exposed from defects of this head."
>
> "On an examination of charts in office, we find a mass of information requiring digest, which might be utilized, but owing to the want of an establishment for this duty, His Majesty's officers are deprived of the advantages of these valuable communications."
>
> "The extent of such an establishment not to exceed the sum of £650 per annum." (Edgell)

Within thirty years the Hydrographic Service in the United Kingdom had expanded to conduct its own surveys and to service the maritime community of the nation as a whole, a community upon which Britain's natural wealth as a trading nation largely depended. As an international charting agency the Admiralty has continued to survey the oceans and seas of the world and published the results as charts for all who needed them.

Only a country with wealth could afford such an effort for the good of all mariners. However times have changed and the state of Britain's economy is such that a hard look at her surveying policies has had to be taken.

The Hydrographic Service is funded as part of the Defence budget and the crisis has arisen with budgetary cuts following the withdrawal of the Royal Navy from areas east of Suez. A concentration of the defence effort on the approaches to Britain means that the requirements of merchant shipping can no longer be integrated within defence requirements.

The defence requirements of hydrography are at variance with those of industry. An ever increasing number of merchant ships greatly exceed in size any draught any surface warship likely to be built. Surveys that were adequate for men of war, other than submarines, are not adequate for modern deep draught ships. There is a need for surveys for safe routes in the North Sea for oil and gas production platforms, drawing up to 40 fathoms, on route from construction sites to the wellheads. The offshore industry is calling for support in the form of bathymetric and geophysical surveys of the continental shelf. Fishermen and recreational boaters have their special requirements.

The U.K. has some 530 ports. About 54 of the major and medium sized ones have their own hydrographic capability and a few more have contracted their surveys to private industry. Surveys of the remainder have, in the past, been undertaken by the Hydrographic Service in the course of their coastal surveys. A study of 46 ports which have handled passengers and cargo during the past ten years shows that one third had been resurveyed within the past twenty-five years but at the other end of the spectrum eleven had not been looked at for over seventy-five years!

At the end of 1974 slightly over 134,000 square miles, or 72% of the U.K. continental shelf remained unsurveyed or had been surveyed only by hand lead line.

Priority areas only were identified as 36 ship years and overseas commitments were estimated as a further 34 ship years which together is in excess of the surveys possible with the present fleet for the next decade.

Field surveys are only the beginning of the process leading to a new chart and extra staff are required at Taunton to deal with the flow of information.

As a world charting agency Britain receives information from the other 84 national hydrographic agencies and in 1974 received no less than 1,825 new charts and new editions from overseas. A backlog has built up and though the Admiralty plan for no more than ten years between editions of a chart about 42% of their charts have had no major revision for the past fifteen years.

A major demand from the British Department of Energy is for natural resource charting which is required whether or not the R.N. undertakes the surveys. But a review of the 22 British companies reported to have surveying capabilities indicates that only about 5 have the resources and expertise to carry out surveys of large offshore areas to Admiralty standards and these companies have their order books full. The Department of Energy already has one R.N. ocean survey ship committed to it for the next few years and their budget is fully committed for the next three years. Unless the oil industry itself can be persuaded to make some contribution, and this is thought to be unlikely, the cost of the ship can only be borne until 1978-79 by an increase in their Department of Energy budget.

With its present hydrographic fleet, the Royal Navy has said that it can meet its defence requirements, but unless the Government digs into its pocket the losers will probably be the Merchant Navy, marine insurers and the offshore industry.

Though Canada does not produce a world wide coverage of charts it has a vast coastline, it is an exporting nation, it has a large fishing industry, its natural resource mapping is sparse and an extension of its territorial limits to 200 miles offshore will place further calls on our field surveys.

We have legislated tough charting regulations which will mean little if we do not carry out modern surveys in support of our charts and also have the cartographic services to process the collected data to usable form.

The Stewart-Dickie report identifies the growth areas for hydrography and concludes:

> "It is our opinion that virtually all of this growth should take place by systematically contracting out surveys. The Government in-house surveying capability need not expand, and could eventually even contract slightly."

> "More and more of the routine surveying should be let to contract with private operators. Contracts should not occupy the full capability of these operators who would be expected to sell their services not only to the Government but also to private concerns such as, for example, oil companies and private marine operators. Private survey vessels could also be available to be contracted as research vessels by other government agencies and by universities."

Despite these recommendations, contracts to industry for hydrographic surveys have been 'spotty' and the number and type of contracts placed has not yet brought forth many companies with hydrographic competence. To date no Canadian company has attempted a total hydrographic survey of a large offshore area. Certainly insufficient contracts have been placed to sustain the industry - indeed one large company has been forced to lay off experienced hydrographic staff. As some of these staff left government service for the private sector it is not an encouragement for others presently employed by the Canadian Hydrographic Service (C.H.S.) to consider such a move. This will make it difficult for industry to recruit hydrographers with experience of Canadian conditions and possibly lessens their efficiency.

No final compilation for hydrographic charts has been attempted by industry.

Thus presently the only real hydrographic competence lies entirely in the government sector.

Judging from the British experience we can see that this is not a healthy situation. There is a definite need for competence in both sectors, a competence that can be maintained by the sustenance and competition of each sector.

We must place hydrography in industry on a firm continuing basis to enable it to build up a total competence in hydrography within the next few years. Scraps from the government table will not build a healthy competitive body. On the government side definite long term commitments of cash for these surveys and of man-years and money for C.H.S. surveys and compilation back up must be made if we are not to seriously endanger the standards of our charts and diminish the support we presently give to our offshore industry, fishing fleets and mariners entering our waters.

Let none be "deprived of the advantages of these valuable communications."

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New Scientist, Vol. 67, No. 966, September 1975.

The Speed of Sound in Water

C.D. MAUNSELL

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Bedford Institute of Oceanography
Dartmouth, N.S.

The introduction of the echo sounder into routine hydrographic surveying, replacing dependence on use of the lead line, produced a major change. It must be remembered that a sounder actually registers a time interval and that the speed of sound must be known to convert the time to depth. The International Hydrographic Bureau resolved that 1500 metres per second should be adopted as a standard velocity. Most Canadian waters are cold enough that this causes an overestimate and, for calibration, the value of 1463 metres per second (800 fathoms per second) is frequently used. Since fresh water has to have a temperature of 14.2°C before this speed is attained most soundings in deep lakes will be overestimated with this calibration.

The velocity of sound in water depends upon temperature, concentration of dissolved constituents (for which salinity is the conventional quantity in oceanography) and pressure. The actual value at a given location and time may be evaluated by use of one of the following procedures:

1) A "bar check" by which the echo from a reflector lowered to a known depth is observed. This is conveniently carried out in shallow water with low currents, gives a mean velocity to the observed depth and simultaneously checks the calibration of the sounder. It is not too useful if the bottom soundings become very different from the check value because the average velocity is likely to change with depth.

2) Direct measurement of the sound velocity as a function of depth. The appropriate mean velocity must then be calculated. This procedure can be time consuming in deep water and one must be satisfied that the velocimeter has been accurately calibrated.

3) Reference to files of oceanographic or limnological station data observed in the same area at a similar time of year. The sound velocity is then found by reference to tables or use of an appropriate formula.

Early tables (up to 1939) were based on calculation from laboratory measurements of compressibility and additional thermodynamic data. Matthews' tables proved especially convenient since, in addition to tables enabling calculation of in situ velocities, he divided the oceans into oceanographically similar areas and published tables listing sounder corrections.

Following the introduction of digital computers formulas were fitted to the tabular data to permit large numbers of sound velocities to be routinely calculated.

By 1952 it had been shown that the near surface velocities given by Matthews and similar tables were about 3 m/s too low. In 1960 Wilson published the first measurements which included the variation with pressure to the values reached in the ocean depths. His formulas were widely adopted by oceanographers, replacing the earlier computation schemes. It is worth noting that in spite of the 3 m/s increase in near-surface velocity from earlier values the Wilson results agree with the tables for pressures corresponding to depths of 2000 metres.

Over the next decade there arose some questions about values from the Wilson equation. Part of this arose from the fact that the observations used by Wilson in developing his equation included combinations of temperature, salinity and pressure not found in nature. In addition it appeared that his atmospheric pressure values were high, perhaps as a result of inadequate abolition or correction of systematic errors. There was of course no guarantee that additional systematic errors were not introduced at high pressures.

A new program of determining sound velocities over range of temperature, salinity and pressure matching conditions throughout the oceans was engaged in by Del Grosso and Mader of the Naval Research Laboratory, Washington. Their results have been fitted to a new equation by Del Grosso which is also valid for fresh water. Recalculation of velocities for a meridional section of oceanographic stations in deep water gives velocities near the surface 0.2 m/s less than Wilson with the discrepancy at greater depths increasing, until the Del Grosso formula gives velocities 0.5 to 0.6 m/s less than the Wilson formula. Recently Medwin has published a much simpler formula than Del Grosso's which for depths less than 1000 metres gives values in good agreement with those from the more complete formula.

An independent study of the dependence of sound velocity on temperature, salinity and pressure is being carried out by Kroebel and Mahrt of the University of Kiel. Their preliminary work at atmospheric pressure in both fresh and sea water agrees with that of Del Grosso within a few centimetres per second. They have not yet reported results on pressure dependence.

The effect of the changes in sound velocity formulas on echo sounding can be summarized as follows. In marine waters of Canadian interest Matthews gives corrections to raw depths read from a sounder calibrated for 1463 m/s. As percentages of the raw depth these are:

	Approximate Depth		
	200 m	3000 m	4800 m
Off Nova Scotia	1.5 %	1.7 %	-
Off Labrador	0.5 %	1.6 %	-
SE of Grand Banks	-	2.3 %	3.2 %
Arctic	- 1.5 %	0.5 %	-
Near B.C. Coast	0.5 %	1.5 %	-
Pacific Offshore	-	1.7 %	-

These are of sufficient magnitude to deserve consideration.

Going from Matthews' velocities to those of Wilson involves a further correction increasing depths by up to 0.2 % of their value. It is probably not worth applying such a modification to values from the tables because the zone boundaries as published do not exactly describe the oceanographic conditions. The formula of Del Grosso predicts depths about 0.04 % less than those given by use of Wilson's formula.

Use of the modern sound velocity formulas for correcting soundings in areas with adequate oceanographic coverage will give better estimates of true depth. Great care must be taken in combining old and new soundings to avoid contouring in imaginary features arising solely from the use of different depth corrections.

Because oblique propagation as is involved in side scan sonar is affected in a complicated manner by ray bending depending on the gradient of velocity with depth the effects of the different formulas cannot be easily summarized.

AUTHOR'S NOTE: Purists may cavil at the use of the word "velocity" to describe a scalar magnitude. However it is the conventional use in underwater acoustics.

References

There is considerable literature on sound velocity in water. I have referred to work reported in a small number of papers. Examination of the recent papers will provide a comprehensive list.

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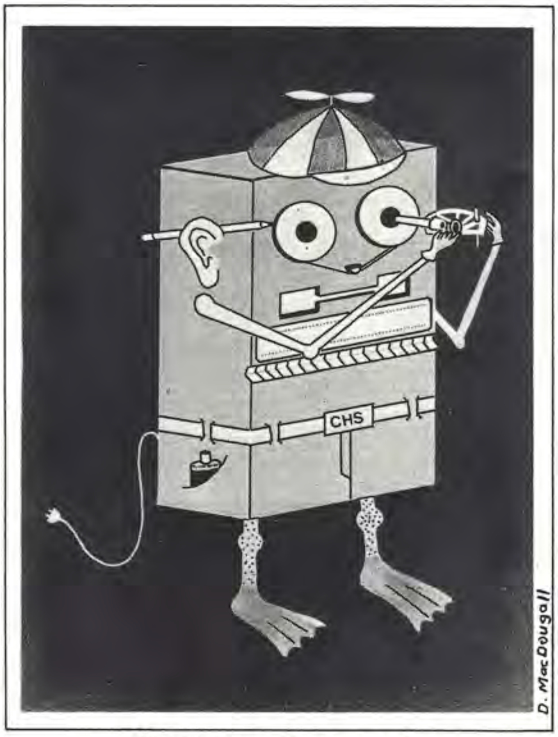

The Modern Hydrographer

15th Annual
Canadian Hydrographic Conference
1976

Sponsored by
Canadian Hydrographic Service, Headquarters,
and
Canadian Hydrographers Association

The conference is to be held at the Canadian Government Conference Centre, Ottawa. It will open Tuesday morning, April 20, 1976 and will close on Friday, April 23, 1976 with the Annual Meeting of the Canadian Hydrographers Association.

Program

Approximately twenty papers covering a broad range of hydrographic interests will be presented. Abstracts of these papers will be available at the registration desk from 17.00 hours, Monday, April 19, 1976.

There will be a large display for commercial exhibits at the Conference Centre.

A compilation of papers presented will be published and distributed to the registrants after the conference.

Social Activities

An "Ice Breaker Party" will be held at the Conference Centre Monday evening, April 19, 1976 at 20.00 hours.

A luncheon will be held at the Chateau Laurier on Tuesday April 20, 1976. Tickets are $6.00 per person.

A dinner dance will be held at the Chateau Laurier on Wednesday evening, April 21, 1976 commencing at 18.30 hours. Tickets are $12.00 per person and $20.00 per couple.

Accomodation and Transportation

A block of rooms has been reserved at the Chateau Laurier Hotel. Participants are advised to confirm their accommodations at their earliest convenience. The airport limousines call at the Chateau Laurier Hotel. A hospitality suite will be available to the ladies during the day.

General Information

Registration fee is $35.00 per person. Fee includes all sessions and the "Ice Breaker Party". The registration desk will be open during the conference to provide information and issue conference program kits to the registrants. Registration forms and further information concerning the conference are available from:

Mr. S. van Dyck
Conference Co-Chairman
15th Annual Canadian Hydrographic Conference
Canadian Hydrographic Service
Rm 241, 615 Booth Street
Ottawa, Ontario
Canada
K1A OE6

News from Industry

Tellurometer Assists Supertanker Docking

Tests in Durban, South Africa and Singapore have demonstrated that the intricate task of mooring super tankers to a single buoy discharge system can be greatly simplified by the use of a Tellurometer MRB201.

A recent development, the Digital Velocity Indicator, fitted as an option on the master unit precisely measures and displays the approach speed and range of the vessel. Using a remote on the buoy and the master on the bow of the tanker, dockings were successfully completed both day and night in half the time normally required. The photograph below shows the 190,000 D.W.T. "Esso Mercia" discharging her cargo in Singapore following the mooring trial.

Banister Tracked Vehicle Program

In November 1975 Banister Technical Services were awarded a $450,000 contract by the Federal Government to provide and evaluate a Flexitrac CF23 vehicle, using Banister's BANQUES system, for spot sounding through ice. A field trial will be carried out at Resolute during April and May of this year. Mike Crutchlow of Central Region, C.H.S. will work with Banister during the project, and will be reporting on this development in the next issue of LIGHTHOUSE.

DEEPTOW Seismic Profiler Developed in Canada

Over the past three years marine geophysicists, engineers and research scientists at the Bedford Institute of Oceanography and Huntec ('70) Limited of Scarborough, Ontario have worked together on Project SEABED. Conceived by Huntec and partially funded by the Department of Supply and Services, the project has developed and evaluated a deep towed high resolution seismic profiler capable of operating in previously impossible conditions.

Significant improvements over conventional systems have been realized with the DEEPTOW System. Signal to noise ratio is improved since noise from the sea surface, ship and tow vehicle is less at tow depth, while reflected signals are stronger due to reduced water column attenuation. Propagation geometry remains stable despite pitch and roll of the ship, and cable loss is eliminated by placing the energy source for the seismic pulse and the pre-amplifiers in the tow vehicle. Operation at speeds of 8 knots in 7 metre swells has been demonstrated with excellent penetration in water depths to 1400 metres.

Over 6000 line kilometres of seismic data have been collected to date from the Nova Scotia and Labrador shelves for the purpose of evaluating the system in seismic studies and geological reconnaissance. The ultimate goal of the project is the remote and automatic classification of the material properties of the sea floor and underlying strata. At present one DEEPTOW System is being used in Senegal on the CSS BAFFIN as part of a resource survey of the continental shelf and slope, and a second system is destined for use in the North Sea oil fields.

C. H. A. personal notes

Atlantic Branch

Arthur Kenny retired on Dec. 29, 1975 after 25 years with CHS; *George Yeaton* is on French language training prior to taking up his new position in Ottawa as Chief, Nautical Geodesy; *Gary Henderson* recently left Bedford Institute and CHS to take up the position of Flood Risk Mapping Engineer with the Inland Waters Directorate, Halifax.

Ottawa Branch

Gerry Ewing (Dominion Hydrographer) is among many of those taking the French language training course of the Federal Government; *Donald Bayne*, a compiler in Chart Construction from 1950 until his retirement in 1972, passed away recently at his residence in Ottawa.

Central Branch

Tom McCulloch, known to many as Vice-Chairman of Commission IV (Hydrographic) of FIG and as President of CIS was in hospital over Christmas and operated on for kidney stones on hogmanay (New Years Eve you Sassenachs!); *Chris Gorski* is back at work after contracting hepatitis on field duty last year on L. Winnipeg; *George Fenn* fell into the "tender trap" on Dec. 13 and *Sam Weller* will follow on his return from the Senegal Survey; *Joe McCarthy* has recently gone into the Dairy Queen business but is having trouble keeping up with the local demand for complimentary gift certificates.

Pacific Branch

Ian Campbell left the C.H.S. last April and after extensive refit and shakedown cruise plans to sail up the B.C. coast to Prince Rupert this summer on a National Film Board project; *Roger Hlina* has transferred from C.H.S. to D.P.W. but continues his career as a hydrographer, working on the Fraser River; *Jerry Rogers* has forsaken the sea for farming in the interior of B.C. and is busy building a log cabin; *Ken Highton* has returned to B.C. after extensive travel in Europe, Asia and Africa and is presently studying for his Real Estate examinations; *Lorne Landry* has returned to University and is studying at U. Vic prior to taking up a teaching career; *Charlie McIntosh* who retired from the C.H.S. in 1974 is now doing consultant work in hydrography; *Trevor Jones* retired from Sailing Directions (B.C.) and is enjoying hacking out a garden at his new home on Saltspring Island.

News from C. H. S.

Cartographic Decentralization

As a part of the move to greater decentralization of cartographic activities in the Canadian Hydrographic Service, Central Region will be acquiring two new staff this summer, and a start made on chart production in the region.

Polar Continental Shelf Project

A survey party from Central Region, led by Ed Thompson, will be working in Belcher Channel and Penny Strait in the High Arctic this winter. As well as helicopters, they will be using a "BOMBI" tracked vehicle with a mounted transducer developed by the Tidal Instrumentation Section in Burlington to obtain soundings through ice.

Senegal Survey

A multiparameter survey funded by Canadian International Development Agency (CIDA) is presently being carried out off the coasts of Senegal and Gambia. The survey party, headed by Bob Marshall, consists of personnel from Central Region, Atlantic Geoscience Centre and industry (see note in News from Industry) working on board CSS BAFFIN gathering bathymetric, gravimetric and magnetic field data. Reports to date indicate that the survey is progressing quite well. More on this in a later issue of LIGHTHOUSE.

Toronto Boat Show, January, 1976

The Canadian Hydrographic Service, Central Region, were again active in setting up and manning a display which attracted considerable attention from yachtsmen. A working INDAPS, including a plotter, attracted much attention, as did a proof copy of the new Olympic chart. Ray Chapeskie had considerable success with a questionnaire aimed at obtaining information concerning recreational boating patterns on the Great Lakes.

1976
H_2O Bonspiel

(From left) Brad Tinney, Brian Monaghan, Henry Boyce and Richard Tobin of the Winning team of the "B" event.

On January 17, 1976, Central Branch of the Canadian Hydrographers Association sponsored the 4th annual H_2O Bonspiel at the Humber Highland Curling Club in Etobicoke. The event was very successful with forty-eight participants and a good time had by all. Top prize was won by Al MacDonald and his rink.

(From left) Ed Thompson, presenting the top prize, Alan Humphry, Walt Andrew, Evelyn Conn and Alan MacDonald of the winning team of the "A" event.

Donations for the 1976 H_2O Bonspiel were gratefully received from the following:

- ComDev Marine, Ottawa
- Canadian Applied Technology, Buttonville
- Motorola Military & Aerospace Electronics, Willowdale
- Tellurometer, Canada Ltd., Ottawa
- Port Weller Dry Docks Ltd., St. Catherines
- Decca Radar Canada (1967) Ltd., Toronto
- Wild Leitz Canada Ltd., Ottawa
- O'Keefe Brewing Co. Ltd., Malton
- Rab Engineering, Mississauga
- Riviera Motor Hotel, Burlington

Letters to the Editor

Sir, --- I disagree with the published answer to the riddle in Edition No. 12, asking "In which state is the easternmost point in the United States?" The Oxford Universal Dictionary defines "easternmost" as "situated farthest to the east" with "east" defined as "the portion of the horizon or the sky near the place of the sun's rising". These definitions do not refer to a specific longitude coordinate system. Maine with West Quoddy Head on Grand Manan Channel satisfied the criterion of the riddle. The U.S. Virgin Islands Territory extends even farther east.

The published answer requires that the question be interpreted as meaning "What state in the United States has the point with greatest east longitude as measured in the conventional system (prime meridian passing through Greenwich and restricting longitudes to a maximum numerical value of 180 degrees)?" With such an interpretation linked to the specific coordinate system how could you answer the question "In which province is the easternmost point in Canada?"

C.D. Maunsell
Atlantic Oceanographic Laboratory
Bedford Institute of Oceanography
Dartmouth, N.S.

EDITOR's NOTE: The original riddle was submitted by our "westernmost" (with respect to the Greenwich meridian) assistant editor, who resides in British Columbia. As you know, there was a time when the sun never set on the British Empire, therefore, why should it ever rise (by some slightly inverse logic!). Confronted with this seeming Gordian knot the Editor struggled to phrase the question bearing in mind the definition of "easternmost" in the Oxford Universal Dictionary.

Sir, --- My compliments on your first edition of the revived LIGHTHOUSE and a suggestion for a future issue. I'd like to see an article about the upcoming scale changes mentioned in your little poem.

Keep up the good work!

N.A. Rukavina, Head
Physical Sedimentology Section
Hydraulics Research Division
Canada Centre for Inland Waters
Burlington, Ontario

EDITOR's NOTE: An elaboration on the topic of chart scales can in fact be found in this issue.