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EDITION NO. 17, APRIL 1978

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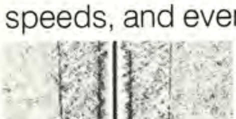

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EDITION No. 17

LIGHTHOUSE

APRIL , 1978

JOURNAL OF THE CANADIAN HYDROGRAPHERS ASSOCIATION

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Canada's Hydrographic Role in FIG

T. D. W. McCULLOCH

Director, Central Region
Ocean and Aquatic Sciences
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The letters FIG may not be familiar to all of you. They stand for Federation Internationale des Geometres or the International Federation of Surveyors, a grouping of the national association or organization of surveyors of all countries with the object of interchanging views on matters of general interest to the profession. It is one of four large organizations that are active internationally in the field of surveying. The other three are the ISP, the ICA and the grandaddy of them all, the IUGG (International Union of Geodosy and Geophysics) formed in 1861.

FIG was founded in 1878 at Paris by delegations of seven national professional organizations (Belgium, Germany, France, Great Britain, Italy, Switzerland and Spain). A continuous development of cooperation began with the III Congress in 1926, the work of FIG being handled by four commissions managing such professional subjects as:

a) Unification of problems of the profession;
b) Instrument and procedures of the surveying practice;
c) Education and rank of the surveyor;
d) The status of the surveyor in the field of land registration.

Twenty-three countries were represented at the 1926 Congress.

By 1968, FIG Congress XII in London, was attended by 36 countries and was organized into three groups. Commission Group A - "Professional organization and activities", Group B - "Surveying, photogrammetry and cartography", Group C - "Land utilization and land administration". Within Group B was Commission 10, a brand new Commission dedicated to Hydrographic Surveying.

For the first time in the history of FIG, hydrographic surveying was included in the programme of the Congress. A total of eleven papers were presented and discussed most enthusiastically by an average attendance of 50 delegates. The Chairman of Commission 10 was Rear Admiral G.S. Ritchie (U.K.) Hydrographer of the Navy. Two CHA members, A.J. Kerr and H. Furuya attended the Congress and took an active part in the business of Commission 10. The Chairman wound up the session by stating that in his opinion the first hydrographic contribution to a FIG Congress had been an unqualified success and should be repeated at further Congresses, a view which was supported by Captain Moitoret on behalf of the other delegates.

The next FIG Congress was held in Wiesbaden and was attended by 43 countries and represented many thousands of surveyors. For this XIII Congress, the structure was altered slightly:

Group A - Commission 1 - Professional Practice
Commission 2 - Professional Education
Commission 3 - Professional Literature

Group B - Commission 4 - Hydrographic Surveying
Commission 5 - Surveying Instruments and Methods
Commission 6 - Engineering Surveys

Group C - Commission 7 - Cadestral and Rural Land Management
Commission 8 - Urban Land Systems, Town Planning and Development
Commission 9 - Valuation and Management of Real Estate

Commission 4, Hydrographic Surveying, was chaired very ably once more by Admiral Ritchie. The Vice-Chairman was Dr. Fagerholm of Sweden with Lt. Cdr. J.C. White of the U.K. as Secretary. Six sessions were held with 15 papers and an impromptu panel discussion on contract surveys of immense and growing interest to all concerned. Probably the most important paper at the Congress was A.E. Ingham (U.K.) discussing "The Role and Training of the Hydrographic Surveyor". That paper lead to demands for the setting up of a Working Group to report on "Training Requirements and Standards of Competence within the Profession". I believe you are all aware that A.J. Kerr has served on that Working Group with distinction. Canadian papers at Congress were delivered by CHA members N. Anderson and T.D.W. McCulloch covering the subjects of Motorola RPS and its application to hydrographic surveys and an overall view of the Canadian approach to hydrography.

Dr. Fagerholm took over as Chairman of Commission 4 in 1972 at the FIG Permanent Committee meeting in Australia, with M. Eyries of France as Vice-Chairman and J.C. White continuing as Secretary. In 1973 Dr. Fagerholm resigned to take up a posting with the UN and Admiral M. Eyries of France became Chairman.

FIG XIV Congress took place at Washington in 1974 and Commission 4 was well represented. There were 22 papers together with a joint session with Commissions 5 and 6. There were six Canadian papers in Commission 4, quite an achievement, with an additional paper given on education and training for hydrographic surveying in Commission 2, the Education Commission. The Working Group on Standards of Competence in Hydrography gave its report and was asked to liaise with IHO with the object of forming a joint Working Group to report back to FIG and IHO in 1977. Two new Working Groups were formed - one to work on data acquisition and processing systems - the second on positioning systems. The first Working Group was a Canadian responsibility, the second a U.S. affair. T.D.W. McCulloch of Canada was appointed Vice-Chairman of the Commission. At least 10 Canadians were in attendance at the Commission 4 sessions.

FIG XV Congress was located at Stockholm in 1977, again with M. Eyries in the chair. Sixteen papers were delivered in Commission 4 sessions, five Canadian, with two additional hydrographic papers given in joint meetings with other Commissions. The joint FIG/IHO report on Standards of Competence was adopted and three FIG members were appointed to the newly formed Board of Education. The Working Groups on Data Acquisition and Processing Systems and on Positioning Systems were asked to continue to update their reports and a new working group was formed to deal with sonar systems and techniques.

A new venture for FIG Commission 4 is planned for 1979, when the very first International Hydrographic Technical Conference will be held in Ottawa under the joint auspices of FIG, CIS, and the CHS. The theme is "Development of Ocean Resources", and papers from around the world will be featured. As at all FIG affairs there will be a mix of commerce, government and academia, with particular emphasis on the unique role of commerce in the exploration of the offshore. Commission 4, FIG, provides that important umbrella where commerce, government and academic interests in hydrographic surveying can meet as equals to the mutual benefit of all.

The Chairmanship and other offices of FIG Commission 4 change in 1978 at the Paris Permanent Committee Meeting. T.D.W. McCulloch of Canada will take over the chair, with an as yet unnamed Vice-Chairman from Japan and with Rear Admiral R. Munson NOS-USA as Secretary. We look forward to strong Canadian and particularly CHA membership involvement in the XVI FIG Congress to be held at Montreux, Switzerland during the summer of 1981.

A final point of interest for those of us still around in 1986, Canada (CIS) will host the XVIII FIG Congress in Toronto. I look forward to CHA making their mark at that time.

* * * * * * *

Landsat Goes To Sea

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Washington, D. C.

Abstract

Current and proposed technological advances in navigation technology and the remote sensing of oceanic parameters will require nautical charts more accurate than many of the charts that are in use today. This is of serious concern to the international hydrographic community since existing hydrographic survey resources are too limited to perform the detailed surveys required to produce the type and volume of charts that will be required in the 1980's.

The Defense Mapping Agency, which has a statutory responsibility to provide charts for civil maritime use in addition to its defense obligations, has been investigating a new charting tool that may provide a partial solution to this dilemma. NASA's Landsat returns data from its Multispectral Scanner (MSS) that can be used to evaluate and update medium- and small- scale nautical charts. The MSS green band data can be used to probe clear oceanic waters to those depths required for safe navigation by most ships. The data may also be used to plan hydrographic surveys of reef and shoal areas so that limited survey resources can be exploited to their fullest. Existing charts can be evaluated for accuracy and currency of hazardous, near surface features, thus permitting the hydrographic survey resources that are now stretched thin to be most effectively used where they are most needed: to define the safe shipping routes.

A recent test project, performed at the Defense Mapping Agency Hydrographic Center, has demonstrated the feasibility of using MSS film imagery to evaluate and revise the positions of islands, banks and reefs on a nautical chart. Additional research is being funded to investigate the practicality of using, and to optimize the digital water depth determination capabilities of the MSS data as demonstrated in the 1975 joint NASA/Cousteau Ocean Bathymetry Experiment. Such techniques could then be more effectively applied to the chart production process.

Introduction

Biologists tell us that man's ancestors emerged from the sea. Economists tell us that man must now turn again to the sea. The world's economy is becoming more and more dependent on the oceans; for food, for minerals, for energy and for transportation. Yet, at a time when cameras and sensors aboard National Aeronautics and Space Administration's (NASA) interplanetary probes have mapped the surface features of the moon and several planets, fully 70% of the earth's surface remains shrouded in mystery beneath the oceans. Major technology development efforts are being oriented towards exploring and exploiting the earth's last frontier. In the United States these marine studies are supported by the Marine Resources and Engineering Development Act of 1966 (Public Law 89-454, June 17, 1966). The policy of the United States as stated therein is "to develop, encourage, and maintain a coordinated, comprehensive, and long range national program in marine science for the benefit of mankind to assist in protection of health and property, enhancement of commerce, transportation, and national security, rehabilitation of our commercial fisheries, and increase utilization of these and other resources."

Hydrographic Surveying History

Although man has been venturing over the oceans for thousands of years, it was only within the last fifty years that advances in technology enabled him to make more detailed observation of features hidden in the depths beyond the limits of his natural senses. Until the invention of the echo sounder, knowledge of the sea bottom topography was primarily limited to that information which could be gleaned by lowering a rod or a weighted line over the side of a boat until it touched bottom, or until it reached its length. In the latter case, a no bottom sounding was recorded in the survey data. Such sounding methods have been documented as early as 1422 B.C. when they were depicted on the wall of the tomb of Menna, an Egyptian scribe (1). Actually, this simple procedure could be said to be the first form of remote sensing. The sounding line continued to be used to determine depth during the extensive world wide surveys undertaken by the major sea powers during the nineteenth and early twentieth centuries. Despite the phenomonal efforts of these early hydrographers, they were able to examine in detail only a fraction of the oceans' 360 million square kilometers. The majority of these surveys were dedicated to ensuring safe passage for vessels with less than ten meters draft. The relative accuracies of many of these early surveys in areas near land features is often astounding, especially considering that their primary tools were leadline, sextant and chronometer. On the other hand, the absolute accuracy of these surveys and the relative accuracy of any surveys made out of sight of land were limited by the ability of the hydrographer to obtain adequate celestial fixes which at best could only define his position to within several kilometres. The fact that they were often unaware of currents that carried them off course also degraded the results.

Data Shortfalls

Since the widespread advent of precision sonar equipment in the early 1950's, more information about sea bottom topography has been collected than during the rest of man's recorded history. However, a recent appraisal by the International Hydrographic Bureau estimates that only about 16% of the oceans have sufficiently adequate soundings to determine sea floor topography. Another 22% of the oceans had data sufficient only for the determination of the major sea floor features and the remaining 62% of the ocean areas have data that is too sparse for determining sea floor topography (2). In fact, one French expert, Captail L. Oudet, Ret., has stated "that any chart based on surveys before 1970 carries with it a risk that the surveyors may have missed some dangerous wreck or other obstacle to navigation" (3).

Changing Requirements

Until recently, in spite of the limitations of the survey data, most charts available have been satisfactory for conventional ships in areas where safe routes have been established. Unfortunately, however, these sea lanes do not always follow the most direct routes (3). Additionally, some conventional passages such as the Strait of Malacca are too shallow for the new deep draft vessels (some of which require clearances of nearly thirty meters). Consequently, they must seek out longer, less well surveyed, but deeper routes to their destinations. A number of other factors are contributing to the opening of new trade routes for vessels of all sizes. The increasing production and export of natural resources from the developing nations, particularly those in the southern hemisphere, is resulting in increased shipping through areas with outdated or inadequate surveys. It should be noted that a large majority of these developing nations have not yet established hydrographic services (2). Present technology trends will result in even more drastic changes to shipping patterns during the 1980's. The proposed NAVSTAR Global Positioning System will provide mariners with continuous, precise positional information anywhere in the world. Environmental monitoring satellites will be providing world-wide weather conditions, ice patterns, sea state, and ocean current data. Maritime communication satellites will make this type of information available to the mariner in near real time. With the inflated fuel costs projected for the next decade, more navigators will plot their course to minimize distance traveled while taking advantage of all favorable winds and currents.

National and International Priorities

Thus, the requirement to acquire accurate and adequate hydrographic surveys over large areas of the world's oceans demands immediate attention. However, hydrographic survey resources are quite limited and tend to be expensive. Both national and international interest is being taken in this problem. In April 1970, the President's message to the Congress (4), prepared by the National Council on Marine Resources and Engineering Development, stated:

> "More efficient sea transportation vitally depends upon portfolios of accurate nautical charts and publications for the open ocean as well as coastal ports and waterways...International, oceanic, legal, and political questions often require facts available only from precise maps and accurate marine data if they are to be answered." —Chapter IX, Page 115:
>
> "The seemingly simple activities of charting the ocean and predicting its future actions are in fact the most massive and intractable problems which now face marine scientists. At our present rate of progress, mapping the topography of the ocean bottom will involve hundreds of ship-years of work... Faced with tasks of this magnitude, the United States clearly must take two steps: First, delineate what parts of the sea are of prime interest and therefore to be given priority attention; and second, increase the speed and efficiency of survey operations." —Chapter IX, Page 127-8.

Internationally, forty-seven nations are cooperating in hydrographic surveying and charting under the authority of the International Hydrographic Organization (IHO) which was established in 1921 as the International Hydrographic Bureau. By means of conferences, publications, and correspondence, the IHO has developed international accuracy standards for hydrographic surveys (5); and an international series of small-scale charts, and is encouraging the exchange of hydrographic data among nations as well as coordinating joint multinational surveying efforts. In spite of international cooperation and even allowing for increased survey efficiency from improved technology, much of the ocean will still lack adequate hydrographic surveys during the 1980's. (As a basic example, a recent British Hydrographic Study Group concluded that 284 ship-years of work will be required to bring their territorial waters up to modern standards and that their foreign areas of responsibility would require an additional 300 ship-years of effort (6).)

NASA / Cousteau Ocean Bathymetry Experiment

With such inadequacies in surveying resources in mind, NASA and the Cousteau Society conducted a joint Ocean Bathymetry Experiment during August and September, 1975. The goal of the experiment was to determine the capability and feasibility of determining water depths from special high gain data collected by the Multispectral Scanners (MSS) aboard the two Landsat satellites currently in orbit. Previous studies with both aircraft and standard MSS data from Landsat-1 (ERTS-1) had demonstrated the general techniques of remote bathymetry from multispectral scanner data (7,8). The NASA/Cousteau Ocean Bathymetry Experiment did prove the feasibility of satellite bathymetry. In the Berry Island test area, depths as deep as twenty-two meters (10% rms accuracy) were measured from the satellite data and verified by the ground truth team on the Calypso (9). Landsat also revealed shoals that were later determined by the Calypso to be at a depth of forty meters. In the less clear waters off the Florida coast, Landsat data were used to map shoals as deep as ten meters (9). Additional research and comparison of Landsat high gain data with aircraft acquired data and recent charts indicated that depths could be deduced without knowledge of the measured optical properties of the waters in the area investigated (10). This capability could be very important when studying remote areas.

DMAHC Evaluation

Within the United States, the Defense Mapping Agency (DMA) through its Hydrographic Center (DMAHC) carries out statutory responsibilities to provide "accurate and inexpensive nautical charts" and other marine navigational data "for the use of all vessels of the United States and of navigators generally" for all areas outside of U.S. territorial waters (11). Following the presentation of the initial results of the NASA/Cousteau experiment, a comparison was made between world-wide Secchi disc data (12) and the areas most deficient in adequate bathymetry (13). It was found that many of those areas lacking adequate survey data have water as clear as or clearer than that in the Berry Islands test area. Thus, in February 1976 the Defense Mapping Agency requested NASA to provide special Landsat high gain

MSS data over three test areas where forthcoming survey efforts would be able to provide ground truth for evaluations. The goal is to test the practicality of using Landsat MSS data for chart evaluation and preparation as well as to appraise their use as a survey planning tool. Pending receipt of data from the special tasking, a research contract was initiated with the Environmental Research Institute of Michigan to convert digital MSS data from two previously acquired high gain images of the Bahamas to a form that could be used in chart production or survey planning. The results of this endeavor will be available later this year.

Chart Revision

At the conclusion of the data acquisition period, only partially cloud free imagery had been received over the Bahamas test area; the Virgin Island test site had been completely cloud covered; but 80% cloud free imagery had been obtained over the third test area, the Chagos Archipelago in the Indian Ocean. It was the initial evaluation of the Chagos imagery acquired in March and April that resulted in a profitable side application beyond the original test design. The film imagery acquired on March 29, 1976 revealed a major reef 8 kilometers long as well as a number of other variations that were not portrayed on the existing chart of the Archipelago (U.S. Chart No. 61610, Second Ed., February 21, 1976, 1:363,230). This discovery resulted in an application of the proven cartographic capabilities of the Landsat film imagery (14, 15, 16) to the evaluation and the correction of the horizontal positions of features on a medium scale nautical chart. Film images at 1:1,000,000 scale were obtained for the Chagos scenes and the chart of the area was reduced to the same scale in order to compare features.

When the imaged island features were registered to the charted island features, significant variations were immediately apparent. There was a major reef or bank where the chart showed safe, deep water and some banks appeared to be out of position by more than 15 kilometers relative to the nearest land. Next, the existence and permanency of the features imaged on Landsat was confirmed by cross comparison of scenes acquired on two different days. At this point, priority evaluation was switched to the Chagos area from the Bahamas. The Director of the DMA Hydrographic Center directed that radio warnings be sent to mariners and that a new chart edition be prepared by the first of September 1976 by using the Landsat images to adjust the horizontal positions of the islands, banks, and reefs. Geodetic control was plotted and a new mosaic of the Landsat photography was prepared at the original chart scale. An initial determination of the positions of the most hazardous uncharted reef edges was made and on June 18, 1976, a radio warning was broadcast to ships at sea (HYDROPAC 1175/76(61), figure 1). These same data were included in Notice to Mariners #28, dated July 10, 1976. Additional refinements were made to the data and Notice to Mariners #29, dated July 17, 1976, carried a more detailed description of the dangerous new reef and corrected reef positions. Work was completed on the third edition of Chart 61610 and it went to press on August 28, 1976. The horizontal positions of islands, banks, and reefs portrayed on the new edition were derived from the Landsat MSS imagery acquired in March and April and which had been adjusted to geodetic control. The present work effort used only film imagery to derive the positioning data for subsurface as well as surface features. Even though water depths for the newly discovered reefs could not be determined from the film, the fact that they could be seen on the film indicated that they represented a navigational hazard.

NAVAL MESSAGE

OPNAV FORM 2110/28 (REV. 3-69) S/N 0107-705-4001

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FOR GLENN R. DEYOUNG	R H MUIRHEAD	31166	

DATE	TOR/TOD	ROUTED BY	CHECKED BY
18 JUNE 1976			

MESSAGE NR	DATE/TIME GROUP	PRECEDENCE	FLASH	IMMEDIATE	PRIORITY	ROUTINE
3159 3160	181809Z JUN 76	ACTION			P	
		INFO				

FM DMAHC WASHINGTON DC

TO AIG 9280

MIDEASTFOR-RHCFMKK

UNCLAS

HYDROPAC 1175 /76(61). INDIAN OCEAN, CHAGOS ARCHIPELAGO.

CHART 61610.

1. DANGEROUS SHOAL EXTENDS BETWEEN 04-51S 04-56S AND 72-36E 72-38E.

2. GANGES BANK IS LOCATED 8 MILES WESTWARD OF CHARTED POSITION 07-22S 71-06E.

3. PITT BANK 07-00S 71-14E EXTENDS 4 MILES FURTHER NORTHWESTWARD AND 6 MILES FURTHER SOUTHEASTWARD THAN CHARTED.

Fig. 1. Radio message to mariners warning of hazards revealed by Landsat.

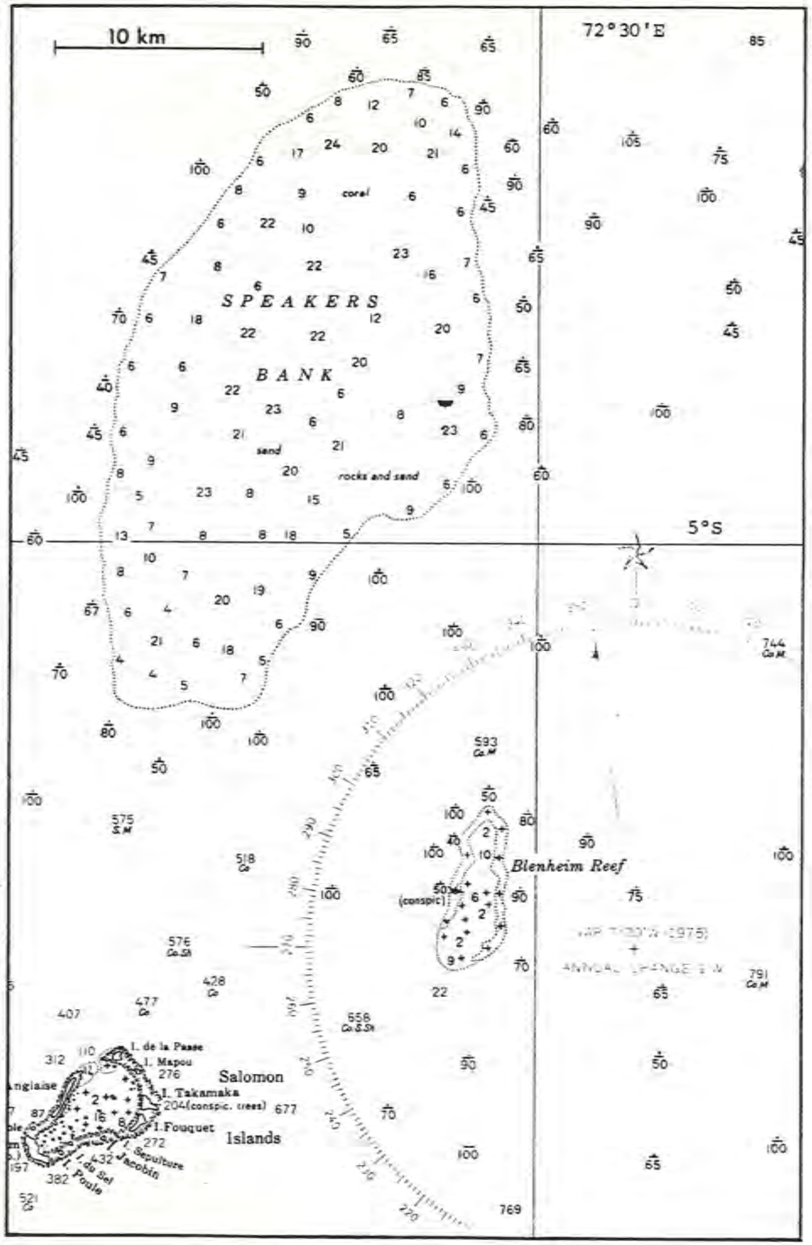

Figure 2. Portion of Chart 61610, 2nd Ed., Feb. 21, 1976; Showing Speakers Bank and no bottom soundings to the east. (± over sounding indicates that no bottom was found at that depth)

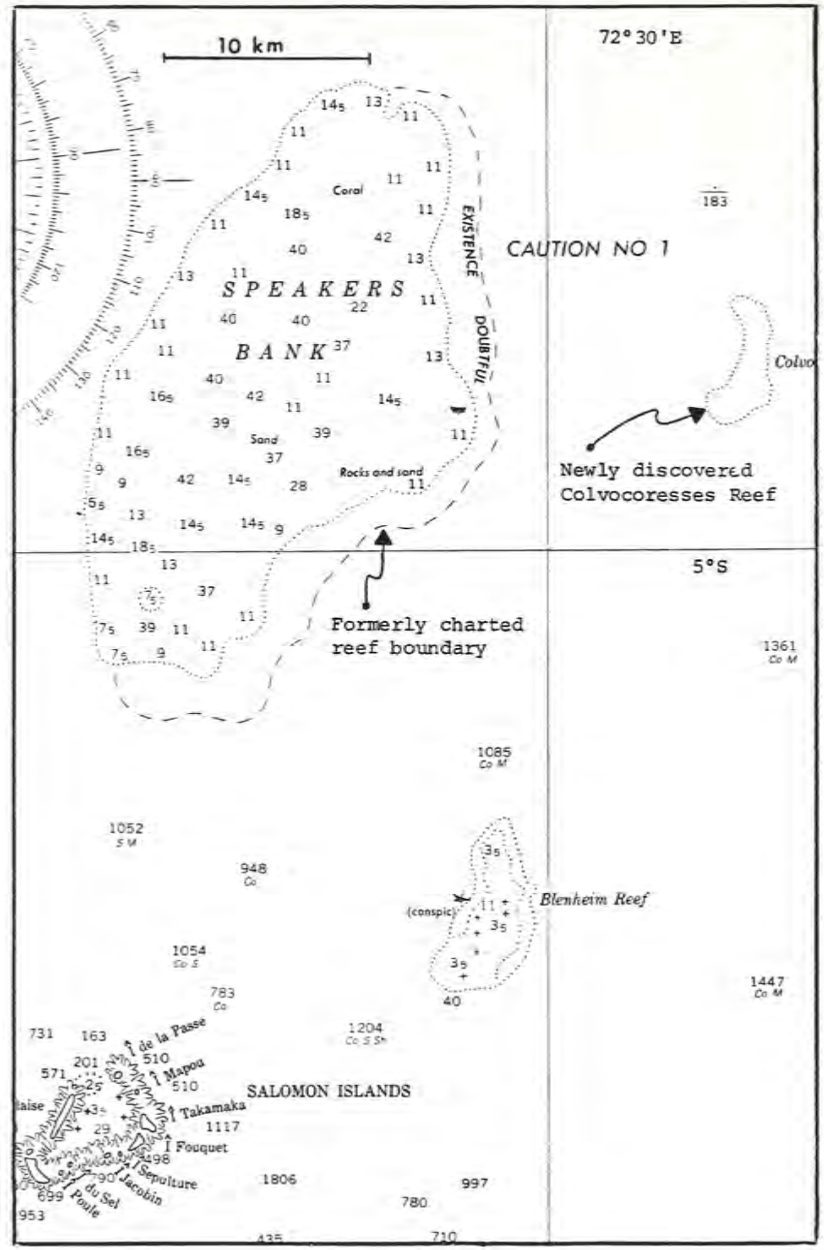

Figure 3. Portion of Chart 61610, 3rd Ed., Aug. 28, 1976; Showing adjusted position of Speakers Bank and new reef revealed by Landsat.

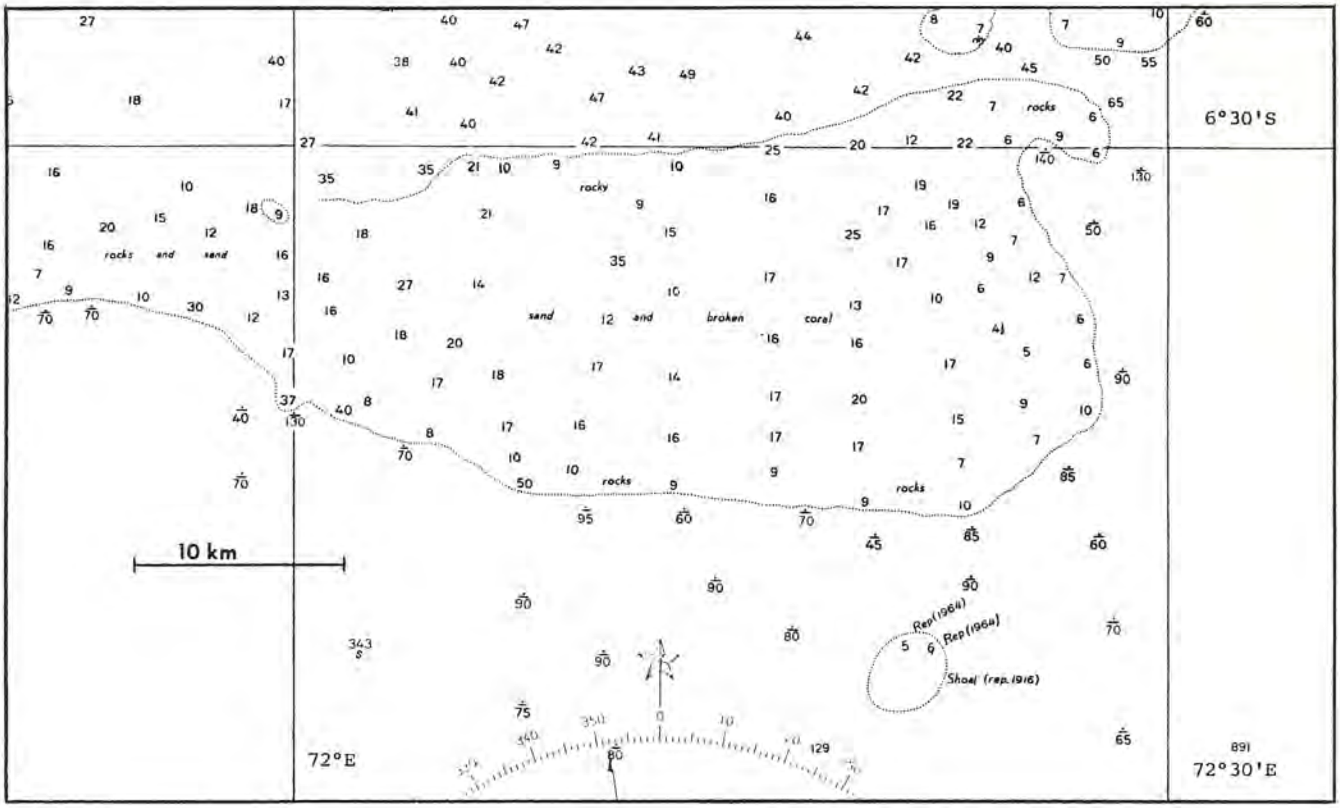

Figure 4. Portion of Chart 61610, 2nd Ed., Feb. 21, 1976; Showing southeast portion of Great Chagos Bank.

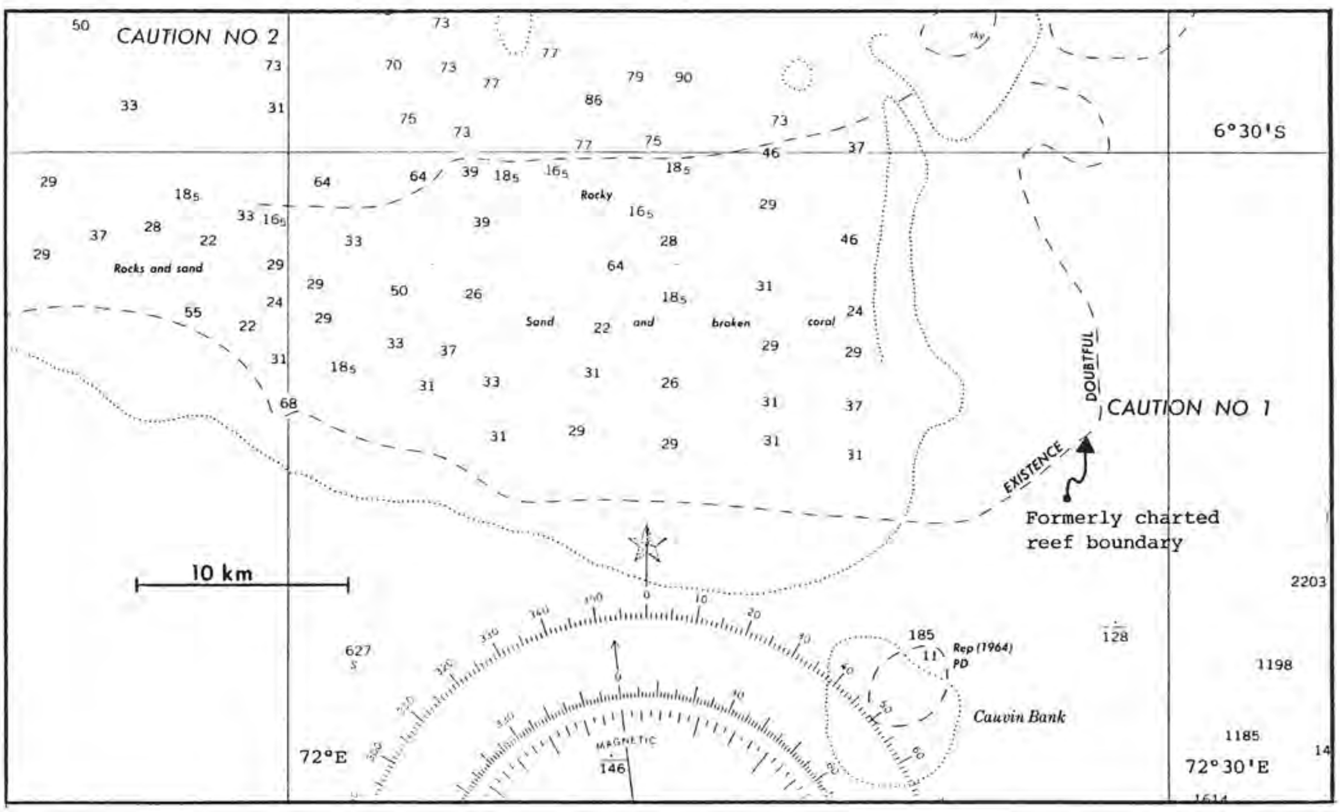

Figure 5. Portion of Chart 61610, 3rd., Aug. 28, 1976; Showing revised reef boundaries. Many soundings have been deleted and Caution No. 2 warns against trusting validity of soundings within this reef.

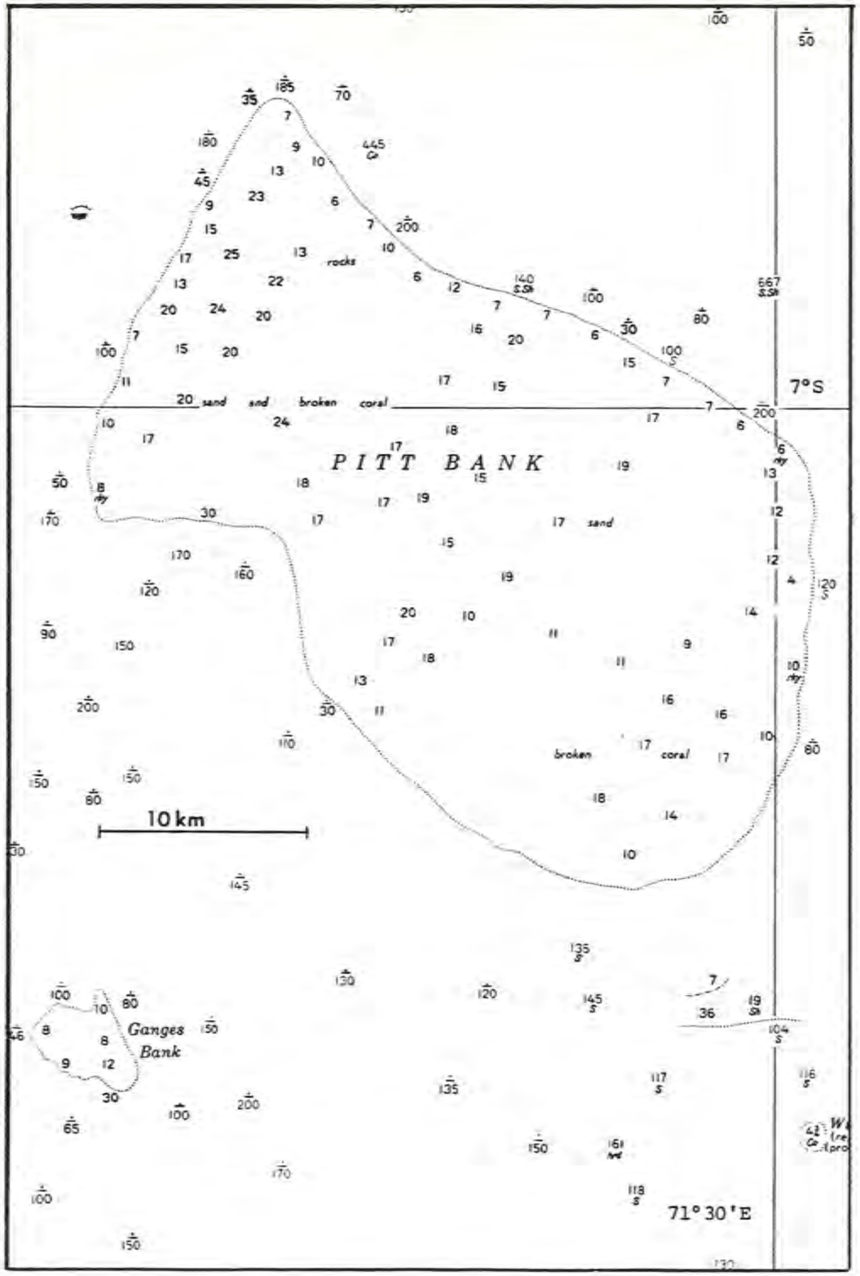

Figure 6. Portion of Chart 61610, 2nd Ed., Feb. 21, 1976; Showing Pitt and Ganges Banks.

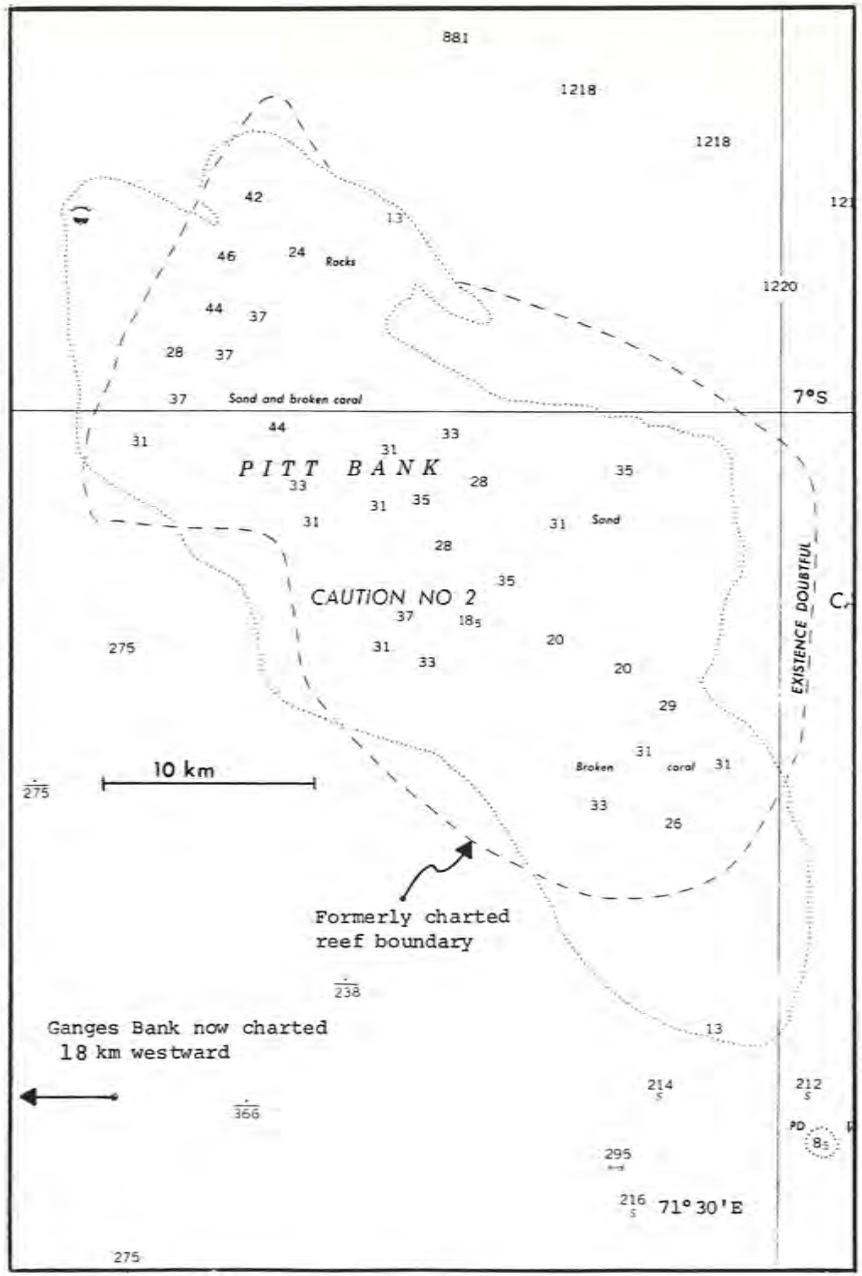

Figure 7. Portion of Chart 61610, 3rd Ed., Aug. 28, 1976; Showing revisions resulting from Landsat imagery.

Such an approach leaves a major problem to be resolved; namely, how to use the old sounding data in areas where the imagery showed changes in the alignment or positions of reef features. The only detailed survey of the entire archipelago had been conducted by the Indian Navy in 1837. Typically, survey accuracy in this time period was limited by navigational capabilities. The data were reasonably accurate in and around islands (as was confirmed in several places in the Chagos area by the Landsat imagery). However, in the more remote areas, out of sight of land, there were problems in obtaining a good navigational fix as well as with omissions in the sounding data, as when the track lines pass on either side of a reef. (These cases were demonstrated by the Landsat imagery revealing positioning errors of up to 18 kilometres and by the discovery of new shoals or reefs as shown in figures 2 & 3.) For the present chart revision, a number of soundings were removed (figures 4 - 7). However, in the future, digital depth analysis of the MSS data as in the joint NASA/Cousteau experiment should permit correlation and adjustment of old soundings to their true positions. In this present work, however, many soundings had to be deleted for the sake of safety.

Summary

National and international concern is being expressed over the growing need to improve the quantity, currency, and accuracy of world-wide hydrographic survey data to assure navigational safety. Thousands of ship-years will be required to acquire adequate world-wide hydrographic survey data. The use of Landsat high gain MSS imagery for bathymetric application was tested in the joint NASA/Cousteau Ocean Bathymetry Experiment. This joint venture proved the feasibility of detecting and mapping shoals in clear water to depths equal to or greater than those required for most surface shipping. Although its limited resolution cannot identify small navigational hazards, in many areas it can provide data that are, in some cases, orders of magnitude better than the existing surveys. With this upgraded information, adequate ship surveys need be planned only for those expanses that offer a potentially safe route for shipping. This will result in optimal use of the limited and expensive hydrographic surveying resources. Even though several years of research and development will probably be required before satisfactory algorithms can be developed that will permit operational bathymetric analysis of the MSS digital data, the revision of the Chagos Archipelago chart demonstrated a valuable use of the film imagery: shoal features can be found and positioned with respect to known surface features. The very fact that a shoal or reef appears on the images indicates that it presents a hazard to navigation. Thus, the Landsat high gain imagery currently represents a useful tool that can be used to provide improved relative horizontal information about remote islands and reefs. It also exhibits a great potential in the digital mode for supporting international hydrographic surveying and charting efforts thereby making the seas safer for the international maritime community.

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Geometrical Probability and Hydrography

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Geometrical probability is that branch of statistics that deals with the probability of the occurrence of events in space. Like all statistics, geometrical probability is based on the expectation of events occurring, with the validity of the expectation increasing (or the statistic becoming more stable) as the number of observations increases. Hydrography,too, deals with the occurrence of events in space and the observations required to detect those events. In this paper I tentatively explore the relationship between geometrical probability and hydrography, with particular reference to the age-old problem of detecting shoals.

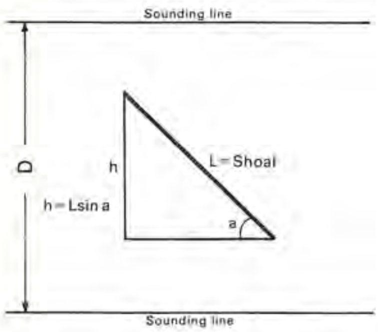

Fig. 1. Explanation of terms used in Equation 1. L is a straight line, length = L, representing a shoal, lying at any angle a to two parallel sounding lines spaced D apart.

Let us assume, for the sake of difficulty, that a shoal can be represented by a straight line segment of length L with any orientation (Figure 1). Further, let any two parallel lines distance D apart, where D is greater than L, represent two sounding lines. What is the probability of one of the sounding lines intersecting the shoal, or, what are the chances that the shoal goes undetected (and upon which a ship could run aground)? If angle a were fixed then the probability of sounding lines D apart intersecting L would be:

$$P\ (a \text{ fixed}) = \frac{h}{D} = \frac{L}{D}\ \sin a \qquad (1)$$

However, a is not fixed. Usually, we do not know in hydrographic surveying what the orientation of the shoal might be. Consequently, we must rewrite equation (1) to allow for a probability distribution of a which we call $P(a)$. Since we want all possible values of a we integrate, thus:

$$P\ (\text{all } a) = \int_a \frac{L}{D}\ \sin a\ P(a) \qquad (2)$$

Since a can have any value, and since all values are equally likely we distribute a uniformly between 0 and π, with the equation:

$$P\ (a) = \frac{1}{\pi}\ da,\ 0 \leq a \leq \pi \qquad (3)$$

Combining equations (2) and (3) and substituting gives us:

$$P\ (\text{all } a) = \frac{2}{\pi}\frac{L}{D} \int_0^{\frac{\pi}{2}} \sin a\ da = \frac{2}{\pi}\ \frac{L}{D} \quad (4)$$

Equation (4) has two interesting facets. Notice first, that there is no orientation term in the right hand side of the equation. From a probabilistic point of view, therefore, the relative orientation between sounding line and shoal are unimportant. We stand just as good a chance of detecting a shoal whatever its orientation to the sounding lines. (Note, however, that this applies when we do not know the orientation of the shoal. If we do know the orientation, then that is a conditional probability, as in equation (1), and our chances are maximized by making $a = 90^0$). This is the good news in the equation. Now for the bad. Consider the case where L equals D, that is the shoal is as long as the separation between sounding lines. Here there is only a probability of 0.64 (= $2/\pi$) of intersecting the shoal, because the shoal does not have to be oriented normal to the sounding lines. That is, for any survey, there is a 36% chance that there is a shoal as long as the distance between sounding lines that has not been detected by that survey.

Let us now consider the case where the shoal is longer than the distance between sounding lines. That is, where L is greater than D, (and letting D = 1). Through a similar line of reasoning to the above we arrive at:

$$P(L>D) = \frac{2}{\pi}\left(\frac{\pi}{2} - \sin^{-1}\ L^{-1} + L - \sqrt{L^2-1}\right) \quad (5)$$

The results of this are graphed in Figure 2. This curve never reaches 1, since it is always possible that the shoal is parallel to the survey lines. If the curve were extended to larger values of LxD it would show a 17% probability that a shoal twice as long as the distance between sounding lines is undetected and an 8% probability that one four times as long is lurking about the surveyed area waiting for some innocent ship.

This situation can be improved somewhat by running check lines at right angles to the first set, as all good hydrographers do.

Then, the probability of intersecting a shoal = the probability of intersecting one set of parallel survey lines + the probability of intersecting the second set of parallel survey lines - the probability of intersecting both of them at the same time (6).

The latter part of this equation is the trickiest to derive. Let us assume that the parallel sets of survey lines are the same distance, D, apart (Figure 3). Then the probability of intersecting both at the same time is:

$$P\ (\text{both}) = \frac{h}{D}\frac{b}{D} = \left(\frac{L}{D}\right)^2 \sin a \cos a \qquad (7)$$

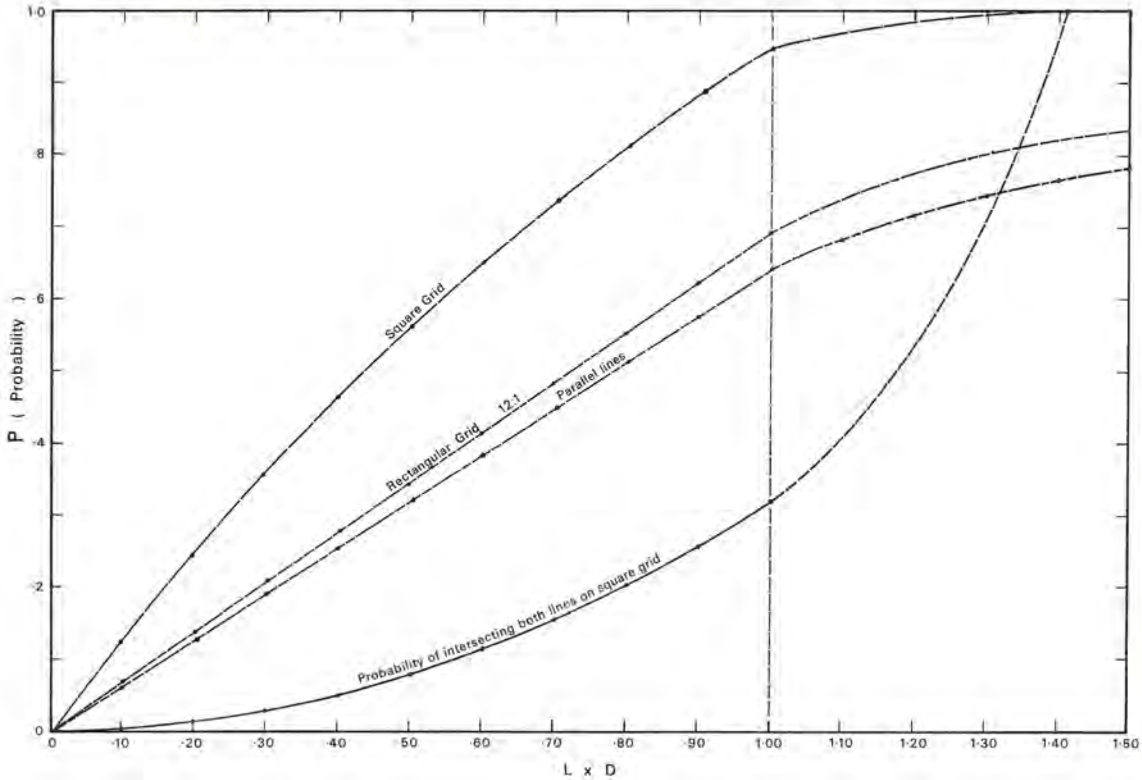

Fig. 2. Probability of intersecting a straight line, length = L, representing a shoal with the following sounding line patterns: parallel lines, square grid and rectangular grid. The probability of intersecting both lines on a square grid is also plotted.

for a particular value of a. Since we are again interested in all values of a we integrate:

$$P\ (\text{both, all } a) = \frac{2}{\pi}\left(\frac{L}{D}\right)^2 \int_0^{\pi/2} \sin a \cos a \, da = \frac{1}{\pi}\left(\frac{L}{D}\right)^2 \qquad (8)$$

Now since we let the parallel sounding lines both be the same distance apart, the probability of a line of length L (less than D) intersecting the grid is:

$$P\ (\text{Grid}) = \frac{2}{\pi}\frac{L}{D} + \frac{2}{\pi}\frac{L}{D} - \frac{1}{\pi}\left(\frac{L}{D}\right)^2 \ \text{(from equations (4)(6) \& (8))} \qquad (9)$$

This could be simplified but will not be for reasons that will become apparent.

These values are also graphed in Figure 2 and are also instructive. Notice, that now there is only a 5% probability that a shoal as long as the distance between sounding lines is undected but that it took twice as much work to reduce tne risk from 36% to 5%. Looked at another way, although the square grid requires twice as much work, it doesn't double the probability of detecting a shoal with a length less than the distance between the grid lines. The power of the square grid becomes apparent however, when L is greater than D, since the probability of intersection equals 1 when $L = \sqrt{2D}$ (thanks to Pythagoras). The square grid guarantees a result that parallel lines can never promise.

As far as I know, the C.H.S. does not run square grids of sounding lines. Standing Orders do call for check lines and the combination of parallel sounding lines and check lines as specified in Standing Orders creates a rectangular grid whose length to width ratio is 12 to 1 or 24 to 1, depending on the water depth. To determine the probabilities of intersecting a rectangular grid we rewrite Equation 9 as:

$$P\ (\text{rectangular grid}) = \frac{2}{\pi}\frac{L}{D} + \frac{2}{\pi}\frac{L}{ND} - \frac{1}{\pi}\left(\frac{L}{ND}\right)^2 \qquad (10)$$

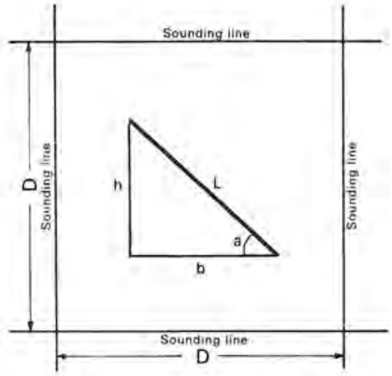

Fig. 3. Explanation of terms used in Equation 7. See Figure 1.

where N is the number of times the length of the rectangle is greater than the width. This was calculated for N = 12, as Standing Orders specify for depths less than 183 metres, and the results plotted on Figure 2. Notice that for $L < D$, this result is little better than running no check line; but for $L > D$, P does reach one at 12.04. Halving the distance between these check lines does not improve things very much, and it is not until check lines are about four times the distance between sounding lines that they become very effective for shoal detection (Figure 4).

purists might quibble, points can be considered to be very short straight lines. Obviously, the probability of intersecting very short straight lines is very, very low.

Another shape often used for shoals is a circle. The probability of intersecting a circle of diameter d with parallel lines distance D apart is $\frac{d}{D}$, since this is equivalent to equation (1) where α equals 90^0.

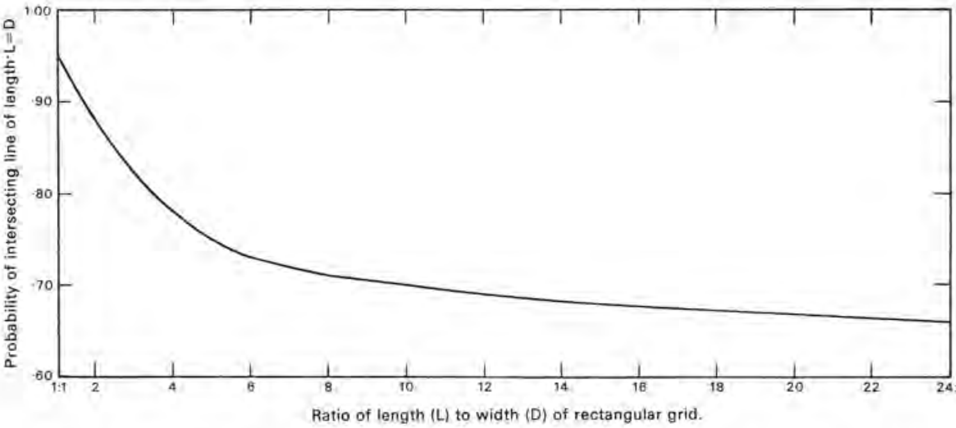

Fig. 4. Probability of intersecting a straight line of length L = D with rectangular grids having various length to width (D) ratios.

Returning to the square grid of sounding lines, if we consider just the points where the lines intersect one another, we have a grid of spot depths similar to those used for through-the-ice soundings. It should be possible to determine the probability of a line intersecting these points, but I have been unable to summon the necessary mathematical acumen to do so. (All suggestions cheerfully accepted). However, we can put an upper limit on this probability. In equation (7), the probability of intersecting both sets of grid lines at the same time was considered. Since intersecting the grid intersections is a special case of intersecting both sets of grid lines at the same time, the first probability must be less than the latter. How much less is not determined but, intuitively, it seems that it must be very much less. The probability of intersecting both sets of grid lines simultaneously is plotted in Figure 2 and the curve for intersecting only the grid intersections must fall below this. Obviously, spot soundings cannot compete with profiles.

If you have read this far, you probably have two objections to the applicability to this method. The first is that sounding lines are not really lines but swaths, since the echo sounder produces a beam which sweeps a swath of seafloor. Fine. Consider the edge of one swath to be one of the "sounding lines" in Figure 1 and the nearest edge of an adjacent swath to be the other "sounding line", and the equations will work.

The second objection is that shoals seldom are straight lines, although many other features of the seafloor are. Consider then other shapes that shoals might have. Pinnacles could be regarded as points, and, although mathematical

We can also use circles to allow us to make some further observations about spot soundings. For a square grid of spot soundings, the probability of detecting a circular target whose diameter is less than the grid spacing is given in Figure 5, which is modified from Koch and Link. Tables exist for ellipses and could presumably be developed for other regular shapes.

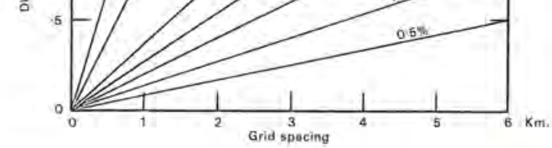

Fig. 5. Probability of intersecting a circular shoal with square grids of various sizes. (Modified from Koch & Link).

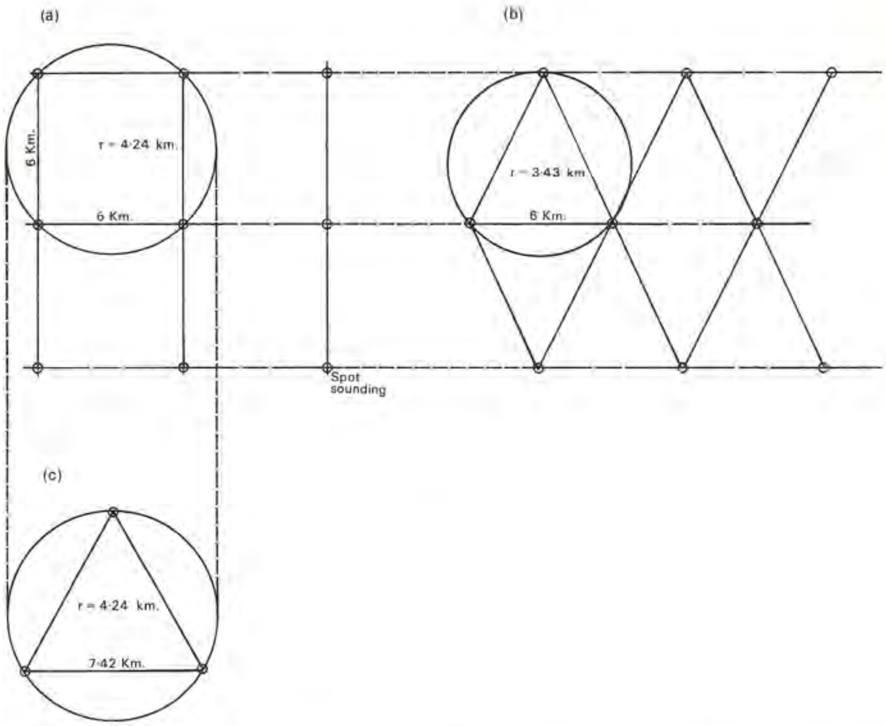

Fig. 6. Illustrating the relative efficiency of square and hexagonal grids in detecting a circular shoal. See text.

It is interesting to note that the probability of detecting a circular shoal using a square grid of spot soundings is 1 when the grid spacing equals 1.414 times the radius of the circle. For a six kilometer square grid, then, circular shoals of radius 4.24 kilometers or greater will always be detected Figure 6(a). Now, using the same number of observations, if we shift every other row of spots one-half the grid spacing to the right, we create a hexagonal grid. This type of grid will detect, with probability of 1.0, a circle when the distance between grid points is 1.75 times the radius of the circle. That is, a 6 kilometer hexagonal grid will always detect a circle of 3.43 kilometers or greater radius, vastly more efficient than the square grid Figure 6(b). Looked at another way, the hexagonal grid is 80% more efficient (6 km/7.42 km) than the square grid. That is, spot sounding programs which now utilize 6 kilometer square grids could obtain results as good by switching to a 7.42 km hexagonal grid that would require 20% fewer soundings Figure 6(c). That should interest a Regional Hydrographer who is in a manpower squeeze.

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NavBox — A Microprocessor-Based Navigation Aid

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Introduction

Since the mid-nineteen sixties, the Canadian Hydrographic Service (C.H.S.) has routinely used radio positioning systems on production surveys and, although these systems permit high-speed launch operations, they pose a problem in optimizing survey efficiency. While it is convenient to follow lines of constant radio position using a left-right indicator as an aid to steering the survey craft, this often results in an inefficient pattern of survey lines that must be run to obtain adequate coverage. Figure 1 illustrates a survey pattern of this type for a hyperbolic positioning system, where the heavy lines represent the survey pattern.

Parallel, straight-line surveying accomplishes the same coverage with fewer, less complicated lines as illustrated in Figure 2. Unfortunately, with conventional survey equipment, this necessitates conning the vessel by hand-plotting, and deriving the heading required to stay on line. This problem is further compounded by rough seas, cross-winds and currents.

In 1974, the development group within Central Region designed and implemented a hydrographic data acquisition system, INDAPS (Integrated Data Acquisition and Processing System)(Bryant, Doekes and Tripe, 1976), which utilized a mini-computer to provide system control, ensure data quality with filtering techniques and to record the data on magnetic tape. In 1975 INDAPS was further refined with the addition of a navigation function to allow the survey vessel to follow straight lines, using the computer to calculate the vessel's geographic position and derive steering information for the helmsman. The helmsman steers the vessel along a specific survey line using directions from a standard television monitor interfaced to the computer. Steering information is updated once per second, thereby providing the helmsman with an almost continuous indication of his position relative to the line.

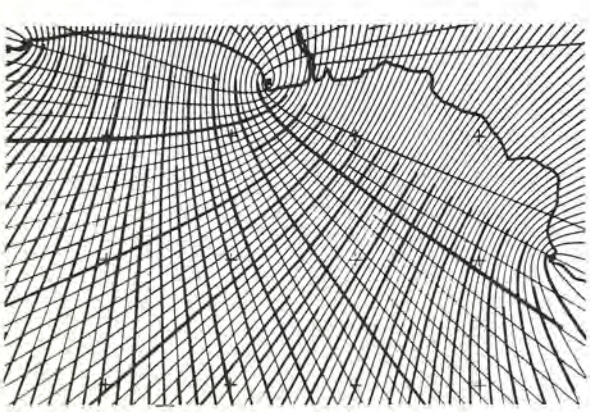

Fig. 1. Conventional surveying practice. The heavy lines indicate pattern lines to be followed to obtain adequate coverage.

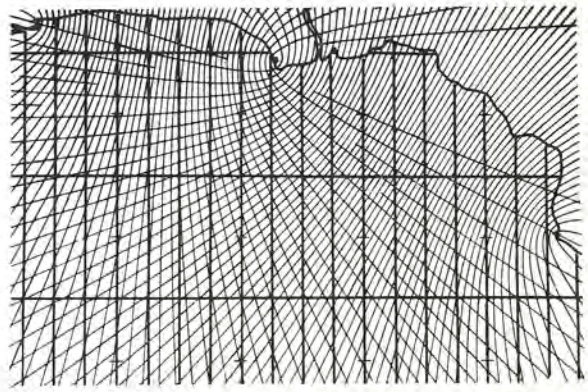

Fig. 2. Straight line surveying practice. The heavy lines result in the same coverage as that illustrated in Fig. 1 with 24% less distance travelled.

In 1976, an investigation into the possible use of micro-computers for navigation was conducted. The result of this investigation has been the design, construction and deployment of four prototype systems to provide a straight-line navigation function for hydrographic surveys.

Design Criteria

The experience gained with INDAPS and particularly the enthusiasm of users with regard to the navigation function led to the examination of other survey applications where straight line navigation could be employed. A prime target area was the through ice "spot" echo sounding operations carried out in the Arctic during the spring months each year. This operation relies on helicopters to fly a 6 km grid and,at each grid intersection, land on the ice and obtain an echo sounding. Both range-range (Mini-Ranger III) and hyperbolic (Decca 6f) radio positioning systems are used. The radio positions at the 6 km grid intersections are pre-plotted and the pilot flys to these points using the positioning system readouts - a difficult task which requires considerable skill and results in a fair amount of "hunting".

Implementing INDAPS for helicopter operations posed a number of thorny problems. To begin with, INDAPS (figure 3) is housed in a 50 cm wide, 90 cm high by 75 cm deep rack and weighs approximately 80 kg. The system also requires standard 110 v., 60 Hz power. The helicopters used in Arctic operations are Bell Jet-Rangers which fly with a complement of two, the pilot and a hydrographer, along with an echo-sounder and the radio positioning system receiver. Space and weight are at a premium; power is also a problem since the helicopter has a 24 v. DC system and we require 110 v. AC for INDAPS. It was obvious that for helicopter operations, INDAPS was impractical. Experiments with the use of small tracked vehicles for Arctic surveying were begun in 1975 - these vehicles also had space, weight and power limitations. It was felt, however, that navigation for the tracked vehicles was almost mandatory due to the manoeuvering required to avoid pressure ridges and so forth on the ice. INDAPS was proving to be troublesome in small launches (under 7 metres) due to size, weight, and power requirements which necessitated the installation of small gasoline generators - impractical in a small tracked vehicle.

In the late summer of 1976, a system design phase to satisfy the above requirements was initiated, based on the following criteria:

- a computer to control data acquisition and provide navigation,
- a package which was compact and rugged, rack mountable and weighed under 23 kg,
- operating power should be 24 v., DC at under 5 amps,
- 16 character keyboard for data entry, small printer for hard copy,
- T.V. monitor for navigation display,
- wherever possible use standard off-the-shelf components to keep the system cost under $10,000.

The SBC80/10 single board computer manufactured by INTEL, and based on their 8080 microprocessor was selected. This computer was chosen mainly because the SBC80/10 is virtually an industry standard and consequently numerous manufacturers can supply compatible hardware. A floating-point arithmetic processor board from North Star Computers Inc. was chosen because of its compatibility with the card cage of SBC80/10. The third board in the computer card cage is a custom-designed board which contains a video display controller from Matrox Electronic Systems, a clock, additional memory and peripheral interfaces. Total system memory consists of 7000 8-bit words of eraseable, programmable, read-only memory (EPROM) for program storage and 2000 8-bit words of random-access memory (RAM).

The remaining major system components are as follows: (figure 4)

Fig. 3. INDAPS Logger (Cat. 8100)

Fig. 4. NavBox—Front panel

- 6 column thermal printer from DATEL,
- 16 character keyboard from Maxi-Switch,
- 12 v., 5" T.V. monitor (CRT) from Motorola,
- system cabinet from Interlock.

Total system weight is approximately 14 kg and draws 3 amps @ 24 v.; total system hardware cost is under $4,500.

Therefore, in terms of our hardware criteria, the system met specifications. In addition, by using standard components, we were able to go from the design phase in the fall of 1976 to system completion by the end of January 1977.

System Software

The software design for the system was, of course, based on our experience with INDAPS. Data filtering and smoothing and the navigation algorithms had already been developed and tested so it was a question of application and ease of user-system interaction.

It was decided that there should be basically two modes of operation. The first, or data entry and system initialization mode (figure 5), permits the user to enter various navigation parameters such as time of day, the locations of the radio position transmitters, survey lines to be run and filtering parameters. As data is entered on the keyboard, it is displayed on the CRT. Having entered and verified survey parameters, the operator keys in a command to change to the navigation mode (figure 6). In this mode, radio position data is acquired, filtered, and converted to U.T.M. coordinates; distance off-line and distance to the next station along the line are also computed. The CRT, updated once per second, displays the following: time of day, radio positions, U.T.M. coordinates, distance off-line, steering indicator and distance to the next station. Any errors in data detected by the system are also displayed. At any time, the operator may return to the data entry mode to change survey parameters as required.

In addition to the above facility for navigating to equally-spaced points along a survey line, a point-to-point navigation function has been included.

The operator may key in the coordinates of up to 20 points such as calibration locations, fuel caches and survey camp coordinates in Arctic operations, and so forth. In navigation mode, the operator has only to key in the number of the point to which he wishes to go. The system then computes the bearing and distance to the point and navigates to it with CRT display parameters as mentioned above.

Radio Position Inputs

To date NavBox has been interfaced to two radio positioning systems: Mini-fix and Motorola Mini-Ranger III. The Mini-fix is a phase comparison system used in the hyperbolic mode; the receivers have digitizers built into them which provide a computer compatible digital output of the two pattern readings.

Mini-Ranger III from Motorola is a range-range line-of-sight, V.H.F. positioning system with a range, depending on transponder height, of about 30-40 km with accuracies under 10 m. The range console displays distance to each of two transponders and provides computer-compatible output as well.

Error detection for the hyperbolic system consists of monitoring pattern readings for excessively high rates of change indicating that one or more of the phase-locked loops in the receiver has lost lock. This occurs under conditions of low signal strength and/or atmospheric interference. With the Mini-Ranger systems, signal cancellation and multi-path signal reflection can occur, resulting in erroneous range readings. These readings are detected and rejected using a range gating technique which operates as a function of the rate of change of range.

System Deployment

The first system was taken up to the Arctic in the spring of 1977 and installed in a small tracked vehicle (figure 7). The vehicle, called a BOMBI, was equipped with an experimental echo-sounding system which had the transducer mounted on a spike connected to a hydraulic ram. The NavBox was to provide navigation to points along the survey line which were 100 m apart; Mini-Ranger III was used for positioning (figure 8).

Fig. 5. NavBox - Data Entry display

Fig. 7 'BOMBI' tracked vehicle

Fig. 6. NavBox - Navigation mode display

Fig. 8. NavBox installation in 'BOMBI'

Fig. 9. C.S.S. Agile

Fig. 10. NavBox installation aboard Agile

Fig. 11. Helmsman and display aboard Agile

As a first operational trial for the NavBox a worse environment could not have been chosen. Operating temperature inside the cab was about 7°C, non-operating temperatures fell to -40°C. On a number of occasions a heat gun was used to pre-warm the components prior to turning the power on, to prevent thermal shock. In addition, the ride of the BOMBI, in large part due to the short wheelbase, is extremely bumpy and, since the ice also tended to be rough, the NavBox received a thorough "shake-down"! In fact, vibration and shock were so severe that integrated circuits were popped out of their sockets and connectors worked loose. To compound these problems the Mini-Ranger system was performing poorly. However, enough survey work was completed to indicate that with proper shock mounting and better internal packaging the system would be very useful.

While work started on a second system, the first system was modified for use on a limnogeology survey off the east coast of Lake Huron. Again Mini-Ranger was used for positioning. The requirement was to navigate along survey lines orthogonal to the coastline and, at 1 km intervals, print out time, the two ranges, depth and a serial number. The lines were spaced 1 km apart. In addition to these points and lines, the hydrographic requirement was a print-out of points spaced at one minute intervals on lines 250 m apart. An interface to the echo-sounder basically involved wiring up a connector since a spare interface was already available. A software module to read in the depth was written and a modification for timed print-outs and serial numbers included. The system was installed aboard the survey launch AGILE (figures 9, 10, 11) in mid-May, 1977 and operated successfully until mid-October, 1977. On one occasion, the system's internal power supplies shut down due to overheating; operation resumed when the system cooled. Also, a minor software problem relating to system initialization required that power be turned off for a short period of time before certain of the navigation parameters could be changed. Generally, this did not affect system operations to any great degree since the parameters were usually constant for a complete day's surveying.

The second system was completed and a software module to accept hyperbolic Mini-fix input tested by the end of June, 1977. Field trials were successfully carried out by comparing navigation results with an INDAPS equipped survey using Mini-fix for positioning and operating on the northern portion of Lake Huron. The system was installed aboard the survey vessel PETREL which was to leave Burlington in mid-July to conduct a corridor survey off Eskimo Point on the west coast of Hudson Bay. Unfortunately the Mini-fix chain which was to be used could not be made operational so Mini-Ranger was used instead. It was felt that since the survey could be conducted conventionally by following arcs of constant range, no attempt would be made to re-program the system to accept Mini-Ranger input.

Current Development

During the latter part of the summer of 1977, work began on two more systems, to be deployed on helicopters engaged in through-ice spot sounding operations in the Arctic in the spring of 1978.

Fig. 12. VOR Indicator: Fine scale, leaving station

Fig. 13. VOR Indicator: Coarse scale, leaving station

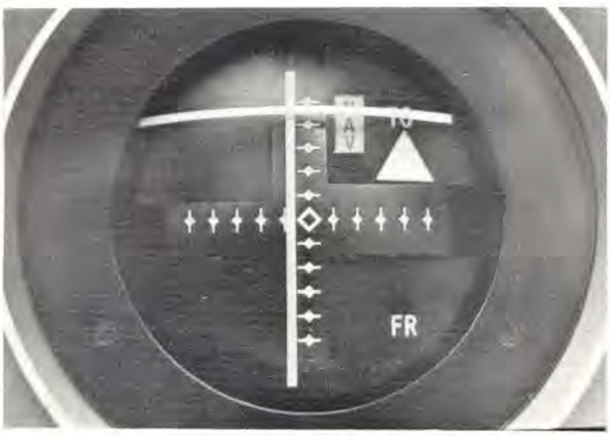

Fig. 14. VOR Indicator: Coarse scale, approaching station

The positioning system to be used is Mini-Ranger. One of the difficulties associated with many of the digital types of display such as LED, liquid crystal, and Nixie-tube as well as CRT's is that they all tend to "wash out" in high ambient light conditions. In the Arctic, of course, it is very bright due to sunlight reflection from the snow and the Jet-Ranger helicopters have large areas of glass for visibility. Thus, unless encased by a cumbersome hood, the above types of display are of limited use.

To solve this problem it was decided that it would be sensible to use a standard aircraft VOR/LOCALIZER/GLIDE SLOPE indicator. There are several advantages to this solution: it is an indicator with which the pilot is familiar and because it is a standard aircraft instrument, it fits into the display panel of the helicopter and high ambient light conditions have little effect on its visibility.

In practice, the indicator operates as follows (the helicopter is always assumed to be at the centre of the indicator): the vertical bar indicates distance to the right or left of the survey line (resolution is entered by the operator), and the horizontal bar indicates distance to or from survey points along the line. The TO-FROM flags indicate whether the helicopter is less than half-way to the next point (FROM flag displayed) or more than half-way (TO flag displayed). If radio position data degrades to the point where either or both readings are not useable and a position cannot be computed, the NAV flag is displayed to indicate loss of navigation. Since the point spacing along the survey line may be up to 6 km, the resolution of the horizontal bar is quite coarse, half scale being 3 km. Thus, when the helicopter approaches to within a few hundred metres of the survey point (this distance is operator selected) an automatic scale change to finer resolution is effected and the GS flag set. The GS flag stays set until the helicopter leaves the high resolution zone on the way to the next station. This facilitates orientation since the helicopter has likely not landed facing in the direction of the next station. Figures 12-15 illustrate typical displays for the various operating conditions (the NAV flag is displayed for illustration purposes). Trials with this system were conducted at Burlington during the week of November 1 - 4, and the pilot's reaction was quite favourable - he "caught on" to the indicator very quickly.

As an adjunct to the VOR/LOC/GS indicator one of the small CRT displays will be mounted on top of the helicopter dash and a hood installed to block out as much ambient light as possible. To further alleviate display "wash-out", the front of the CRT is covered with a sheet of polarizing lens control film from 3M which acts to block out rays of light striking the film surface at low angles. With both displays available, the pilot should have little difficulty flying lines and landing at the sounding points. Figures 16 - 18 illustrate the helicopter with NavBox and navigation display installation for the trials.

Future Hardware Development

One very useful feature of the SBC80/10 computer is that it has a built-in communications interface or UART which can be operated as a 20 mA current loop for a teletype or as a standard EIA port with selectable baud rates up to 9600 for use with higher speed keyboard/printers or keyboard/CRT's. There are also available on the market, stand-alone magnetic tape recorders, either cassette or cartridge, which connect directly to a standard EIA port. Canadian Applied Technology near Toronto is currently developing a specially "ruggedized", micro-processor controlled cartridge tape drive which will connect to the EIA port of the NavBox. This cartridge drive, also designed to operate from a 24 v. DC power supply, is compact and rack mountable. This will complete a data acquisition, navigation and logging system in a package weighing under 23 kg.

In the spring of 1978, the total design will be turned over to an electronics firm for manufacturing. Part of this contract will possibly include an INTEL-compatible single board computer based on the Zilog Z 80 microprocessor which has a more powerful instruction set; the specification will also require a more rugged, splash-proof case and rugged internal packaging.

Future Software Development

To make the system a little more universal in application, a software module will be written to accept LORAN-C as positional input. The system could then be used on survey ships equipped with LORAN receivers operating on the east and west coasts. Software will also likely be developed to display coordinates in latitude and longitude rather than U.T.M. coordinates.

Conclusion

There are two conclusions which may be drawn from our experience with the design and implementation of the NavBox. The decision to use standard off-the-shelf components wherever possible provides reliable hardware at a reasonable price and in no way restricts design, in fact quite the opposite. Using a computer to control data acquisition and display ensures data quality and provides as much flexibility as any user could possibly want - it is "merely software".

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Fig. 15. VOR Indicator: Fine scale, approaching station

Fig. 16. Bell jet-ranger helicopter

Fig. 17. NavBox and Mini-Ranger III console aboard the helicopter.

Fig. 18. CRT display and VOR indicator mounted above pilot's console aboard the helicopter

On-Line Automation of a Hydrological Data Acquisition System

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Introduction

The Data Processing Division (DIV) of the Department of Public Works and Water Control, Netherlands, has provided for some years now a fairly satisfactory on-line computer service to its various remote computer users. However in order to satisfy the diverse requirements of the users a number of special systems had to be developed.

The telex terminal, already available in most offices for the traditional exchange of telex messages, proved to be a useful data terminal. However, since the telex terminal is not a standard terminal of the available central host computers (2 x Philips P 1400), special minicomputer-based concentrators had to be developed. For many computer users, more sophisticated terminals had to be introduced. The installation of asynchronous 300 baud terminals such as the Dataprint 300 with papertape and card input, the Tektronix T4010 and T4014 graphic terminal (1200 baud), and synchronous ones such as the Philips 1088 (CRT) and various remote batch terminals (4800 baud), satisfied the users but required a considerable amount of special system design and software development. More minicomputer-based development was required for the coupling of the Philips P1400 to a CDC6600 of the Control Data Computer Centre. Remote batch terminals had to be equiped with special peripherals such as plotters, and some users wanted their terminals to communicate with both the Philips host and the occasionaly available IBM 370 or CDC 6600 installations of other institutes. All this was achieved, but at the cost of a considerable amount of design and testing.

In the same period a growing number of PDP 11-based data acquisition systems came into existence. These systems allow data on water quality and water quantity to be acquired and checked locally, then transported to concentrating minicomputers and processed for on-line presentation and off-line storage. Interconnection of these systems and connection to the central hosts or data bases are considered to be extremely useful new developments.

However, the different systems do not always use the same processing structure, data communication procedure, or programming language, to mention a few areas of concern.

The decision to install a Univac 1100/41 system along side the existing P1400 systems finally demonstrated the absolute necessity to proceed in a more organised manner, as far as networking is concerned. A critical analysis of the situation showed the data communication area to be of the greatest concern. A multi-node, multi-route switching network with standard protocols appeared to be more advantageous than a continuation of the ad-hoc approach. A financial extrapolation gave further evidence to support this conclusion, indicating that in only three years, the multinode network would be the cheaper approach.

CNET—The Multinode Data Communication Network

Although the necessity to define a good structure in the task field was appreciated, particularly in the area of hydrological data acquisition, it was felt that highest priority ought to be given to a properly organised system for the transportation of data.

This resulted in the specification and construction of a packet switching network, "CNET", with such "en vogue" principles as virtual circuit, HDLC line procedure and, where possible, X.25 access procedures. However, the general constraint of shortage of available time made compromises necessary. In using the experience in datagram switching on a lower level, virtual circuits had to be simulated on a higher level. This combination has the advantage of the ordinary datagram-oriented techniques, such as routing alternatives in case of node or line failures. However, it also provides the user with the integrity of the virtual

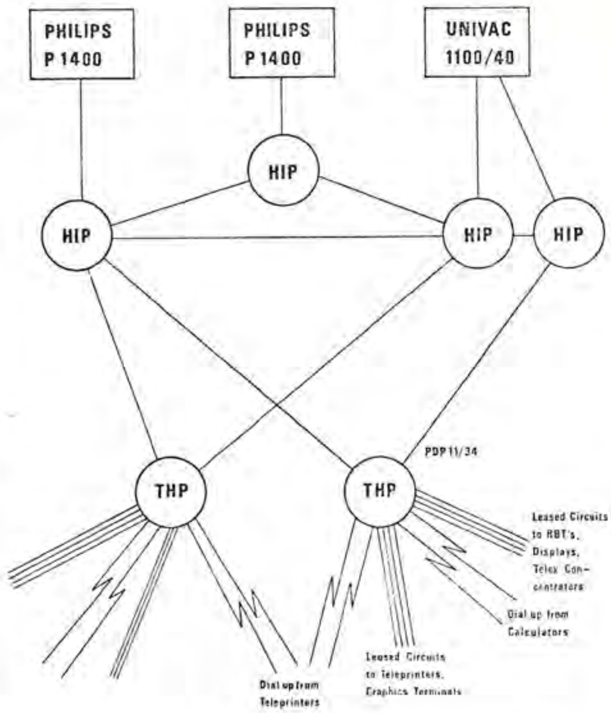

Fig. 1. The six-node configuration of CNET.

circuit principle. Furthermore, it was decided to structure the software in such a manner that interface functions should not interfere with switching functions. Hence protocol conversion and special user functions could be presented in case public data network services should be provided on a X.25 basis. For this reason, the network will be furnished with a X.25 packet level DTE interface, facilitating the connection to this type of service. The initial configuration consists of six PDP 11/34 minicomputers (Fig. 1). Use will be made of hardware HDLC line drivers for the internode traffic. Programming of the network is done in the high level language RTL II and use is made of the DEC operating system RSX 11 S/M. The network will gradually replace and complement the existing datacommunication facilities. Planned to be operational in 1978, CNET will interconnect the three hosts (2x P1400, 1x U1100/41), 2 telex concentrators with 16 ports each, 30 Dataprint terminals, 20 Tektronix terminals, 20 Philips alpha numeric displays, 9 Hewlett Packard HP 9830 calculators and 10 minicomputer-based (3x Philips P9205, 4x Philips P855 and 3x Univac UTS700) remote batch terminals. The network will be implemented in close collaboration with Logica B.V. Rotterdam. A further step will be the connection to the CNET of the various hydrological data acquisition systems and presentation terminals.

The Hydrological Data Acquisition System

Measuring water quantity parameters has been a traditional necessity in the Netherlands due to the peculiar situation of the country. With more than 50% of the land mass underneath sea level (Fig. 2), water heights have to be controlled consistently. The growing awareness of the ecological aspects of industrialisation, and the particular dependancy of drinking water plants and agricultural development on the purity of the rivers Rijn, Waal and Maas has stimulated new types of monitoring activities. Although water quality is not easily analysed, measurements were started on various elements.

The complexity of the required sensors and the processing of the data obtained resulted in minicomputer-oriented data acquisition networks. In integrating measurements of both water quality and quantity into single networks, fairly complex systems came into existence. It would have been nice if the available time scales for the realisation of such systems had permitted a careful analysis of the user requirements and the ideal network structure. As it was, some users could define their requirements immediately and others could not. In some cases operational pressure was so high that immediate solutions had to be

Fig. 2. Land periodically flooded by seawater in the absence of dikes.

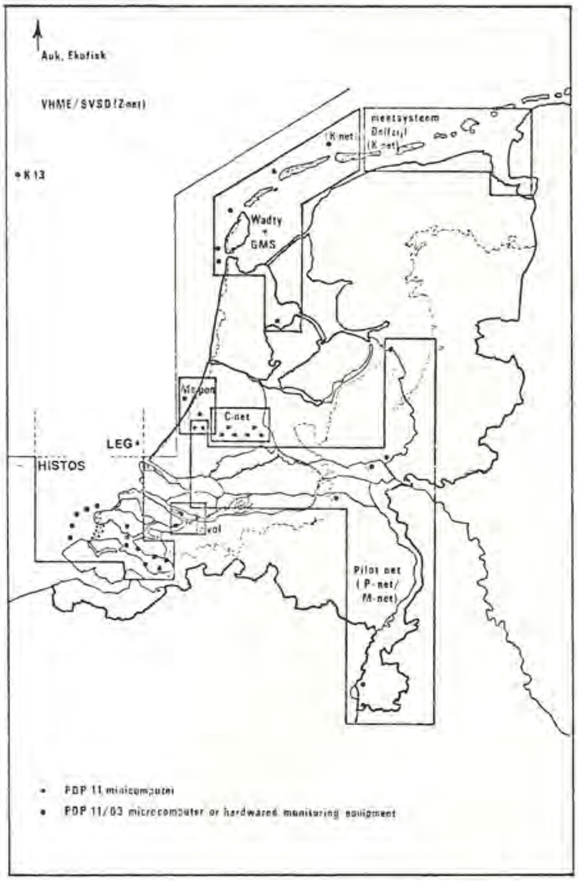

Fig. 3 A simplified survey of the various data acquisition and data communication networks.

provided. The result was a series of ad-hoc data acquisition networks for sea water measurements, a pilot network for measurements on river water, and partly completed studies specifying the structure and shape of a final hydrological data acquisition network to replace and complement the existing systems (Fig. 3). This will allow a much better modularity and an easier maintainability.

Mainly due to the organisational structure of the different authorities within the Rijkswaterstaat, areas of concern have been controlled and supervised by different bodies. Development in the minicomputer-based data acquisition fields has been united under the name ZNET (Dutch for sea = Zee), which mainly concerns measurements at sea. The name KNET (Dutch for coast = Kust) is being used for similar developments in the coastal areas. Measurements concerning rivers have been developed under the common name MNET (measuring net).

MNET—Hydrological Measuring Net

Prior to finalizing the general specifications for the Hydrological Measuring Net (MNET), a pilot project (PNET) for river water was established and operated.

The system as implemented comprises a number of measuring instruments connected via leased communications lines to a central computer station. This station monitors the instruments, collects and processes telemetry data, generates reports in various formats for various output devices, and distributes the output data to user terminals. The instruments measure concentrations of dissolved gases and soluble matters (FL-, $NH4^+$, CL-, $NO3^-$), temperature, turbidity, water levels, etc. Some instruments are pure hardware, and communicate using a non-standard synchronous communications protocol. Some are minicomputer-based, and communicate using a simple asynchronous protocol (ISO 1745/ECMA16).

The user terminals are each equipped with a printer for reports and alarm messages, and a number of specially designed recorders for monitoring individual "channels" (sensors or computed data streams). Communication with the central station is achieved using the already mentioned asynchronous protocol.

The central station located in Rijswijk comprises two computer systems: one, the Pilot Data Acquisition System (PDS), is responsible for monitoring the telemetry outstations and performing initial processing of the collected data; the other, the Deel Net Computer (DNC) performs further processing of the data and distributes reports and sensor data to the user terminals (one local and four remote). Both computer systems generate data for the terminal recorders, ad-hoc alarms and status reports, hourly statistical reports, and regular statistical reports at 0600, 0800, 1800, and 2400 hrs. The PDS and DNC are connected via a simple communications interface, using the same asynchronous protocol as is used for DNC terminal communications. Early considerations of potential growth of the network indicated that a small number of outstations or monitor types might be added, but that improvements would generally be made by adding existing stations, and by replacing monitors as and when technological improvements were made. The original design limit (of the DNC) was for a maximum of 100 monitor channels, but later considerations have indicated that in the order of 250 channels are desirable. The Pilot network has been operational since the beginning of May, 1977 and appears to be very satisfactory. As a necessary addition seven microcomputer-based (PDP11/03) logging devices have been developed. Using the same asynchronous protocol they will be connected to the PDS in a manner similar to the existing measuring instruments.

KNET and ZNET

Measurements at sea are required for many reasons. Data on water quantity are needed in order to prevent floodings such as those in 1953. This data also plays an important role in the computer simulation of the behaviour of the North Sea and delta areas. Data on waves are required for the optimisation of the harbour accessibility for oil tankers, etc. These and other reasons gave rise to the development and installation of different types of sensors installed on fixed or floating platforms. With sensors situated on land and at sea, the sampled data are stored locally or transmitted by telephone line and/or radio link to suitable data handling facilities.

So far equipment mounted on floating platforms (Waveriders) have made use of radio channels in the 27 MHz radioband, and equipment mounted on fixed platforms have made use of channels in the 173 MHz and the 450 MHz radiobands.

The 27 MHz radio channels are used in a purely analog fashion to transmit the wave heights as frequencies between 0 and 4000 Hz. They are also used in a simplex, point to point fashion, one sensor per channel. Continually transmitting with directed antennas, the channels are used simultaneously. The 175 MHz and 450 MHz bands are sometimes used more efficiently. Here digital methods allow for the use of frequency shift keying transmission, and facilitate the use of offshore multiplexors. In some cases radio receivers are connected to modems to allow for a more convenient installation of the onshore part of the telemetry system. In many cases data is directly transferred to an analog plotter, in order to present the user with the results immediately. In other cases fairly advanced teleprocessing systems have been developed (HME - Hydro Meteo Europoort).

Using a PDP 11/40 system, for example, a system has been made to survey the accessibility of Rotterdam harbour. Another minicomputer-based system is the experimental offshore "MEPON". This project is intended to test sensors under harsh environmental conditions, such as temperatures varying from $-20^{\circ}C$ to $+55^{\circ}C$, windspeeds up to 50m/sec, iceloads of 200 gr/dm^2 and a relative humidity of 95% with a high salt percentage.

Another system keeps track of the water level in the shallow sea in the north of the country (Waddenzee), and in particular of the influence of the tides in these areas (Palen Plan Hoorn).

A land-based PDP 11/10 interrogates five installations at sea. Every installation is furnished with a solar cell and a battery. A fairly complex controller and a buffer for storing measurements up to 5 minutes allow smooth interrogation. Like most systems, data is analysed and checked in the minicomputer and stored in a rubricated manner on papertape. The data is then processed and stored by the central computers in Rijswijk. The system has been operational for some months now. Apart from some minor problems in the pole and sensor electronics the major problem appears to be the software. New services are difficult to implement and, for this reason, it has been decided to re-write the software completely in the high level language RTL.

Two more PDP 11-based data acquisition networks (INVOL and HISTOS) are under construction in the delta of the big rivers (Rhine, Waal, Maas, Schelde) for monitoring both quality (salt) and quantity of the water.

A serious area of concern in developing these systems is the data transmission via radio channels. The fairly rapid growth in the number of measurements necessitated an investigation of a new method of transmitting data, particularly from stations at sea. As a result of a recent revision in radio channel allocation by the Dutch Post and Telegraph Office (PTT) the 173 MHz band radio channels were no longer available for use. Instead, 9 channels in the 450 MHz band had to be used. The withholding of these 173 MHz channels added to the already growing need for the Rijkswaterstaat to abandon the current telemetering techniques. A preliminary study on this issue clarified the situation somewhat. Although the amount of transmittable data appeared to be small in comparison to the total capacity of the available radio channels, the different measurements turned out to be too numerous. Only if multiplexing techniques were used, could service be continued and grow. A study carried out in conjunction with a research laboratory of the PTT (Dr. Neher Laboratory) facilitated the decision on what type of multiplexing techniques should be applied by demonstrating the advantage of time division multiplexing (TDM) in favour of a further multiplexing with frequencies. A prototype of such a TDM system is under development. The system will be highly flexible with only a limited number of interfaces. The synchronisation will be derived from an external mother clock. Use of the system on both land and at sea will be feasible.

Summary

Reviewing the situation as it stands today, one notes a growing serious interest in on-line automation. This has resulted in a number of individual data-acquisition networks. These networks do not communicate with each other but do communicate in an off-line manner with the central computer facilities. These facilities have grown quite substantially in recent years and, particularly due to the lack of common communication protocols on the mixed hardware which Rijkswaterstaat has, and is forced to use, have turned into fairly complex data communication networks. The first step in harmonising the development consists of the communications network (CNET). The second step will come with the definition of end to end protocols, file handling procedures, and a better understanding of the future of the distribution of processes and the database policy of the Rijkswaterstaat. The final combination of the CNET, MNET, KNET and ZNET is called the Rijkswaterstaat network (RWS-net)

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The purpose of this article has been to generally outline the most important data acquisition and data communication systems developed and installed by or for the Rijkswaterstaat (RWS). Technical details may be obtained through the appropriate literature, or the people responsible for the individual projects.

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Correction

In the Nov. 1977 issue of LIGHTHOUSE, p. 37, we affiliated Dr. R. Gilbert with the Canadian Hydrographic Service when he is, in fact, Manager, Institute Facilities, Bedford Institute of Oceanography, Dartmouth, N.S. We apologize to Dr. Gilbert for our error.

Sound Velocity Distribution and its Effect on Sounded Depths for Hudson Bay

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Introduction

As more and more hydrographic data analysis is accomplished by computer techniques, it becomes easier to correct each final hydrographic sounding for various outside parameters before the soundings are used to update hydrographic charts. The increased accuracy in location achieved by SATNAV Doppler sonar navigation and the refinement of the echo sounders warrants that the depths obtained from the echo sounder travel time be corrected for tidal fluctuations as well as for sound velocity variations in the sounded water column. Tidal corrections for any particular place and time can be predicted by the use of numerical tidal models which are calibrated by observed tidal measurements. On the other hand, the distribution of sound velocity correction cannot be predicted that easily, as it changes constantly in time and place in response to weather conditions. Since sound velocity is dependent on the salinity and temperature of the water it travels through, the variability in time and space will indicate the degree of reliability that should be placed upon the sound velocity used to correct the echo sounder travel time to actual sounded depth.

Velocity of Sound in Hudson Bay

As an example, Hudson Bay was chosen to show what errors can possibly be introduced when a constant sound velocity is used to convert the echo sounder travel times to actual sounded depths. Bathymetric data needed to update hydrographic charts of Hudson and James Bays has been collected by the Canadian Hydrographic Service in past years. Since the Ministry of Transport's vessel 'NARWHAL', used to collect the offshore data, can operate in Hudson Bay only during the ice-free summer months, its data collection program will span several years. During the first summer of operation (1975), besides collecting bathymetric, gravity, and magnetic data, oceanographic data was obtained by an underway towed-body data collection system (Prinsenberg, 1977). The salinity and temperature profile data were extrapolated to the sounded depth, as well as interpolated to standard depths. The resulting

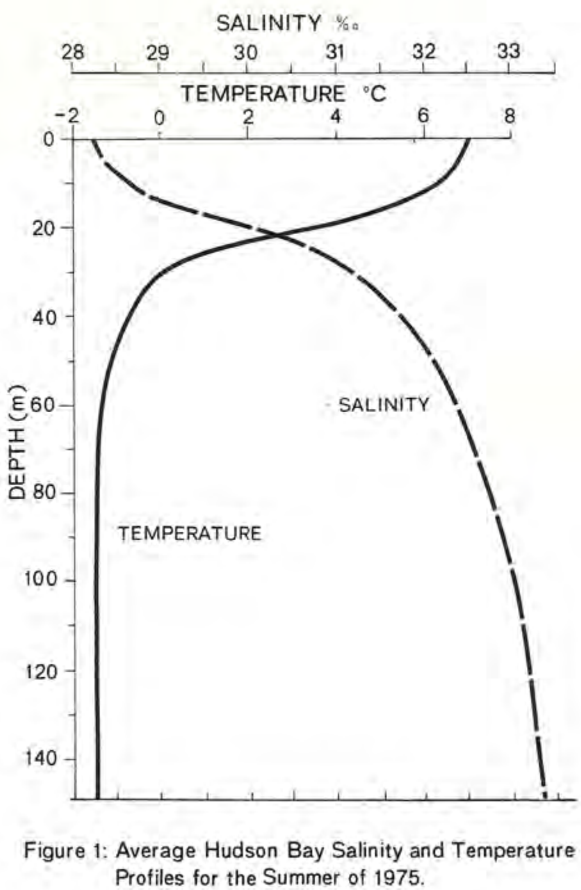

Figure 1: Average Hudson Bay Salinity and Temperature Profiles for the Summer of 1975.

standard depth profiles were used to obtain vertical and horizontal distributions of sound velocity in Hudson Bay using Wilson's equation (U.S. Naval Oceanographic Office, 1962). Refinement of this equation of sound has been published by Del Grosso (1972) and others as discussed by C.D. Maunsell in the April, 1976, issue of LIGHTHOUSE. However, the spatial and temporal variations in sound velocity, and the sounding errors derived by the use of a constant sound velocity, are similar when either equation is used.

As the Hudson/James Bay region is ice-covered for half of the year, the salinity and temperature distribution exhibits large seasonal variations. The average Hudson Bay salinity and temperature profiles for the summer of 1975, as obtained from volumetric averaging of all available data, are shown in Figure 1. The summer profiles, with the characteristically more fresh and warm surface layer, will be completely destroyed in the fall as the heavier surface water, produced by cooling and then freezing, sinks until the total water column is homogeneous. After the ice cover is well established, the river runoff and spring ice-melt will again establish a salinity profile similar to that found in the summer. Until all ice is melted, the temperature remains homogeneous. Then, throughout the latter part of spring and summer, the thermocline structure (as shown in Figure 1) slowly develops. An average Hudson Bay sound velocity profile will thus experience a similar seasonal cycle, and it is necessary to understand the effects the three variables (salinity, temperature, and pressure) have on the sound velocity.

Figure 2 shows the sound velocity profiles for combinations of the three variables using the mean Hudson Bay salinity and temperature profiles of Figure 1. In fall and early winter when the homogeneous water column is present, the sound velocity depends only on pressure and increases slowly with depth. When the salinity structure becomes established in late winter and spring, the fresher water in the surface layer decreases the sound velocity, reinforcing the sound velocity increase with depth of the pressure effect. During the summer months, the effect of the high temperature in the surface layers offsets the effect of the low salinity on the sound velocity. The resulting sound velocity profile is thus similar to a temperature profile, except for the steady increase of sound velocity with depth in the deeper layers due to the salinity and pressure effects. The fourth curve of Figure 2 represents the integrated sound velocity for the layer from the surface to the required depth. For the average salinity and temperature profiles, this curve will give the correct sound velocity as a function of the sounded depth that should be used to convert the echo sounder travel time to sounded depth. The spacial variation in salinity and temperature values for Hudson Bay does not allow such an easy solution as a single integrated sound velocity profile for the correction of the sounded depths.

Sounding Errors

Table 1 lists the sounded depth errors that will result when a constant sound velocity value of 1447 m/sec is used rather than a variable with depth as shown in Figure 2. The table lists

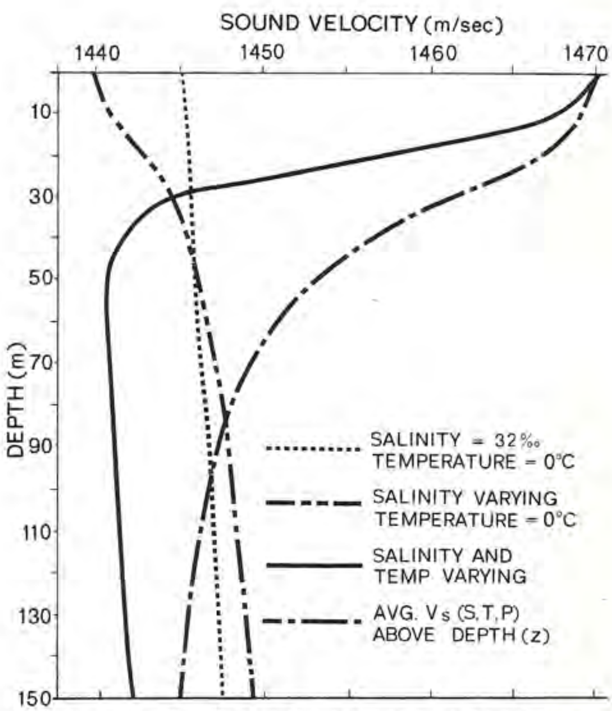

Figure 2: The Effects of the Salinity and Temperature Depth Variation on the Sound Velocity.

TABLE 1. ERRORS RESULTING FROM USE OF CONSTANT VS. INTEGRATED VELOCITY OF SOUND

Depth (m)	Temp. (°C)	Sal. (°/oo)	Vel. (m/sec)	Avg.Vel. (m/sec)	Error (cm)	Acc. Error (cm)
0	7.0	28.2	1470.2	1470.2	0.0	0.0
5	6.6	28.4	1469.0	1469.6	7.8	7.8
10	6.2	28.6	1468.0	1469.1	7.5	15.3
15	5.1	29.2	1464.1	1468.1	6.6	21.9
20	3.1	30.0	1456.9	1466.2	4.6	26.5
25	1.1	30.7	1448.8	1463.5	2.0	28.5
30	0.0	31.2	1444.4	1460.7	- 0.1	28.4
35	- 0.5	31.4	1442.6	1458.2	- 1.2	27.2
40	- 0.8	31.7	1441.6	1456.2	- 1.7	25.5
50	- 1.2	32.1	1440.6	1453.1	- 4.1	21.4
75	- 1.4	32.6	1440.7	1448.9	-10.9	10.5
100	- 1.5	33.0	1441.3	1447.0	-10.3	0.2
125	- 1.5	33.2	1441.8	1445.9	- 9.4	- 9.2
150	- 1.5	33.3	1442.3	1445.2	- 8.6	-17.8
175	- 1.5	33.4	1442.9	1444.9	- 7.6	-25.4
200	- 1.5	33.5	1443.3	1444.6	- 6.8	-32.2
250	- 1.5	33.6	1444.4	1444.5	-10.8	-43.0
300	- 1.5	33.8	1445.5	1444.6	- 7.1	-50.1
350	- 1.5	33.8	1446.5	1444.8	- 3.6	-53.7

temperature, salinity, sound velocity, and integrated sound velocity with depth (Avg. Vel.) values as a function of depth, as used for Figures 1 and 2. Also listed are the sounding errors for each depth interval (Error) and the accumulated sounding depth error (Acc. Error) as one adds up the sounding depth errors for each layer as one goes deeper in the water column. The sound velocity values larger than the mean value will underestimate the calculated sounded depth in the surface layer. The sounded depth obtained with a constant sound velocity value thus records a shallower depth than it should be, and therefore positive errors in the surface layer are listed. The accumulation of error with depth shows that sounded depths are underestimated by 1/4 metre between the sounded depth range of 20 and 40 metres. Below the surface layer, the sound velocity values become less than the mean and the layer depth error is negative, causing the accumulation of error to approach zero. At this depth, the calculated sounded depths by a constant or variable sound velocity are the same. At deeper depths, the sound velocity values smaller than the mean value will overestimate the depth of each layer, and the accumulation of error reaches a value of negative 1/4 metre at the average depth of Hudson Bay (200 m). The deeper depths of Hudson Bay will thus be underestimated by 1/4 metre at around 200 metres and 1/2 metre at 300 metres.

The variation of salinity and temperature values from the mean Hudson Bay profiles prevents the use of the single sound velocity profile for correction of sounded depth over the entire region. Figure 3 shows the variation of sound velocity profiles for four different stations. Three of the profiles were chosen since they show the variation that occurs in traversing the bay from Churchill to Hudson Strait. The profile of Station #34 was taken just outside Churchill;

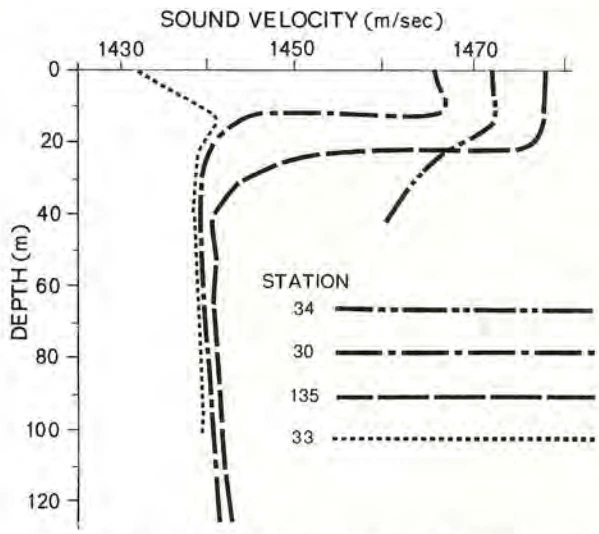

Figure 3: Variation in Sound Velocity Profiles Across Hudson Bay.

Station 34 - Outside Churchill,
Station 30 - Centre of the Bay,
Station 135 - Entrance of the Bay, and
Station 33 - North of Churchill close toMelting.

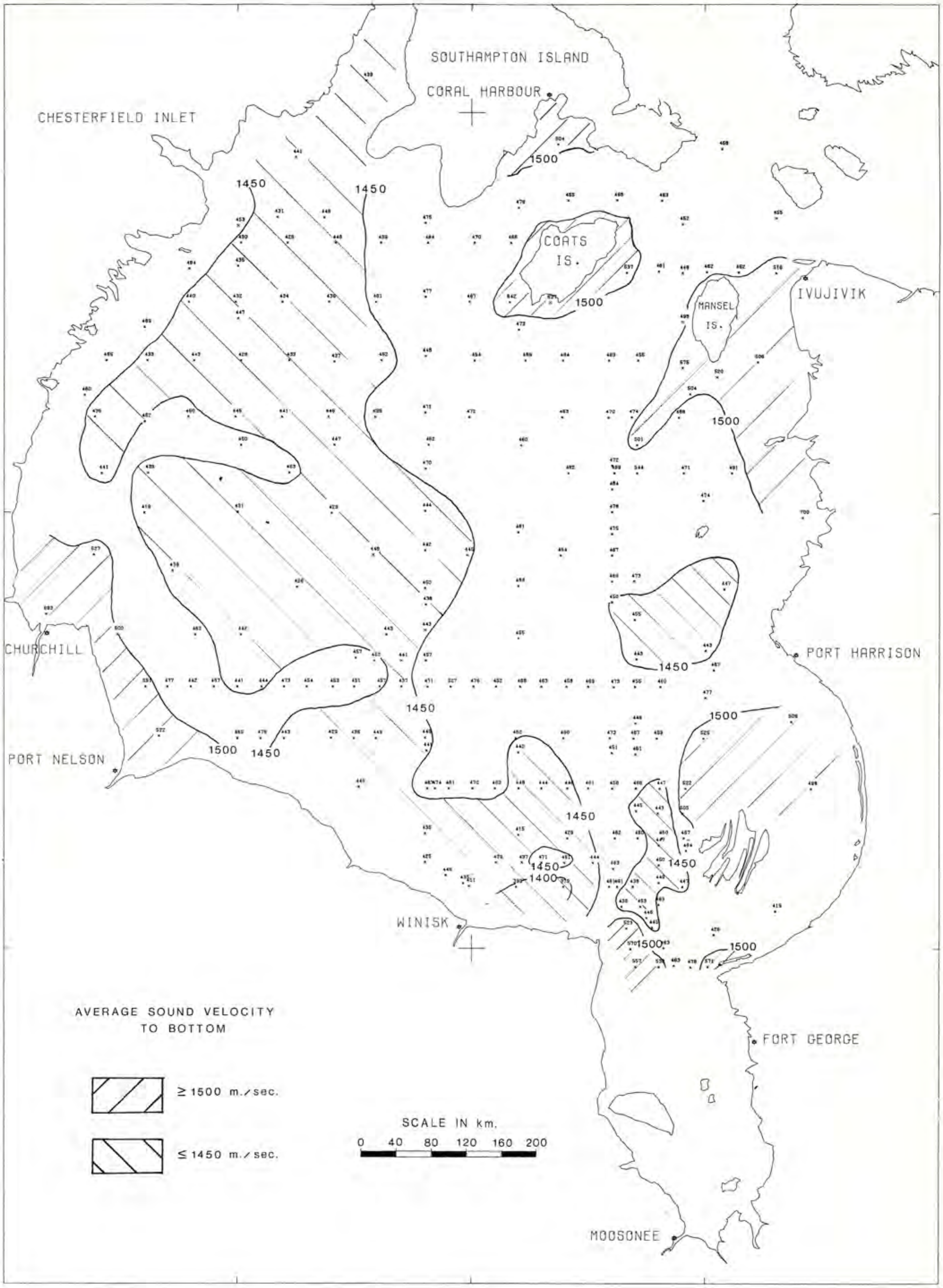

Figure 4: Distribution of the Depth-Integrated Sound Velocity to the Sounded Bottom for the Summer of 1975.

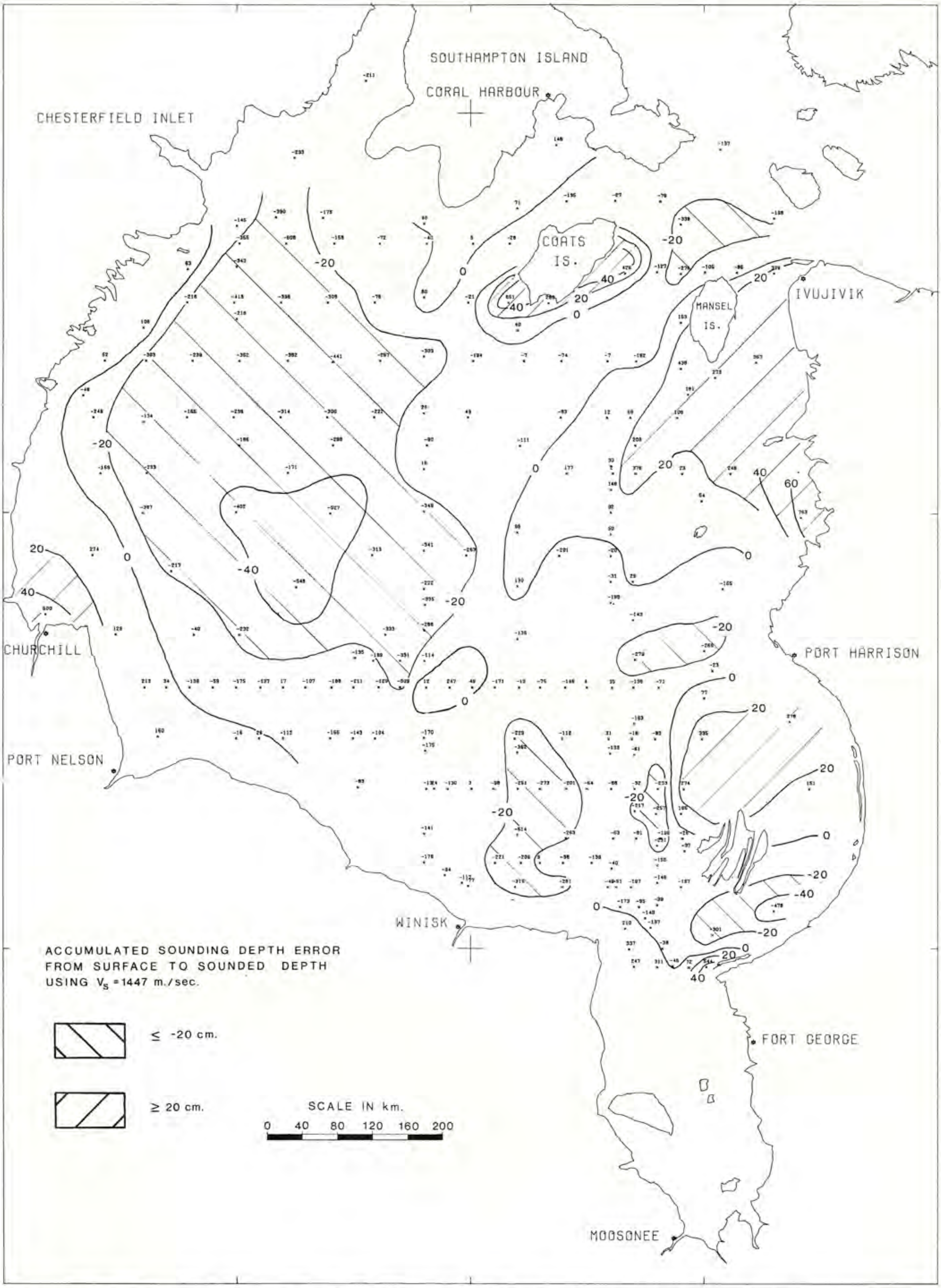

Figure 5: Distribution of the Sounding Depth Error when a Constant Sound Velocity Value of 1447 m/sec is used; Negative Error Values indicate an Underestimation of the True Depth and Positive Values indicate an Overestimation.

Station #30 is located in the middle of the bay; and Station #135 was taken at the entrance of the bay between Coats and Mansel Islands. The Churchill station velocity profile reflects the high temperature of surface water which is mixed down to depths of 40 metres by the strong tidal mixing over the shallow topography. In the middle of the bay (#30), a shallow surface layer is present; whereas the surface layer deepens at the entrance of the bay (#135) where the water is also warmer. The integrated sound velocity value to a 40-metre depth would be 1468 m/sec for Station #34, 1448 m/sec for Station #30, and 1462 m/sec for Station #135. The sounded depth error for shoals around 40 metres would thus be over-estimated by 1/2 metre at Stations #34 and #135 and would be exact at Station #30 when a constant sound velocity value of 1447 m/sec was used. The fourth velocity profile of Figure 3 is of Station #33, located north of Churchill, but was taken at a time when ice was still present. The large values of sound velocity due to warm surface water are thus not present, and the small values due to low surface salinity values are revealed instead. The integrated sound velocity value to 40 metres is 1439 m/sec, and the depth of a 40-metre shoal would be underestimated by 1/4 metre if a constant sound velocity value of 1447 m/sec was used. When ice is present at a station which is influenced by river runoff, the underestimation of a shoal depth can reach 1/2 metre when the surface salinity is 20 $^{o}/oo$. Large errors can thus result when a constant sound velocity is used in the calculation of sounded depth for an area which experiences major changes in surface layer salinity and temperature values as well as actual total depth.

Sound Velocity Charts

The oceanographic data of the 1975 survey of Hudson Bay was used to plot the distribution of the depth-integrated sound velocity and the accumulated sounding depth error in Figures 4 and 5 respectively. Station data which revealed the presence of the melting ice-pack, such as Station #30 (Figure 3), were not included in order that the figures would represent the average Hudson Bay conditions during the ice-free summer months. Each figure shows the location of the 232 oceanographic stations used for contouring. Each station's computed value is listed as an integer; the first significant figure '1' of the sound velocity was omitted; and the depth errors are listed as millimetres. Twelve stations from previous surveys ("CALANUS" Cruise, 1959) had to be included in order to fill in the large data-gap areas east of the Belcher Islands and in Roes Welcome Sound.

The average sound velocity map (Figure 4) shows that the colder western half of the bay has, on the average, lower sound velocity values. Due to their shallow depth and higher surface layer temperature, the inshore areas usually have larger velocity values than those farther offshore. Hudson Bay's outflow of relative warm and low salinity water shows up between Mansel Island and the Quebec mainland. The sounding depth errors of Figure 5 reveal a similar partition of the bay. The sounded depths are underestimated on the west side of the bay while overestimated on the north-east side. If the depth of Hudson Bay was constant, the features of Figures 4 and 5 would be the same. The rapid changing depth in the southeastern part of the bay is reflected in both figures. The James Bay outflow of warm water (high sound velocity) can just be seen in both figures.

Summary

Thus, sounded depths can be underestimated by 1/2 metre for deeper parts of the bay where a relative colder surface layer is present, while they can be overestimated by 1/2 metre in the shallow parts of the bay where a deep warm surface layer is found. The shallow inshore depths are most likely to be overestimated if they were sounded during the summer ice-free season. However, when melting ice is present, they can be underestimated by 1/2 metre if they are located near a river, which reduces the surface salinity values in addition to the ice-melt. The overall depth average sound velocity diagram of Hudson Bay will be used to correct the sounded depths of the bay. However, care must be taken with some of the early season sounded depths when melting ice is still present and with some of the inshore stations where large changes in temperature are found.

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Book Review

Electronic Surveying and Navigation

SIMO H. LAURILA

John Wiley and Sons, 1976

With the ever increasing reliance on electronics in surveying, books such as Simo H. Laurila's "Electronic Surveying and Navigation" are becoming an important addition to the surveyor's library.

In his book Laurila approaches this subject in 3 parts. Part one deals with the fundamental concepts of electronics. Here he deals with the basic principles of radio theory and light emission. Subjects such as a.c. current, resonant circuits, frequency mixing, vacuum tubes, transistors, oscillators, modulation, measurement of phase difference, radio wave transmission, light wave transmission, lasers, etc. are dealt with in relatively general terms. His descriptions are easy to follow and the use of mathematics is kept to a minimum. This section would not suffice as a text in basic electronics but does, as Laurila suggests, serve as a good reference for the reader familiar with electronic concepts, such as hydrographers of today.

Part II of the book is titled Electronic Surveying. This section, with the exception of the final chapter, deals with the theory and mathematics of electronic surveying. The reduction of measured data is discussed in detail and one whole chapter is devoted to hyperbolic and circular location. The science of Geodesy is quite prevalent throughout this section and subjects such as, ellipsoidal parameters, universal space rectangular co-ordinate system, reduction of spatial chord distance into ellipsoidal chord distance, cyclic zero error in microwave distances, and solving the inverse problem in geodesy by the chord method are dealt with in considerable detail. Much of the information contained in this section would be of special interest to the theoretical geodesist or geodetic surveyor. The chapters on Geometry of Electronic Surveying, Velocity Applications to Surveying, and Instrumentation should be of interest and pertinent to hydrographers. However because of the mathematics involved in these subjects one could, as I did, find the reading very slow and difficult.

Part III and Chapter 20 of Part II appear to be the most interesting to the hydrographer. Here the author does an excellent job of cataloging todays electro-optical and microwave distance measuring equipment as well as microwave, medium and low frequency positioning systems. Equipment and systems are described in a very complete manner along with their expected range, accuracy and reliability. Included in this section are descriptions of Hi-Fix 6, Loran A and C, satellite positioning, omega, Radist, trisponder, etc. It is obvious throughout this section that the author took great pains to provide information as up to date as possible and therefore, he has produced a book which should be beneficial to the hydrographer as a reference text.

F.W. Hall
Training and Standards
Canadian Hydrographic Service
Ottawa

News from C. H. S.

Atlantic Region Tests Hi-Fix 6

Atlantic Region's new Hi-Fix 6 chain was tested during November, 1977 by Navigation and Development personnel. The chain was set up outside Halifax Harbour and C.S.S. MAXWELL used to complete a week-long test program. Although the chain didn't perform as well as had been expected, no major problems were apparent. The test data is being analysed and it is expected that all the bugs will be worked out before the chain is put into operation in the Gulf of St. Lawrence this coming spring.

TATS in the Arctic

One of the prototype Tidal Acquisition and Telemetry System (TATS) units developed in Central Region is being used with two Paroscientific 'Digiquartz' pressure transducers this winter to obtain tidal records during a survey of Viscount Melville Sound. One transducer is bottom mounted in 60 meters of water and the TATS unit is located, with the second transducer, in a Parcol on the ice above. The software package converts the frequency modulated sensor outputs into digital numbers, linearizes and scales the data, and computes the water level after subtracting the atmosphere pressure measured by the surface transducer from the total pressure. The water levels are stored in memory and recalled on a daily basis with a portable data terminal.

In-House Training in Atlantic Region

Atlantic Region is carrying out a fairly comprehensive in-house staff training program this winter. Courses are being given to interested staff in positioning systems, HP 9815A programmable calculators, sounders, radar, tide gauges, data processing, Fortran, mini-computer systems (R.T.E.), practical tidal work, report writing, and staff relations. As well, tours and briefings of B.I.O. facilities are given to the new hydrographers.

NUCLEUS Trials

One of Central Region's newest survey vessels is the NUCLEUS, a 34 ft. English-built Nelson with a single screw and fibreglass hull. NUCLEUS is presently being tested on the east coast and, after returning to Burlington for a refit, will be loaned to the west coast for testing purposes. Two additional Nelson, these with twin screws, have recently been delivered to the Central Region's Ships Division.

Loran-C Calibration in Central Region

In the 1978 field season C.H.S. Central Region will be using an Accufix mini Loran C chain in a Range/Range mode on Lake Superior. The chain was first used by Central Region in Senegal, West Africa. In 1978 a commercial Loran C receiver will be installed aboard the C.S.S. BAYFIELD and interfaced with a Central Region INDAPS logger. In 1978 the offshore portion of Lake Superior north of the Canada/U.S.A. border and the area between Michipicoten Island and St. Ignace Island will be covered.

* * * * * * *

C. H. A. personal notes

Atlantic Region

Roy Amero recently visited Lima, Peru in connection with the BAFFIN cruise in December; *Steve Forbes* spent two weeks of training in Ottawa on the GOMADS system; *Kent Malone* is with the training section in Ottawa for the winter, instructing the Hydrography I students; *Dave DeWolfe* recently made an informal presentation on the Bay of Fundy Tidal Study at a seminar at the Tidal Institute, Liverpool, England; *Nick Stuifbergen* and *Rick Mehlam* will be attending the University of New Brunswick this fall; congratulations to *T.B. Smith* on being awarded a Queen's Silver Jubilee Medal; *Renaud Pilote* has transferred to Quebec Region; *Doug Wilson* is with the Notices to Mariners Unit in Ottawa.

Quebec Region

Ron Saucier formerly with GEBCO at Headquarters returned to Quebec last fall after a field season with George Macdonald on the Winnipeg River; field staff *Denis Trudel, Jean-Yves Poudrier, Paul Bellemare, Charles Allard,* and *Patrick Hally* are presently on Hydrography I; *Jean-Paul Racette* recently won the Production Chief competition; *Mike Martin* has successfully completed language training.

Ottawa Region

John O'Shea has taken a one-year appointment as Acting Regional Hydrographer in Quebec Region; *Ron Parker* has joined the Cartographic Development Section as a programmer/analyst; *Paul Warren* will soon be transferring to the Central Region Cartographic Unit; *Ron Lemieux* has transferred from Notices to Mariners to Cartographic Development.

Central Region

Sam Weller has taken a one-year assignment with Quebec Region; *Peter Kielland* has transferred permanently to Quebec Region; *Reg Lewis* is in Ottawa for a one-year assignment with the Planning and Development Section; *Rick Bryant* has left his position as head of the Hydrographic Development Section for a job with M.O.T. in Toronto.

Pacific Region

Jack Chivas, after 24 years as a hydrographer, will be retiring in June; *Ken Josephson* and *Mike Hall* have returned from Ottawa where they successfully completed the Cartographic training course.

On April 10, 1978, F.L. "Dusty" DeGrasse began enjoying the fruits of his thirty-two years of service with the Canadian government. On April 6, Dusty's friends honoured him and wished him and his wife, Grace, happy retirement years together.

Dusty was born and raised in New Brunswick. He began work at Fairchild Aircraft in 1940, then served in the Royal Canadian Air Force from 1943 to 1945 - when he began Civil Engineering studies at Mount Allison University. He then surveyed with the New Brunswick Department of Highways during 1948 and 1949. From 1949 to 1951 he surveyed in New Brunswick and North West Territories with Topographic Surveys of Canada. While in the North West Territories, he snowshoed three hundred miles delineating preliminary border sections of Alberta, British Columbia, and the North West Territories. In 1951 Dusty began twenty-seven years of distinguished service with the Canadian Hydrographic Service.

During Dusty's early years in the Canadian Hydrographic Service, he surveyed waters off New Brunswick, Newfoundland, Labrador and the Queen Charlotte Islands of British Columbia. In 1956 Dusty was appointed as a Hydrographer-in-Charge and then surveyed for six years along the Nova Scotia shoreline. During this term he made the C.H.S.'s first use of tellurometers for precise surveying. During 1962 he was in charge of the Hudson Bay survey and, then in 1963, of the C.S.S. KAPUSKASING surveys off New Brunswick and Nova Scotia. The C.H.S.'s first use of Decca 6F, for offshore surveying, occurred on this project. Dusty surveyed three years between 1965 and 1969 as Hydrographer-in-Charge of the C.S.S. BAFFIN surveys on the Grand Banks and Gulf of St. Lawrence. These were the first C.H.S. multidisciplinary surveys. From 1970 to retirement, he directed several hydrographic and scientific support programs on the Great Lakes. During 1972, Dusty directed hydrographic surveys and was Project Manager for horizontal electronic positioning logistics for the international scientific and survey communities during the International Field Year for the Great Lakes.

Dusty and Grace have two children; Cathy is studying at the University of Western Ontario and John is attending High School. For the present, the DeGrasses will indulge in retirement activities in Burlington, Ontario

Ellsworth McLean Walsh

1918–1977

On 19 November the Canadian Hydrographic Service and the cartographic community in Canada and abroad were shocked by the sudden death of Ells Walsh. Ells' death at the age of 59, after he had enjoyed less than two years of his retirement, is a poignant reminder of life's uncertainties. Our sympathy goes to his wife Doreen and son Keith in their tragic loss.

A big, handsome friendly man, Ells was one of the Ottawa Valley Scots with their roots in Pontiac County. He was educated as a draftsman at Ottawa High School and then joined the Bureau of Geology and Topography as a junior draftsman in 1935. He enlisted in the Royal Canadian Air Force in 1942 and served until 1946 in the Construction Engineering Branch at Air Force Headquarters. His final year was as a Flight Sergeant in charge of drawing all site plans and co-ordinating surveys with Air Commands.

A year after returning to civilian life, he transferred to the Canadian Hydrographic Service which was just beginning a major post-war expansion. He became a supervising draftsman in 1951 and in 1954 received a Suggestion Award for the development of a tool to scribe dots on plastic. The CHS was just then starting to move away from fair sheets drawn by pen and ink on metal mounted paper, to engraving on plastic, commonly referred to as scribing. In 1954 he became a supervising compiler and, in April 1955, Chief Compiler. Ells inventive turn of mind quickly showed itself in the rapid adoption of the photo-mosaic as the standard technique for preparing a compilation drawing instead of the tedious method of "squaring down". He was immediately faced with probably the biggest challenge of his career, as the construction of the St. Lawrence Seaway required the compilation of fourteen charts from a vast array of ever-changing drawings emanating from both Canadian and American Seaway and Hydro authorities and aids to navigation authorities. It quickly became evident that the meetings that Ells organized were the only place where all of those concerned with navigation could find out what was really going on!

Ells was always an enthusiastic small boat owner and played a major role in developing the format for the recreational charts, the production of which was fast becoming an important commitment of the Canadian Hydrographic Service. He organized the first display of these charts at the Toronto Boat Show in 1960. This was done on such a tight budget that the entire exhibit was built in his basement, for Ells always enjoyed working with his hands and had a good workshop.

In 1968 he was appointed Chief of Chart Production, the position he held until 1974 when he accepted a special assignment as the CHS International Hydrographic Bureau Officer. Ells had been a member of the Canadian delegation to the 1972 International Hydrographic Conference and was one of the original members of the U.S.-Canada Great Lakes Charting Advisors. His broad knowledge of charting and his ability to get on easily with other people came into its own during his last three years when he served on the North Sea International Chart Commission which was charged with preparing the first specifications for a truly international set of medium and large scale charts. This has been a dream for every hydrographer since the first International Hydrographic Conference in 1919 and Ells had a major hand in making it become a reality. His last major task was to chair the Chart Format Steering Committee which oversaw the adoption of new four-colour, metric, bilingual contoured format for Canadian Charts compatible with the international specifications. Work on the prototypes was well in hand when he retired at the end of 1975 after forty years of civil and military service to his country.

Ells saw first fruits of his final labour, the new charts of Vancouver Harbour and the joint U.S. and Canadian Charts of Lakes Erie and Ontario. These will be an enduring monument to Ells' major contribution to Canadian and international charting.

1978
H_2O Bonspiel

(From left) Brian Power presenting the top prize to Barry Little, Ricky Schmidt, Brad Tinney, and Marg Chapeskie of the winning team in the "A" event.

On January 28, 1978, Central Branch of the Canadian Hydrographers' Association sponsored the 7th Annual H_2O Bonspiel at the Humber Highland Curling Club in Etobicoke. The "A" event was won by Barry Little and his rink, and the "B" event by Al Macdonald and his rink.

(From left) Bonspiel Coordinator, Brian Power, with Al Macdonald, Bill Snead, Irene O'Connor, and George Fenn of the winning team in the "B" event.

Donations for the 1978 H_2O Bonspiel were gratefully received from the following:
- Canadian Applied Technology, Buttonville
- W.T. Chatham Associates Ltd., Hamilton
- Marinav Corporation, Ottawa
- Marshall Macklin Monaghan Ltd., Don Mills
- Motorola Military & Aerospace Electronics, Willowdale
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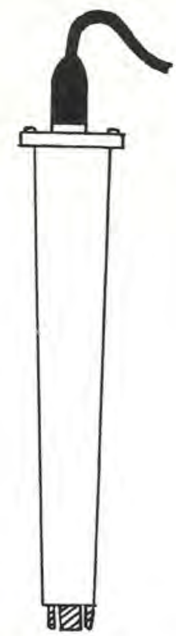

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