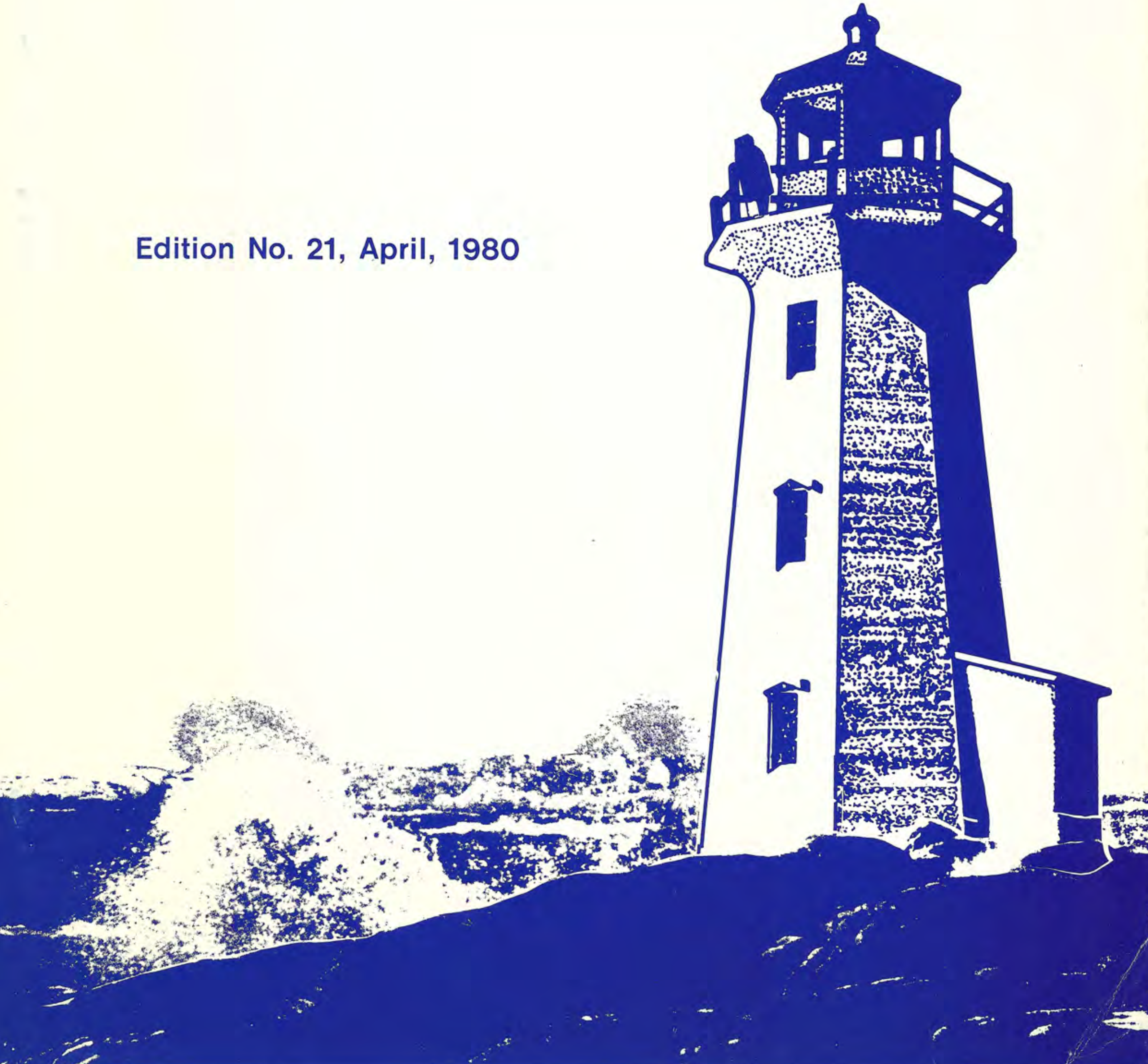
Lighthouse

JOURNAL OF THE CANADIAN HYDROGRAPHERS' ASSOCIATION

Edition No. 21, April, 1980



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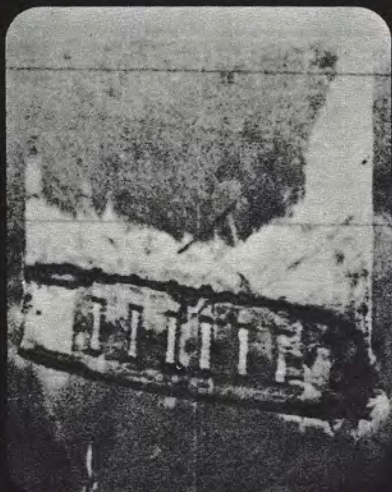
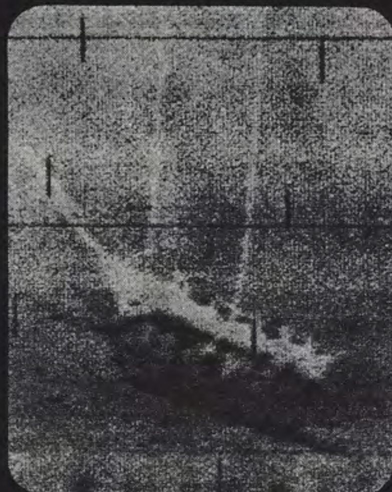
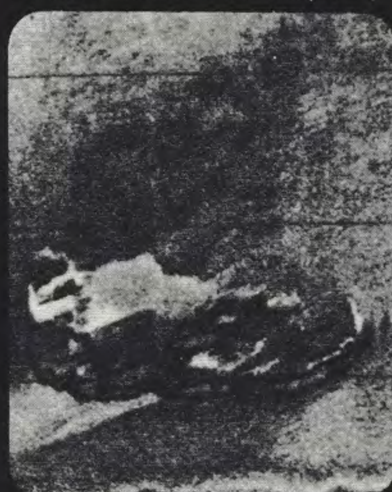


Klein HYDROSCAN Side Scan Sonar Record of an Old Wooden Sailing Barge in the Great Lakes.



American Schooner Hamilton which sank in Lake Ontario in the war of 1812 [Courtesy Royal Ontario Museum and Canada Centre for Inland Waters].



Klein HYDROSCAN Side Scan Sonar Record of the Ironclad U.S.S. Monitor [Courtesy of the Harbor Branch Foundation].

Schooner Turned into Barge.

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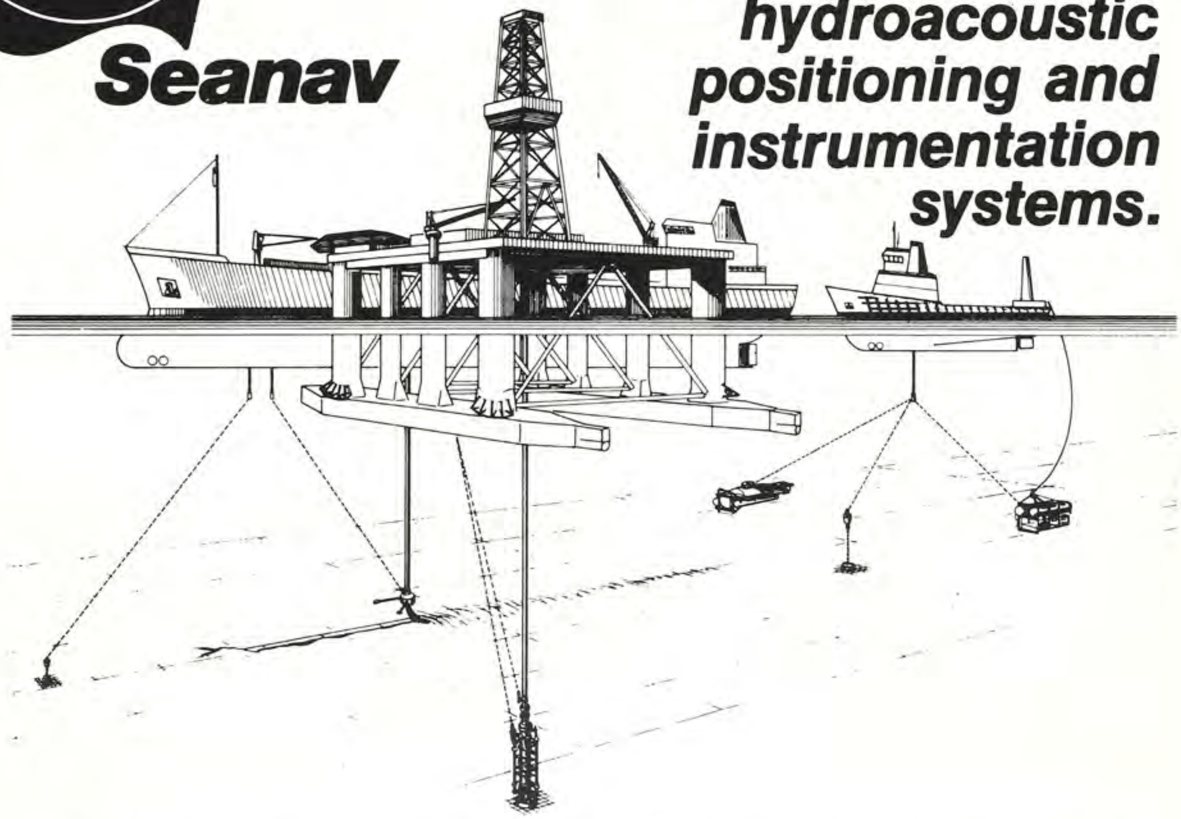

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Plan to Attend

the

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April 7 to 9, 1981

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The Hydrographic Commission of FIG

(The International Federation of Surveyors)

T.D.W. McCulloch

Central Region
Ocean and Aquatic Sciences
Dept. of Fisheries and Oceans
Burlington, Ontario

Two years ago LIGHTHOUSE kindly published a short article of mine entitled "Canada's Hydrographic Role in FIG". In my new submission, I will look at Commission Four from a different perspective, as that of its present Chairman with all the international implications and involvements that such a role ensures.

Brief History of FIG

FIG (Federation International des Geometres) was founded in 1878 in France by the delegates of seven national organizations representing the surveying profession in Belgium, Germany, France, Italy, Spain, Switzerland and Great Britain. The success of FIG is largely dependent upon the strength of its many affiliated national organizations, the administration of the FIG Bureau, and most decisively on the vigour of the technical commissions. In 1980, 47 countries, with 51 organizations, are affiliated with FIG, and a majority of UN member nations maintain professional contact. FIG's official languages are English, French and German.

Organization of FIG

The FIG Organization structure consists of four main parts:

Part I - is the FIG Bureau consisting of seven persons (the President, three Vice Presidents, the Secretary-General, the Treasurer and the Congress Director).

Part II - is the FIG Permanent Committee consisting of the national delegates of each member organization and the Chairmen of the FIG Commissions.

Part III - is the grouping of FIG Technical Commissions.

Part IV - is the FIG General Assembly, the forum where all the more than 100,000 International Surveyors can have their say.

The FIG Bureau is the administering body for the day to day operation of FIG, the arranging of annual meetings of the Permanent Committee, and the FIG Congress, usually held every third year.

The FIG Permanent Committee is the planning and budgetary arm and the coordinating mechanism.

The FIG Technical Commission (Nine of them at present) is the professional spearpoint of FIG in all technical and scientific matters.

The FIG General Assembly reviews, modifies, and ratifies Permanent Committee nominations and proposals.

Hydrographic Surveying

The nine technical commissions are grouped into three categories: A, B and C, with the Hydrographic Commission (4) fitting into Group B which concerns itself also with surveying instrumentation, methodology and engineering.

In 1968, for the first time, hydrographic surveying was included in the programme of the XII FIG Congress held in London, as a separate entity. The breakthrough was spearheaded by Rear Admiral G.S. Ritchie of the United Kingdom. The inclusion of hydrographic surveying as "Commission 10" at this Congress was a highly successful experiment. The newly formed commission met for four sessions where a total of eleven papers were presented. The papers were discussed most enthusiastically by fifty or so delegates. As a result of this success the technical commission "Hydrographic Surveys" was incorporated as FIG Commission Four at the 1969 Permanent Committee Meeting in Denmark.

Rear Admiral G.S. Ritchie remained as Chairman of the new Commission and called for papers for the 1971 Congress to be held in Weisbaden, West Germany. The Vice Chairman of the Commission was Dr. Fagerholm of Sweden and the Commission Secretary was Lt. Commander White of the U.K.

The theme of the 1971 Congress was "Surveying in the Space Age". 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". Canadian papers at the 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.

There were about sixty people attending the hydrographic commission sessions who could truly be said to be hydrographers. Of that number somewhere between one third and one half were non government types. They included representatives of survey companies, oil exploration companies and major port authorities. Out of these discussions the following points emerged. The impact of the non-government hydrographic surveyor on hydrographic surveying is of worldwide importance. The tremendous wave of interest in hydrocarbon exploration and development in the North Sea has resulted in an urgent requirement for detailed hydrographic surveys in areas never before contemplated. The Port Authorities constitute fairly large hydrographic organizations with ever growing responsibilities as their port limits are extended. Last, but not least, all were searching for a common approach to the problem of educating and training the hydrographic surveyor.

Dr. Fagerholm took over as Chairman of Commission Four 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 ingenieur-General M. Eyries of France became Chairman.

FIG XIV Congress took place at Washington in 1974 and Commission Four was well represented. There were 22 papers together with a joint session with Commissions 5 and 6. An additional paper was given on education and training for hydrographic surveying in Commission 2, the Education Commission. Highlights of the meeting were the increased number of papers from industry and from the field of education, and the resolution, endorsed by the Permanent Committee and General Assembly, that Canada host the very first International Technical Hydrographic Conference during May, 1979.

The theme of the Washington Congress was "FIG responds to environmental problems". 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 under Rick Bryant, the second a U.S. affair under Bob Munson of NOS. I was appointed Vice-Chairman of the Commission.

The FIG XV Congress was located at Stockholm in 1977, again with M. Eyries in the Commission Four chair. Sixteen papers were delivered in Commission Four sessions, 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, Alan Ingham, UK, Burke, Netherlands, and Bourgoin, France, were appointed to the newly formed Board of Education as Kerr of Canada moved to the IHO side of the house. 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 underwater detection systems and techniques.

Canada retained responsibility for chairing the Working Group on Data Acquisition and Processing Systems, the chairmanship of the Working Group on Positioning Systems went to Commodore Cooper of IHO, and the new working group on underwater systems and techniques became the responsibility of Bourgoin of France.

Of significant importance at the XV Congress was Ritchie's paper on "International Cooperation in Hydrography" and Beazley's paper dealing with "Law of the Sea - Developments of interest to the Hydrographic Surveyors". The theme of the Stockholm Congress was "Earth - limited resources of man".

M. Eyries, France, handed over the Chairmanship of Commission Four to myself on January 1, 1979. During his term of office three Working Groups were created and a former Working Group evolved into the joint IHO/FIG International Advisory Board on Standards of Competence for Hydrographic Surveyors.

The new officers of the Commission, Vice-Chairman, M. Nagatani, Japan, Secretary R. Munson, USA, and myself were faced with the very large task of maintaining M. Eyries thrust in the promotion of the hydrographic surveying profession.

Commencing last October, Rear Admiral Munson and myself have met on numerous occasions. In March, 1979 I visited with M. Nagatani in Japan, and of course, all officers of the Commission were present at the FIG-sponsored International Hydrographic Technical Conference during May, 1979 in Ottawa, Canada.

Prior to the IHTC we designed and published a BROCHURE describing the mandate and activities of Commission Four. That brochure was proven popular with Commission Four delegates, Working Group members and other participants in hydrographic surveying affairs. At present it is in English only, but translation into the other two official FIG languages will proceed if sufficient interest is shown.

Another activity prior to the IHTC was the designing of an EXHIBIT to advertise FIG and in particular Commission Four. The exhibit contained photographs of Commission Four officers past and present, photographs showing hydrographic surveying around the world together with stacks of copies of the brochure. The centerpiece was a COMMISSION FOUR FLAG designed in Canada, which we intend to fly at the Congress in Montreux.

The INTERNATIONAL HYDROGRAPHIC TECHNICAL CONFERENCE in May, 1979 was co-sponsored by FIG, the Canadian Institute of Surveying and the Canadian Hydrographic Service. It was the first of its kind and brought out a strong contingent of hydrographic surveyors and other interested individuals from around the world. In excess of 400 persons participated in the Conference and associated events. The Conference was held in the Government Centre and opened with a keynote address by L.H. Legault, Canadian High Commissioner to Nigeria and Sierra Leone and a recent member of Canada's Law of the Sea negotiating team on the Law of the Sea and its implications for the surveyor. Papers that followed dealt with the techniques and technology of hydrographic surveying around the globe, with papers from government, commerce and academia. Examples of such presentations were a paper by Kreffer of the Netherlands on the requirement for high accuracy in tidal datums and positioning in the North Sea, use of Argo positioning system off Orinoco Delta in Venezuela by N. Makin, Canada's R&D imperatives in ice-covered waters by J. O'Rourke and how the contractor contributes to the development of modern survey practice by

W.J. Roberts, U.K. Lapel buttons boosting Commission Four were distributed to all attendees. Each Working Group presented an Interim Report at the IHTC.

WORKING GROUP 414a Data Acquisition and Processing Systems interim report was presented by R.S. Bryant, Canada, WG Co-ordinator. Its task for Montreux, 1981, is to prepare an updated report for the 16th Congress. Eight members of the WG met in London in October, 1978. The Group decided that an update of the current series of national reports would not be adequate for the next Congress. The new report must have broad international content. Investigation was not to include the field of automated cartography as this is already accomplished by the International Cartographic Association. Finally, as FIG provides an important forum for the private practicing surveyor, a conscientious effort would be made to report on private sector and non-government survey activity.
The task will occupy three phases - Data Collection, Analysis and the Preparation of Recommendations or Standards. The data collection phase will culminate in the preparation of three catalogues. The first catalogue will consist of automated hydrographic survey users reports. The second catalogue would contain the names of manufacturers of survey equipment and systems. The third catalogue would contain information on people involved in the development, implementation and application of automated systems and their specific areas of expertise. The analysis could lead to specific recommendations. Preparation of standards is beyond the mandate of the Working Group at present, however, a suitable resolution to that end will be entertained at the 16th Congress. Finally, Group membership will be broadened with particular reference to including the private sector, and to include representatives from the Royal Navy, the U.S. Corps of Engineers and Rijkswaterstaat in the Netherlands.

Working Group 414b, Positioning Systems interim report was presented by A. Cooper of the IHO. Its task for Montreux in 1981 is to develop a standardized text programme for radio positioning systems and a related Report Form. The programme would test the stability, repeatability, reliability range and ease of operation of a system as standard practice throughout the profession. Through the Report Form a library of valuable comparative data would be built up. The trials will also serve to establish performance assurance on each occasion of deploying the system and determine standard deviation for use as real time criteria during operations. Commodore Cooper has received help so far from Captain Mobley, USA and Mr. Riemersma of Shell International, but will require the active participation of all members of this Working Group if his task is to succeed. A number of WG members met during the IHTC.

Working Group 415, Detection of Underwater Anomalies Interim report was presented by N. Schrumpf, France on behalf of J. Bourgoin, France, who was unable to attend the IHTC. This is a new Group, formed after the Stockholm Congress, 1977, which has corresponded between members to define the subject and the purpose of the report. It has been agreed that the subject to be studied will deal with both the detection and the identification of underwater anomalies, and that the purpose of the report will be to provide the user with rational points enabling the choice of materials and methods, by inventory and comparison of characteristics, methods of detection and utilization. A number of WG members met during the IHTC to analyse fundamentals and discuss contents, to nominate co-ordinators to each task and to evaluate available information.

The FIG/IHO International Advisory Board on Standards of Competence for Hydrographic Surveyors met in Ottawa, Canada, immediately prior to the IHTC. In attendance were Rear Admiral D. Kapoor, IHO; Lt. Cdr. Don, Netherlands; Mr. B. Schrumpf, France; Lt. Cdr. A. Ingham, U.K; Mr. A.J. Kerr, Canada; Dr. T. Uchino, Japan. Also in attendance were Mr. G.N. Ewing, Canada and Mrs. L. Belly, Interpreter. It was noted that the "Standards of Competence" publication has become a best seller and the German edition, just issued, would be on display at the IHTC. India and Brazil had been approached regarding membership on the Board, but so far only India has responded. The Chairman of Commission Four of FIG would be approached to stimulate interest in the provision of national focal points for responding to the 1st Edition of the FIG/IHO International Advisory Board publication on "Standards of Competence for Hydrographic Surveyors" and to approach Nigeria to provide a member for the Board. Further discussions took place on suggested modifications to the publication, and on matters pertaining to a "Policy towards developing countries". It was noted that a hydrographic training facility was being developed in India which with the assistance of United Nations Environment Program could turn into a regional centre. The next meeting of the Advisory Board will be in Monaco, April, 1980, to coincide with the dates of the Hydrographic Society Symposium.

A FIG Commission Four National Delegates meeting was held at the time of the International Hydrographic Technical Conference in Ottawa, 1979. The meeting was attended by 12 National Delegates, 2 Alternatives and 7 Observers.

Attendees:

T.D.W. McCulloch	- Chairman
M. Nagatani	Vice-Chairman (Japan)
R. Munson	Secretary (USA)
S. Berugoda	Delegate (Sri Lanka)
M. Bolton	Delegate (Canada)
M. Calder	Alternate (Australia)
R. Choo-Shee-Nam	Observer (Guayana)
A. Cooper	Chairman WG 414b (IHO)
A. Hausken	Delegate (Norway)
C. Horsfall	Delegate (Nigeria)
A. Ingham	Advisory Board (U.K.)
F. Kidd	Delegate (South Africa)
G. Nordstrom	Delegate (Sweden)
J. Ollaranta	Delegate (Finland)
W. Roberts	Delegate (U.K.)
B. Schrumpf	Alternate (France)
C. Souto	Observer (Portugal)
W. Van Gein	Delegate (Netherlands)
C. Wagenfeld	Observer (South Africa)
H. Armstrong	Observer (Jamaica)
B. Jonanovic	Observer (Yugoslavia)

Lt. Cdr. Don, Netherlands was appointed to the Advisory Board to fill the vacancy caused by the resignation of W. Burki, Netherlands. Commission Four has approached Nigeria to nominate a FIG member to serve on the Advisory Board.

The Montreux Congress

The XVI FIG Congress will be held in Montreux, Switzerland from the 9th to 18th August, 1981. The theme for the Congress is "FIG fulfills its International Mission" and the theme for Commission Four is "Hydrography and the Challenge of the EEZ's for developed and developing nations".

There will be seven sessions allocated to Commission Four activities plus joint sessions with Commission 2, 5 and 6 on Education, and with Commission 5 on Positioning Systems. The keynote address will be given by Rear Admiral Ritchie, President of the Directing Committee of the International Hydrographic Organization. It is hoped that we can attract goodly numbers of hydrographic surveyors from the developing nations, and therefore plan to have papers from or about the Caribbean and the Red Sea, in addition to a paper about India's Hydrographic Surveying Training Facility. High technology will be served by papers on photobathymetry, sea-bed acoustic systems, multibeam echo-sounder systems, Arctic techniques and technology and the new problems faced in hydrocarbon exploration into deeper waters. There will also be reports from the three working groups and from the joint FIG/IHO Advisory Board on hydrographic education and training. Finally, the chairman is hoping to spark sufficient interest in Commission Four activities that will lead to a resolution or resolutions, as the case may be, directed toward greater liaison between governments and industry on a worldwide scale. I hope you can all be there in 1981.

In summary the International Federation of Surveyors provides a unique umbrella for the surveying profession, where people from government, industry and education can mingle, communicate and interrelate to their mutual advantage. Commission Four has become the world technical forum for all aspects of hydrographic surveying and charting. It is of particular importance in an era where so much of surveying at sea is carried out by industry. Although the North Sea is an obvious example, other seas and oceans are also the object of hydrographic surveying activity by industry, as the pace of the search for hydrocarbons and metals quickens.

The Law of the Sea with all its vitally important texts relating to boundary questions and delimiting zones, makes it imperative that government agencies and industry internationally, cooperate and consult with one another. Commission Four provides such a mechanism.

If you accept the UN definition of hydrography as the science of measuring and depicting the parameters that are necessary to describe the precise nature and configuration of the sea-bed, its geographical relationship to the land-mass, and the characteristics and dynamics of the sea, then those parameters encompass bathymetry, geology, geophysics, tides, currents, waves and certain other physical properties of sea water. The primary use of the data collected is to compile graphic documents used by mariners and others concerned with the marine environment, such as ocean engineers, oceanographers, marine biologists and environmental scientists. If one of the most important applications of hydrographic knowledge today is its use in the planning of marine resource exploration and exploitation then Commission Four has its work cut out for it already.

Meeting of Commission Four, IHTC, Ottawa, 1979

Tellurometer MRD1 Field Evaluation

J.R. MacDougall

Canadian Hydrographic Service
Central Region
Burlington, Ontario

Introduction

In September, 1979, A tellurometer MRD-1 was rented from Tellurometer (Canada) Ltd. to be used in the evaluation of the Precise Radar Navigation System (PRANS). This project was a joint venture of Transport Development Corp. and the Dominion Marine Association, with the Canadian Hydrographic Service (CHS) involvement limited to providing positioning information. Unfortunately, due to delivery problems with the PRANS equipment the trials were postponed after the MRD-1 had been acquired. Consequently, the CHS evaluated the MRD-1 system under field conditions. These trials were carried out by the Lake Nipissing Survey Party.

The MRD-1 is a continuous wave system that operates in the microwave frequencies (2920-3080 MHz and 3200-3300 MHz). The master unit consists of a display unit with a built-in microprocessor and an antenna unit (Figure 1). It requires a power supply in the range of 10.5 v. to 34 v. d.c. and has a power consumption of approximately 90 watts. The remote units are designed to be free standing or mounted on a tripod (Figure 2) and require a power supply of 10.5 v. to 16.5 v. d.c. while consuming 40 watts maximum (10 W at 20°C in standby mode). This system radiates one watt of power.

The system that was rented consisted of a master unit, three remote units, a printer and power converter (24 v.d.c. to 120 v. a.c.) for the printer. However, the printer and its converter were not sent to the field because the evaluation of the MRD-1 was being conducted in a 6.4 metre Botved launch and these components appeared somewhat fragile.

System Features

The MRD-1 claims some features that are of interest in hydrographic surveying. One of the more important features is the multi-user capability of the system, which allows up to six master units to operate with the same two or three remote units, employing a multi-plexed time sharing technique. Three range operation is also possible, thus permitting continuous coverage in areas where terrain, signal reflections or bad geometry would make two range operation impossible. The system is capable of directly converting two or three range information into X-Y co-ordinates. Range and co-ordinate information as well as time from a built-in real-time clock can be displayed by the master unit or output to peripheral devices.

The system claims an operating range from 100 m to 100 km, depending on atmospheric conditions and radio line of sight. The MRD-1 also claims an accuracy of 1 m ± 3 ppm, a resolution of 0.1 m and a display update rate of 0.5 sec. The system is capable of dynamic operation at speeds up to 100 m/sec. (194 knots) relative to the remote instrument. The system can be mounted in either helicopters or fixed wing aircraft without any modifications, making it a versatile positioning system for both conventional and airborne hydrographic surveys, as well as for other surveying applications.

The MRD-1 claims to be self calibrating and, unlike the earlier dynamic mode Tellurometers, no tuning is required. The system uses continuous comparison of range data to overcome any signal ambiguity, thus automatically verifying the range information. It also minimizes multi-path effects due to the use of continuous wave comparison techniques. This allows on-line analysis and correction of phase errors resulting from multi-path effects.

The master unit can display and output data in a wide variety of formats, such as:

a) range/range/real-time clock
b) range/range/range
c) X - Y co-ordinates (two ranges)
d) X - Y co-ordinates (three ranges)
e) Speed in m/sec. or knots

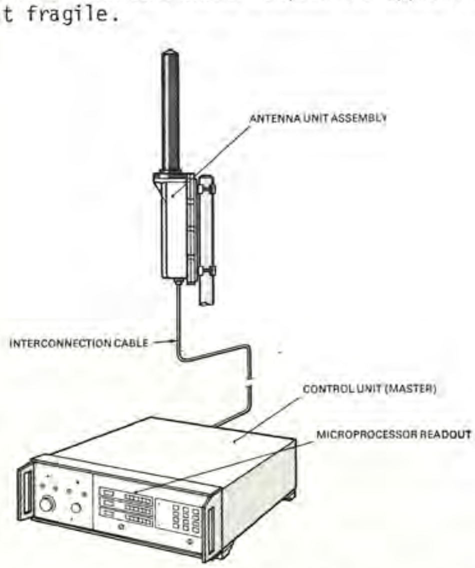

Figure 1. Master Instrument and Antenna Unit

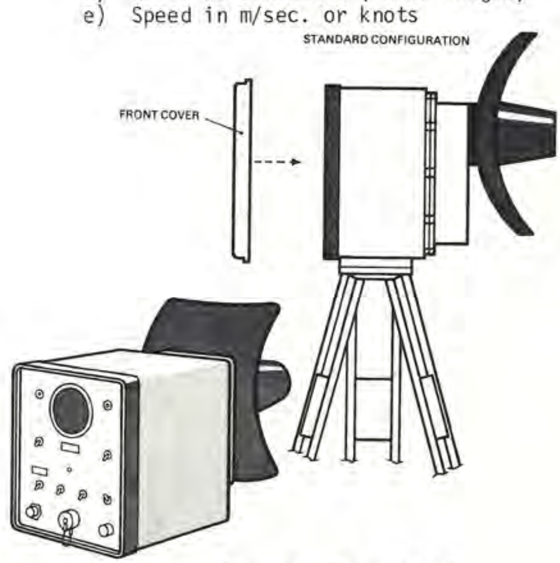

Figure 2. Remote Unit

It is also possible to output this information in a variety of formats or in all formats simultaneously to peripheral devices such as printers, digital data recorder, track plotters and computers or computer terminals. This is accomplished through two optional interface units that can link one input and two output devices simultaneously. Thus it is possible to combine information such as digital depths and position data.

Since the MRD-1 system was evaluated in the fall of 1979, Tellurometer has developed an optional Left Right Indicator (LRI) that can be connected to the PRINT output of the MRD-1 master. This unit was not evaluated but the literature was examined since the need for such an indicator was noted during the trials. The LRI requires the operator to enter the start and end positions of each line. A logarithmic analogue display unit indicates the perpendicular distance the launch is off-line (Figure 3). The LRI has internal storage capacity for 40 lines and it digitally displays the line number and distance from the current launch position to the end of the line. A head-set or loudspeaker can be attached to an audio output that emits different tones if the vessel is left of, right of or on the line.

Testing

The MRD-1 was tested on Lake Nipissing in September, 1979. The major objective of this evaluation was to observe the instrument's performance under actual field conditions and assess its suitability for hydrographic surveying. Therefore, the trials were of a practical nature, checking range and the various operational options of interest to the CHS. It should be noted that no attempt was made to analyse the system with respect to accuracy, other than to compare its results with other equipment.

The initial trials of the system were less than successful when intermittent signals were encountered at ranges in excess of 4000 metres. However, these problems appeared to be related to "loose circuit cards" within the master control unit. The system became operational after the master had been opened, all connections checked visually, the circuit cards re-seated and the cables examined. It is possible that the ride from Burlington to North Bay in a government vehicle contributed to this problem.

The second attempt at evaluating the system encountered similar problems after operating satisfactorily for a distance of approximately 1000 metres. The launch was steaming into a stiff chop (.5 m to 1 m seas) and the whole display unit appeared to "freeze" with no interaction possible between the keyboard, switches and microprocessor. Once again the problem was eliminated by "rocking" and re-seating the circuit cards in the master unit. When the MRD-1 became operational, the launch was deliberately steamed into the seas at full speed but this rough treatment did not adversely affect the operation of the system.

The initial evaluation of the system was to determine the working range of the system under the prevailing field conditions. A Motorola Mini-Ranger and NavBox combination was also installed in the launch to provide measurements with which to compare the MRD-1 results. Initially the

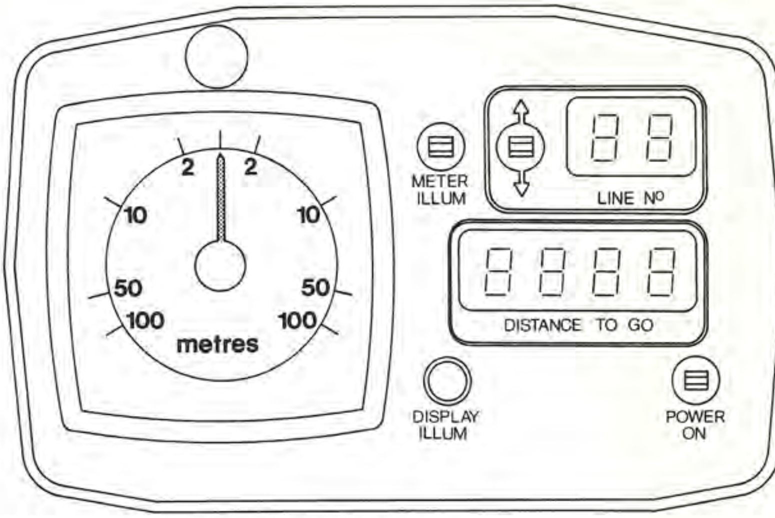

Figure 3. LRI Front Panel

remote units were situated on the North Bay government wharf (3.5 m above lake level) where a Mini-Ranger transponder was also located. The MRD-1 worked well and a range of 7400 m was attained before the signal strength became too weak.

The remote units and transponder were then moved to station THIBEAULT shown in Figure 4 (Geodetic Survey of Canada (GSC), elevation 320 m, 124 m above lake level). The launch steamed west and the ranges displayed on the MRD-1 and Mini-Ranger units were compared. Those displayed by the MRD-1 appeared to be updating in a more uniform manner than those of the Mini-Ranger, which often varied by a noticeable amount.

The MRD-1 system operated, with a very steady signal, to a range of 35,000 metres. As the signal strength deteriorated the launch continued west and a range in excess of 41,000 metres was reached before the signal became too intermittent to be reliable. Near the extreme range of the system, (41,216 m) the MRD-1 was shut down for a short period and then re-started. It was noted that the system "locked in" on the correct range after only two cycles of the automatic range comparison checks.

Although no precise trials were conducted to verify the claimed accuracy of the system, the launch was brought alongside several control stations and the ranges displayed on both the MRD-1 and Mini-Ranger were compared to the computed slope distance between the remote site and each station. These checks were made at ranges of 22,205 m, 31,058 m, 34,295 m and 41,216 m and in all cases the values obtained with the MRD-1 were within several metres (± 3 - 4 m) of the computed values while the Mini-Ranger readings were much less stable and tended to vary by ± 10 m. A major portion of the discrepancies between observed and computed ranges may be attributed to problems in getting the launch close alongside the control station, thus introducing errors in estimating the distance from the launch to the station as well as the relative position of the launch and control station with respect to the position line described by the range arc from the remote unit.

To evaluate the other optional operations available on the MRD-1 the remote units and transponders were moved to station CROSS REF (GSC) and TURN (CHS). The Mini-Ranger was calibrated with the launch alongside a third control station, Man (CHS). While the launch was stationary the X - Y co-ordinate option of the MRD-1 was activated and the values obtained were compared with those displayed on the NavBox. It was observed that the co-ordinates displayed by the MRD-1 were more consistent than those of the NavBox. This was due mainly to the superior stability of the MRD-1 ranges as compared to those of the Mini-Ranger. The following co-ordinate fluctuations are indicative of the results of this portion of the MRD trials:

SYSTEM	FLUCTUATIONS
MRD-1	± 1 to 2 m
MINI-RANGER/NAVBOX	± 5 to 10 m

While the remotes were set up at these two locations, the two systems were compared during the actual running of a sounding line. A north-south line was run because the MRD-1 was not equipped with the option to run skewed lines. However, the coxswain encountered no difficulties in following a constant Easting and once again the stability of the MRD-1 co-ordinates was very noticeable.

The range-range option of the MRD-1 was employed to test the system while following a constant range. Again no problems were encountered and it was possible to maintain a constant range within ± 5 m while the launch was operating at full speed (30 knots). During this exercise it was noted that the updating of the MRD-1 display was very consistent and did not fluctuate as was the case with the Mini-Ranger. Arcs were also run around one of the remote units at ranges of 200 m and 1000 m in an attempt to determine the horizontal limitations of the standard (22^o) remote antenna. However, no problems were encountered through an arc of 190^o, possibly due to signal strength at these short ranges.

Other options available on the MRD-1, such as launch speed in m/sec. and knots, were tested and appeared to work satisfactorily. However, these particular options are of little practical use in hydrographic surveying. This final effort brought the planned trials to a conclusion and the MRD-1 system was "incorporated" into the daily operations of the production survey for the remainder of its stay, mainly in a range-bearing mode during shoal examinations. In this mode the built-in duplex speech link between the master and remote units was most useful.

Conclusions

The overall performance of the Tellurometer MRD-1 was impressive, the most noticeable feature being the stability of the displayed ranges and co-ordinates. The fact that the system can be used in the range-range mode, especially when using the X - Y co-ordinate option, creates interesting possibilities for large scale work requiring the accuracy this system provides.

However, several minor problems were encountered, the most obvious being the start-up problems after the system was transported to the survey area. M. Mogg, Tellurometer (Canada) Ltd. indicated that a shock-proof shipping case was being developed for the master unit and, that this case, with the ends removed, would double as a means of mounting the master in a launch. The master unit tested exhibited one other pecularity throughout its trials. At times the digital display unit would not "light up" after the function switch was turned through the warm up cycle to on. However, this was a minor irritation, since switching the system off and on several times usually overcame this problem.

The optional LRI could present some practical problems with data entry. The accuracy of the MRD-1 makes it ideal for large scale surveys such as harbours and wharf plans but this would entail entering positions for at least 40 lines (80 northings and 80 eastings) daily. This is both time consuming and a possible source of error due to the number of digits to be entered.

Recommendations

Several ideas for improving the system arose from discussing its operation with members of the survey party. These were passed on to M. Mogg at Tellurometer and action has been initiated on some items.

i) The remote display unit for the coxswain appears adequate for guiding the launch along a sounding line but the manner of entering the parameters of the line could be improved. If the system could be modified to accept an input similar to that used in the NAVBOX (enter northing and easting of the start and end of the first line and the line spacing) it would be greatly simplified and reduce the chances of errors in inputting up to 160 numbers (960 digits) each day.

ii) The addition of a printer to record position information would definitely enhance the operation of the MRD-1, especially in rough sea conditions. If the system could be programmed to fix and print a position on a regular basis (by time and/or at regular distance intervals along the line) the hydrographers' tasks could be simplified, since this would eliminate "freezing" the display while notes are taken.

iii) The optional wide angle remotes are more feasible for hydrographic work than the standard (22^o) models. In addition, an antenna for the remote units that could be mounted on a tower would increase the range and versatility of the system. Again, Tellurometer representatives agree that an arrangement similar to the antenna used on the master units of the MRB 2 and MRB 201 should prove feasible.

iv) An extra headset, to be used by the remote operator when using the system in a range-bearing mode, would facilitate communications between the remote site and the launch. Thus the remote operator would not have to depress the speech switch to contact the launch and his hands would remain free to perform other tasks.

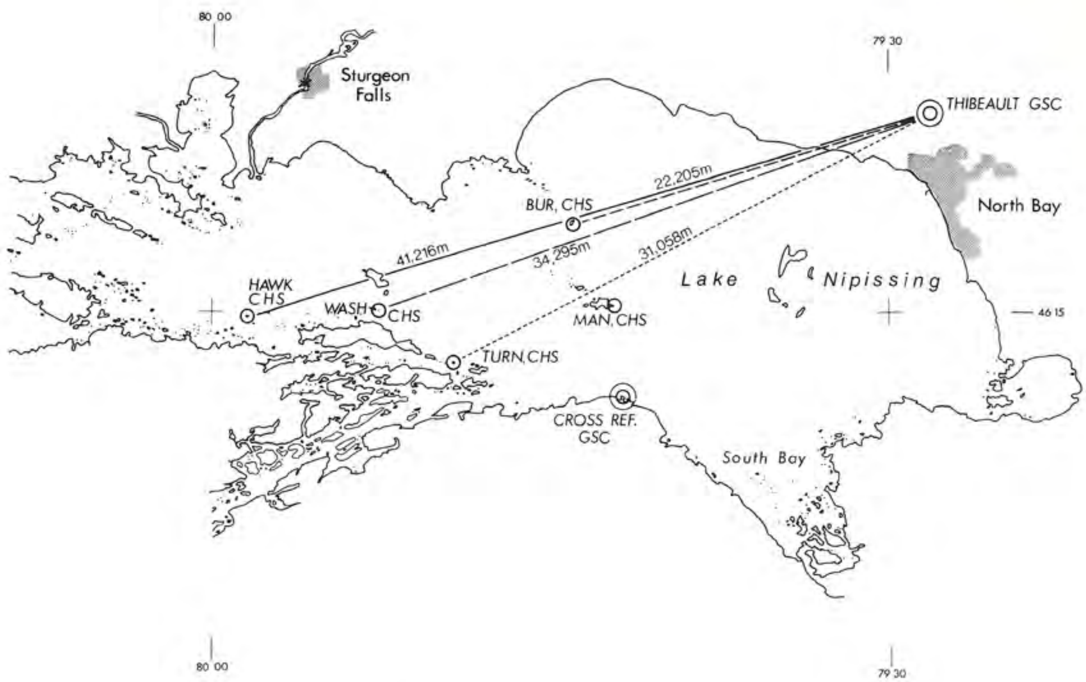

Figure 4. Testing Area

The Case of the Poached Lobsters

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(This paper is based on a lecture given to students in Survey Law at the University of New Brunswick)

A request to provide advice on the plotting of boundaries on a navigation chart to delimit a Lobster Fishery District provided a good basis for discussion on more general matters of boundary delimitation under the law of the sea. The request was to plot the boundaries of Lobster Fishery District 7B, defined in regulations under the Fisheries Act, on an official navigation chart. It soon became clear that the matter was not straightforward and involved some interesting interpretation and knowledge of the pertinent law.

Law can be conveniently classified as international or municipal, the latter being the national law. Thus in Canada we may be concerned with international law, which governs our code of behaviour with other countries, and with the national or federal law, which concerns the behaviour of Canadian citizens. There are also in Canada the provincial laws and laws governing lower hierarchical areas. There is a growing interplay between international and national law. For example, concerning the law of the sea at the international level there is the Geneva Convention on the Territorial Sea and Contiguous Zone (1958). This international law can be found reflected in Canada's Territorial Sea and Fishing Zones Act (1964). If the proposal to give more jurisdiction to the provinces over the offshore is followed through it seems likely that the provincial laws governing the use of the continental shelves may well follow, at least in part, the national law. It follows that the interpretation of national laws can be helped by an examination of international law, which is the approach that has been adopted here.

Lobster Fishery District 7B is defined in the regulations as follows:

> The area on and along that portion of the coast of the waters of the Province of Prince Edward Island bounded by the waters of the Gulf of St. Lawrence and in the said waters within the following boundaries:
>
> south of a straight line drawn from a point in the Gulf of St. Lawrence five nautical miles bearing 155° true from a point at High Capes, Inverness County, Nova Scotia, as marked by a fishery officer at Latitude 46° 58' 42" North and Longitude 60° 40' 00" West to a point five nautical miles north magnetic from North Point Lighthouse, Prince County, Prince Edward Island, (the said point being at Latitude 47° 08' 25" North and Longitude 64° 02' 10" West) and north of a line drawn from East Point, Prince Edward Island, to a point at Latitude 46° 27' 52" North and Longitude 61° 51' 06" West; thence to a point five nautical miles bearing 115° true from a point at High Capes, Inverness

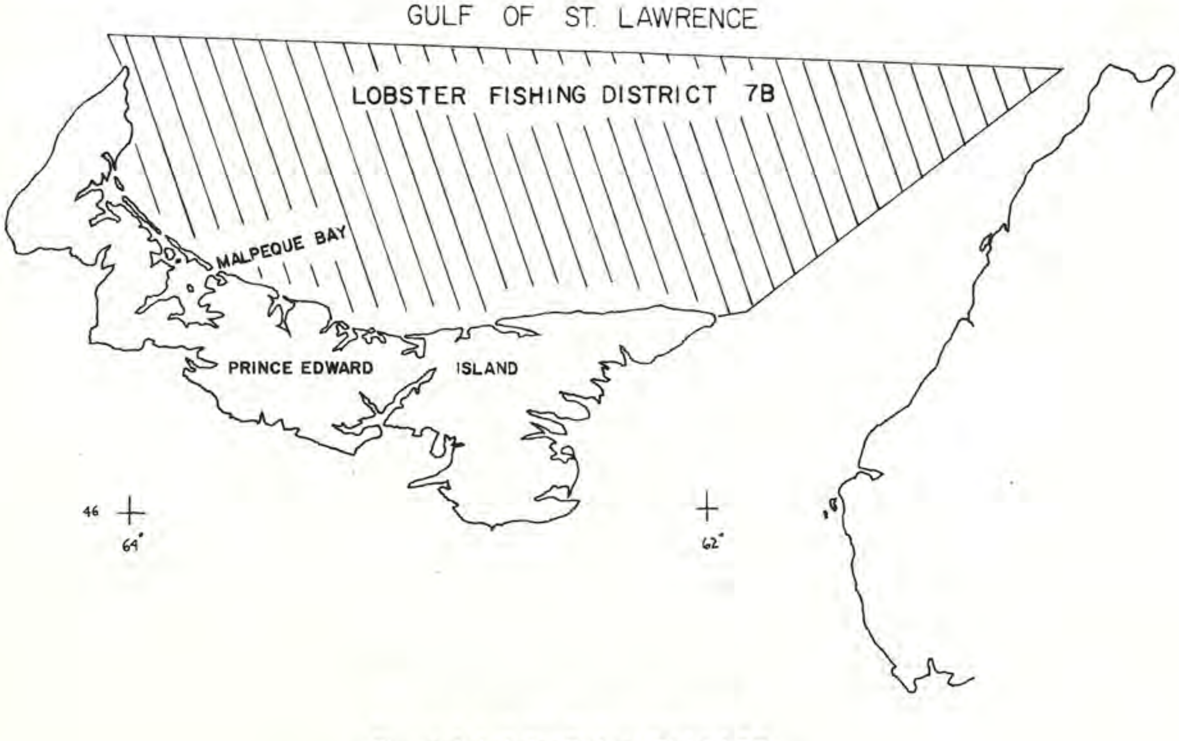

Figure 1. Lobster Fishery District 7B

County, Nova Scotia, as marked by a fishery officer at Latitude 46° 58' 42" North and Longitude 60° 40' 00" West.

The approximate location of this area is shown in Figure 1. Taking the second paragraph of the regulation first, it will be seen that there is not too much difficulty in defining the northern boundary. It must be assumed that the bearings and distances from the point at High Capes and from North Point Lighthouse do in fact agree with the geographic coordinates that are given. The main point to consider is the meaning of "drawing a line." The shortest distance between two points will follow a geodesic line which, when drawn on a mercator chart, will not necessarily be a straight line. In this instance the alleged poaching of lobsters was in Malpeque Bay and the precision of the northern boundary does not enter the case. However, definitions of this kind which are not precise can lead to difficulties. At one time most boundary lines at sea were short and the error caused by drawing straight lines on various map projections was insignificant. Today, with 200 mile economic and fishery zones, care must be taken to use precision in defining the type of line or exactly how it should appear on the map or chart.

The more interesting issues are associated with the first paragraph of the regulation. What exactly does it mean to be "bounded by the waters of the Gulf of St. Lawrence?" An inspection of the Sailing Directions and various dictionaries shows that Prince Edward Island is considered to be in the Gulf of St. Lawrence. From this we must interpret that Prince Edward Island is bounded on all sides by the Gulf of St. Lawrence. But now we must consider whether the Gulf enters all the bays and estuaries of the island, and this in fact is the nub of the case. Does the Gulf enter Malpeque Bay?

The definition is further complicated by the words "of the waters of the Province of Prince Edward Island." What does this mean? Is it a jurisdictional term and does P.E.I. govern those waters, or is it simply to be considered in a geographic sense to mean location or adjacency? In looking for an answer to these questions guidance is sought in international law of the sea.

First we should dispense with matters concerning the precise point of "bounding." It must be assumed that this means the line where the sea meets the land. But even this has its complications because we must be concerned whether it is the line of high water, low water or mean tide. As hydrographers we may want a tighter definition, such as mean high water spring tide or higher high tide or ordinary high tide. Both the high-water and low-water lines are used in the Geneva Convention on the Territorial Sea and both have given rise to difficulty due to their lack of precision. Since the concern here was on lobster fishing it must be assumed that it took place in water well below the lowest low water line and, consequently, well within the area as "bounded" by the coast.

A more important matter in the Lobster Fishery case is whether or not the area of Malpeque Bay is to be considered part of the Gulf of St. Lawrence. The definition of bays has proven difficult for many years. We can trace this back to the North Atlantic Fisheries Tribunal (1910) which attempted to interpret the Convention of 1818 between the United Kingdom and U.S.A. In this case the U.S.A. renounced the rights of its nationals to fish within three miles of any of the coasts, bays, creeks or harbours of the British Dominion in America. The issue was whether bays could be cut off with baselines across their mouths and, if so, how long these baselines could be. At the time of the Tribunal it was stated that this width should be a maximum of 10 miles. Following the work of the International Law Commission in the nineteen fifties the closure distance for a bay was extended to 24 miles in the Convention of the Territorial Sea and the Contiguous Zone (1958). In passing it must be noted that bay closing lines must not be confused with straight baselines. Baselines are permitted between points on a deeply indented and cut-into coast, have been assigned no maximum length, and as a consequence have, in the opinion of this writer, been frequently abused.

Considerable thought has gone into defining aspects of bays. This has resulted in the semi-circle rule which is a geometric method that may be used to find out when an indentation in the coast may be treated as a bay (Figure 2). Having decided upon the "natural entrance points" for the indentation, a matter which has many complications on its own, a line is drawn across the entrance. If the area enclosed by a semicircle with the closing line as a diameter is less than the area of water within the indentation then it may be treated as a bay. It is then a matter of closing off the bay or a portion of the bay which may be covered by a 24 mile line. All the water enclosed is considered as inland water and comes under a different type of jurisdiction than the water outside the bay.

Frequently, islands are located across the mouth of a bay and confuse the measurement of both the distance across the mouth and the area within the bay. In spite of attempts to handle all cases in the written law, various geographers have shown that an almost infinite number of geographical situations exist which may still give rise to considerable ambiguity. Malpeque Bay represents a text book example of one of these complex bays with islands across its mouth. There seems little doubt that, if this was a case of deciding whether the waters of Malpeque Bay are internal waters with respect to Canada and the rest of the world, they would indeed be considered such and the Bay would have baselines across its mouth. Whether the waters of the bay are internal waters as far as P.E.I. is concerned seems an open question.

The jurisdiction of the offshore resources off Canada is at present giving rise to much political speculation and has, in fact, recently been an election issue. Since, if the offshore resources do end up under the jurisdiction of the provinces, there will be much work for hydrographers in delimiting the extended provincial boundaries, it may be of interest to end this article by trying to clarify some of the issues. First there are primarily two different types of resources that are being considered, the fishery and the mineral resources. Internationally a different regime is considered for each one. While at present most fisheries limits, including Canada's, extend to 200 miles offshore, the continental shelf, which is the area being considered for mineral exploita-

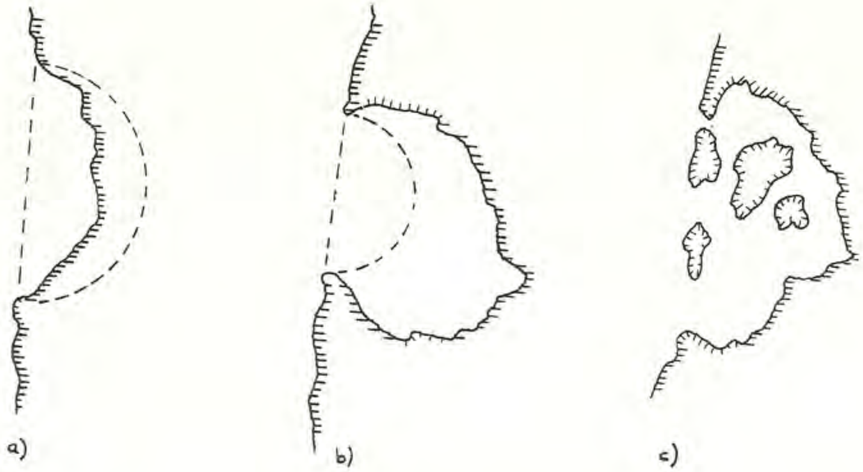

FIGURE 2. THE SEMICIRCLE RULE

A) Not a bay : Area < Semi circular area
B) A bay : Area > Semi circular area
C) Complications caused by islands

tion by the coastal state, has been the source of a separate debate. The offshore limit of the shelf has not been settled but probably will be fixed by some function of geology and, perhaps, depth of water.

The majority of legal authorities in Canada feel that the jurisdiction over the offshore resources are firmly etched in the British North America Act (1867) and that constitutional change is required to move the jurisdiction from the Federal to the Provincial governments. The position that mineral resources clearly come within federal jurisdiction was supported by the reference Re: Offshore Mineral Rights of British Columbia (1967). Newfoundland argues that, as a late comer to Confederation, its case is different. Unlike the rest of the provinces which did not bring their own continental shelves with them into Confederation, Newfoundland argues that by 1949 the continental shelf had gained acceptance in international law. Nova Scotia argues that it has been mining under the sea for many years and governing this operation, and that it should continue to have this right when it comes to oil and gas resources. Arguments for control over the fisheries remain more in the political than the legal arena as yet, and "Sea Coast and Inland Fisheries" remain under federal power by Section 91(12) of the British North America Act. If, though, political persuasion is strong enough to result in future constitutional change concerning these offshore resources, we hydrographers will never lack for work in the waters off Canada.

Reference

In the matter of a Reference by the Governor General in Council concerning the Ownership of and Jurisdiction Over Offshore Mineral Rights as set out in Order in Council PC 1965-70 dated April 26, 1965 (1967) Sup. Ct. 792, 65 D.L.R. 2d. 353.

FIG WORKING GROUP 414a
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The FIG (International Congress of Surveyors) Commission 4 Working Group on Data Acquisition and Processing is preparing a catalogue of Automated Hydrographic Survey Systems, Users and Manufacturers. If you are a commercial user of an automated hydrographic survey system, or a manufacturer or distributor of systems or system components, the working group would like to hear from you. Participants will be asked to complete a questionnaire and the answers will be used to compile the catalogue, which will have world-wide distribution. Each participant will be provided with a copy.

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The Acadia Goes to the Nova Scotia Maritime Museum

R.M. Eaton

Canadian Hydrographic Service
Atlantic Region
Dartmouth, N.S.

The *"C.S.S. Acadia"* found a happy and appropriate retirement job this February when she was turned over to the province of Nova Scotia to be moored alongside the new Maritime Museum at present being built on the Halifax waterfront.

"Acadia" was built for hydrographic service in Canada by Swan, Hunter and Wigham Richardson at Newcastle, England. She arrived at Halifax in July 1913, and for the next 56 years she surveyed on the Atlantic Coast, in the Gulf of St. Lawrence and in Hudson Bay. She also did some oceanography, was used as an icebreaker, and served as a patrol vessel in the first world war and as a training ship in the second. Her history is well described in *"CSS 'Acadia'* - 50 Years of Service"*.

"Acadia" is a 170 ft. ship, of 1,700 tons displacement, strengthened for ice with 7/8" plating and extra framing. She has coal fired boilers, and triple expansion steam reciprocating engines which were so quiet that you could hold a conversation at the top of the engine room. She cost $300,000 to build in 1913.

Originally she could make 12 1/2 kts, but as the boilers aged and could no longer stand full steam pressure this dropped to 8 or 9 kts. Going around C. Race into a westerly gale it was all she could do to hold her own. She carried 250 tons of coal in her bunkers, and additional coal on deck, which gave her 18 days endurance. Her complement was 60, including 10 hydrographers. The HIC was treated like the Owner, and had a cabin to match. The bunk was so big that it was impossible to wedge yourself in properly during a gale; and it was just too narrow to be able to sleep athwartships!

"Acadia's" ice capability was tested during her first two seasons, 1913 and 1914, surveying on the west coast of Hudson Bay, particularly around Port Nelson. These years happened to be two of the worst for ice on record, and *"Acadia"* ran into trouble making her way through the pack on one occasion when her crew were forced to push her because they had on board survivors from another ship which had been holed by the ice, and they were running short of coal and food. 1914 photographs of *"Acadia"* in "50 Years of Service" show her in heavy ice; they also show the spars that could be used to set sail if necessary.

"Acadia" returned to Hudsòn Bay in 1929, '30 and '31 to survey the approaches to Churchill, which opened as a grain port in 1931. However, between the wars most of her surveys were on the eastern shore of Nova Scotia and around Yarmouth from C. Sable to Digby Neck; and also in the Gulf of St. Lawrence, particularly around Prince Edward Island and along the Quebec shore from the St. Lawrence estuary to the Strait of Belle Isle. From 1949, when Newfoundland joined Confederation, she spent most of her time in Newfoundland waters, working on coastal charts from Cape Race northward past St. John's to C. Freels, and surveying outports on all coasts.

"Acadia" left a strong impression on hydrographers who worked aboard her. The seamen tended to make a life career of the ship - someone who had only been on board 15 years was a new hand - and they knew their job. When the coxswain asked the night before what was on for tomorrow and the hydrographer told him "station building", then lumber, spikes, cloth and whitewash would be on the launch next morning. Once ashore, all a hydrographer had to do was say he needed a station there, to be seen from this and that direction, and then stand back until the job was done. Out sounding, the coxswain would keep an eye open for weed and breaking rocks that indicated shoals. It was the same way on board; the Captain would know the next day's programme, and he would be up at 0400 to judge by the seas on the outer rocks whether it was fit to work outside. If it was, the ship would be out on the survey ground ready to lower the launches by 0800; if not, she would stay in for wharf sounding. And the ship and her launches were always clean, and the food was good.

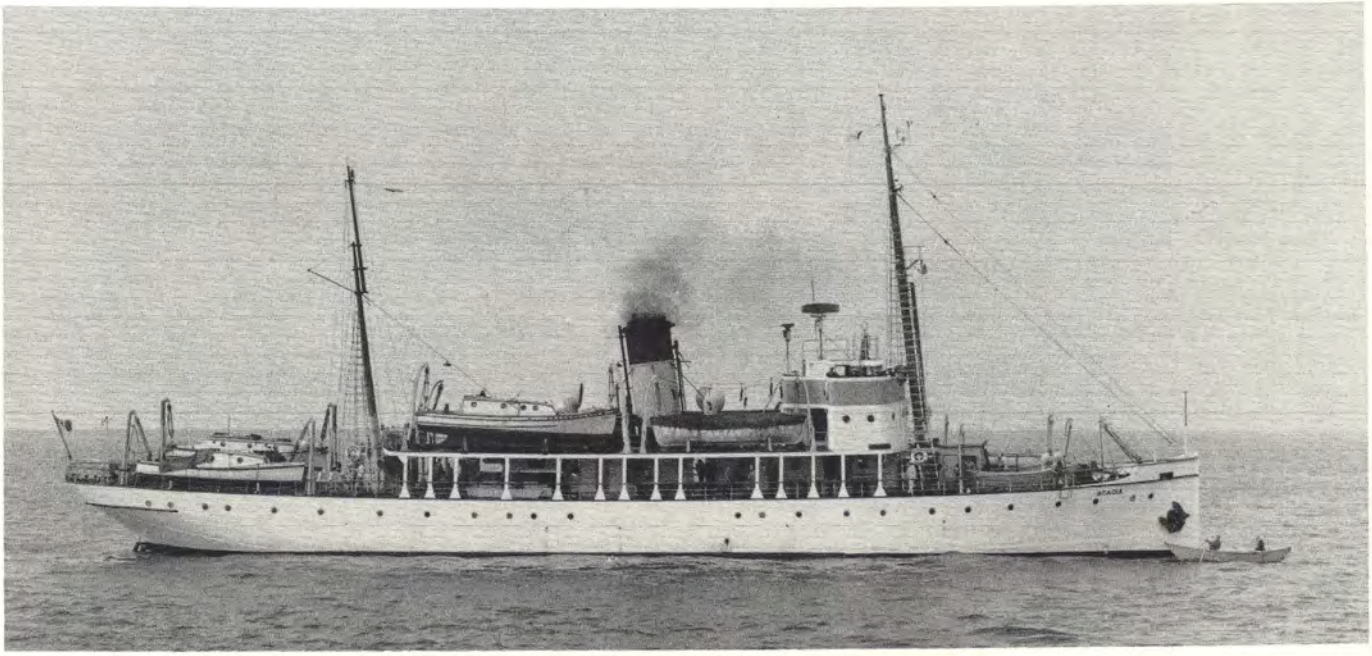
"Acadia" used to leave a port with a better reputation than she went in. This is a rare thing for a ship, but the crew made a point of getting on well with the people on shore, and on Sunday evenings when they hung a screen on a dockside shed and projected a movie through a porthole, the ship took on quite a list from the number of people who came aboard to see the show.

She will be doing the same kind of public relations job in showing visitors to the Maritime Museum what a hydrographic ship is all about.

Acadia's Sounding Gig, 1931
(from 50 Years of Service)

* * * *

* *"CSS 'Acadia'* - 50 Years of Service". Queen's Printer, Ottawa, 1964. Cat. No. M52-1764



Acadia in 1968

The Man Who Had Been Right

G. Macdonald

Canadian Hydrographic Service
Central Region
Burlington, Ontario

Born in 1866 in East Bolton, Quebec, Reginald Fessendon spent his childhood in Fergus, Ontario. As a boy he was excited by Bell's invention, the telephone, and was always involved in some experiment of his own. Once he held his head under water to find out if he could hear a friend strike two rocks together a half mile away on the Grand River. He dreamed of sending speech over great distances without using wires.

After finishing school, Fessendon took a teaching position in Bermuda, but eventually ended up in New York where he finally got a job working for Edison. When Fessendon questioned Edison about the chances of sending speech without wires, he was told "Fezzie, what do you say are man's chances of jumping over the moon? I figure that one is about as likely as the other."

In his spare time Fessendon worked out how to run a gyroscope with a small electric motor, and published his results in the magazine "Electrical World." Since he neglected to take out a patent, he reaped no rewards for such an important development.

In 1890 he married Helen Trott, a girl he met while he was in Bermuda. When he was laid off at Edison, he went to work for Mr. Westinghouse. Fessendon made improvements to the light bulb that enabled Westinghouse to jump the patent hurdle and manufacture his own light bulbs.

Fessendon began to work on his broadcasting theories and, just as Marconi was trying to achieve the same goal, broadcast his first message a distance of one mile, in 1900. In 1903, Fessendon was hired as the consulting engineer on the Niagara Falls power project. He designed the power station so that it would not detract from the natural beauty of the falls.

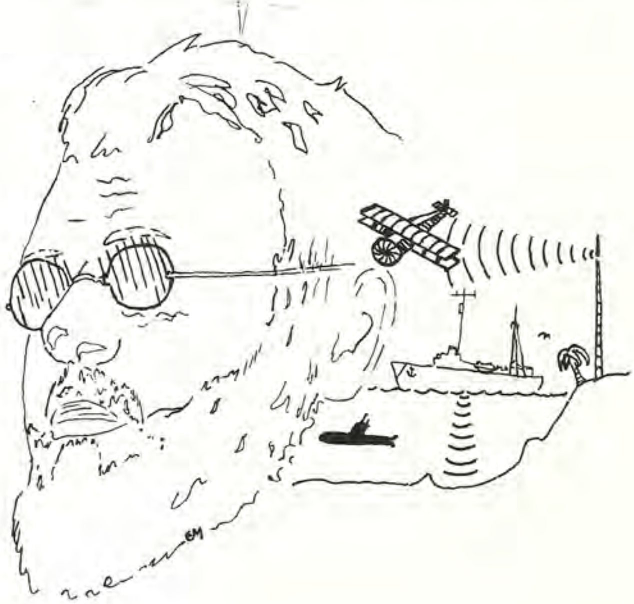
In 1905, Fessendon broadcast speech across the ocean to Scotland and, in 1906, while the Canadian government was still paying Marconi to develop overseas broadcasting equipment, Fessendon was broadcasting a Christmas message to a ship at sea from Brant Rock, Massachusetts. Unfortunately, to raise the money to develop his system, he had been forced to sign over control of his patents to the American firm that was backing him, and it was not until 1928 that he was compensated for his invention.

In 1912, Fessendon met an old friend in Boston. Mr. Fay, of the Submarine Signal Company, gave him a job. The Titanic had gone down a few months before, and the Signal Company was busy developing and manufacturing equipment for detecting icebergs and other obstacles, and equipment for communicating under water. In only three months Fessendon developed a new form of wireless that submarines could use under water to communicate over distances of up to fifty miles. In the spring and summer of 1913, Fessendon was experimenting off the coast of Newport, Rhode Island, and on the Grand Banks of Newfoundland. In his notebook he wrote, "I can bounce my radio waves off icebergs miles away, accurately gauging their distance from the ship. And today, April 27, I tried another experiment; I sent the waves to the bottom of the ocean and found that I could tell the depth of the water from the interval between when I sent the signals and received the answering echoes. When I have time I want to do more work here because I'm sure it will lead to something important. Think what an advantage it would be for sea captains to always know the depth of the water under their keels, and while the ships are moving no less!"

In 1914 war broke out, and Fessendon offered his services to the Minister of Militia in Ottawa. Many of his theories and inventions were too far ahead of their time to be accepted by the military. Fessendon had developed a silent but powerful airplane engine and wanted to build a fleet of bombers - an innovation that might have shortened the war considerably. He did invent an underwater submarine detection system and a method of determining whether the sub was one of ours or one of theirs. He invented a means of detecting enemy artillery, designed a new gun site, and found a way to use radio signals (using his wireless direction antenna) to position enemy aircraft.

Just after the war, Fessendon invented his "last jewel of great worth" - the fathometer, as he called it. It was used on the largest ocean liners of the day, accurately measuring the depth beneath the keel, and was manufactured by the Submarine Signal Company of Boston and Montreal.

Reginald Fessendon died in Bermuda on July 22nd, 1932. He was buried in St. Marks Church cemetery.



Inscribed on the marble tablet on his grave are these words: "By his genius distant lands converse, and men sail unafraid upon the deep."

At the time of his death, an editorial in the New York Herald Tribune said, "It sometimes happens, even in science, that one man can be right against the world. Professor Fessendon was that man. He fought bitterly and alone to prove his theories. It was he who insisted, against the stormy protests of every recognized authority, that what we now call radio was worked by continuous waves sent through the ether by the transmitting station as light waves are sent out by a flame. Marconi and others insisted that what was happening was a whiplash effect. The progress of radio was retarded a decade by this error. The whiplash theory passed gradually from the minds of men and was replaced by the continuous wave one with all too little credit to the man who had been right."

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Analytical Models for Automated Water Level Reduction of Soundings

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Abstract

Reasons for developing the analytical models for automated water level reduction of soundings are given in this paper. An overview of the proposed analytical scheme is given. Details regarding the modeling of the time series at a reference station using a one-dimensional trigonometric polynomial are stated. The modeling of the range ratio and time lag fields, using surfaces described by two dimensional algebraic polynomials, is then presented. Finally, it is shown how, with the coefficients of the trigonometric and algebraic polynomials stored in a computer, the range ratio and time lag at any point can be readily predicted, and the water level at any time can be predicted using the predicted water level at the reference station. Test computations, using data extracted from the "Canadian Tides and Current Tables 1978" for the Bay of Fundy, are presented. It is shown that with this data the water level at a location can be predicted to within 0.6 m (1σ r.m.s.).

Introduction

The corrections of soundings for heights of the water surface relative to the reference (chart) datum is a tedious task. For example, in a brief report on The Hydrographic Society Symposium on Depth Measurement and Sonar Sweep (The Hydrographic Society, Information Sheet 31, 1978), the statement was made that "... tidal reducations are a bore, ...". It appears that present practices, whether referring to the use of a single water level (tide) gauge, or several primary and secondary gauges between which interpolations for changing range ratios and time lags are made, are generally oriented towards manual computations or a computerization of the manual procedures (cf e.g. Manual of Tide Observations, 1965; Admiralty Manual of Hydrographic Surveying, Volume II, 1965; Umbach, 1976).

Some automated (computerized)water level reduction techniques have been devised and implemented. For example, the Canadian Hydrographic Service has used digitized cotidal charts for real-time reductions (e.g. Tinney, 1977). An appropriate cotidal chart is digitized by splitting a survey area into equal sized blocks based on parallels of latitude and meridians of longitude and approximating the boundaries of cotidal zones with the edges of blocks. The choice of block sizes depends on accuracy requirements and available computer space (e.g. with smaller block sizes, zone boundaries are better approximated but more computer storage is required). The digitized values are coded and stored in the computer memory. To retrieve the cotidal values, the geodetic coordinates of a sounding position are used.

The analytical scheme for the automated water level reduction of soundings presented in this paper is aimed at using a minimum of computer storage and computational time for real-time and post mission reductions. Other fundamental objectives have been the ability to compute reliable accuracy estimates of the reductions and to maintain maximum flexibility of the overall analytical techniques.

In the first section of this paper, an overview of the analytical approach is given. The remaining parts are devoted to explanations of the formulation and general solutions of mathematical models referring directly to the use of range ratio and time lag fields. The results of a set of test computations for the Bay of Fundy are given.

An Overview of the Analytical Scheme

Simply stated, the approach is to approximate the water level surface by a set of two dimensional algebraic polynomials $P_n(\phi, \lambda)$ and the observed or predicted time series at a reference station by a one dimensional trigonometric polynomial $P_n(t)$. With the coefficients of these polynomials stored in a computer, and knowing the time (t_j) and position (ϕ_j, λ_j) of a sounding, the water level correction can be computed and applied.

The mathematical models whose solutions yield the coefficients of the approximating polynomials

$P_n(t)$ and $P_n(\phi, \lambda)$ have been formulated to allow the use of different sources of water level data (e.g. observed water levels; previously constructed range ratio/time lag or amplitude/phase cotidal charts). The polynomials can be updated when new data becomes available. The flexibility leads to a dual role for the method: using a priori water level data, polynomials are pre-computed for real-time prediction purposes; at the completion of a survey, the water level data collected in that time interval is used to update the polynomials which can then be used in the final reduction of soundings. Of course, if the computing power is available in the field, the polynomials may be updated during the course of a survey.

The same objective (automated reduction) is achieved using either range ratio/time lag or amplitude/phase lag information. Two disadvantages of the amplitude/phase lag approach, particularly for real-time computations in mini or micro computers, are:(i) for each constituent tidal frequency taken into account, two polynomials of the form $P_n(\phi, \lambda)$ must be constructed and the coefficients stored for subsequent reduction, and (ii) computations for the water level reduction of soundings are more extensive. A complete explanation of the use of the amplitude/phase lag approach employing the analytical methods described is given in Okenwa (1978). The remainder of this paper deals solely with the use of the range ratio/time lag methodology and is subject to the restrictions imposed by it.

Mathematical Model for a Reference Station Time Series

The model used is that which is employed for the harmonic analysis and prediction of tides (cf e.g. Schureman, 1976, p. 123). This trigonometric polynomial, written to suit our present purposes to predict the water level $h_o(t)$ at a reference point, at a discrete time t, as a function of constituent frequencies ω_k and mean level height with respect to datum h_o, is

$$P_n(t) = h_o + \sum_{k=1}^{n} A_k \cos(\omega_k . t) + \sum_{k=1}^{n} B_k \sin(\omega_k . t) \approx h_o(t), \quad (1)$$

in which n represents the number of constituent frequencies to be used and A_k and B_k are the polynomial coefficients. To utilize this equation to predict $h_o(t)$ at any time t, one must know the quantities h_o, A_k, B_k, ω_k.

The frequencies ω_k of the desired constituents are known. Water level heights $\bar{h}_o(t)$ at discrete times t in the time interval M come from observations. Rewriting (1) in observation equation form yields

$$\bar{h}_o(t) = \hat{h}_o + \sum_{k=1}^{n} \hat{A}_k \cos(\omega_k . t) + \sum_{k=1}^{n} \hat{B}_k \sin(\omega_k . t) + \hat{v}_{\bar{h}_o}(t), \quad * \quad (2)$$

in which $\hat{A}_k$ and $\hat{B}_k$ are estimates of the polynomial coefficients, $\bar{h}_o(t)$ is the measured water level at t, and $\hat{v}_{\bar{h}_o}$ is the measurement residual.

For each of the m measurements, an equation of the form (2) is written. This system of linear equations will have u unknowns, where u is given by

$$u = 2 \cdot n + 1. \quad (3)$$

With $m > u$, least squares approximation methodology is used to determine $\hat{h}_o$, $\hat{A}_k$, $\hat{B}_k$ and their associated variance-covariance matrix $C_{\hat{x}}$ (cf e.g. Vanicek and Wells, 1972; Okenwa, 1978) to define the polynomial that will best predict the water level $h_o(t)$ at any other time $t \in M$. The parameters $\hat{h}_o$, $\hat{A}_k$, $\hat{B}_k$ are used in equation (1) in place of h_o, A_k and B_k to yield the predicted water level $\hat{h}_o(t)$ at a reference station, while $C_{\hat{x}}$ is used in the covariance law to determine the standard deviations of the predicted heights, $\sigma_{\hat{h}_o(t)}$. A complete numerical example of this procedure is given later in this paper.

Mathematical Models for Range Ratio and Time Lag Fields

The assumptions used in the formulation of an appropriate set of mathematical models to represent the range ratio and time lag fields are basically the same as those for the graphical construction of a range ratio/time lag cotidal chart. The body of water considered for modelling should be of an extent such that one can assume that meteoroligical variables in the area are not markedly

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* $\hat{v}_{\bar{h}_o(t)} = \hat{h}_o(t) - \bar{h}_o(t)$

different from place to place and that there are no topographic and/or bathymetric features to severely alter the propagation of the tidal waves. It can then be assumed that the water levels at any two points bear a constant relationship to one another. If one establishes the water level relationship between a reference station (designated o) and any other point j, it is then possible to predict, with some degree of certainty, the water level at j based on water level information at o.

The relationship between the water levels at any two points can be expressed in terms of the ratio of their ranges (r_j) given by

$$r_j = R_j / R_o, \tag{4}$$

in which R_o and R_j are the mean ranges to o and j respectively, and the mean time difference (time lag α_j) between the times of high and low waters at a reference station (t_o) and at other discrete points (t_j), namely

$$\alpha_j = \frac{1}{\ell} \sum_{i=1}^{\ell} (t_j - t_o), \tag{5}$$

where ℓ represents the number of observed high and low water differences ($t_j - t_o$). Underlying these expressions ((4) and (5)) is the assumption that unwanted noise has perturbed the water levels equally so that when r_j and α_j are determined, the effects of the noise are minimized.

We can define mathematically surfaces that describe the distributions of r_j and α_j within the area of interest. The range ratio at a point (x_j, y_j) may be approximated by the mixed algebraic polynomial

$$p_n^r (x_j, y_j) = \sum_{u,v=0}^{n} c_{uv}^r \; x_j^u \; y_j^v = r_j (x_j, y_j), \tag{6}$$

in which $r_j (x_j, y_j)$ is the range ratio, c_{uv}^r are the polynomial coefficients, n is the order of the polynomial, and (x, y) are either grid coordinates or a set of locally orthogonal coordinates given by

$$x = \rho(\phi - \phi_o) \quad , \tag{7}$$

$$y = \rho \cos \phi \quad (\lambda - \lambda_o) \; , \tag{8}$$

where ρ is a mean radius of curvature of the earth in the area of interest and (ϕ_o, λ_o), are the geodetic latitude and longitude respectively of a suitably chosen origin. To use equation (6) for the prediction of the range ratio at an arbitrary point with respect to a reference station, the quantities c_{uv}^r, x_j^u, y_j^v must be known. Using measured range ratios ($\bar{r}_j(x_j, y_j)$) at several (m) stations with known coordinates, we can write a set of m algebraic equations of the form

$$\bar{r}_j(x_j, y_j) = \sum_{u,v=0}^{n} \hat{c}_{uv}^r \; x_j^u \, y_j^v + \hat{v}_{r_j}, \tag{9}$$

containing u unknown coefficients $\hat{c}_{uv}^r$, where

$$u = (n + 1)^2 \tag{10}*$$

A least squares solution of the set of equations ($m > u$) yields u coefficients $\hat{c}_{uv}^r$ and their associated variance-covariance matrix $C_{\hat{c}_{uv}^r}$

Subsequently, $\hat{c}_{uv}^r$ are used in (6) to predict the range ratio $\hat{r}_j(x_j, y_j)$ at any coordinated point, and the elements of $C_{\hat{c}_{uv}^r}$ are used to yield an accuracy (e.g. standard deviation) of the predicted value.

After some experimentation (Okenwa, 1978, pp. 87-92) it was found that the representation of the time lag field α_j could not be done by one algebraic polynomial of the form of (6) but was best accomplished as follows. The water level at any point j, relative to a chosen datum, can be written as

$$h_j(t) = \sum_{k=0}^{\infty} H_k \cos (\omega_k t + \alpha_k) \; , \tag{11}$$

in which H_k is the amplitude of the constituent frequency ω_k and α_k is the phase of the constituent at time t = 0. Replacing H_k by $R_j/2$, where R_j is the mean range at the station of interest, and α_k by the time lag relative to the reference station, α_j (in degrees of arc), and limiting the series to the M_2 tidal constituent, we can rewrite (11) as

$$h_j(t) = \frac{1}{2} R_j \cos (\omega_k t + \alpha_j) \; , \tag{12}$$

or

$$h_j(t) = \frac{1}{2} R_j \cos \alpha_j \cos \omega_k . t + \frac{1}{2} R_j \sin \alpha_j \sin \omega_k . t, \tag{13}$$

* The u used to designate the number of coefficients is not to be confused with the subscript u (e.g. eqn. (9)).

Setting

$$A_j = \frac{1}{2} R_j \cos \alpha_j, \qquad (14)$$

$$B_j = \frac{1}{2} R_j \sin \alpha_j, \qquad (15)$$

then the time lag is given by

$$\alpha_j = \tan^{-1}(B_j/A_j). \qquad (16)$$

The problem now is one of estimating A_j and B_j. For any point (x_j, y_j) these quantities may be estimated by the mixed algebraic polynomials

$$P_n^A(t) = \sum_{u,v=0}^{n} c_{uv}^A x_j^u y_j^v \approx A_j(x_j, y_j) , \qquad (17)$$

$$P_n^B(t) = \sum_{u,v=0}^{n} c_{uv}^B x_j^u y_j^v \approx B_j (x_j, y_j), \qquad (18)$$

in which c_{uv}^A and c_{uv}^B are unknown polynomial coefficients. Using the measured ranges R_j and time lags α_j at m stations, one obtains m "measurements" each of $\bar{A}_j$ and $\bar{B}_j$ (equations (14) and (15) respectively). The two sets of m observation equations are then

$$\bar{A}_j(x_j, y_j) = \sum_{u,v=0}^{n} \hat{c}_{uv}^A x_j^u y_j^v + \hat{v}_{A_j}, \qquad (19)$$

$$\bar{B}_j(x_j, y_j) = \sum_{u,v=0}^{n} \hat{c}_{uv}^B x_j^u y_j^v + \hat{v}_{B_j}, \qquad (20)$$

Least squares solutions of each of the two sets of linear equations yield u estimated coefficients $\hat{c}_{uv}^A$ and $\hat{c}_{uv}^B$ and their associated variance-covariance matrices $C_{\hat{c}_{uv}^A}$ and $C_{\hat{c}_{uv}^B}$. For subsequent prediction purposes, sounding positions, $\hat{c}_{uv}^A$, and $\hat{c}_{uv}^B$ are used in (17) and (18) to predict $\hat{A}_j (x_j, y_j)$ and $\hat{B}_j (x_j, y_j)$, whereupon the predicted time lag $\hat{\alpha}_j$ is given by (16). The elements of $C_{\hat{c}_{uv}^A}$ and $C_{\hat{c}_{uv}^B}$ are used, in the covariance law, to estimate the accuracy of the predicted value.

Finally, the water level at any sounding location is predicted using

$$\hat{h}_j(t_j) = \hat{h}_o(t_j') \cdot \hat{r}_j , \qquad (21)$$

in which $\hat{h}_o(t_j')$ has been predicted using the corrected time at the reference station given by

$$t_j' = t_j - \hat{\alpha}_j, \qquad (22)$$

where t_j is the observed time of the sounding at any point j and $\hat{\alpha}_j$ is the predicted phase lag. The reduced sounding d_j is then

$$d_j = D_j - \hat{h}_j (t_j) , \qquad (23)$$

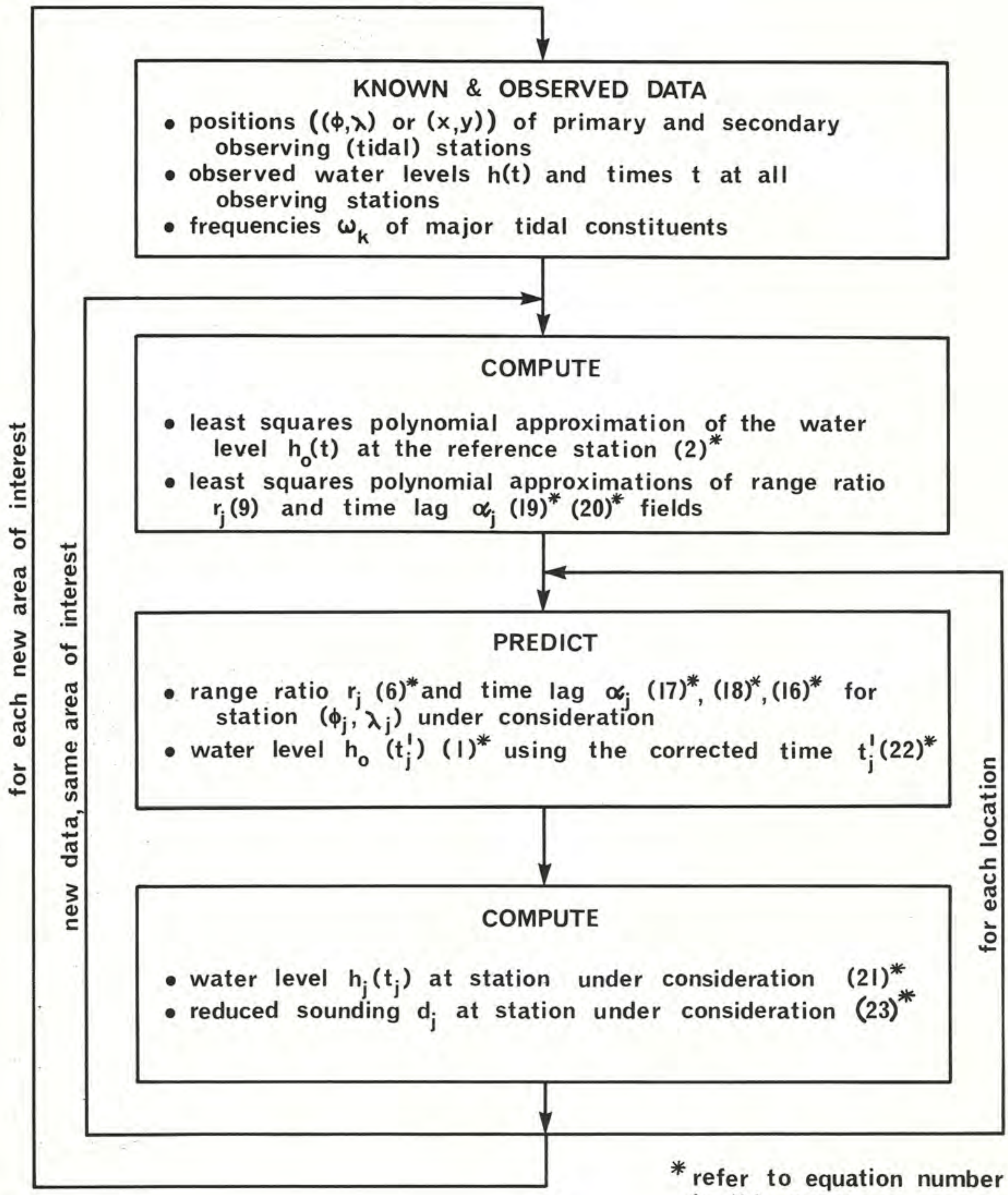
in which D_j is the sounded depth corrected for all other influences (e.g. dynamic draft, sound velocity correction, instrumental errors).

Tests, Computations and Results

The overall analytical scheme for computations involving the range ratio and time lag fields is given in Figure 1. Since no observed water level data was available for testing purposes, data for twenty-one secondary ports and one reference port (Saint John) on the Bay of Fundy were extracted from the Canadian Tides and Current Tables (1978). The locations of these stations, all on the main body of the bay, are shown in Figure 2. The standard deviation of an observed height was set at 0.05 m, that of an observed range at 0.1 m, and it was assumed that all measurements were independent (uncorrelated). The observation period for the primary (reference) station (Saint John) was 1-15 January, 1978. Subsequent predictions were within this time period. The time origin was taken as the zero hour of the first day of observations; the origin of the locally orthogonal coordinate system was approximately at the centre of the modelled area ($\phi_o = 45^o$ 05' N, $\lambda_o = 65^o$ 35'W)

For the reference station (Saint John), fifty-eight water level values $h_o(t)$ and their associated local times t (Greenwich Mean Time = t + 4 hrs) and the frequencies ω_k of the seven tidal constituents M_2, S_2, K_2, N_2, O_1, K_1, P_1 were used to form fifty-eight observation equations (equation (2)) containing fifteen unknown coefficients ($\hat{h}_o$ and seven each of $\hat{A}_k$ and $\hat{B}_k$). The estimated coefficients and their standard deviations are listed in Table 1.

Range and time data from the twenty-two tide gauge stations were used to model the range ratio and time lag fields. After some preliminary testing (Okenwa, 1978), it was found that polynomials of degree 2 were most adequate. Three independent sets of observation equations were formed - twenty-two each of (9), (19) and (20) - each containing nine coefficients to be estimated. For the time lag equations ((19) and (20)) the frequency of M_2 constituent was used. The results are given in Table 1. The final results for the polynomials of $r_j(x_j,y_j)$ and $A_j(x_j,y_j)$ each contain only five coefficients $\hat{c}_{uv}^r$ and $\hat{c}_{uv}^A$ respectively. Statistical testing during the solution phase indicated in



* refer to equation number in this paper

FIGURE 1
RANGE RATIO/TIME LAG SCHEME

each case that the last four coefficients were insignificant (Okenwa, 1978).

With the coefficients of the approximating polynomials and other data as required (e.g. variance-covariance matrices of polynomial coefficients, requencies of seven tidal constituents, latitude and longitude of the origin of the locally orthogonal coordinate system) stored in a computer memory, any number of computations associated with the water level reduction of soundings can be performed. The reference station time series (equation (1)) can be used to predict the water level at any time. Table 2 is an example of hourly predictions (hours 6 to 50 inclusive) and their associated standard deviations. Also tabulated are the water levels as predicted using the Canadian Tides and Current Tables (1978). As expected, the differences in water levels are small (maximum absolute difference = 0.4 m, r.m.s. difference = 0.2 m). Using $\hat{c}^{r}_{uv}$, $\hat{c}^{A}_{uv}$, and $\hat{c}^{B}_{uv}$ in the appropriate equations, the range ratio/time lag was predicted for a 10' grid interval over the area of interest. The result of this process was the range ratio/time lag cotidal chart shown in Figure 3. A visual comparison of this result with that given in Dohler (1966) showed no discernible differences.

A test of the entire water level reduction process was made. Simulated soundings were generated for the twenty-two original observation points. At each sounding location j, the sounded depth D_j, the time t_j, and geodetic coordinates (ϕ_j, λ_j) were treated as observed quantities. Using t_j and (x_j, y_j) $(\phi_j, \lambda_j$ transformed using (7) and (8) respectively) as arguments in the predicting polynomials, (6), (17) and (18), the required range ratios and time lags were computed. Using the corrected sounding time t'_j, the water level at the reference station h_j (t_j) was predicted via equation (1). The water levels at the sounding locations j were then obtained using equation (21). Throughout this process, errors were propagated. The standard deviations of predicted water levels vary from a high of 1 m to a low of 0.3 m, with an r.m.s. of 0.6 m. The results are summarized in Table 3.

As a check on the predicted range ratios and time lags, the predicted values were compared with "observations" (taken from the Canadian Tides and Currents Tables (1978)) at the same station (Table 4). The r.m.s. differences in range ratio and time lag were 0.05 and 9.4 minutes respectively. The reasons for the rather large values of $\Delta\alpha_j$ at stations 5, 7, and 9 have not been explained to date. Those at 12 and 13 appear to be caused by the fact that they are separated from the main body of the bay.

Conclusions

The least squares polynomial approximation methodology lends itself to the problem of the water level reduction of soundings. From a theoretical point of view, it is appropriate since it ties in so closely with the traditional harmonic analysis and prediction of tides. The ties with the traditional graphical models for cotidal charts makes the methodology relatively easy to understand and apply. On the practical side, it meets the criteria of flexibility, minimum on-board computer storage requirements, and the possibility of using a variety of data for real-time and post-mission computations.

In the test computations carried out for water level reductions on the Bay of Fundy during the period of 1-15 January, 1978, it was necessary to store in a computer memory only thirty-four polynomial coefficients and associated standard deviations plus the frequencies of seven major tidal constituents. The resulting predicted water levels have standard deviations of 0.6 m (r.m.s.). The rather large magnitudes of the standard deviations of the predicted water levels are believed to originate from three sources: the sparseness of data which limited the degrees of polynomials used to model the rather extensive Bay of Fundy region; the distribution and unknown quality of the test data used; and possible inadequacies of the model which could be determined via further testing using observed data of known quality and more adequate distribution for the region being modelled.

While the major thrust of this paper is the use of trigonometric and algebraic approximating polynomials for a traditional range ratio/ time lag

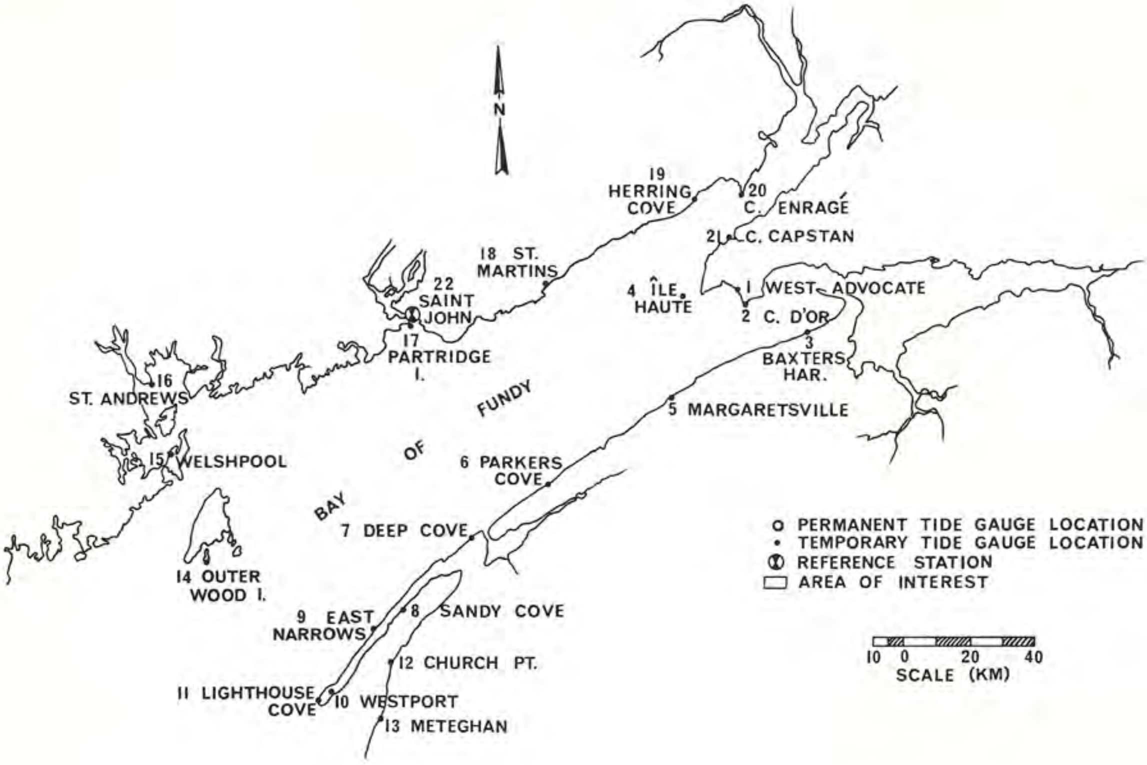


FIGURE 2
BAY OF FUNDY TIDE GAUGE LOCATIONS

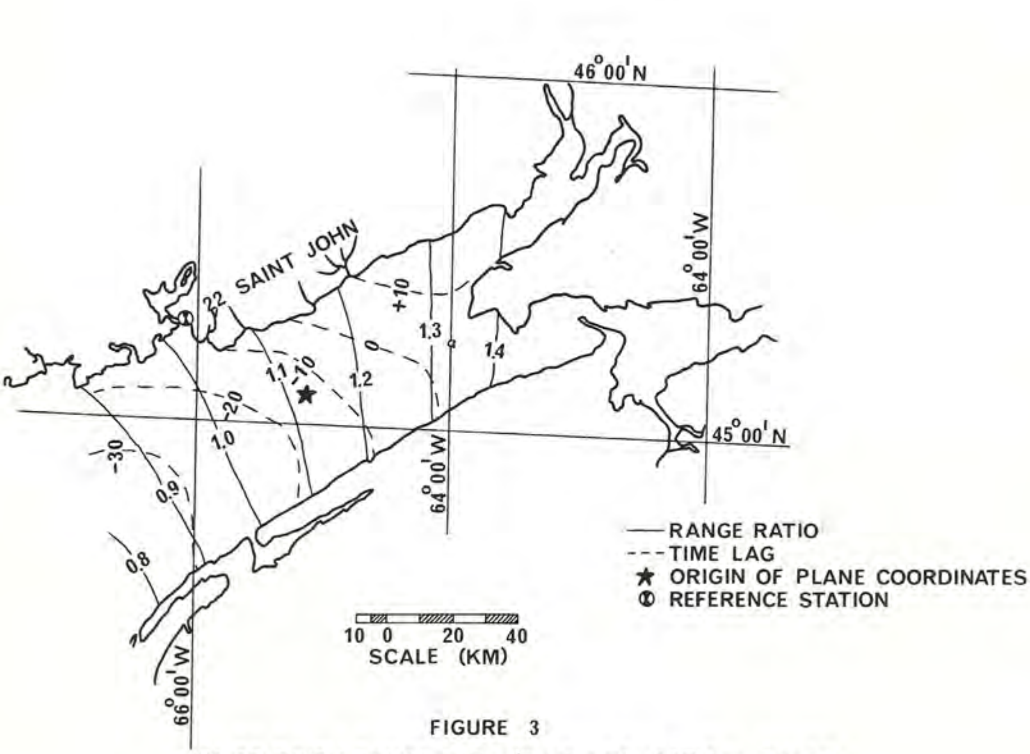


FIGURE 3
BAY OF FUNDY RANGE RATIO/TIME LAG COTIDAL CHART

approach to water level predictions, the methodology is by no means limited to this application. As was previously stated, the method can easily be applied to amplitude/phase lag predictions for numerous tidal constituents (cf Okenwa, 1978, 65-78).

The modelling technique is very flexible with regard to available computational power: it can be easily partitioned to allow for real-time water level reductions; or, in its most expanded form, can be configured to compute new surfaces, thus a predicted water level for any point, for any instant of time. The flexibility of the approach also extends to the data that can be employed: it can be taken simply from shore and/or offshore water level gauges, or can include any combination of these plus predicted data such as can be obtained from amplitude/phase lag physical oceanographic co-tidal charts.

As with all models, there are restrictions for its use. For the specific technique described in this paper, one is limited to modelling semi-diurnal tidal regions. In the more general sense, however, the model is restricted more by data -- quantity, quality, and distribution.

Further testing of these modelling procedures, particularly in cases where adequate data are available, is required to yield more conclusive results.

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TIME SERIES AT REFERENCE STATION		RANGE RATIO		TIME LAG			
$\hat{h}_o, \hat{A}_k, \hat{B}_k$	$\sigma_{h_o}, \sigma_{A_k}, \sigma_{B_k}$	$\hat{c}^r_{uv}$	$\sigma_{\hat{c}^r_{uv}}$	$\hat{c}^A_{uv}$	$\sigma_{\hat{c}^A_{uv}}$	$\hat{c}^B_{uv}$	$\sigma_{\hat{c}^B_{uv}}$
4.28	0.01	1.120	0.035	4.264	0.136	-0.569	0.170
-1.95	0.14	0.404E-5	0.568E-6	0.155E-4	0.218E-5	0.873E-5	0.361E-5
2.23	0.11	0.136E-10	0.764E-11	0.537E-10	0.293E-10	0.148E-9	0.432E-10
-1.18	0.21	0.125E-5	0.715E-6	0.484E-5	0.274E-5	0.170E-4	0.553E-5
0.26	0.40	-0.265E-10	0.135E-10	-0.114E-9	0.518E-10	-0.262E-9	0.194E-9
0.07	0.01					-0.389E-14	0.221E-14
-0.10	0.01					0.427E-9	0.139E-9
-0.23	0.03					0.579E-15	0.183E-15
0.03	0.03					-0.522E-19	0.335E-19
0.14	0.04						
0.08	0.02						
0.41	0.16						
-0.03	0.36						
0.77	0.13						
0.43	0.12						

TABLE 1

COEFFICIENTS OF APPROXIMATING POLYNOMIALS

Time (hrs) t	$h_o(t)$ PRED	$\sigma_{h_o}(t)$	from TABLES $h_o(t)m$	Time (hrs) t	$h_o(t)m$ PRED	$\sigma_{h_o}(t)m$	from TABLES $h_o(t)m$
				29	7.4	0.4	7.4
				30	6.7	0.4	6.7
6	5.5	0.4	5.8	31	5.4	0.4	5.5
7	4.0	0.4	4.4	32	3.9	0.6	4.0
8	2.6	0.6	3.0	33	2.4	0.6	2.6
9	1.6	0.6	1.8	34	1.5	0.6	1.6
10	1.2	0.6	1.3	35	1.2	0.4	1.2
11	1.7	0.4	0.5	36	1.7	0.4	1.6
12	2.7	0.4	2.5	37	2.8	0.4	2.6
13	4.2	0.4	3.9	38	4.3	0.6	4.0
14	5.7	0.6	5.4	39	5.8	0.6	5.5
15	6.8	0.6	6.7	40	6.8	0.6	6.7
16	7.3	0.6	7.3	41	7.3	0.4	7.3
17	7.0	0.4	7.1	42	6.9	0.4	7.1
18	6.1	0.4	6.1	43	5.9	0.4	6.1
19	4.6	0.4	4.7	44	4.5	0.6	4.6
20	3.1	0.6	3.2	45	3.0	0.6	3.1
21	1.9	0.6	1.9	46	1.8	0.6	1.8
22	1.2	0.6	1.2	47	1.2	0.4	1.2
23	1.3	0.4	1.4	48	1.4	0.4	1.4
24	2.2	0.4	2.2	49	2.3	0.5	2.4
25	3.6	0.4	3.5	50	3.7	0.6	3.8
26	5.1	0.6	5.0				
27	6.5	0.6	6.4				
28	7.3	0.6	7.2				

TABLE 2

PREDICTED HEIGHTS AT REFERENCE STATION

STA j	ϕ_j^o	λ_j^o	D_j m	t_j hrs	t'_j hrs	$h_o(t'_j)$m	r_j	$h_j(t_j)$m	$\sigma_{h_j}(t_j)$m
1	45.350	-64.817	12.00	2.750	2.624	6.85	1.40	9.62	0.90
2	45.300	-64.783	13.62	3.250	3.124	7.18	1.42	10.18	0.92
3	45.233	-64.517	14.25	4.500	4.274	7.22	1.54	11.10	0.96
4	45.250	-65.000	13.72	4.833	4.758	6.94	1.34	9.26	0.67
5	44.050	-65.067	12.82	5.417	5.403	6.31	1.31	8.25	0.54
6	44.800	-65.533	10.60	6.500	6.775	4.39	1.10	4.83	0.45
7	44.400	-65.833	13.98	25.333	25.312	4.04	0.91	3.68	0.49
8	44.500	-66.100	10.12	28.533	28.965	7.39	0.83	6.12	0.63
9	44.483	-66.083	12.08	29.250	29.647	7.03	0.83	5.83	0.59
10	44.267	-66.350	9.88	30.300	30.737	5.82	0.87	3.88	0.71
11	44.250	-66.400	9.50	31.500	32.020	3.87	0.64	2.49	0.57
12	44.333	-66.117	8.52	32.250	32.425	3.25	0.78	2.53	0.52
13	44.200	-66.167	7.08	32.833	32.755	2.78	0.72	2.01	0.50
14	44.600	-66.800	8.75	33.750	34.285	1.32	0.66	0.86	0.35
15	45.883	-66.950	8.35	35.167	35.111	1.20	0.75	0.91	0.32
16	45.067	-67.050	12.33	45.333	45.090	2.86	0.83	2.37	0.59
17	45.233	-66.050	13.10	46.583	46.700	1.29	1.03	1.33	0.44
18	45.550	-65.533	14.23	145.583	145.448	2.12	1.17	2.48	0.56
19	45.567	-64.967	15.33	149.300	148.966	2.02	1.35	2.71	0.54
20	45.600	-64.983	16.20	152.300	152.099	7.34	1.40	10.30	0.98
21	45.467	-64.850	15.89	155.917	155.744	6.13	1.39	8.50	0.63
22	45.267	-66.067	15.69	156.250	156.306	5.09	1.03	5.26	0.43

TABLE 3

PREDICTED WATER LEVELS

STA $_j$	α_j min OBS.	α_j min PRED.	$\Delta\alpha_j$ min	r_j OBS.	r_j PRED.	Δr_j
1	-1.0	8	-9	1.31	1.40	-0.09
2	16	8	8	1.46	1.42	0.04
3	12	14	-2	1.49	1.54	-0.05
4	0	5	-5	1.36	1.34	0.02
5	-12	1	-13	1.26	1.31	-0.05
6	-14	-16	2	1.06	1.10	-0.04
7	-16	1	-17	0.96	0.91	0.05
8	-18	-26	8	0.84	0.83	0.01
9	-37	-24	-13	0.76	0.83	-0.07
10	-34	-26	-8	0.72	0.67	0.05
11	-34	-31	-3	0.71	0.64	0.07
12	18	-10	28	0.72	0.78	-0.06
13	18	5	13	0.67	0.72	-0.05
14	-28	-32	4	0.66	0.66	0
15	5	3	2	0.67	0.75	-0.08
16	16	16	0	0.90	0.83	0.07
17	-10	-7	-3	1.00	1.03	-0.03
18	9	8	1	1.20	1.17	0.03
19	19	20	-1	1.32	1.35	-0.03
20	17	12	5	1.41	1.40	0.01
21	11	10	1	1.32	1.39	-0.07
22	0	-3	3	1.00	1.03	-0.03

TABLE 4

OBSERVED v.s. PREDICTED TIME LAGS AND RANGE RATIOS

Notes

William J. Stewart Reunion

The November, 1979 issue of LIGHTHOUSE carried an article by Mr. R. W. Sandilands commemorating the 46 years of service that the survey vessel CSS WILLIAM J. STEWART had provided to the Canadian Hydrographic Service on Canada's Pacific coast.

Memories of the WILLIE J will be rekindled soon at a reunion dinner dance that the Pacific Branch of the Canadian Hydrographers' Association has planned. All persons who were associated with the WILLIAM J. STEWART - or who wish that they had been! - are cordially invited to attend. The event is scheduled for November 15, 1980 at the Empress Hotel in Victoria, B.C. Further information may be obtained by contacting Tony O'Connor, C.H.S., Sidney, B.C., tel. (604)656-8377.

19 th Canadian Hydrographic Conference

The 19th Annual Canadian Hydrographic Conference was held March 18-20, 1980 in Halifax, N.S. Sponsored jointly by the Canadian Hydrographic Service and the Atlantic Branch of the Canadian Hydrographers' Association, the conference attracted 280 delegates from universities, private industry and government agencies both in North America and abroad.

The conference opened with a keynote address from Mr. S. B. MacPhee, the Dominion Hydrographer. Hon. R.J. Thornhill, Minister of Development for Nova Scotia, was the guest speaker at the C.H.A. luncheon held on the last day of the conference, and addressed the need for research and development incentives in the Atlantic Coast provinces in the area of offshore technology.

Papers were presented in sessions dealing with positioning systems, offshore surveys, depth measurement technology and tides, and marine charting and computer applications. An extremely interesting opening session included: a discussion of the changeover of the "Dominion Land Surveyor" Commission to "Canada Lands Surveyor;" a film presentation on the Class IV icebreaker, KAGORIAK, which was built for use in the Beaufort Sea drilling operations; and a slide presentation on the Lomonosov Ridge experiment (LOREX). Conference proceedings will be published soon and will be distributed to all delegates.

Navigation Group to Meet

The International Omega Association will hold its Fifth Annual Meeting on 5 to 7 August, 1980 at the Chr. Michelsen Institutt in Bergen, Norway. The topic of the meeting will be "Omega Growth". Papers are planned to emphasize Information Processing, Special Applications, and Operational Problems and Procedures. A system review including current status and plans will also be presented.

Formed in 1975, the International Omega Association exists for the benefit of individuals and organizations having a common interest in the art of navigation by means of the International Omega system.

Further information is available from: International Omega Association, P.O. Box 2324, 1720 S. Eads Street, Arlington, Virginia 22202, or John Veastad, Norwegian Tellecommunications Administration, Universitetsgata 2, Oslo, Norway: Tel: (02) 48 89 90.

Hydrographic Society Announces American Branch

The Hydrographic Society announces the formation of an American branch under the direction of its current President, Rear Admiral Robert C. Munson, NOAA, of the US National Ocean Survey.

The formation of the branch is designed to directly service the growing requirements of The Hydrographic Society's North American membership. It will be based at 6001 Executive Boulevard, Rockville, Maryland, 20852.

News from Industry

Fish-Finding Echo Sounder

EPSCO Marine announces the newest addition to its line of echo sounders. The chromascope displays reflected echo signals in up to eight different colors according to type of target and density. Sea water shows blue, and the colors of displayed echo signals vary from red for the most intense returns, such as those from the seabed, to light blue for the weakest echoes of all, such as plankton. These color echo signals move across the 11-inch cathode ray television-type screen in a manner similar to the presentation on recorder paper in conventional sounders.

Five range scales from 40-640 fathoms are available. A digital readout in conjunction with a variable range marker work together to determine the depth of the fish or seabed. A tape recorder/reproducer may be used to store displayed information.

Three models, the CVS-885, CVS-885 Mk I, and CVS-886, are available.

In Canada contact: Box 429, Bedford, Nova Scotia, B4A 2X3.

CHA Personal Notes

Atlantic Branch

Ted Radmore joined the ranks of Cartography in January; *Dave Wells* will be heading to U.N.B. as an associate professor for two or three years; congratulations are extended to *Gunther Schutzenmeier* on winning the training position in Ottawa; *Julien Goodyear* will be graduating from the Surveying Engineering program at U.N.B. this spring.

Quebec Branch

The Canadian Hydrographers' Association is proud to announce the establishment in January, 1980 of the *Quebec Branch;* the branch vice-president is *Ronald Saucier* and the membership presently stands at 15; *Patrick Hally*, who has a degree in Civil Engineering, is presently studying geodesy at Laval University; *Yvan Berthiaume*, electronics technician, has returned to university to earn a degree in electronics engineering.

Central Branch

Ray Chapeskie left Central Branch early in April to take up a position as unit head in the cartographic section of C.H.S., Pacific Region. Ray's enthusiasm and competence will be sorely missed in Burlington.

C.H.A. Challenge Bowl

The fourth annual Challenge Bowl football game was held November 4, 1979 at Beaver Lake Park. The game, which features the hydrographers (Gophers) vs. the electronics technicians (NADS), drew more than 50 spectators as sunny weather and a dry field provided excellent playing conditions.

The opening kickoff was taken by the new Director of I.O.S., Dr. C.R. Mann, whose support of such an event is welcomed by everyone.

Early in the game the Nads passing combination of John Watt and Nick Said brought them to the 20 yard line only to have a field goal attempt blocked. Rick Thomson grabbed the loose ball and scampered 75 yards for a Gophers touchdown. Tony O'Connor's convert attempt was just wide, and the Gophers lead of 6-0 was carried through to half time.

In the second half the Gophers passing attack dominated the game and kept the NADS hemmed up in their own half of the field, until Alex Raymond unleashed a bomb to Ernie Sargent late in the game to finish off the scoring.

Final Score: Gophers 12, NADS 0. Better luck next year NADS.

Many thanks to Referee Mike Bolton and the chain gang of Willy Rapatz and Stan Huggett.

CHS GOPHERS

Back: Doug Popejoy, Alex Raymond, Art Lyon, Tony O'Connor, Mike Woods, Rick Thomson

Front Row: Bill Van Duin, Dennis Johnson, Frank Coldham, Ernie Sargent.

Retirement of Ralph Wills

Ralph Wills, Regional Field Superintendent of the Pacific Region's Canadian Hydrographic Service, retired on December 31, 1979. A large gathering of his friends met at a farewell dinner on November 28th at the Princess Mary Restaurant vessel where both Ralph and his lovely wife Sue were honoured. During the evening the master of ceremonies, Mike Bolton, introduced speakers from across Canada as many of Ralph's friends and business associates arose to honour by word and gift, Ralph's 25 years with the Canadian Hydrographic Service. T.D.W. Mc-Culloch and H. Blandford were among those who spoke on this occasion.

Ralph joined with Canadian Hydrographic Service in 1954 after spending 6 years with the Union Steamship Company on voyages along the B.C. and Alaska Coasts and coastal Newfoundland. Prior to this he worked as a supervisor of the fairdrawing department of Aero Surveys Ltd. in Vancouver. In 1946 he qualified in one sitting for 2nd Mate, 1st Mate and Master and was granted a certificate as Master (foreign going). Ralph's 25 years with the Canadian Hydrographic Service saw him successfully rise from junior surveyor to Hydrographer in Charge of the Pacific Region's major ship the WM. J. STEWART. He participated in Decca surveys in Hecate Strait and was responsible in the early 60's for some of the regions larger survey parties. Ralph came ashore in 1968 and was appointed Regional Field Superintendent; directing the field survey operations in the Pacific Region until his retirement.

During Ralph's retirement banquet he was presented with a number of gifts: a ships clock (from the surveyors mess of the WM. J. STEWART), mounted on a wooden plaque and autographed by many of his friends at the Institute of Ocean Sciences; an honorary membership in the Canadian Hydrographers' Association, (an association that he helped set up); a framed picture showing the Pacific Region areas surveyed by Ralph over the years; a bronze cast hydrographic crest suitably inscribed; a 35 m camera; binoculars; and other memorabilia. A presentation by Joan McIntosh was made to Sue Wills during the evening and good wishes extended to her as well.

The editors of LIGHTHOUSE and all C.H.A. members would like to extend to Ralph our best wishes for a long and happy retirement and hopefully to see Ralph at some of the C.H.A. activities and meetings in the future.

H_2O Bonspiel

Forty-eight curlers braved heavy snowfalls and strong winds on March 8th, 1980 to participate in the 9th Annual H_2O Bonspiel sponsored by Central Branch of C.H.A. Top prize went to the "A" Division winning rink skipped by Dell Coleman. Dan Mahaffy's rink took away the "B" Division trophy.

A turkey shoot was featured at this year's spiel. Debbie Mahaffy displayed great form, winning the prize bird in a playoff round against runner-up Ken Hill.

Sincere thanks are extended to the sponsors of the spiel: Ross Laboratories Inc., Marinav Corporation, Wild Lietz Canada Ltd., Port Weller Dry Docks, Tellurometer Canada Ltd., Motorola, Inland Tracked Equipment, the Royal Bank, and the C.H.A. Film Club.

Special mention must be made of the "Team Quebec" foursome, skipped by Jean Gervais, who travelled from Quebec City to represent their branch in the competition.

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