Lighthouse

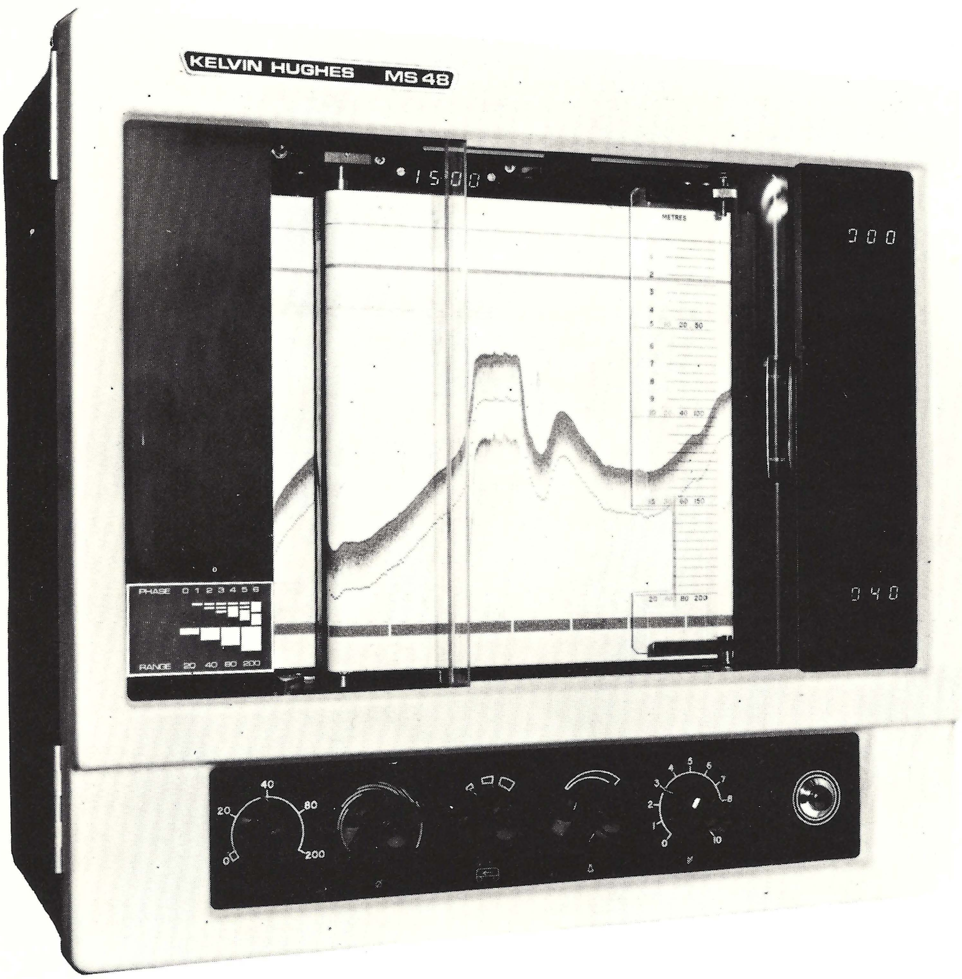
JOURNAL OF THE CANADIAN HYDROGRAPHERS' ASSOCIATION

EDITION NO. 15, APRIL 1977

Introducing,

THE MOST ADVANCED, COMPREHENSIVE, PRECISION ECHO SOUNDER FOR HYDROGRAPHERS

KELVIN HUGHES MS48



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

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

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

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

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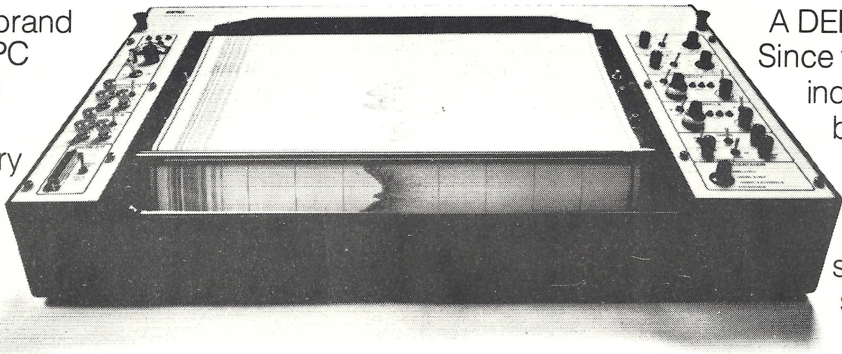

No baloney. The brand new dry paper EPC Model 3200 does everything.

It includes every worthwhile function on existing side scan, profiling and spectrum recorders.

And it features functions never before seen on any machine. Look—

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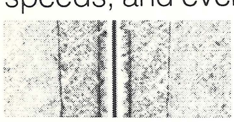
Sweeps are continuous or single, at any rate, in either direction. Single sweeps can be internally or externally triggered.

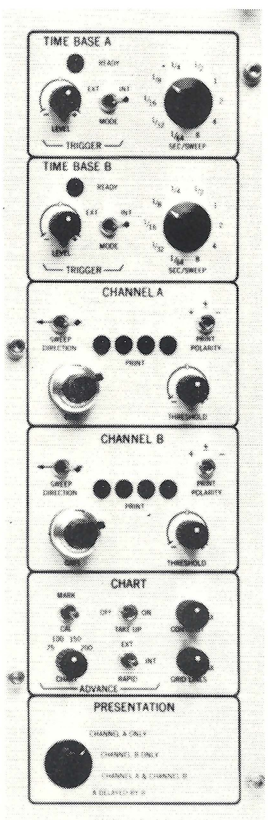
TWO CHANNEL OPERATION.

The 3200 can record a single channel across the entire printout—or record simultaneously on two channels, splitting the print-out in half. In the two channel mode, each channel is operated by a totally independent time base. It can therefore simultaneously record two different energy sources, sweep at two different speeds, and even sweep in two different directions.



Run on two channels as the ultimate 19.2″ dry paper center-out side scan. Or with two energy sources creating a high resolution shallow profile while simultaneously recording deep seismic penetration data.

A creative mind boggles at the possibilities.



A DELAYED BY B.

Since there are two independent time bases available, the 3200 can initiate a key pulse, delay the sweep by the time selected at B and then sweep at the time selected at A. Delay ⅛ second, sweep at 8 seconds; delay 8 seconds, sweep at ⅛ second.

Crucial data therefore can be located accurately, and compressed or expanded to suit your needs.

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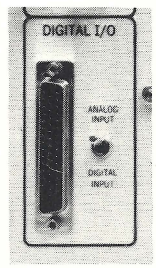

Since the Model 3200's memory requires digital data, all input data is digitized. This means that data received as analog can be sent out to tape recorders as digital. Data recorded as digital is accepted directly.

TRIED AND TRUE COMPONENTS.

The construction is pure EPC. Jitter-free digital drives. Records on 19.2″ dry paper with 23db dynamic range. Vernier chart advance. Rugged marine construction. State-of-the-art engineering. Functionally handsome looks.

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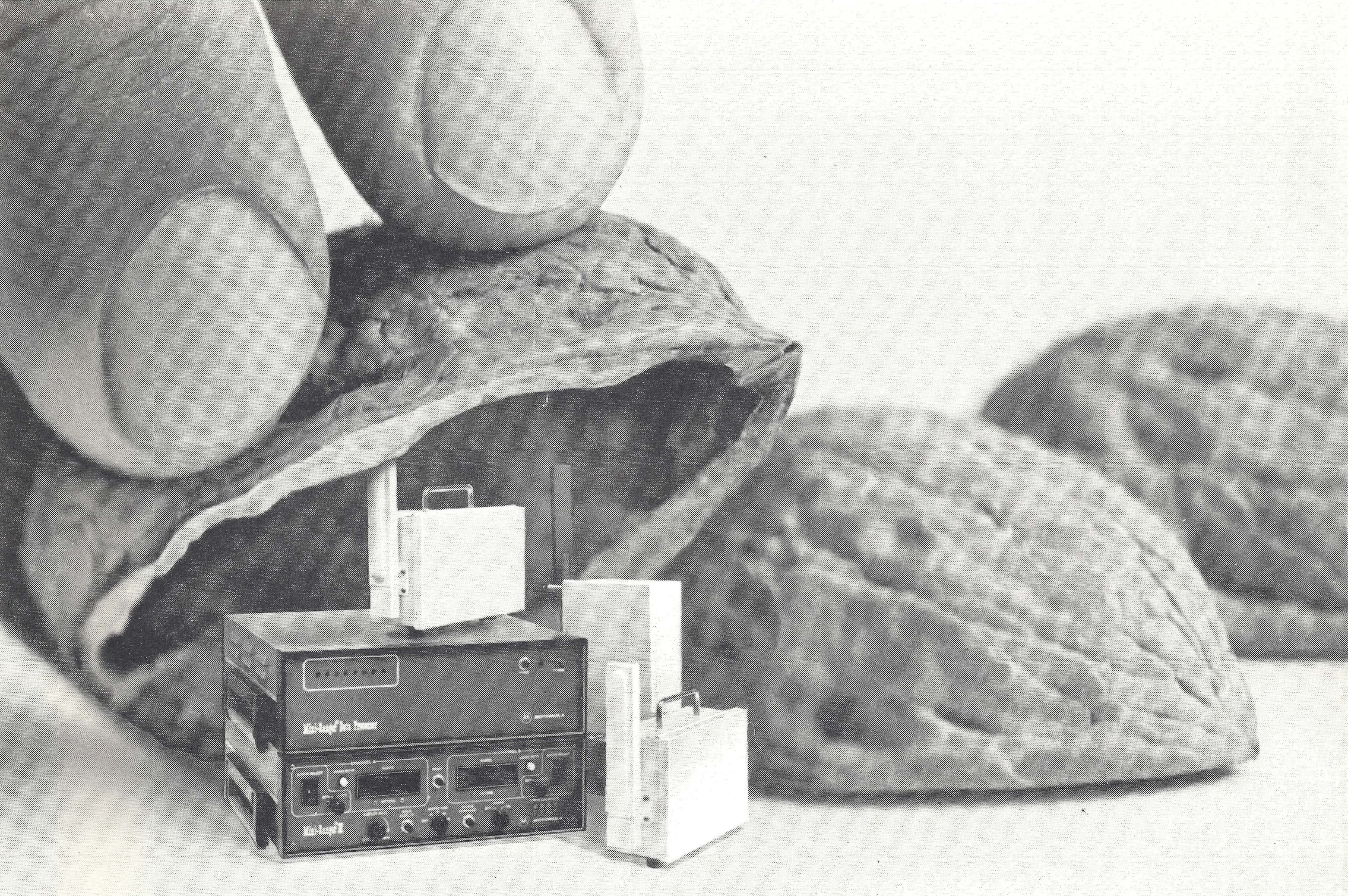

No Guesswork.

Mini-Ranger is there every time.

Motorola's new Mini-Ranger™ automated positioning system takes the guesswork out of pre-dredge and post-dredge surveys. And it can increase profits by keeping dredging operations right on line.

Lightweight and versatile, the system can be moved easily from dredge . . . to survey boat . . . to dredge in minutes, instead of days. The whole automated survey/dredge system uses less than 300 watts of power, including its data processor, or "brain." Connect it to your vessel power. Or use two regular auto batteries (24 to 30 vdc) and operate for up to eight hours between charges. This Motorola system is designed and built specifically for field use . . . it is not adapted office equipment. And we are a single source of service because Motorola supplies all key system components.

In operation, set up the lightweight reference stations at known locations . . . and leave them unattended. For dredging, use the system's track plotter and track indicator to tell you exactly where you've dredged and where you're headed. For pre-dredge surveying or post-dredge proof, connect a depth sounder and mag tape recorder for precise records of water depth and accurate position within a probable 3 meters at 37 kilometers. Mini-Ranger's automated system is adaptable to several tasks . . . simply add peripherals or plug in field-replaceable modules.

To take the guesswork out of your dredging and surveying, write the problem solvers at Motorola Military & Aerospace Electronics Division of Motorola Electronic Sales Ltd. 3125 Steeles Avenue East, Willowdale, Ontario, Canada or call (416) 499-1441. In the U.S. write Motorola Position Determining Systems, P.O. Box 2606 Scottsdale, AZ 85252, or call (602) 949-4176.

MINI-RANGER III

MOTOROLA

The mind to imagine . . . the skill to do

The 16th Annual Canadian Hydrographic Conference

The 16th Annual Canadian Hydrographic Conference was held in Burlington, Ontario from March 8-10, 1977, under the joint auspices of the Canadian Hydrographic Service and the Canadian Hydrographers' Association. A total of 250 delegates attended the Conference, coming from the following countries: Canada, New Zealand, South Africa, The United Kingdom, and The United States. Five different Canadian government departments were represented.

The goal of the Conference organizing committee was to encourage the participation of working Hydrographers and Cartographers and the technical program was designed with this goal in mind. For the first time workshop sessions were held. Three separate sessions were running simultaneously. The session topics were: "ERROR DETECTION AND CORRECTION IN HYDROGRAPHY", "CALIBRATION OF SURVEY SYSTEMS", and "THE INTEGRATION OF WATER LEVEL DATA IN HYDROGRAPHY". The sessions each lasted one hour and were repeated three times so that all delegates could participate in all workshops. Approximately 100 delegates took part.

During the main technical sessions, thirteen papers were presented. These papers covered a wide area of interest, from the accounts of one hydrographer searching for a sunken shipment of railway tank cars containing toxic chemicals, to the use of Landsat imagery to position uncharted islands and rocks in the Canadian north. An interesting paper, "The Use of Hydrographic Data in the Modelling of Tidal Estuaries", pointed out several ways in which hydrographic data is used in numerical modelling and how, with little more effort, hydrographers can satisfy modelling data requirements.

An afternoon was allocated exclusively for industrial exhibits. One wing of a local hotel was taken over with displays in each of 19 separate rooms. Each representative displayed equipment and presented a short talk to small groups of delegates.

Rear Admiral D.W. Haslam, The Hydrographer, United Kingdom, gave a very interesting luncheon address on the immense task of carrying out modern hydrographic surveys on the continental shelf of the U.K. The search for hydrocarbons and the prospect of enormous drilling rigs operating in this shallow sea have changed many of the survey ground rules used with confidence in the past. Hydrographers must now consider the requirements of underwater pipeline construction, the unrestricted use of large tankers and tow out routes for concrete production platforms with 100 metre drafts.

Mr. Blair Seaborn, Deputy Minister of the Federal Department of Fisheries and The Environment delivered the keynote address in which he outlined the steps the Canadian government has taken, either unilaterally or as a member of the United Nations, to protect the environment of the sea and to manage its responsible exploitation. Mr. Seaborn also stated the concern the Canadian government has with the transfer of technology to developing countries to assist them in reaping the benefits of the ocean resources.

The Seventeenth Canadian Hydrographic Conference will be held at the new Institute for the Ocean Sciences at Patricia Bay, British Columbia in March 1978.

Copies of the Proceedings of the Sixteenth Conference are available at a cost of ten dollars ($10.00) from the Editor of LIGHTHOUSE.

"International Hydrographic Technical Conference" will be held May 14-18, 1979 at Ottawa. Sponsored by the Canadian Institute of Surveying, Fédération Internationale de Géomètres and the Canadian Hydrographic Service.

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New cover prepared by A. Gris.

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Contents

Views expressed in articles appearing in this publication are those of the authors and not necessarily those of the Association.

EDITORIAL

The need to make the western world more independent concerning its need for petroleum has risen to the fore during recent years. No where has it been more evident than in the United Kingdom where the North Sea bonanza is considered as the salvation of a badly depressed economy. In Canada, as in most parts of the world, offshore exploration for hydrocarbons has assumed great importance. Earlier drilling on the Pacific Coast has been stopped. Earlier excitement in the area of Sable Island on the Atlantic Coast may possibly be rekindled with another recent oil find. Other exciting frontier areas at present are the Labrador Shelf and the two Arctic hotspots - the Sverdrup Basin and the Beaufort Sea.

In Europe the oil industry developments has changed the face of hydrography. We must wonder therefore whether the same thing will happen in Canada. In the United Kingdom there are today more hydrographic surveyors in industry than there are in government. Certainly, that is not the case today in Canada. The Canadian government has made some attempts to develop expertise in industry in hydrographic surveying but realistically, until the oil is found in decent quantities, the situation remains artificial. The timing of events seems impossible to predict. In the North Sea a considerable time elapsed between finding gas off the Netherlands and the first oil strike - indeed there were some who predicted it did not exist at all. When it was found, developments occurred with amazing speed.

Canada speculating on its potential offshore riches started multi-parameter offshore surveys a decade ago. Systematic measurements of gravity, magnetism and depth have now been made over much of the continental shelf. While these measurements provide clues to where the oil is and where it is not - are these the right parameters to measure and is the exercise worthwhile? Should there be more emphasis on seismic operations? We are told that in the United Kingdom only two multi-parameter survey operations were carried out by the government before the ships had to be taken off that task to work on the more immediate job of detailed surveys of tow out routes for the production platforms. The question that arises is should we too not be looking down the line? Then there are the port requirements. Observing the situation in the Shetlands and northeast Scotland, can we expect the same development of supply ports and the construction of production platforms in remote fjords? Much of this requires very detailed surveys. Our present hydrographic knowledge of the Labrador coast is very limited and one must wonder that if oil is found and the pace of development be as fast as the North Sea can we be ready in time?

It is difficult to appreciate the scale of our work in Canada compared with surveys in European waters. While fortunately we are not faced with the thousands of wrecks that are found in European waters the very size of our continental shelf presents a formidable task. When the U.K. Hydrographer in a recent address to our Association tells us that they now specify that ships and boats must cover the whole area less than 200 metres deep by sidescan sonar we must think in terms of a total area of 670,636 square nautical miles - a truly formidable task.

The concept of surveying corridors with total bottom coverage has been discussed for some time. The technique is apparently being used in the North Sea for tow out routes. In this country corridors are being surveyed along the Labrador Coast and in the Arctic but not with total bottom coverage. It seems that hydrographers are still suspicious of sidescan used as an insurance that no obstacles remain. The 'Bosun' System shows great promise but there still seems to be a need for software development to release its full potential. The British sector scanning system is now being fitted on their survey vessels and we look to it as another possible answer for total bottom sweeping.

Another interesting problem for the oil companies drilling off the Labrador Coast are the boulders that seem to cover much of the shelf in that area and make drilling difficult. Marine Surveys are needed to define where the boulders are situated and possibly to what depth they exist. Is this government's task or is it industry's task?

The questions remain are whether Canada is prepared for a series of events similar to those that have taken place in the North Sea? Are its surveys in the right place and of the right type and do we have an industrial infrastructure that can rise to the occasion when it happens?

Message from the President to CHA

Our annual conference, March 8-10 inclusive, was very successful and Central Region is to be congratulated for a series of well-organized lectures and workshops as well as a very hospitable atmosphere throughout the conference.

I wish to express my appreciation to the members of C.H.A. for having elected me as National President. This is, as Sam Weller stated at the last meeting, the first time anyone outside the Canadian Hydrographic Service has had that distinction.

On behalf of the members of C.H.A. I would like to take this opportunity to express our appreciation for the fine job done by my predecessor, Willie Rapatz and his executive. Willie, by the way, along with Mike Bolton will continue to represent us in discussions with C.I.S. concerning C.H.A. affiliation with C.I.S.

We were very pleased to have a number of very distinguished visitors at our conference, among them Alan Ingham who not only addressed those at the Conference but also visited both Erindale and Humber Colleges where he gave two very interesting and well-received lectures on Hydrography. On your behalf I would like to express our thanks to Alan for a sterling effort. He is an excellent ambassador for Hydrography.

The Hydrographic Technologist course presently being conducted at Humber College is progressing very well. Those presently undertaking this course are an interested and enthusiastic group. Several prospective students have been interviewed, and a number have phoned and enquired concerning the course. Presently it appears that the number expected to enrol next year may increase by three times the present number. I certainly feel encouraged (optimistic) concerning the future of Hydrography at Humber and the expansion of Hydrography in private industry.

There is a great deal of activity in our field and in related fields in which a large number of our members and associates are involved. This would make for interesting and informative articles which I am sure the Editor of LIGHTHOUSE would be happy to include in future editions.

We hope you will submit this type of material and support our publication.

Information concerning C.H.A., LIGHTHOUSE, or any of our activities may be obtained by contacting me or any of the Branch Vice-Presidents whose names and addresses appear on the front page of LIGHTHOUSE.

Sincerely,

"Gerry"

G.E. Wade
National President

Coastal Survey in Africa Using Loran-C

R. MARSHALL • G. MACDONALD • R. BRYANT

Canadian Hydrographic Service
Central Region

Abstract - Loran-C signals from a pair of Accufix stations provided position data aboard the Canadian Survey Ship *BAFFIN* while surveying the continental margin of Senegal early in 1976. The signals were processed in rho-rho mode by an Austron 5000 receiver interfaced to a Magnavox integrated navigation system. Loran-C and ship's gyro compass were used to derive speed and heading to dead reckon the ship between satellite fixes (NNSS - transit). Survey operations continued 24 hours per day for a period of 50 days, at ranges from the stations up to 650 km.

This paper deals with the contract raised to provide the Loran-C signals and the logistics of commissioning, operating and maintaining the Accufix chain within the constraints imposed by a short duration survey in a foreign water with short lead time. The history of the project is reviewed briefly, the objectives of the survey outlined, and operations aboard ship are described. Data comparing Loran-C derived positions with satellite navigation are presented and the methods used to improve the quality of position data through post analysis are presented.

The two hundred mile limit poses a challenge to the marine surveyor. This paper demonstrates the applicability of the Accufix system as a tool to accomplish his task.

Introduction

Part III of the informal single negotiating text of the Third Conference on the Law of the Sea proposes that states "..... shall promote the development of the marine scientific and technological capacity of developing states ..., in consonance with their economics and needs, with regard to the exploration, exploitation, conservation and management of marine resources ..., with a view to accelerating the social and economical development of developing states... .

In order to achieve the above mentioned objectives, states shall endeavour to:

(a) establish programs of technical co-operation for the effective transfer of all kinds of marine technology to developing states

(b) undertake projects ..., and other forms of bilateral ... co-operation".

In discussions before and during the Third Conference on the Law of the Sea held in Geneva in March and April, 1975, the Senegalese delegates pointed out to the Canadians that they, like many third world countries, did not possess the resources or experience necessary to allow them to establish the extent and resources of their continental shelf. In the light of the discussions on the development and transfer of technology in committee three of the conference, the Canadian delegation suggested that this might be a suitable foreign aid project.

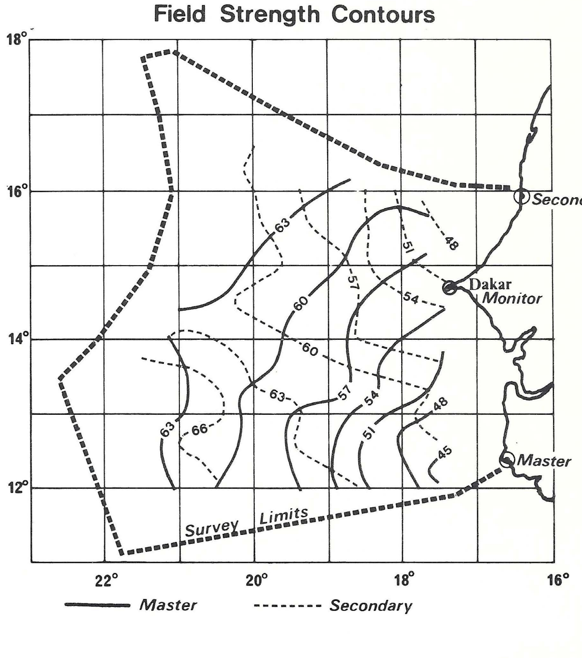
A formal agreement was eventually signed by the Canadian International Development Agency (CIDA) and the governments of Senegal and Gambia by which CIDA would pay the costs of the Canadian Hydrographic Service and the Atlantic Geoscience Centre to send *CSS BAFFIN* to carry out a multi-parameter survey of the continental shelves and margins of those countries. This would include gathering bathymetry, gravity and magnetic field data along with observations of the extent of hydrocarbon pollution. High resolution seismic profiling would also be carried out on the continental shelf to assist the Centre de Recherches Oceanographique de Thiaroye (CROT) in Senegal with the interpretation of their studies of the surficial geology of the continental shelf. Senegal and Gambia were invited to name staff to assist in and be trained in the various data gathering and analysis programs on board *BAFFIN*. Subsequently, the main responsibility for planning and carrying out the survey, was given by the Dominion Hydrographer to the Hydrography Division, Central Region, based at the Canada Centre for Inland Waters, Burlington, Ontario. *BAFFIN*, one of our major hydrographic vessels, based at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, was officially assigned to the project.

Meetings were held with representatives from various Canadian government departments and agencies, and on October 1, 1975, the specific objectives of the survey were spelled out and the necessary financial arrangements were made.

Positioning System

Once we knew we had a ship to carry out the survey, our major concern was how to accurately position her on a continuous basis at distances of up to 650 km offshore. Central Region possessed a Magnavox Integrated Navigation System with Doppler Sonar, which we had used successfully in Hudson Bay during the summer of 1975. However, the depths off Senegal, down to 5000 metres, greatly exceeded the useful range of our sonar. Our Decca Lambda chain could not give us the 200 metre accuracies required 24 hours a day at the extremes of the survey area.

ACCUFIX
Field Strength Contours



In our continual search for optimum positioning of our survey vessels, our Hydrographic Development Section had previously studied the Accufix Loran-C system. We felt that a mini Loran-C chain, set up in rho-rho mode with stations in the extreme north and south of Senegal, integrated into our navigation system would provide the best possible positioning for this area.

As the Canadian Hydrographic Service did not possess such a chain, we thought it advantageous to contract private industry to operate a Loran-C chain for us on a leased basis. Accordingly, our Hydrographic Development Officer drew up contract specifications for "The Experimental Use of a Position Fixing System in Support of Scientific Data Collection". These specifications were turned over to our Department of Supply and Services on October 22nd. They set up a bidders' conference for November 21st and a closing date for tenders on December 1st.

In early November, Rick Bryant, Hydrographic Development Officer, John O'Shea from our Headquarters' Training Staff, and Bob Marshall, went to Senegal to select sites for the antennas, transmitters and monitor. We also wanted to discuss various aspects of the survey, particularly the training of local personnel, with Senegalese government officials.

To obtain the best possible fix geometry over the survey area, we wanted stations as far apart as possible, but because of political considerations, within the boundaries of Senegal. We located potential transmitter sites near St. Louis and Diembering, 430 km apart, and a monitor site in Dakar. As 100 m towers were required to get the necessary range, special permission to erect them was arranged with the Senegalese Government. The Canadian Embassy in Dakar promised to give us all possible assistance, especially in getting speedy customs clearance for the equipment which would be brought into the country. The Senegalese Navy offered us berthing space for *BAFFIN* at their base in Dakar.

We returned to Canada and at the bidders' conference on November 21st, we briefed six (6) potential suppliers on our site selection and the conditions they could expect to find in Senegal. On December 12th, we entered into a contract with ComDev Marine of Ottawa, who proposed to supply and maintain a Megapulse Accufix Loran-C survey positioning system in conjunction with Megapulse Inc. of Bedford, Massachusetts.

The contractor had just under two months to acquire, pre-test and ship the equipment, erect two 100 m towers, install and shake down the chain and establish initial calibration data. All this, plus celebrate Christmas and New Year's, have endless immunization shots, get acclimatized, learn how to haggle with Customs Officials, and establish domestic facilities. Presumably, any extra time was spent swimming in the surf, sightseeing and checking out the night life in Dakar. It is a credit to ComDev Marine, Megapulse, Leblanc and Royle (the tower sub-contractor) and the Canadian Embassy in Dakar that all this was accomplished. A hydrographer was in Senegal during this period acting as liaison between the contractor and Senegalese officials.

We had hoped to have the chain operating for one week prior to the arrival of the ship. This hope was dashed however, when the antenna assembly shipped from Dakar to Diembering took two weeks to arrive on site. As it was, the chain was up one day before the departure of *BAFFIN* to begin survey operations on February 11th.

The tight survey schedule left little room for down time and, in an effort to maintain continuous operation, spares of all modules were kept at each site and the stations were manned 24 hours per day. Power was provided by two diesel generators used alternately. The contractor provided two technicians at each transmitter site, a chain supervisor based in Dakar and Scott Winick of Megapulse, who provided engineering support on installation and general system trouble-shooting.

A communications network, using S.S.B., was established between Master, secondary, monitor and ship. Maintenance activity was co-ordinated by the chain supervisor who tried to schedule outages to coincide with "on station" work by *BAFFIN*.

The first week of operation was plagued with system failures that could have been avoided if more time for shakedown had been available. Almost daily outages resulted in the system availability reaching only 83%. However, after the first six (6) days, chain availability exceeded 98% with two down time periods of one hour each scheduled to correspond with "on station" activity by the ship. March availability exceeded 99.5% with only one outage not corresponding to on station work.

Chain G.R.I. and timing was established by a cesium standard at the master station. Timing of the secondary was regulated either by a timing receiver locked to the master transmission or by a cesium standard with timing adjustments introduced to maintain the time difference observed at monitor within 50 nanoseconds. During the first half of the operation, timing was maintained by cesium at night and receiver by day when the S/N ratio was good. Later, complete reliance on the cesium standard was adopted with three regular timing adjustments per day that totalled 90 nanoseconds.

Survey Summary

BAFFIN began a previously planned refit on November 12, 1975, which was due for completion on January 16, 1976. Because we anticipated leaving Halifax for Senegal on January 26th, we had to begin installing our survey equipment, including computers, gravimeter, echo sounders, portable laboratories and satellite navigation system while the ship was still in the hands of the shipyard. In spite of this, we were able to leave on schedule. The voyage to Senegal lasted until February 8th and was used as a shakedown cruise during which all our equipment and systems were tested. Bathymetry, magnetics and gravity data were collected on a continuous basis; daily oil tows were made and a 40 cu. inch air gun was towed over the Mid-Atlantic Ridge. A mooring with 2 current meters and 1 tide gauge was laid in 50 m of water, 55 km south of Dakar prior to our docking in the Senegalese capital.

After a two day stop in Dakar, we began the survey on February 11th. *BAFFIN* steamed on prearranged lines collecting bathymetry, magnetics and gravity on a continuous basis. An oceanographic station was occupied on a daily basis. Wildlife observations were made during daylight hours; weather observations were recorded every 6 hours and the results transmitted by radio to Dakar. This program, interrupted by a visit to Dakar from March 5-8th, continued until March 18th. From the 18th to the 28th, we towed a Huntec high resolution deep seismic system over the near shore area. The current meter mooring was recovered on March 27th. After a further two day stop in Dakar, we sailed for Halifax. On route, we spent 2 days running seismic lines over drill site number 13 on the Mid-Atlantic Ridge.

Navigation

From Halifax until we were near the Azores, we used the satellite navigation system with inputs from the East Coast Loran-C chain and the North Atlantic chain. After we were out of range of the N.A. chain, we used SatNav with gyro and manual speed inputs.

When *BAFFIN* left Dakar on February 11th to begin the offshore survey, our complete navigation system was on line. However, for the first few days, we had some difficulty maintaining lock on the Loran signal, due to excessive atmospheric noise levels at night, especially between 2300 and 0400 hours. When we temporarily lost the signal, as we did on some occasions, we reverted to manual speed input. After a few days, we were able to make some tuning and operating adjustments to our receiver and, until the end of the survey, the SatNav/Loran-C combination worked exceptionally well. We found that by tracking on the fifth cycle and using a high J (averaging) value on the Austron 5000 receiver, we were able to maintain lock throughout the survey area, even at the extreme range of 720 km from the secondary station and 770 km from master.

The Satellite navigation system, Loran receiver, gravimeter and magnetometer readouts and echo sounder recorders were located in *BAFFIN's* plotting room immediately above and abaft the wheelhouse. This arrangement enabled one hydrographer, on normal sea watch, to monitor all equipment and con the ship along pre-determined tracks.

Ship's position, time, depths and Loran readings were automatically logged on mag. tape, displayed on a CRT and on a printout from a teletype terminal.

A CRT showing latitude, longitude, depth, course to steer, distance off line, distance to go, etc., was located in the wheelhouse and kept the officer of the watch informed on the progress of the ship along the survey line. The helmsman used information displayed on the CRT to keep the ship on line. A similar display was set up in the seismic lab. Voice communication between plotting room, wheelhouse, seismic lab. and oceanographic lab. was continuously available. The officer of the watch could instantly over-ride the survey navigation system when required for the safety of the ship.

During the return trip from Dakar to Halifax, we tracked the Loran-C signal to a distance of 1100 km from the most distant station before the chain was taken off the air. We picked up the signal from Cape Race of the East Coast chain south of the Azores, but it was not until Mid-Atlantic that we were able to use the East Coast chain on a continuous basis.

Positioning with the Integrated Navigation System

In conventional applications, Loran-C lines of position generated by the Austron 5000 are subjected to a computation that derives the ship's position based on the exact location of the transmitters, measured time delay, predicted clock drift, predicted propagation factors and measured initial synchronization errors. If calibration is precise and careful records of clock drift are maintained, chains with repeatability in the order of 50 metres yield positions with errors in the order of 180 metres subject to geometric dilution.

By comparison, at the time of the Senegal Survey, the location of the transmitters was only known to within 500 metres. No calibration or initial synchronization was made, and no effort was made to rate clock drift. Instead, satellite navigation fixes were used to establish the ship's position, and Loran-C range "changes" were used to derive the relative motion of the ship between fixes, acting in a similar manner to a doppler sonar providing velocity information to a dead reckoning computer program. The derived Loran-C velocity data provided accurate dead reckoning navigation, and improved the quality of the satellite fixes by providing accurate speed and heading data during the fix.

Clock drift and station location uncertainty resulted in errors in the dead reckoning that showed up at the time of the next satellite pass. The real time navigation program applied this correction and, as a result, a discontinuity (the update) appears in position data at each satellite fix. These updates were removed in a subsequent position processing program that also improved the accuracy of the D.R. positions based on the update value.

Position Adjustments

At the time of the satellite fix, the amount of the update can be computed. It is the difference between the dead reckoned position and the satellite position for the same instant.

Update (lat.) = lat. (dead reckoned) - lat. (satellite)
Update (long.) = long. (dead reckoned) - long. (satellite)

A portion of this update can be applied to each recorded D.R. position, as a proportion of the distance travelled since the last satellite fix.

$$\text{lat. (corrected)} = \text{lat. (dead reckoned)} + \text{update (lat.)} \times \frac{d}{D}$$

$$\text{long. (corrected)} = \text{long. (dead reckoned)} + \text{update (long.)} \times \frac{d}{D}$$

where d is the distance travelled from the last satellite fix to the present D.R. position, and D is the total distance travelled between satellite fixes.

The corrected positions were stored on magnetic tape along with the other survey parameters. This data was used to produce the bathymetry plot.

Position Accuracy

A large update is an indication that velocity information supplied to the integrated system is incorrect. Since it could also indicate a bad satellite fix, only those satellite fixes which passed the fix acceptance criteria were used to derive the figures in the following discussion.

By comparing the amount of the update to the normal error in the satellite fix (60 metres), an indication of the accuracy of the Accufix as a velocity sensor becomes evident. For this comparison, the survey area was divided in two; a short range (near shore) area extending 300 kilometres off the coast of Senegal and a long range area extending from 300 kilometres to 600 kilometres off shore.

In the near shore area, the median update per hour was 42 metres. This indicates that after one hour of dead reckoning the computed position of the vessel differs from the actual position (as determined from satellite) by 42 metres. Since the total error can be attributed to the satellite fix, the accuracy of the Accufix at short ranges was better than the system to which it was referenced. Updates as small as 3 metres per hour and as large as 152 metres per hour were observed. Survey accuracy was further improved by using the position adjustment techniques previously described.

In the offshore area, the median update of 95 metres per hour is larger than the error observed at the shorter range. The smallest update observed was 9 metres, while the largest update was 201 metres. After position adjustments had been made, the accuracy fell well within the required limits of ±200 metres. The deterioration of accuracy with an increase in range can be solely attributed to the Accufix derived velocity. A median error in D.R. of 67 m would yield a median update of 90 metres. Although this is not a precise measure of the accuracy of the Loran-C, it is a good estimate of its repeatability.

The update figures quoted are 'per hour'. Satellite fixes, however, occur at irregular intervals throughout the day. The interval between good fixes could vary from 20 minutes to 4 hours. In Senegal, the average interval between updates was 1 hour and 56 minutes.

Bathymetry

Bathymetry was collected using a Raytheon deep sea sounding system consisting of:

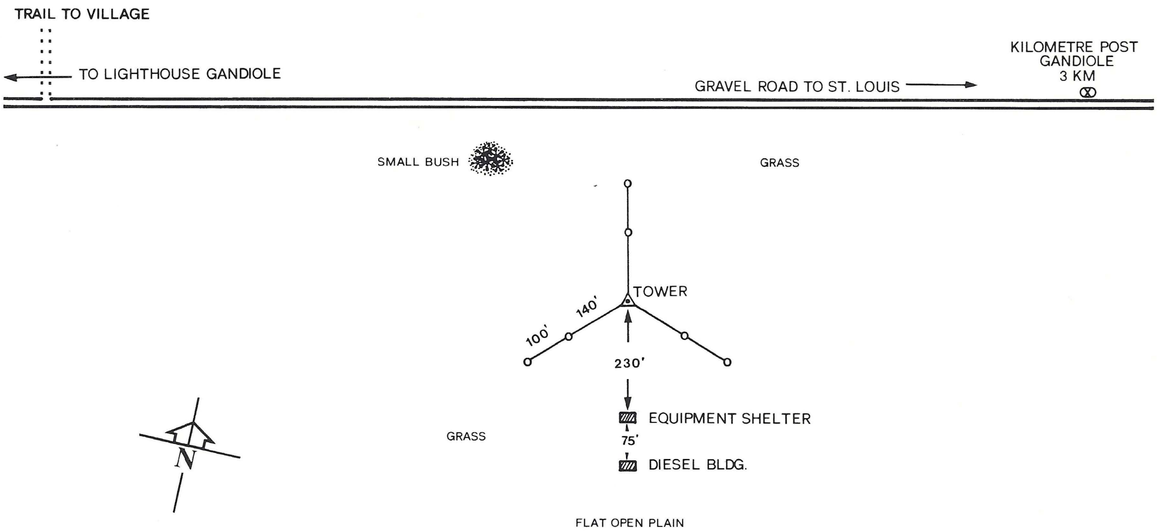
- universal graphic recorder
- PTR-105 transceiver
- correlation echo sounder processor
- precision depth digitizer

Digitized depths were logged on the SatNav mag. tape. The analog record was constantly monitored by the hydrographer of the watch and annotated at regular intervals. Every 24 hours, the mag. tape was removed, the data processed, and the soundings plotted on a Calcomp plotter at a scale of 1:1,000,000. Processing software was based on programs previously developed for our 1975 Hudson Bay survey and modified for use on the Senegal Survey. Seven preliminary field sheets were plotted at a scale of 1:300,000 on plastic on the Calcomp plotter. Permanent sheets were plotted on a Gerber 22 flatbed plotter on our return to Burlington.

G.E.B.C.O. sheets, at 1:1,000,000 covering the voyage to and from Senegal, were completed at the end of the survey.

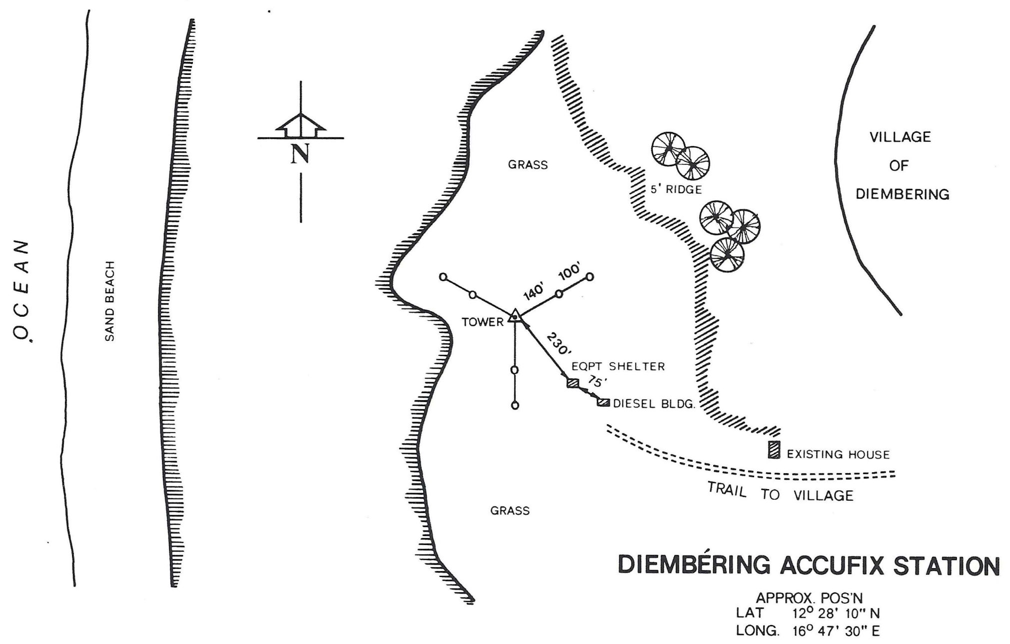
Geophysics

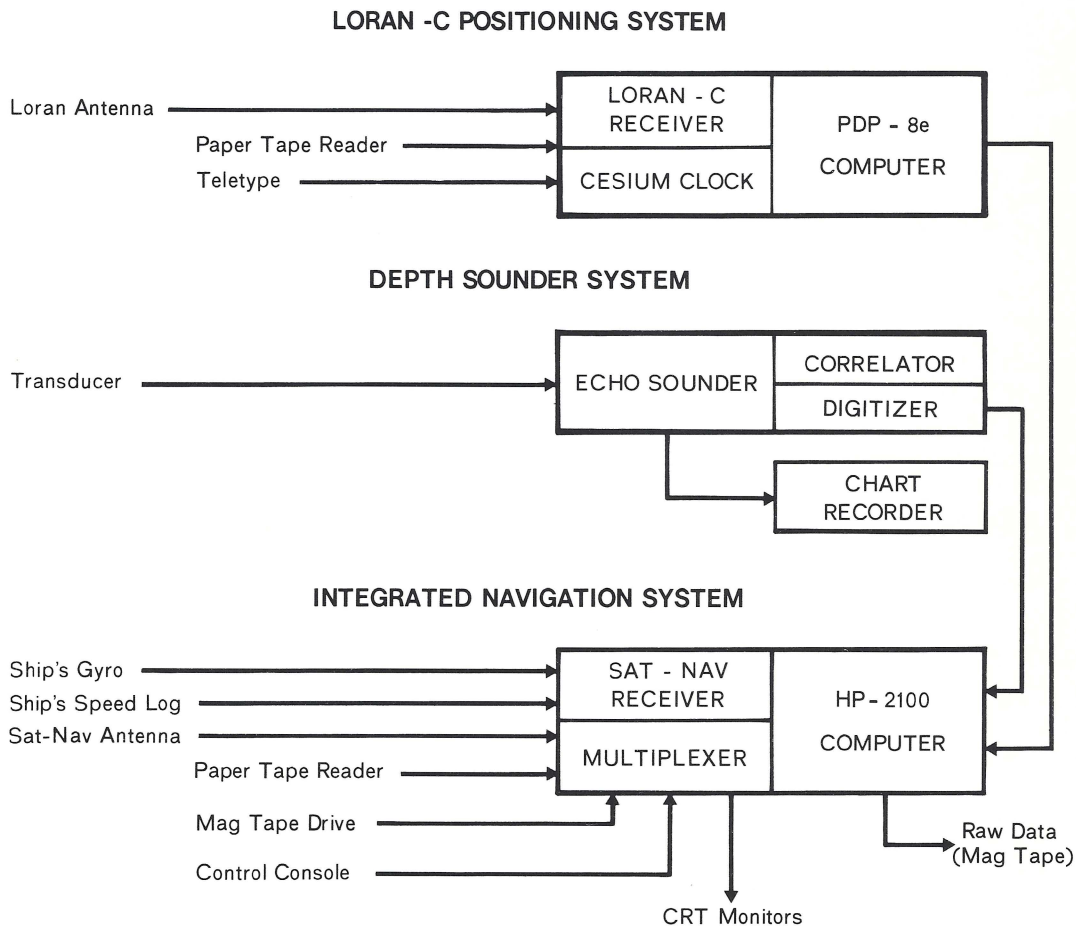
The objective of the geophysics program was to provide data on the earth's magnetic and gravity field to assist the Senegalese and Gambian Governments in assessing the resource potential of their



ST. LOUIS ACCUFIX STATION

APPROX. POS'N
LAT. 15° 54' N
LONG. 16° 29' E


OCEAN
SAND BEACH
N
GRASS
5' RIDGE
VILLAGE
OF
DIEMBERING
TOWER
140'
100'
230'
EQPT SHELTER
75'
DIESEL BLDG.
EXISTING HOUSE
TRAIL TO VILLAGE
GRASS
DIEMBÉRING ACCUFIX STATION
APPROX. POS'N
LAT 12° 28' 10" N
LONG. 16° 47' 30" E


LORAN -C POSITIONING SYSTEM
Loran Antenna
Paper Tape Reader
Teletype
LORAN - C RECEIVER
CESIUM CLOCK
PDP - 8e COMPUTER
DEPTH SOUNDER SYSTEM
Transducer
ECHO SOUNDER
CORRELATOR
DIGITIZER
CHART RECORDER
INTEGRATED NAVIGATION SYSTEM
Ship's Gyro
Ship's Speed Log
Sat-Nav Antenna
Paper Tape Reader
Mag Tape Drive
Control Console
SAT - NAV RECEIVER
MULTIPLEXER
HP - 2100 COMPUTER
Raw Data (Mag Tape)
CRT Monitors

continental margin and to permit them to correlate the results of geophysical and geological surveys carried out by oil companies under licence to them.

Gravity and magnetometer data was gathered on a continuous basis over the entire survey area. In addition, a 40 inch air gun was operated over selected areas. From March 18-28th, in addition to the air gun, a high resolution deep towed seismic system (Huntec) was used over continental shelf areas to provide information on the structure of the upper few tens of metres.

Gravity and magnetic data were automatically logged on mag. tape and processed on board using a H.P. 2100 computer.

Maps were produced showing:
(i) total magnetic field contours
(ii) magnetic anomaly contour
(iii) free air gravity anomaly contour
(iv) Bouguer gravity anomaly contour

Chemical Oceanography

This program was set up to sample the distribution of temperature, salinity, oxygen, dissolved and particulate oil, dissolved and particulate organic matter and oxygen isotope ratios on the continental margin of Senegal and Gambia.

Thirty-nine (39) stations were occupied throughout the survey area from February 11th to March 27th. Station depths ranged from 25 to 4500 metres and time on station varied from 45 minutes to 4 hours.

The analysis for temperature, oxygen concentration, salinity, phosphate and silicate concentrations and particulate C.H.N. were performed on board *BAFFIN*. Raw data from these analyses was transmitted by W.T. to the Atlantic Oceanographic Laboratory (A.O.L.) in Nova Scotia in a similar format to that of weather observations. Other samples were returned to A.O.L. for analysis at the end of the cruise.

A comprehensive report with maps was prepared for inclusion in the final report to be handed over to the Senegalese Government later in 1976.

Wildlife Observations

From January 26th to March 6th, 1976, a representative from the Canadian Wildlife Service carried out a series of observations from *BAFFIN*. This allowed the quantitative mapping of sea birds, flying fish and dolphin distributions throughout the survey area. A chart of the surface temperature was prepared and the biological distributions were interpreted in terms of the various temperature zones. The importance of the offshore upwelling system to sea birds and other animals was investigated. Surface tows were made for oil particules and plankton samples were frozen for laboratory analysis.

A full report on these investigations was prepared for inclusion in the final data report for Senegal.

Conclusions

The Loran-C mini chain used in Senegal proved to be a reliable, flexible positioning tool.

Accuracies of better than $\pm$200 metres were maintained on a 24 hour basis over a survey area which extended 600 km offshore.

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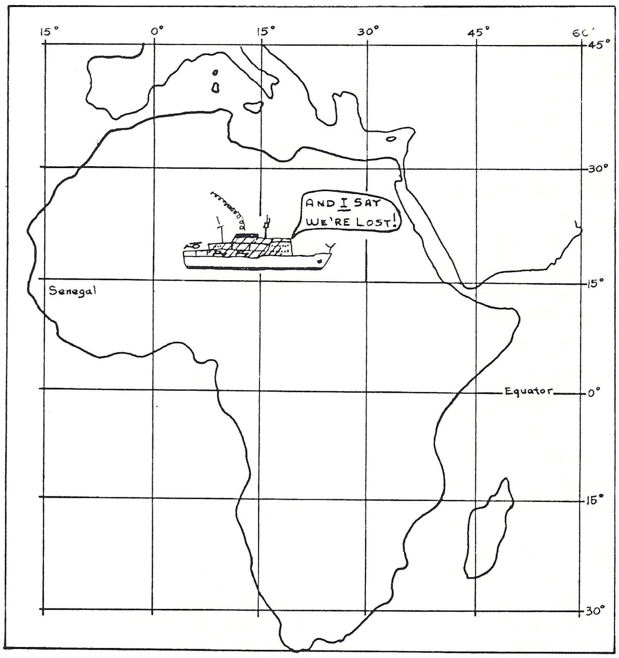

Early in 1976, the CANADIAN HYDROGRAPHIC SERVICE used a sophisticated SATELLITE INTEGRATED NAVIGATION SYSTEM to position the CSS BAFFIN, during a hydrographic survey off the coast of Senegal.

Automated Tidal Reductions

B. TINNEY

Canadian Hydrographic Service
Central Region

With the advancement of automated data logging in hydrographic surveying, an increasing number of previously manual tasks such as reduction of soundings to datum in tidal waters are being removed from the field hydrographer's list of chores. Two field surveys in 1976, namely the Hudson Bay survey operating from the ship *NARWHAL*, and the Lower St. Lawrence River survey at Rimouski, Quebec, employed tidal reduction programs in their processing systems to automatically reduce their soundings. The reduction programs were based on digitized co-tidal charts for the appropriate areas. The simple digitization procedure and straightforward approach to the reduction programs resulted in rapid system implementation and problem-free operation.

Semi-Diurnal Co-Tidal Charts

A semi-diurnal (highs and lows twice daily) co-tidal chart divides the survey area up by two sets of curves. One set of curves connect the points having simultaneous high and low waters. The other represents the set of points having equal ranges. Therefore, these curves separate the survey area into tidal zones. Each zone has specific time and range differences that relate the tide of that zone to the tide at a reference port. This enables one to convert the tide at the reference port, be it from predictions or observations, to any zone.

For example, the tide at zone 1 may occur 1/2 hour before it does at the reference port and its range might be reduced by a factor of 0.90 from that of the reference port. If the tide at the reference port at 1330 hours was 4.60 m then the tide in zone 1 at 1300 hours would be 4.14 m. The hydrographer can therefore apply these differences to the tide as recorded or predicted at the reference port to obtain a reduction for each sounding. Other factors or differences may be included if necessary, such as differences in the elevation of mean water level, or a breakdown of the time changes into high water and low water differences. This can be a time consuming task but one that lends itself very well to automation.

The Concept

The first logical step toward automating tidal reductions is to digitize the co-tidal charts and to store these digitizations in the computer. The factors of each zone must be stored and the tidal record of the reference port must be available before the reduction can be made. With this data in the computer the position of each sounding is used to locate it within the proper zone on the digital co-tidal chart. The tidal differences for that zone are then used to calculate the tidal reduction as in the above example. Two different applications of this concept were used in 1976.

Hudson Bay

The Digital Co-Tidal Chart

The tidal characteristics of Hudson Bay have been well analyzed and documented by Dohler, 1966 and Freeman, Murty and Ter Heijdon, 1974. Dale Kimmett of the Tides and Water Level Section, O&AS, Burlington produced a co-tidal chart from this data for use by the Hudson Bay survey in 1975. This co-tidal chart used Churchill, Manitoba as the reference port and was the basis for the digital co-tidal chart described here.

The approach used was to digitize the co-tidal chart by breaking the survey area into equal size blocks based on lines of latitude and longitude, and to approximate the boundaries of the co-tidal zones with the edges of these blocks (Figure 1). Each block corresponded to one cell (byte) in the computer memory containing the zone number in which it lay. Therefore, to obtain the zone number, the position of the sounding was used to locate the particular block or byte of memory.

The construction of the digital chart was done by simply approximating the analogue curves of the old chart with these block boundaries. The choice of the size of the blocks involves a trade-off between the amount of computer memory available and the accuracy of the approximation. With a smaller block size the zone boundaries will be better approximated but the available computer memory limits the number of blocks. The Hudson Bay survey used the INTERDATA Model 70 mini-computer for processing its soundings. This computer had 64 bytes of memory to hold the operating system, the program, the tidal record of Churchill, the zone factors, and the co-tidal chart. A block size of 5' latitude and 10' longitude was chosen. This produced an array of 111 by 126 blocks (13,986 total blocks) and divided Hudson Bay into 93 zones.

The accuracy loss of the digitized co-tidal chart over the analogue version was very small. If we assume the analogue version to be exact, which is a broad assumption, then there was a maximum error of V2/2 times the length of the block. This was approximately 3.5 miles or 6.5 mm at the sounding scale of 1:1,000,000. The storing of the entire co-tidal array in memory was for ease of programming and increased execution speed. If significantly smaller blocks were used, more compact methods of storing the zone numbers would have had to be used. This would have resulted in a more accurate representation of the analogue co-tidal chart with a corresponding reduction in execution speed.

The Hudson Bay Satnav Processing System

The program to take the digital co-tidal chart and apply the proper reduction was easily inserted into the processing system. The final processing system consisted of six programs:

1) REBLOCK, reblocks SATNAV raw data for further processing
2) DMPSAT, dumps data for visual checking
3) POST, adjusts positions between satellite updates
4) REDUCE, adjusts the fix times to even minute intervals and reduces the soundings
5) GEBCOP, produces the plot tape for plotting
6) PLOT, plots the soundings

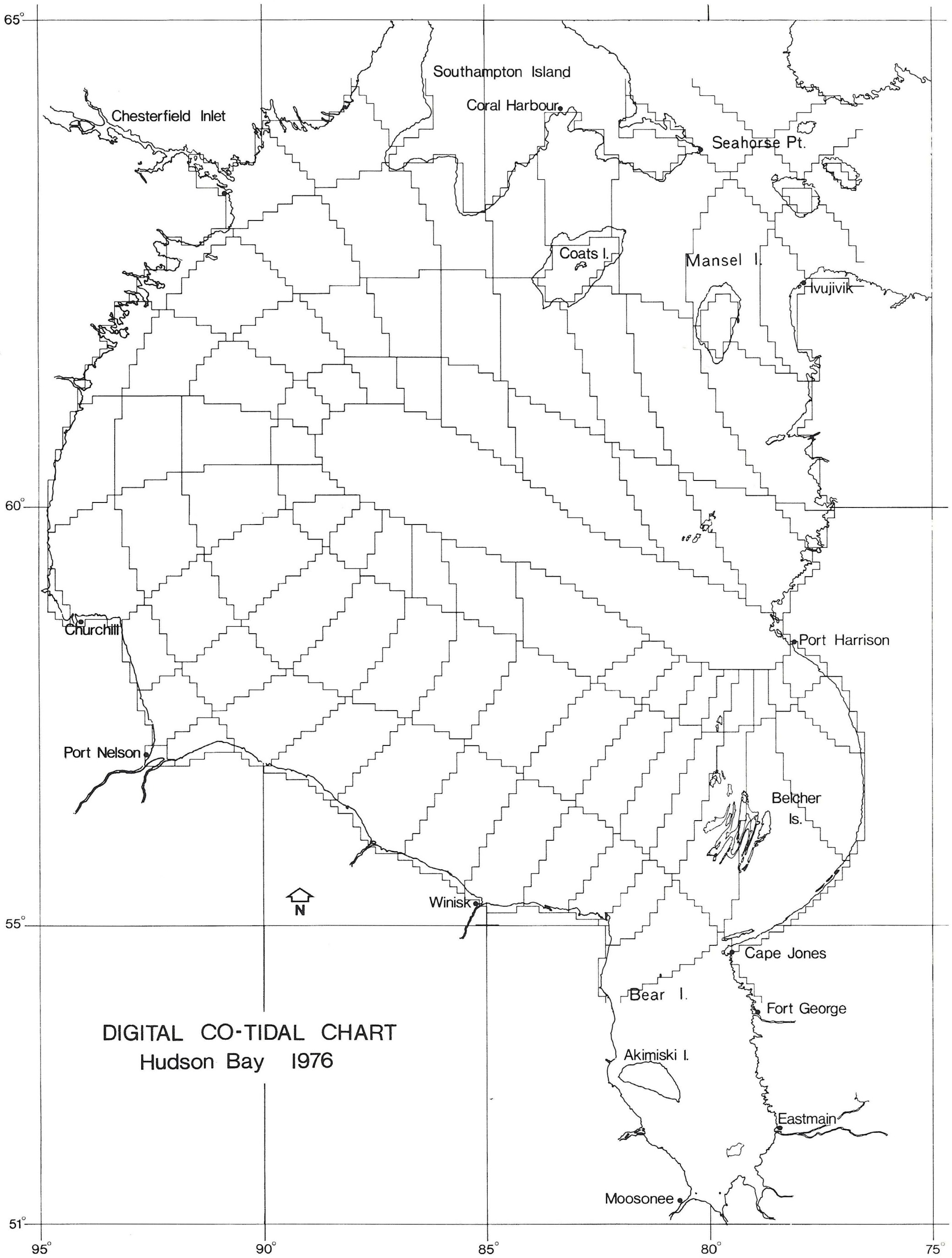

Figure 1.

Since a complete processing step existed to adjust the fix times it was a logical place to apply the automatic tidal reductions. In this way no extra steps were necessary and the total processing time was not significantly increased.

Tidal Predictions

The choice of using observed or predicted tidal data from Churchill was an easy one. Without proper digital telemetry equipment to link the ship to Churchill it was necessary to use predicted values. In this way the entire seasons predictions could be stored in the REDUCE program for access at any time. Predictions were also used in 1975 when reductions were done by hand.

Reduction Logic

The program took each sounding and used the latitude and longitude of the position to locate the proper zone in the co-tidal array. This gave the proper zone number which in turn led to the reduction factors in the zonal differences array. From these reduction factors the time difference was applied to the time of the sounding. The resulting Churchill time was used to obtain the Churchill water level from the tide prediction array. Then the height ratio was applied yielding the proper tide reduction. This procedure took very little time as the computer would process 24 hours of sounding in approximately ten minutes. The 1976 season was very successful, completing 23,561 kilometres in 72 days. An updated version of the reduction program will be used during the 1977 survey season.

Lower St. Lawrence River

The Digital Co-Tidal Chart

The production of the digital co-tidal chart for the Lower St. Lawrence River first required the construction of an analogue chart. The permanent tide gauge at Pointe-au-Père was chosen as the reference port due to its long period of operation and well known tidal characteristics. Thirteen secondary ports throughout the survey area were used to produce the analogue version, with time zones at five minute intervals and range ratios in steps of 0.02 (about 9 cms) times the range at Pointe-au-Père. There was a difference in time changes between high water and low water, so both values were used. That is, if the tide was above mean water level, the high water time difference would be used, otherwise the low water time would take effect. Since the survey was in a river the changes in elevation of mean water level due to the hydraulic gradient of the river surface had to be taken into account. The co-tidal chart was verified in the field by the installation of temporary gauges on both sides of the river.

The digitizing of the co-tidal chart was the same as for the Hudson Bay chart. The processing system for the Lower St. Lawrence River survey used the same mini-computer but with one-half the memory. The block size was therefore chosen relatively larger than Hudson Bay at 2.5 kilometres. The resulting array was 70 by 50 giving 3500 equal sized blocks on the UTM grid (Figure 2). The maximum error in digitizing the analogue version was just over 1-3/4 kilometres.

The INDAPS Processing System

The Lower St. Lawrence River survey used INDAPS (Integrated Data Acquisition and Processing System) with Mini-Fix positioning and, later in the season, Mini-Ranger in the range-range mode. The final processing side of INDAPS contained six main programs. They were:

- IN005 - Reblock INDAPS raw data tapes
- IN007 - Mini-Fix lane jump detector
- IN010 - Position calculation and sounding selection
- IN010B - Tidal Reductions
- IN006 - Processed Tape editor
- IN011 - Sounding Plot

The size of the reduction program was too large to be combined with any of the existing steps so a new step was created. This program was called IN010B and took the selected soundings and applied the reductions to them.

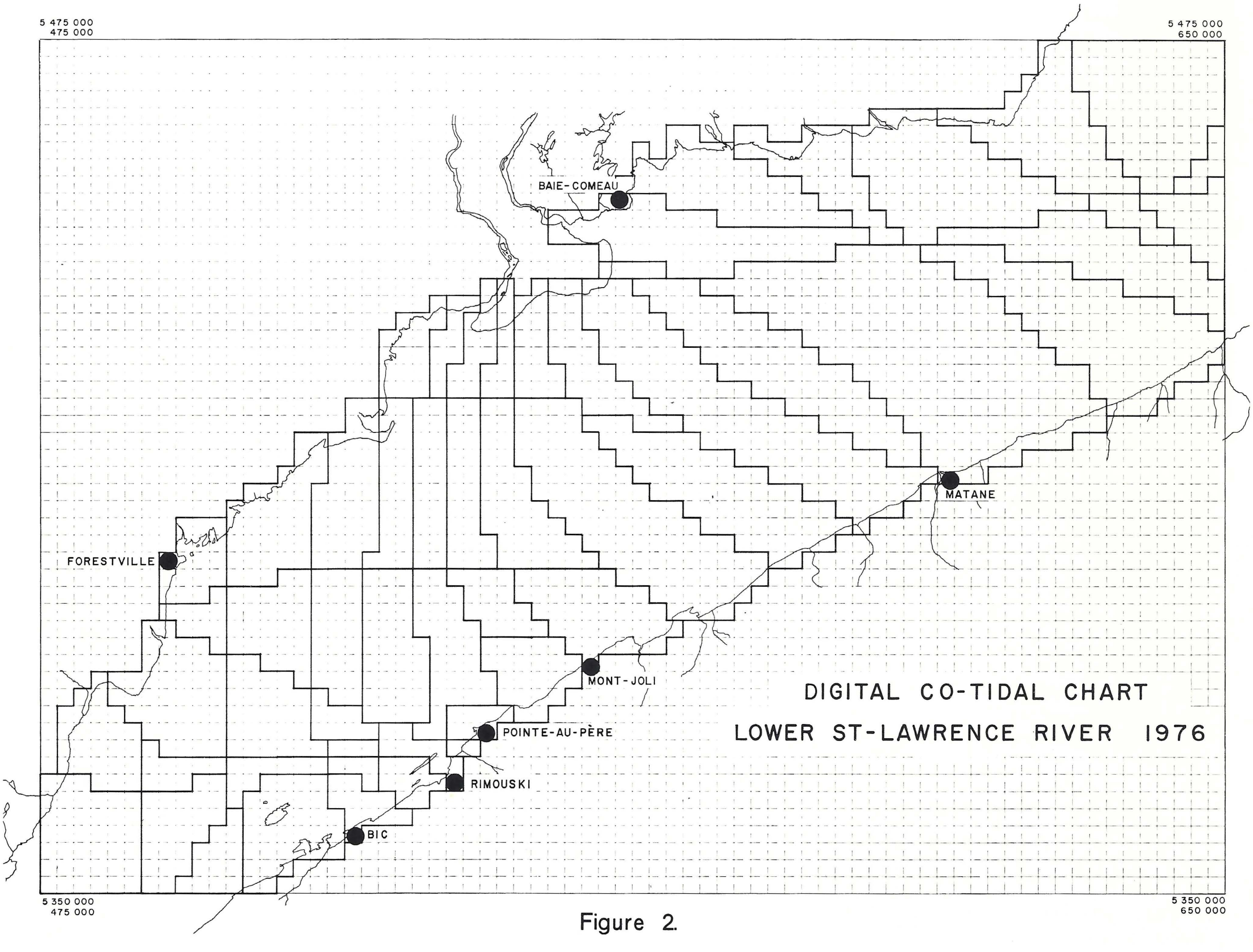

Figure 2.

Observed Water Levels

Observed water levels from Pointe-au-Père were used as the input reference data for the digital co-tidal chart. The survey party was based in Rimouski, Quebec, just four miles distant from Point-au-Père. Therefore, it was convenient to obtain daily water level records. To obtain the required five minute values a Hagenuk punch paper tape float gauge was installed in the Pointe-au-Père gauge house. This produced a paper tape that could be removed at any time and read directly into the computer.

Reduction Logic

The logic of the reduction program was similar to the Hudson Bay program, the only difference being the handling of observed over predicted water levels. The paper tape containing the days water levels was first read into the computer. Then these values could be listed, plotted and edited if necessary. Then the processed soundings could be read in and the proper reduction applied, exactly like the Hudson Bay system. Once the day's paper tape was read in, all the launches' soundings could be reduced together, resulting in a considerable time saving. The reduction program allowed the hydrographer in charge of processing to reduce a complete day's soundings in approximately 30 minutes. One minor round-off error was encountered in the field, but was quickly remedied and corrections made. The 1976 St. Lawrence River survey was quite successful with 18,732 kilometres sounded.

A Brief Look Ahead

The success that these two surveys had with automated tidal reduction systems spurs one to visualize possible future systems. Imagine a system of several reference ports providing real time water levels to the onboard computer. The computer could have a numerical model or co-tidal chart resident in memory. The continuous data from these reference ports, or at least the data at set time intervals would be input parameters to the program. This would provide a real time tide reduction as well as a display of the current tide reduction, all while logging!

Even if a real time system was not possible or practical, the addition of several reference ports would improve the accuracy of the tidal reductions. New digital tide gauges that can be called by telephone or radio could be used to enter the water level values directly into the computer. This would be well suited to a shore based survey such as the Lower St. Lawrence River. Submersible tide gauges (seabed pressure recorders) with acoustic transmitters could be used as reference ports. They could be moored at the beginning of the season and accessed on a regular basis. This equipment exists now and is not some future dream.

For the 1977 survey season on Hudson Bay, an improved digital co-tidal chart will be used. The possible acquisition of digital telemetry equipment could provide actual water levels to the ship. Whether predicted or observed values are used, it appears that automated tidal reductions are now an integral part of the automated hydrographic survey.

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The Cook Bicentennial

R. W. SANDILANDS

Canadian Hydrographic Service
Pacific Region

1778 is a most important date in the history of the west coast of Canada as on 29 March of that year Captain Cook arrived at Nootka on the west coast of Vancouver Island.

The Department of History at Simon Fraser University, Burnaby, B.C., is convening a conference from 26 to 30 April 1978 to mark the bicentennial of Cook's landing. The international, interdisciplinary conference is designed to appeal to people throughout the world who are interested in the results of the voyages of exploration and scientific studies made by Captain Cook and his teams of scientific observers.

Projected are seven main themes, each with three papers and speakers from Canada, Britain, Australia, New Zealand, Hawaii and West Germany will be presenting them. The themes are: 1) Implications of Cook's Voyages; 2) Impact on the European Mind; 3) Cook and Navigation; 4) Scientific Aspects of Cook's Voyages; 5) Cook's Influence on Subsequent Exploration of the North Pacific; 6) Cook and Indigenous People; and 7) Cook's Contemporaries.

Theme three is of particular interest to hydrographers and the proposed papers in that topic are Cook's Influence on Hydrographic Surveying - Rear Admiral G.S. Ritchie of the I.H.B.; Navigation at the time of Cook's Voyages and its Influence on the opening of the Pacific - Commander D.W. Waters of the National Maritime Museum in Greenwich, England, and Hydrographic Surveying on the St. Lawrence River before Cook - Professor J.S. Pritchard, Queens University, Kingston.

A modest exhibition of maps and prints illustrating Cook's voyages is also planned at the University while the new museum of anthropology at the University of B.C. is organizing a major exhibition of Cook and Nootka artifacts to coincide with the conference.

The organizers are hoping for Indian co-operation to make possible an excursion to Nootka Sound after the conference with some small ceremony there to mark the bicentenary of Cook's landing and the friendly relations he established with the Indian people there.

Digitization
How the Atlantic Region is Approaching the Problem

R. BURKE · S. FORBES · K. WHITE

Canadian Hydrographic Service
Atlantic Region

Abstract

The Canadian Hydrographic Service, Atlantic Region has commenced a bathymetric digitization program. A Gradicon Digitizer, Xynetics 1100 Flatbed Plotter and HP2100 Computer System are employed. Rudimentary software has been written for data manipulation, editing and plotting. Digitization rates of 400 depths per hour have been achieved.

Introduction

The Atlantic Region, although realizing that it cannot meet a suggested deadline of 1978 for the submission of all hydrographic data in digital format, has commenced a program toward this goal. One facet of this program that has been underway for a number of years - the automation of field surveys - will continue. The main thrust of this effort will concentrate in replacing aging systems with up-to-date equipment.

A second facet, is the implementation of a computerized digitization and data editing facility in the Region. A number of components for such a system have already been acquired, namely a Xynetics 1100 Flatbed Plotter and a Gradicon Digitizer.

Initial Planning

A study was commenced in 1976 to draft plans for the implementation of a digitization program in the Atlantic Region. While this is an ongoing study, a number of important decisions have been made.

A number of the major components required for an automated digitization facility were available in the region. It was recognized that a digitization program would provide valuable experience and develop the necessary expertise in the region. At the same time, it was also recognized that the long-term goal would be to implement the work of the Automated Cartographic Development Unit at Headquarters rather than to embark upon any major inhouse development projects. Consequently, any major incompatible software developments or capital acquisitions would be avoided.

A second outcome of the study was the appointment of a digitization coordinator. The major responsibilities of the position are the development of software and techniques needed to integrate the digital data with the existing Technical Records and to ensure that this data will meet the requirements of Automated Cartography. In addition, the incumbent provides operator training, orders supplies, and oversees scheduling of equipment use.

Equipment

The Instronics Gradicon Digitizer is an offline system and has the following components:

1. Table and Cursor Assembly (.9 X 1.2 Meters)
2. Display and Control Console
3. Alpha Numeric Entry Keyboard
4. 7 track incremental digital tape recorder

Data (table coordinates and keyboard entry) is recorded on 7 track magnetic tape for subsequent computer processing, editing and plotting. One serious drawback of the offline configuration lies on the inability to correct and edit mistakes at the digitization stage.

Final plots are produced on a Xynetics 1100 flatbed plotter system. This system is well suited for this role because of its size and speed. It is capable of plotting any 1 X 1.4 meter field sheets at rates of up to 15000 digits per hour or 40 inches of line data per second. A HP2100 Computer with 8K of core and an SG 51 look ahead slope generator are used as a controller. A number of options - pen reassignment, scaling, rotation velocity limit and acceleration limit - are available to the operator at plot time. The head assembly handles four pens (see figure 1). Plot tapes are generated on an inhouse CDC 3150 Computer system.

In addition, a HP2100 Computer system equipped with dual MT drives, disc, line printer and a Calcomp 563 drum plotter are employed for editing and verification.

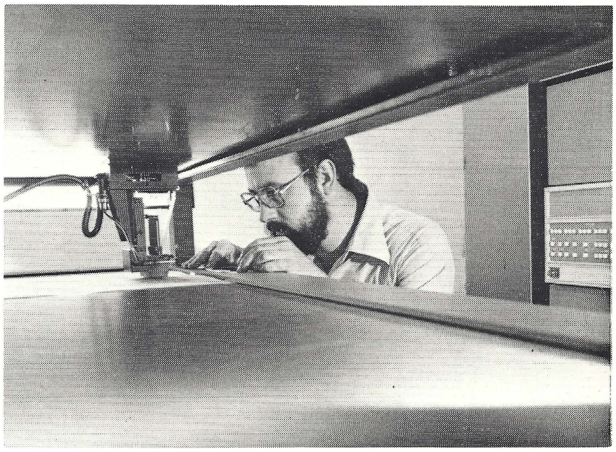

Figure 1. Xynetics 1100 Plotter

Software

Two parallel processing and editing software packages have been written in Fortran for the CDC 3150 Computer system and HP2100 computer system. The reason for parallel software is twofold. First, the HP2100 is better suited to the initial processing and editing. Turn around times up to 24 hours are avoided by bypassing the inhouse CDC3150 batch processing computer facility. Plots on the Calcomp 563 drum plotter with an HP2100 are of sufficient quality and accuracy to be used for verification and editing.

Second, the two parallel processing systems provide a backup. Delays resulting from system downtime or heavy work loads are minimized. Figure 2 is a simplified flow diagram of the editing, verification and plotting procedures followed.

A Tektronix Plot 10 Package has been acquired for use on HP2100 and 21MX Mini Computers. This Package is a comprehensive set of subroutines which allows the operator to interact with the computer using a CRT Terminal.

Routines have been written to display blocks of sounding data within specified limits and scales. The operator then has the option to change, delete or insert soundings utilizing the graphic cursor. The updated data can be displayed between edits if desired, or specified portions of the block can be re-displayed at a larger scale.

At this time, the only data being digitized on a production basis is bathymetry from an offshore survey in the Labrador area. The bathymetry is digitized on the Gradicon table using two personnel. The source document is the field sheet. One operator positions the cursor (depth position) and the other operator enters the depth via the keyboard. This data is stored on magnetic tape in a given format (controlled by the Display Control/Console) for subsequent computer processing. Using this method, a digitization rate of approximately 400 depths/hour can be achieved. The offshore bathymetry data is digitized with an error rate of less than one percent of the total number of soundings digitized. Normally one edit pass is sufficient to correct all errors.

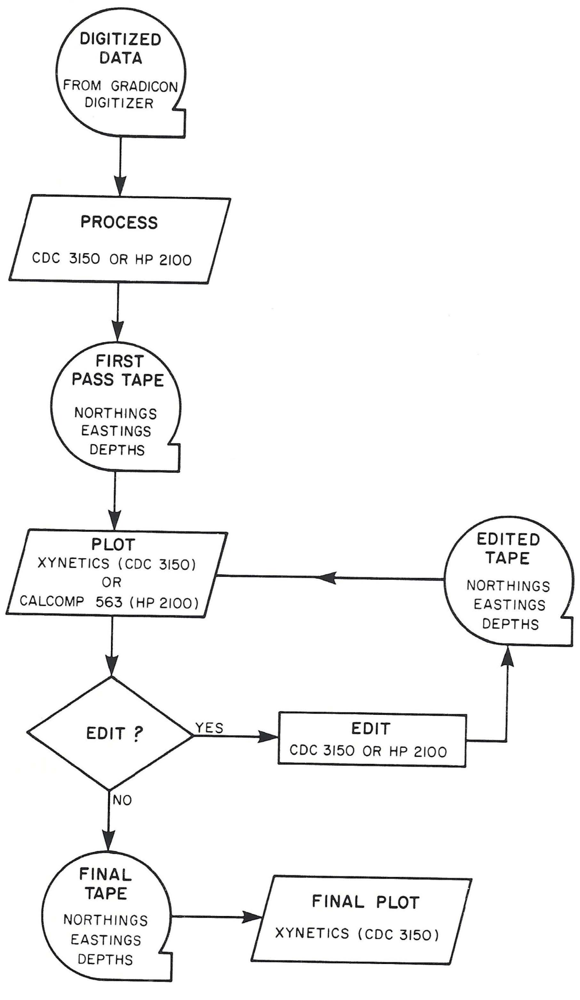

Figure 2. Flow Diagram of Bathymetric Digitization

The offshore data has been selected for the initial trials as it is the simplest to digitize. These field sheets are at a scale of 1/150,000, have a line spacing of 5 or 10 miles and contain approximately 3500 soundings each.

Although shoreline and contour data is not being digitized on a production basis some experiments have been conducted in this area. Software is available to plot line data; however, editing of this data requires more sophisticated routines than we have at this time. Until the proper editing facilities are acquired, errors can only be corrected by re-digitizing.

Gomads

Better digitization and editing facilities will be required when the digitization program is fully implemented. It would not make sense for this region to commit extensive resources to develop specialized systems in light of the work that is being carried out by the automated Cartographic Group at Headquarters. GOMADS (Graphical Online Manipulation and Display System) is implemented on a PDP-11 computer system. Initial investigations have indicated that it would not be advisable to transfer this system to a HP2100 because of software conversion costs, regional incompatibility and the problems presented by system upgrades. Consequently, as a result of limited resources it is not clear at what point in time such a facility can be acquired.

Efforts are underway to formulate an overall national development plan for the implementation of standardized digitization facilities in each region: one facet of this plan that can cut costs, if accepted, is providing both the editing and digitization functions on a PDP-11. On the Headquarters system, digitization is a separate function and uses Gradicon table interfaced to a PDP-8 Computer.

The Data Base

The limited volume of data that has been generated does not present any great difficulties with respect to storage and retrieval. As the volume increases and additional parameters are digitized (i.e., aids to navigation, wharf plans, etc.) a fast, efficient and foolproof data base and management scheme will be essential.

The design and development of a specialized computerized data base system for hydrographic and cartographic applications would be a complex and costly undertaking. A number of computer companies and software vendors offer data base systems. Unfortunately, most of these systems have been designed for commercial applications (payroll and inventory control) and are ill suited to hydrographic purposes. In summary, the data base question needs additional study.

Conclusions

The Atlantic Region's Digitization Program has provided valuable experience and given insight into many practical problems. If the program is to continue in a logical manner, a number of important considerations that must be dealt with in the near future are:

1. The establishment of digitization standards. No written guidelines exist and exact specifications will be required if cartographic requirements are to be met.

2. Steps must be taken to ensure regional compatibility throughout the hydrographic service. If standardization is not established, costly and time consuming duplication of effort will result.

3. Standards must be established for the storage and handling of field data. If a logical approach is not worked out for this question, serious problems are bound to surface in the future.

Tidal Measurement Program of the Bay of Fundy — Gulf of Maine Tidal Regime

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Bedford Institute of Oceanography
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Introduction & General

The study of the Tidal Regime of an area such as the Bay of Fundy/Gulf of Maine requires that there exist a high quality data base of tidal observations. Before the commencement of this study such a set of observations did not exist, with the exception of shore based observations made during past years. It was realized that in order to more fully understand the physics of the Bay of Fundy and hence be better able to predict the ramifications of changes to the system by the placement of barriers, that the accurate measurement and analysis of the tides in the offshore areas would be necessary. These measurements would then form the basis of input and calibration for the numerical modelling of the area.

As in any programme of oceanographic observations carried out on the continental shelf, there exists a certain element of risk with respect to the recovery of moored instrumentation. Many variables can affect the recovery of these moorings, such as the presence of the fishing industry, weather, corrosion, navigation, as well as the failure of key electronic components in the mooring hardware. The mooring of instruments in the upper reaches of the Bay of Fundy presented the additional problem of keeping a mooring in place under conditions of high surface-to-bottom currents.

Instrumentation

The instrument package was designed on the philosophy that the package must be simple and uncluttered, and that it be as unobtrusive as possible in view of the large offshore fishing industry.

The configuration of the resulting mooring is shown in Figure 1. Essentially, the package is a "pop-up" mooring, completely uncluttered with ground tackle. The pressure gauge (Aanderaa TG-3A) is set in a hole in the concrete block anchor and is secured to the top of the release (AMF Model 325) with a slack lanyard. The release, complete with syntactic foam (non-compressible) flotation collars, is shackled to a stainless steel rod which protrudes from the anchor. An OAR submersible flasher and an OAR submersible radio beacon, complete with pressure switches, are secured to the flotation, projecting downwards. The pressure gauge is "cemented" into the anchor by packing bread between it and the anchor. This ensures rigidity during deployment, and ease of recovery, as the bread dissolves away during the duration of the mooring. The instrumentation is lowered to the bottom with a "drop-hook" which releases the package immediately on contact with the bottom. This results in a mooring approximately 1 metre square by 2 metres high.

In order to recover the package, the release is fired by an acoustic command from the ship-borne AMF 200 deck unit. As the package starts to rise,

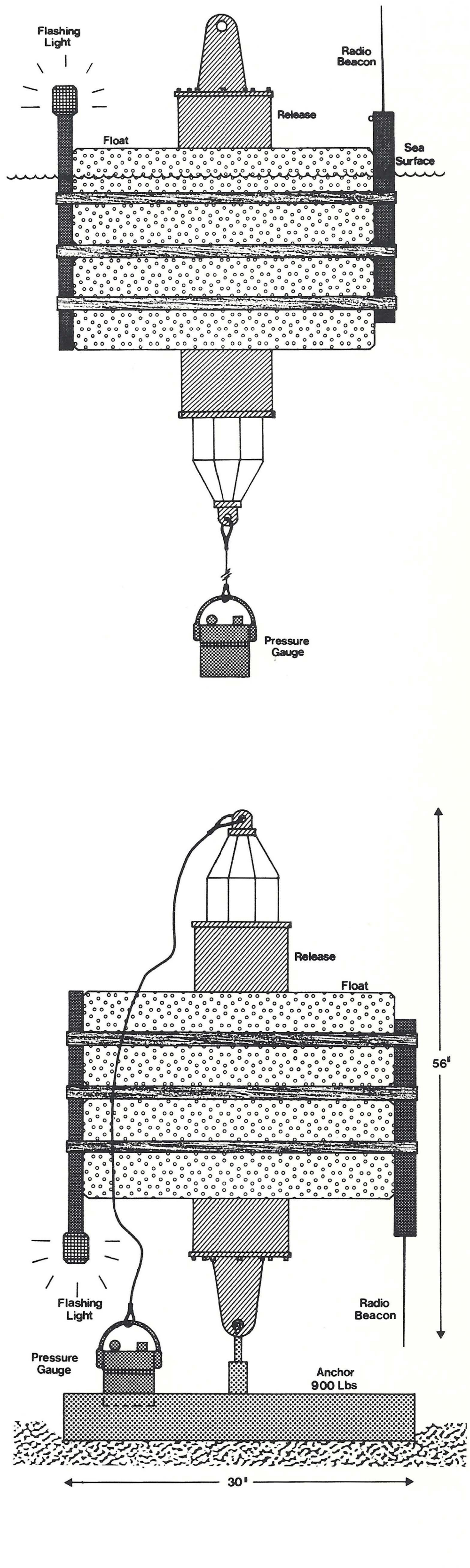


Figure 1.

the pressure gauge produces a turning movement which causes the release to rotate 180° and surface upside down. Once surfaced, both the radio beacon and the light enable easy location. The release hydrophone remains submerged, permitting acoustic ranging on the package.

Design and Execution of the Measurement Program

Stated briefly, the purpose of the program was to obtain high quality tidal measurements along the edge of the continental shelf from Sable Bank to South Cape Cod, in the Gulf of Maine and in the upper reaches of the Bay of Fundy. The resulting measurements would then be used as input and calibration of a numerical model, together with providing support for theoretical work aimed in understanding the physics of the Bay of Fundy/Gulf of Maine system.

Planning

Planning for the field program commenced in February, 1976. It was designed to occur in two parts: Part 1, consisting of a complete set of moorings (7 offshore, 6 inshore) giving a broad coverage of the whole area, and Part 2, consisting of a "filling-in" of gaps left by any non-recovery of part 1 instrumentation, as well as the acquisition of data at locations deemed necessary by the results of Part 1. The mooring locations are shown in Figure 2. In order for the tidal records to be of maximum value, it was decided to obtain 2 months of continuous data at the offshore locations, and 3 months at the inshore sites.

In all cases, the methodology by which the mooring sites were chosen and occupied resulted from discussion with others such that the requirements of theory, modelling and logistics, were satisfied.

Ship Support

During the course of the project, eight cruises were undertaken. All of the inshore cruises were accomplished with the *MV MANGO*, chartered from Advocate, N.S. *MV MANGO*, a 42' Cape Island boat, proved to be very well suited to the inshore Tidal work.
The offshore work was undertaken using *CSS DAWSON* for the two mooring cruises, and the charter vessels *HILLSBOROUGH* and *THERON* for the Part 1 and Part 2 recoveries, respectively.

Reconnaisance Hydrography

As a result of soundings obtained during the mooring of the inshore tide gauges in April, two reconnaissance hydrographic surveys were undertaken to locate and delineate two "deeps", one near Cape Enragé, the other near Cape D'or. The reason for the surveys was to investigate whether the changes, if any, would be sufficient to necessitate changes in the model. The results of these surveys showed deeper water off Cape Enragé than previously charted, and no significant change off Cape D'or.

Mooring Summary — Tide Gauges

The summary of all the tide gauge moorings are contained in Table 1. Overall, the percentage of good data for the project is 71%. The 29% loss of data includes losses by all factors, both loss of mooring and instrument failure.

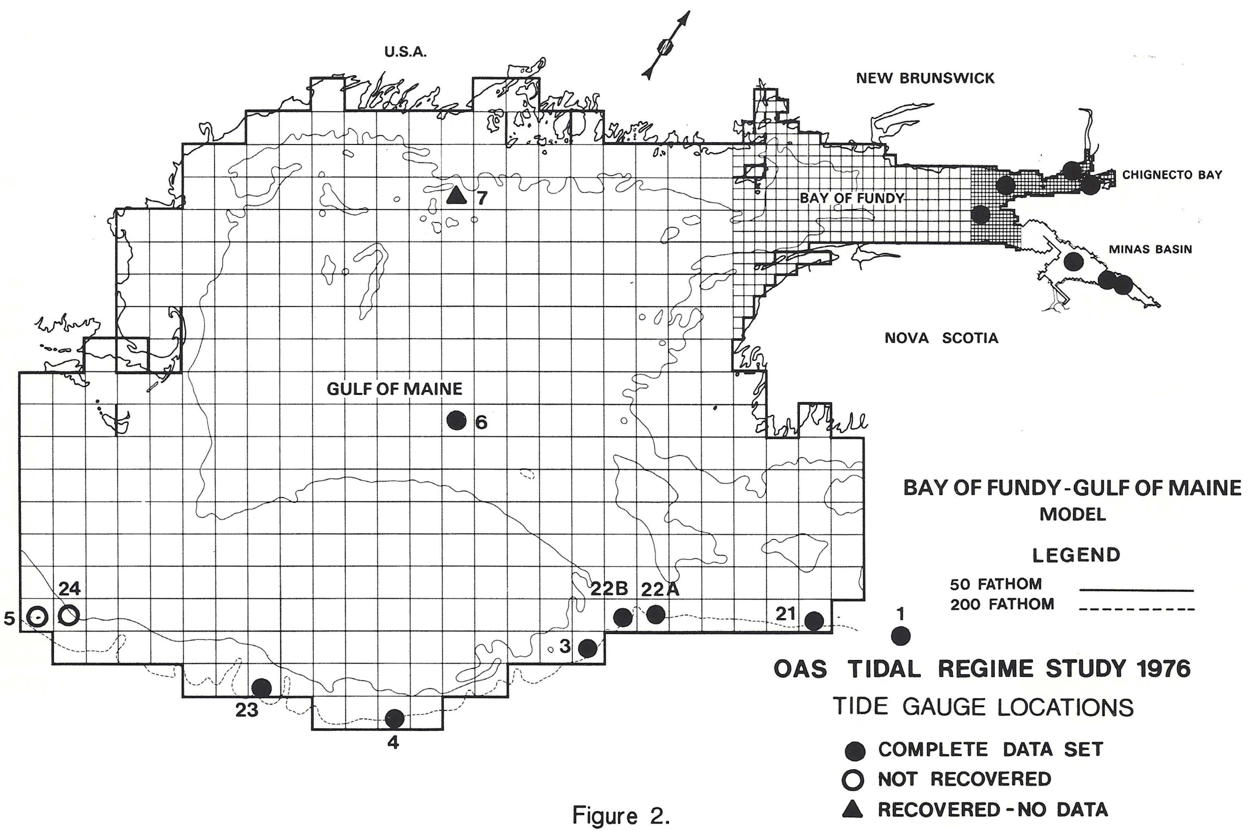


Figure 2.

Current Meters

Two current meter arrays were moored adjacent to stations 2 and 4, both in part 1. The moorings, consisting of two instruments, were placed such that the upper instrument was 27 metres below the surface, and the lower instrument was 100 metres above the bottom. The relevant mooring particulars are as follows:

STN	LAT.	LONG.	COMMENTS
2	$43^0 08'.0$	$65^0 34'.6$	Entire mooring lost, due to flotation failure.
4	$40^0 44'.1$	$66^0 50'.1$	Complete data set, both instruments.

Analysis of the Data - General

The submersible tide gauges used in this project represent the "state of the art" insofar as instruments designed for work on the continental shelf are concerned. They represent such a significant advance in technology that a project of this magnitude would have been impossible a few years ago. Of importance to the analysis of the data are two features of the instrument, namely 1) time keeping ability, ±3 sec/month and 2) pressure resolution, ±0.5 mb, or the equivalent of ±5 mm water. These two features permit, with good calibration techniques, a high measure of confidence in the tidal observations obtained with these instruments.

It must be pointed out that these instruments record bottom pressures and not water levels. Bottom pressures are essentially the sum of the integrated density of the water column plus the atmospheric pressure at the surface. As the purpose of this experiment is to calculate the amplitude and phase lag of the principal harmonic tidal constituents, it is not necessary to calculate water levels from the pressure data. Plots of the pressures recorded at various mooring points are shown in Figures 3 and 4.

The pressure data was extracted at hourly intervals from the half-hourly sampling of the instruments to yield a time series of bottom pressure for each station, suitably adjusted to an arbitrary datum. These time series were then subjected to analysis in order to obtain the amplitudes and phase lags of the various tidal constituents which make up the record.

In order to obtain an independant check on the value of the M_2 tidal constituent, the analysis for each station was done by three different methods, and the results compared. These methods are summarized below. Before analysis, the pressure records were plotted. On some of the records, 'spikes' were evident, caused by difficulties in the translation of the data tape. The faulty records were systematically 'despiked'.

Harmonic Analysis by Least Square

This method of analysis, which is the traditional and most common method, calculates, in a least squares sense, the amplitude, h, of each constituent and its phase lag, g, in degrees behind the corresponding astronomical forcing function.

Cross-Spectral or 'Admittance' Analysis

The second and third analyses employ the techniques of cross-spectral analysis to calculate, at different frequencies, the 'response' of the time series to a suitable reference series. For these tidal records the reference series was a predicted tide for St. John, derived from the harmonic analysis of a 369 day record. This reference series, the components of which are known, is truncated such that the starting and ending time are coincident with the series to be analyzed. This reference series is then used as the 'input', the series to be analyzed becomes the 'output', and the transfer, or admittance, function relating the output to the input, together with the coherence, is calculated over the range 0 to 0.5 cycle/hour, at each of 2 resolutions; 1 cycle/24 hours and 1 cycle/200 hours. From the admittance curves so derived, a linear interpolation is made for the exact frequency of the M_2 constituent. As a result, two additional estimates of M_2 are obtained, independantly of the harmonic analysis.

Analysis Results

The results of this analysis scheme are tabulated in table 2. The values of M_2 obtained by the admittance analyses are used only as a check on the values from the harmonic analyses, therefore the values listed for the harmonic analysis are the accepted values.

The amplitudes of M_2 are in units of centimetres in order to be consistent with the units employed in the model.

As previously stated, the instruments record bottom pressure. In order to convert from pressure units to centimetres suitable assumptions must be made about the gravitational acceleration, g, and the density of the water, ρ. It was initially planned to use temperature and salinity data obtained at the laying and recovery of each mooring to compute a mean value of the density of the water column for each mooring. However, the water column was seen to vary greatly in its characteristics during the duration of a mooring, especially along the edge of the shelf. It was therefore decided to use one mean value for density for all the records.

Using $g = 980.6$ cm-s^{-2} and $\rho = 1.025$ gm-cc^{-1}, the conversion from decibars to centimetres becomes H(cm) = 99.49 (pressure (db)).

Discussion

In comparing the results in table 2, it may be seen that the largest differences between the various analyses are in the order of 2% in amplitude and $<2^0$ in phase. The differences, although not large, would most likely be smaller still if the St. John observed tide rather than the predicted were used.

Perhaps the most significant result of this observational program is the discovery of rapid changes in the M_2 phase lag in crossing the entrance to the Fundian Channel. The phase lag increases quite dramatically in progressing from Stn. 22A to 22B, and then decreases again in progressing to Stn. 3. This is illustrated by the following table:

STN		STN	DISTANCE	CHANGE IN PHASE LAG
22A	to	22B	13 km	$(253.1^{o} - 248.3^{o}) = 4.8^{o}$
22B	to	3	37 km	$(245.9^{o} - 253.1^{o}) = -7.2^{o}$

This result was predicted theoretically by Garrett and Greenberg recently, and is at odds with the assumptions of the numerical model, but in excellent agreement with the results of this field program. To further check the validity of these results, a calculation was made with respect to currents and is described below.

Calculation of M_2 Currents - Fundian Channel

A calculation was made to determine the magnitude of the M_2 tidal current at the entrance to Fundian Channel, by utilizing the values for the M_2 tide at Stations 22A, 22B and 3. The reason for this exercise was to determine what sort of currents would be caused by the rapid phase changes which were found at the entrance to the Fundian Channel.

The current ellipse was arranged such that the V component of current speed was directed into the Fundian Channel (the Y direction) and the U component of current speed directed along the shelf (the X direction). From the equations of motion, we have:

$$U = \frac{1}{\omega^2 - f^2}\left[i\omega g\frac{\partial\zeta}{\partial x} + \frac{\partial\zeta}{\partial y}\right]$$

$$V = \frac{1}{\omega^2 - f^2}\left[-fg\,\frac{\partial\zeta}{\partial x} + i\omega g\,\frac{\partial\zeta}{\partial y}\right]$$

where $\frac{\partial\zeta}{\partial x}$ and $\frac{\partial\zeta}{\partial y}$ are the gradients of the sea surface in the x and y directions respectively, f is the Coriolis parameter, g is the gravitational acceleration and ω is the angular speed of the M_2 constituent (1.41×10^{-1} radians/sec). Solving for U and V gives V = (95.5 cm-sec^{-1}, 97.2^{o}) phase lead of M_2 current into the Fundian channel and U = (65.3 cm-sec^{-1}, -12.6^{o}) phase lead of M_2 current towards the N.W. along the shelf.

These computed quantities do not appear unreasonable, and thus lend support to the existence of the observed phase changes at the entrance to the Fundian Channel.

Summary

As a result of this field program, a wealth of knowledge concerning the tidal regime of the Bay of Fund/Gulf of Maine has been accumulated. The data is of a consistent high quality and will be used as a basis for research work on the continental shelf in a number of disciplines.

References

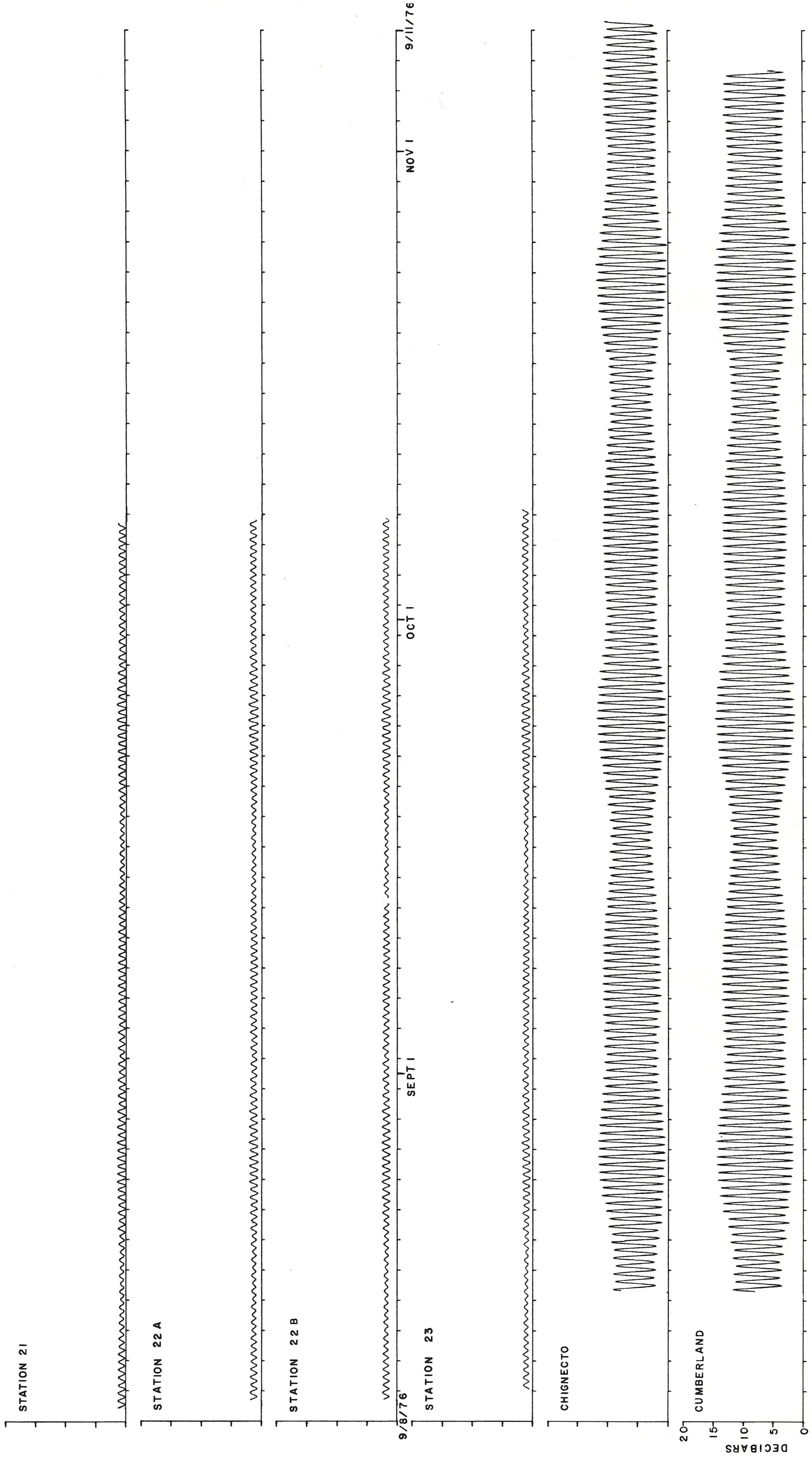
Garrett, C.J.R. and D.A. Greenberg, 1977. Predicting changes in Tidal Regime: The Open Boundary Problem. To be published in *Journal of Physical Oceanography, March 1977.*

Table 1. TIDE GAUGE MOORINGS

STATION	LATITUDE	LONGITUDE	DEPTH	START-END	# DAYS	COMMENTS
1	42°49'.0 N	63°12'.8 W	226M	18/05/76-19/07/76	62	COMPLETE DATA SET
21	42°37'.1	64°22'.5	232M	10/08/76- 8/10/76	58	COMPLETE DATA SET
2	42°08'.4	65°30'.1	192M	---	--	MOORING RELEASED BUT DID NOT SURFACE
22A	42°07'.1	65°30'.1	256M	11/08/76- 8/10/76	58	COMPLETE DATA SET
22B	42°03'.0	65°38'.0	242M	11/08/76- 8/10/76	58	COMPLETE DATA SET
3	41°44'.3	65°48'.1	138M	18/05/76-11/08/76	84	COMPLETE DATA SET
4	40°44'.4	66°50'.6	180M	19/05/76-24/06/76	36	INSTRUMENT FLOODED DUE TO CORROSION AFTER 879 HOURS
23	40°22'.1	67°45'.0	174M	12/08/76- 9/10/76	58	COMPLETE DATA SET
24	40°00'.5	69°36'.0	168M	---	--	LOST
5	39°56'.6	69°44'.9	150M	---	--	LOST
6	42°28'.0	67°43'.0	190M	20/05/76-22/07/76	63	COMPLETE DATA SET
7	43°36'.6	68°47'.7	156M	---	--	MOORING RECOVERED - NO DATA IN TIDE GAUGE DUE TO ELECTRONIC FAILURE
GRINDSTONE	45°43'.2	64°36'.2	11M	29/04/76-29/07/76	90	COMPLETE DATA SET
ISLE HAUTE	45°14'.9	64°58'.2	33M	26/04/76-30/07/76	94	COMPLETE DATA SET (POOR DATA)
CAPE ENRAGE	45°35'.0	64°42'.8	43M	---	--	LOST - REMOVED BY FISHERMAN
MINAS BASIN	45°19'.3	64°12'.2	13M	28/04/76-26/07/76	89	COMPLETE DATA SET
ECONOMY BARRIER	45°18'.7	63°53'.6	16M	28/04/76-27/07/76	90	COMPLETE DATA SET
COBEQUID BAY	45°22'.0	63°44'.4	5M	28/04/76-27/07/76	90	COMPLETE DATA SET
ECONOMY PT.#2	45°19'.1	63°53'.8	20M	---	--	LOST DUE TO MOORING BEING FOULED BY A TRAWLER
CHIGNECTO	45°39'.8	64°59'.4	38M	18/08/76-10/11/76	84	COMPLETE DATA SET
CUMBERLAND	45°40'.4	64°31'.0	15M	18/08/76- 7/11/76	80	COMPLETE DATA SET

Table 2. ANALYSIS RESULTS

STATION	DURATION (hr)	AMPLITUDE (cm)	PHASE (^{o})	TYPE OF ANALYSIS
1	1509	48.25	234.5	Harmonic
		49.35	233.6	Admittance (0.005 cph)
		48.55	234.4	Admittance (0.0417 cph)
21	1405	49.05	241.0	Harmonic
		48.85	240.3	Admittance (0.005 cph)
		47.76	241.4	Admittance (0.0417 cph)
22A	1399	45.77	248.3	Harmonic
		45.57	247.6	Admittance (0.005 cph)
		44.57	248.7	Admittance (0.0417 cph)
228	1400	44.27	253.1	Harmonic
		43.97	252.2	Admittance (0.005 cph)
		43.08	253.5	Admittance (0.0417 cph)
3	2034	39.70	245.9	Harmonic
		38.90	244.5	Admittance (0.005 cph)
		39.70	244.8	Admittance (0.0417 cph)
4	879	40.59	238.9	Harmonic
		40.49	237.2	Admittance (0.005 cph)
		39.99	238.6	Admittance (0.0417 cph)
23	1398	40.79	240.0	Harmonic
		40.59	239.6	Admittance (0.005 cph)
		39.80	240.6	Admittance (0.0417 cph)
6	1523	88.15	330.5	Harmonic
		87.25	329.5	Admittance (0.005 cph)
		87.75	330.3	Admittance (0.0417 cph)
Grindstone	2181	481.1	348.8	Harmonic
		477.5	349.1	Admittance (0.005 cph)
		479.5	349.1	Admittance (0.0417 cph)
Isle Haute	2277	413.9	343.3	Harmonic
Minas	2139	548.5	4.6	Harmonic
		541.5	5.5	Admittance (0.005 cph)
		545.2	5.2	Admittance (0.0417 cph)
Economy	2161	589.3	9.5	Harmonic
		581.4	10.5	Admittance (0.005 cph)
		585.4	10.2	Admittance (0.0417 cph)
Cobequid	2160	595.1	13.4	Harmonic
		597.8	14.5	Admittance (0.005 cph)
		602.0	14.1	Admittance (0.0417 cph)
Chignecto	2018	416.3	347.1	Harmonic
		408.7	347.3	Admittance (0.005 cph)
		409.4	347.3	Admittance (0.0417 cph)
Cumberland	1941	471.1	348.7	Harmonic
		462.4	349.2	Admittance (0.005 cph)
		463.0	349.2	Admittance (0.0417 cph)


STATION 21
STATION 22 A
STATION 22 B
STATION 23
CHIGNECTO
CUMBERLAND
9/8/76
SEPT I
OCT I
NOV I
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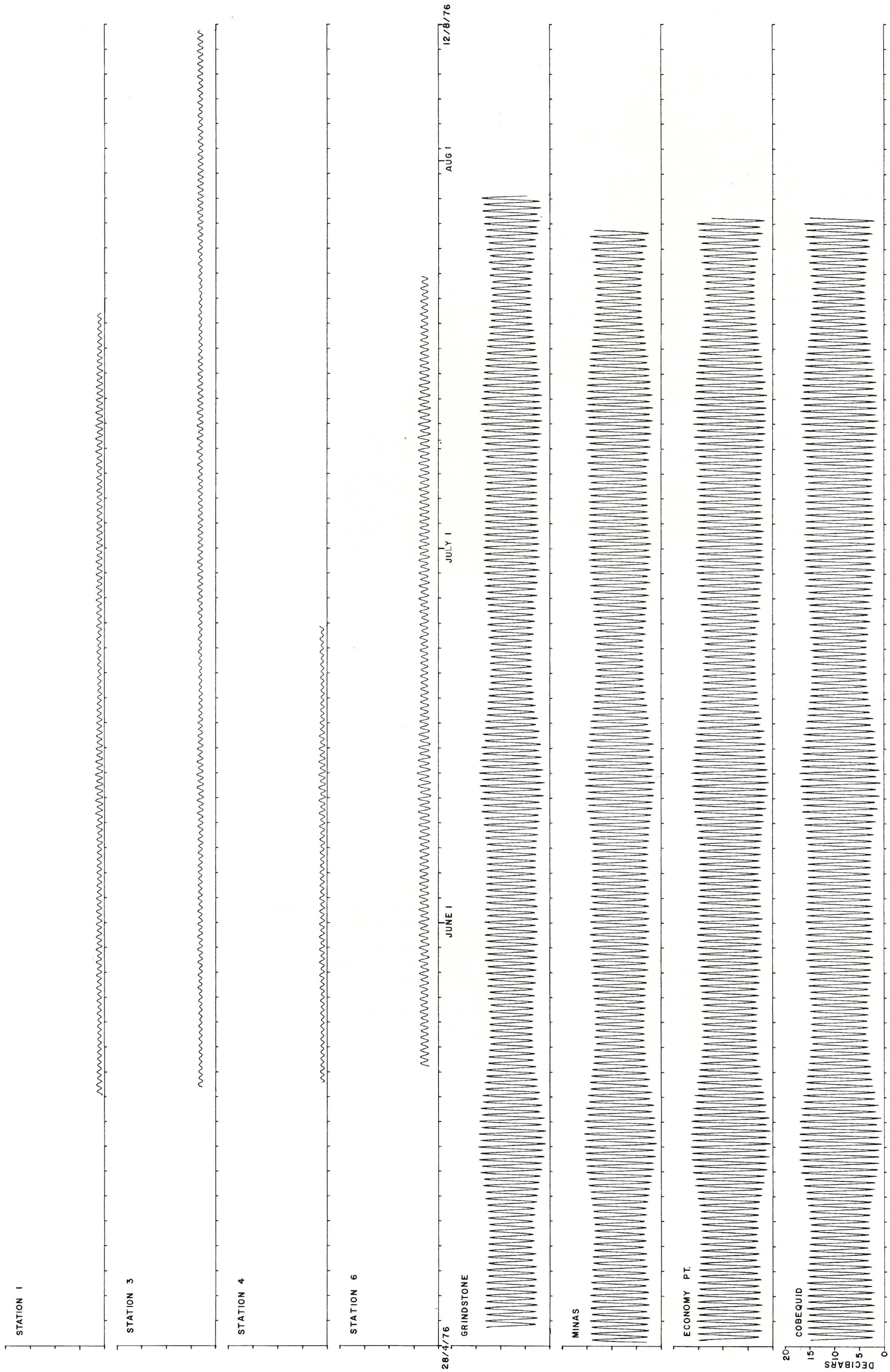
STATION 1
STATION 3
STATION 4
STATION 6
GRINDSTONE
MINAS
ECONOMY PT.
COBEQUID
28/4/76
JUNE 1
JULY 1
AUG 1
12/8/76
20
15
10
5
0
DECIBARS

Towards a Maximization of Information Recorded on Hydrographic Echograms

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Automation versus 'Useful' Echograms

Throughout the past eight to ten years the Canadian Hydrographic Service has been injecting data logging and processing systems into their repertoire of field equipment and is now rapidly approaching the concept described as automation in their field surveys. Concurrent with the coming of automation has been a significant increase in the operating frequencies of many of the survey echo-sounders from about 14 KHz (Kelvin and Hughes MS 26 B) to 100 KHz (Ross 400 Fine-Line) and even 200 KHz (Raytheon DE 719).

> "Is the optimization of echo sounders for automation detracting from the usefulness of their analogue record for geological purposes?"

To this question which was raised during a meeting of the Joint DOE/EMR Guiding Committee on Offshore Surveys, the answer, surprisingly enough, is a simple no.

Although it is clear that an increase in echo-sounder frequency detracts from the sub-bottom information recorded on the echogram and that an increase in frequency was concurrent with the implementation of automation, it is not clear either that the higher frequencies are or are not a result of automation or that they can detract from, rather than enhance, the geological or geophysical usefulness of the echogram. In addressing these problems it is important that the advantages and disadvantages of higher frequencies be considered. However, as they are to be dealt with in considerable detail further on, at this time only a few advantages of the higher frequencies shall be reviewed.

Obviously one of the data requirements for an automated hydrographic survey is a digital depth which, as has often been pointed out, is easier to obtain if the only signals processed by the echosounder are a short, sharp pulse of transmission crosstalk and a single, sharp, coherent pulse of bottom reflected signal. All other acoustic returns originating from water column reverberation, fish, vessel selfnoise, weed, subbottom reflectors, second echos* and the like are indeed regarded as noise in the depth digitization process. However, this ideal condition for depth digitization, which is most readily approached with higher frequency echo-sounding systems, is not strictly necessary. This statement is re-inforced by the success realized during the past few years where automated surveys aboard C.S.S. Parizeau have been conducted using a 12 KHz sounding system.

If then higher frequency echo-sounders are not a strict requirement for automation why have they evolved, why are they in common use throughout the hydrographic community and how do they effect the echogram from a geological or geophysical point of view? The answers to these questions are intimately tied to the following list of advantages gained through the use of higher frequency sounders.

Advantages of Increased Frequency Echo-sounders:

(i) Shorter pulse lengths

- shallower depth capability
- higher resolution

(ii) Lower level of ambient noise

- better signal to noise ratio
- lower acoustic power required
- less noise on echogram
- more definite bottoms

(iii) Smaller transducers

- narrower beam widths
- easier launch installations
- portable sounders

Considering these advantages together with the fact that the major echogram related concern of the Hydrographer is that of a well defined bottom, it should be apparent that the evolution of higher frequency systems was inevitable. This concern for a well defined water-bottom interface is very useful from a geological and geophysical point of interest, possibly even to the extent where it makes up for the loss of sub-bottom information. It is, however, this concern rather than automation which remains a much more serious threat to the multi-purpose (in the sub-bottom, above-bottom sense) echogram; for the hydrographic echo-sounder will typically be adjusted to clarify this interface to the detriment of all other reflectors.

It should now be apparent that the culprit 'Automation' was simply a minor member of a gang of reasons why the Canadian Hydrographic Service does not, at present, produce echograms which provide the maximum amount of information for the geologist or, for that matter, for the physical oceanographer, the fisheries biologist, the fisherman, the chemical oceanographer, the civil engineer, or even for the hydrographer. Is there a means by which these deficiencies can be alleviated and the information content of the echogram can be maximized without detracting from the basic hydrographic usefulness and the digitizing capacity of echo-sounder systems?

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*Could be used by a "smart" digitizer to re-inforce the first echo decision.

Information which could be recorded on Hydrographic Echograms

In order to obtain the maximum amount of useful information related to a particular science whether it be Geology, Geophysics, Biology or Hydrography, the use of specialized equipments, designed specifically for the task is required. In the case of Marine Geology or Geophysics specialized equipment must be utilized if one is to obtain a maximum amount of information relating to sub-bottom structure, or to textural qualities of the bottom or to geomorphology. If records collected for the purposes of Hydrographic Survey are to be examined for geological information it must be recognized that the primary data requirements of these two fields focus on the same point only at that small spot on the sea-bottom vertically below the survey vessel. Additional sea-bottom data, of secondary importance to the Hydrographer but of primary importance to the study of Marine Geology, includes the general or wide angle profile, the general texture and roughness qualities of the bottom, the general bottom composition, and of course the sub-bottom profile. This secondary information can assist the Hydrographer in his judgements as to the contours, the quality of the bottom (composition) and the possible location of shoals, in addition to providing support for his final, overall description of the survey area. Since this 'secondary' information can be of value to the hydrographer and is a definite requirement of the marine geologist, it is apparent that if a means exists to record it, it should be collected.

What then is the maximum amount of useful information which under the constraints of the 'general hydrographic echo-sounder' could be recorded on the echogram(s)? There are no Canadian Hydrographic Service Standing Orders which dictate echo-sounder specifications or system characteristics. The closest approach to such a regulation is found in chapter 3 (Sounding), volume 2 of the Admiralty Manual of Hydrographic Surveying where it states: "Most modern echo-sounders generate fairly high frequency pulses, the criterion being that provided the range of the set is satisfactory, the frequency should be as high as possible". Historically 12 KHz has been the accepted lower limit of system operating frequencies for hydrographic echo-sounders with the upper limit apparently floating to 'as high as possible'. Based on these few precepts I will postulate the 'General Hydrographic Echo-Sounder' as having the following system characteristics*:

Frequency	12 KHz to 200 KHz
Power	100 watts to 2000 watts
Beamwidth	2.5° to 30°
Pulsewidth	0.1 msec. to 3.0 msec.

*A single, vertical working beam is presumed as the possibility of utilizing side-scan, sector-scan, steerable beam or multi-beam systems is not taken into consideration in this paper since it is the optimization of the present type of profiling system which is under review.

With this general echo-sounder it should be possible to collect the following information:

(i) Depth to and content of scattering layers,
(ii) Depth to or quantity of and location of fish,
(iii) Density or quantity and location of weed,
(iv) Detection and location of sunken debris,
(v) Depth to and detection of 'slurry' or low velocity bottoms,
(vi) Depth to sediment or first bottom vertically below vessel,
(vii) Indication of bottom texture or roughness,
(viii) Indication of bottom composition (material),
(ix) Bottom geomorphology (wide beam coverage),
(x) Depth to and location of sub-bottom debris (30 meter max.),
(xi) Depth of sediment overburden (40 meter max.),
(xii) Sub-bottom geomorphology (to 40 meter max.),
(xiii) Indication of sub-bottom texture or roughness,
(xiv) Indication of sub-bottom composition.

Those qualities of echo-sounder systems which are important to the enhancement of each of these types of information differ, in many cases, very significantly. The specific system requirements for each of these data types can be concluded from the following descriptions.

(i) Depth to and Content of Scattering Layers

These scattering layers, or DSL (Deep Scattering Layer) which occur in every ocean, are believed to be comprised mainly of biological scatterers. The layers vary in depth in a diurnal fashion, remaining at a constant depth during the day and at a slightly shallower constant depth during the night. The acoustic return from the DSL is mainly a volume reverberation from within the layer, and the volume scattering strength exhibits a definite frequency dependence. Studies have shown that the DSL is multilayered with strong resonant scattering occurring at different depths dependent upon frequency.

Within the range of frequencies of interest to Hydrographers for deep water surveys, from 12 KHz to say a 50 KHz maximum, resonant peaks, each attributable to a different species of 'beastie', have been observed at 6 to 15 KHz, 15 to 40 KHz and above 40 KHz. The typical mean depth of a DSL is in the neighbourhood of 400 meters with an average thickness of about 100 meters. System characteristics necessary for detection of the DSL are not critical, for indication of content, however, frequency must be specified.

(ii) Depth to or Quantity of Fish

Echo-sounders are often used in studies to determine fish stocks. If hydrographic systems were set up to record fish information, they could provide an excellent source of historical data in surveyed areas. The system characteristics necessary for the enhancement of fish targets are very similar to those required for good bottom definition - that is, as high a frequency and as short a pulse length as possible with target depth as the limiting factor.

(iii) Density or Quantity and Location of Weed

This information of possible interest to commercial interests, marine biologists and to fishermen can be enhanced by keeping system frequency high, pulsewidth short and power levels at a minimum.

(iv) Detection and Location of Sunken Debris

The detection of sunken debris implies the provision of high definition echograms displaying any distinct features of the debris in contrast to simply providing limiting depths over the hazards. Again a requirement to provide high resolution which necessitates short pulse lengths, narrow beam width and frequencies as high as possible under the constraints of the depth.

(v) Depth to and Detection of Slurry

The occurrence of a silt 'slurry' or, as it is often referred to, a low velocity bottom (because the velocity of sound in this slurry is typically less than in the water above it) can constitute a hazard to shipping in that it can clog intakes, foul machinery and sometimes exert damaging pressure on a ships hull. The presence of this type of bottom is most reliably detected with higher frequency sounders since at low frequencies the strong sub-bottom return can mask and even cancel the initial returns.

(vi) Depth to Sediment or First Bottom Below Vessel

Similar to (v); where higher frequency provides a more reliable indication of silt or mud bottom since there are no significant sub-bottom echos to mask initial returns. Bottom definition is important in this case and a narrow beam width is required to ensure that any abrupt changes in the bottom are not smoothed by wide beam geometric effects (hyperbolic effects).

(vii) Indication of Bottom Texture or Roughness

A very good indication of bottom texture or roughness can be obtained from echograms. In this case the system characteristic which most limits resolution is beam width. Two scales of roughness can be recognized. The first or large scale is where bottom variations are on a scale comparable to the diameter of the spot of ensonified bottom (i.e. beam width and depth dependent). For bottoms where the features are large, relative to spot size, a fully resolved bottom is achieved. Where the variations are much smaller than the spot size the beam geometry effectively low-pass filters the returns providing a relatively smooth echogram. For bottom features around the same size as the acoustic spot, the echogram is typically a jumble of hyperbolic returns. The smaller scale of roughness is related to the bottom material and the texture of the bottom surface. For bottoms which have a smooth texture (i.e. smooth rock, flat sand, etc.) the returns will be coherent and the reflected pulse length will approximate the transmitted pulse length. For rougher bottoms (i.e. broken rock, gravel, boulders, etc.) the echos will be a sum of incoherent contributions from the various surfaces and the pulse length will be considerably longer. The enhancement of this information is best achieved by using a very narrow beam width, however, useful information can be obtained even from wide beam sounders. Resolution of roughness in a vertical sense is dependent upon pulse width.

(viii) Indication of Bottom Composition (Material)

The indication of bottom material is typically a result of correlating a grid of bottom samples to echograms, then interpolating. Roughness indications, as described above, can be used in addition to bottom penetration information. A further requirement, over and above the system requirements for (vii), is therefore that of bottom penetration. Bottom penetration is enhanced by lowering the system frequency since the attenuation of sound in the sediments, as in water, decreases as a function of frequency.

(ix) Bottom Geomorphology (Wide Beam Coverage)

As the topic indicates, it is possible to obtain a relatively good concept of the bottom geomorphology by using a wide beam echo-sounder. Although the nature of the system does not permit resolution of side echos insofar as to which side of the beam they lie, a better indication of the type of topography present is provided by an increased beam width.

(x) Depth to and Location of Sub-bottom Debris

The prime considerations in the enhancement of this information are low frequency for sub-bottom penetration and as short a pulse length as possible for increased vertical resolution. A narrow beam width will increase horizontal resolution.

(xi) Depth of Sediment Overburden

Again of prime importance is bottom penetration, in this case all the way down to an impenetrable (at 12 KHz) layer or to a maximum of 40 meters of sub-bottom penetration. Pulse width is of significance in the enhancement of this information in that it determines the resolution to which the layer thickness can be measured, and as was the case in (vi), a narrow beam width is necessary for increased definition.

(xii) Sub-bottom Geomorphology (to 40 meters)

The system requirements for sub-bottom geomorphology are identical with those for determination of bottom geomorphology except that only the low frequencies are useful since penetration is needed.

(xiii) Indication of Sub-bottom Texture or Roughness

The enhancement of this data is achieved as for (vii), however since bottom penetration is required, only the lower frequencies are usable.

(xiv) Indication of Sub-bottom Composition

It is very unlikely that much useful information regarding sub-bottom composition will be recorded on hydrographic echograms. However, if echograms are correlated to core samples and if low frequency, narrow beam, high power systems are used, the possibility of obtaining some useful data will exist.

The following table summarizes the range of system characteristics considered most appropriate to each type of information.

It is clear that this information could not all be collected at a single frequency. Not all would be recorded were a single power level to be used and certainly the utilization of a single beam width or a single pulse width would further restrict the available information. To achieve a maximization of information it is necessary to either trade-off various system characteristics which enhance one type of information against the degradation of another or to operate two or more systems simultaneously. An alternative to these solutions is to operate a multi-purpose system which has selectable characteristics and a simultaneous multi-frequency capability.

How many Echo-Sounders

The following equipment recommendations which are based upon a consideration of the required echogram information and the various system characteristics necessary to enhance it, are put forward as a solution to the problem of maximizing the information recorded on hydrographic echograms.

-Small Boat and Portable Requirements

For applications in small boats (i.e. Boston whalers) and for portable sounders it is recommended that, in the interests of portability and speed of installation (most C.H.S. small boats have 200 KHz transducers installed), the emphasis remain strictly upon the acquisition of a high definition echogram of the "first" bottom. This endorses the continued utilization of a small, 200 KHz echo-sounder (Raytheon DE 719, or equivalent) to meet the small boat requirement.

-Survey Launch (25 to 35 feet) Requirements

The sounding systems presently in use in the C.H.S. survey launch typically meet only the primary hydrographic requirements for echogram information.

The acquisition of maximum information would require the use of more than one echo-sounder. It is generally agreed that, in the survey launch situation, the probability of operational difficulties arising from the additional sounder is high and that the primary echogram would suffer from a lack of necessary attention. The optimum compromise appears to be a dual frequency sounder providing a single echogram capable of exhibiting returns from two separate channels.

In addition to providing the dual frequency capability, the system should provide selectable output power levels and selectable pulse widths. The frequencies suggested for the launch system are included in the following basic specifications for the recommended "Ideal Launch System".

Ideal Launch System:

Frequency:	15 KHz & 100 KHz: Dual Frequency sounder
Power:	500 or 1000 W & 150 or 500 W: Selectable

Type of data		Possible range of system characteristics			
		Frequency (KHz)	Power (watts)	Beam width (degs.)	Pulse width (msec)
(i)	D.S.L.	12-50	300-2000	2.5-30	0.2-2.0
(ii)	Fish	12-200	100-2000	2.5-30	0.1-1.0
(iii)	Weed	30-200	100-500	2.5-15	0.1-0.5
(iv)	Sunken debris	12-200	100-2000	2.5-15	0.1-1.0
(v)	Low vel. bottoms	70-200	100-500	2.5-30	0.1-0.5
(vi)	First bottom	30-200	150-500	2.5-10	0.1-0.5
(vii)	Texture	12-200	100-2000	2.5-30	0.1-1.0
(viii)	Composition	12-30	300-2000	2.5-30	0.2-1.0
(ix)	Bottom geomorph.	12-30	300-2000	20-30	0.2-1.0
(x)	Sub-bottom debris	12-30	300-2000	2.5-15	0.2-1.0
(xi)	Overburden	12-15	1000-2000	2.5-15	0.1-3.0
(xii)	Sub-bottom geomorph.	12-15	1000-2000	20-30	0.1-3.0
(xiii)	Sub-bottom texture	12-30	500-2000	2.5-30	0.2-2.0
(xiv)	Sub-bottom comp.	12-15	1000-2000	2.5-15	0.2-2.0

Beam width: 20° to 30° & 5° to 10°: fixed value
Pulse width: 0.2 to 2 msec. & 0.1 to 1 msec.: selectable

It is worth noting at this point that this equipment is not available as a single, production echo-sounder from any manufacturer.

The Atlas - Deso 10, which at one time was advertised as having a 10 KHz - 100 KHz dual frequency capability is now offered with a 30 KHz minimum frequency. The Pacific Region, C.H.S., is presently using Atlas - Deso 10 sounders in three survey vessels and field results indicate that the 30 KHz is not a low enough frequency, the beamwidths (19° and 15°) are not sufficiently different, and the power levels are too low (150 W) to provide an optimum level of information on the echogram. It is recommended that a system such as the "Ideal System" be considered for launch applications and in the interim any new acquisitions should be dual frequency 30 KHz - 100 KHz Atlas - Deso 10 (or equiv.) as it can, in shallow water (say to 100m) provide fairly good sub-bottom penetration. It is worthwhile noting at this juncture that the technology required to have the selected system characteristics such as power, pulse length, gain, etc. annotated directly and automatically on the echogram is readily available. If this feature were included on the CHS systems and the echo-sounder maintenance programs were modified to include the calibration of system output power, a much more reliable indication of bottom reflectivity would be available.

-Survey Ship Requirements

The lack of space, electrical power and manpower, which prevent the operation of more than one echo-sounder in a launch, is not typically a problem aboard a survey ship. The shipboard survey can generally accommodate the additional equipment and should, therefore, carry and operate the variety of echo-sounder systems necessary to record the maximum amount of information. The recommended systems complement of the survey ship is as follows:

(i) A dual frequency system with the following general specifications:

Frequency: 30 KHz & 100 KHz
Power: 150 or 500 Watts & 150 or 500 Watts selectable
Beam width: 10° to 20° & 5° to 10°
Pulse width: 0.1 to 1 msec. & 0.1 to 1 msec. selectable

(ii) A 12 KHz system as follows:

Frequency: 12 KHz
Power: 500 or 2000 Watts selectable
Beam width: 2.5°* to 30°
Pulse width: 0.2 to 5 msec. selectable

*If a stabilized narrow-beam system is available it should, in most instances, be used in lieu of a wider beam 12 KHz system.

Note: This system could make use of the commercially available "chirp-sonar", correlation-processing transceivers (i.e. Raytheon CESP III) in view of the demonstrated capability of these equipments to dramatically improve the signal to noise ratio. The decision to use this equipment however should not be made without due recognition of the associated, inherent loss of signal amplitude (and therefore reflectivity) information. Although generally too low a frequency for obtaining high definition bathymetry, if a 3.5 KHz system is available and if the Marine Geology/Geophysics community expresses interest in the area to be surveyed, then this equipment should be operated.

With these systems deployed in the field, the hydrographic survey parties should, in an equipment sense, be prepared to attempt the acquisition of a maximum quantity of information on the echograms.

Echo-Sounder System Operator — The Hydrographer

One vital factor which has considerable influence on the quality of the echogram and the variety of information it includes is the operator. In the course of a hydrographic survey the operation of the echo-sounder is carried out by a hydrographer. As would be very noticeable in the case of the "Ideal System", it is the operator who, by optimizing the sounder variables, is able to maximize the quality and quantity of the recorded information.

Since the hydrographer shall be expected to make the correct decisions regarding which data to acquire, as well as the necessary sounder adjustments to ensure that it is recorded, there must be additional training made available. It is not sufficient that he simply understand the instrumentation, if he is to collect meaningful data he must know which data is meaningful. The additional training therefore must provide some background in underwater acoustics, marine geology, marine geomorphology and perhaps even a smattering of marine biology, as well as more extensive training in the operation of the sounding system and the interpretation of echograms.

This additional training could provide the basis for a hydrographer's report containing value judgements on the quality and nature of geological or geophysical information contained in the echograms recorded during their surveys. These reports could result in a significant time saving when the marine geologist reviews the survey records. This further training related to the nature of the seabed may also prove to be of considerable value to the hydrographer when making decisions such as bottom quality and location of possible dangerous areas and when contouring the field sheet.

Summary

The analogue records currently acquired during C.H.S. hydrographic surveys do not typically provide a maximum degree of multi-discipline information. In order to record an optimum level of information on hydrographic echograms further consideration of system specifications and the skilled application of more versatile, multi-parameter sounding systems is required.

It is also safe to conclude that given more training and more equipment the hydrographer should be more capable of collecting more information for more interested parties in more disciplines, more or less.

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I Am Become A Name (Tennyson)

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A few years ago I was engaged in a resurvey of part of Malaspina Strait and Jervis Inlet (Chart 3589). The toponomy of this area is a naval historians delight and gives some insight into the application of place names as practiced by the Admiralty hydrographers on the west coast.

When Captain G. H. Richards R.N. surveyed the area in detail *circa* 1860 the only main feature named was *Jervis Inlet* itself which had been named in 1792 by Captain Vancouver R.N., and this became Richard's starting point in the thread that runs through the names in this area.

Rear Admiral Sir John Jervis was created Earl of St. Vincent in 1797 after his victory over the Spaniards at the battle of Cape St. Vincent. Nelson was a Commodore in the fleet of Jervis at that battle.

As one sails north from Pender Harbour the large island lying to the northwest is *Nelson Island* which is separated from the Sechelt Peninsula by *Agamemnon Channel, HMS AGAMEMNON* being Nelson's first line-of-battle command, a 64 gun ship which later took part in the battle of Trafalgar.

The southeast point of the island is *Fearney Point* named after William Fearney who was Nelson's bargeman. The southwest point of the island, with a light on it, is *Cape Cockburn* after Admiral Sir George Cockburn, Nelson's old friend and captain of the frigate *MINERVE* at St. Vincent.

At the northwest of the island *Blind Bay* and *Telescope Passage* recall the battle of Copenhagen when Nelson put his blind eye to his telescope and ignored his Commander-in-Chief's signal of recall.

Across Blind Bay and appropriately lying side by side with Nelson Island is *Hardy Island*. The northwest point of this island is *Ball Point* named after Rear Admiral Sir Alexander Ball who was another of Nelson's "band of brothers" and who commanded *HMS ALEXANDER* at the battle of the Nile. However it is not clear if *Alexander Point* at the southwest of the island is named after the Admiral or his ship.

Two of Nelson's ships are commemorated on the south shore of the Jervis Inlet. Firstly, on the north shore of Nelson Island, *Vanguard Bay* was named for *HMS VANGUARD*, 74 guns, Nelson's flagship at the Nile and further east at the junction of Agamemnon Channel lies *Captain Island* after *HMS CAPTAIN*, his ship at St. Vincent.

The northeastern point of Nelson Island is *Nile Point* after Nelson's victory over the French at Aboukir Bay.

At the entrance to *Hotham Sound*, named after Admiral William Hotham who preceeded Jervis as C-in-C, Mediterranean, lies *St. Vincent Bay* with *Culloden Point* at its southern extremity. *HMS CULLODEN* was Troubridge's ship at the battles of St. Vincent and the Nile.

The northern point of the bay is *Elephant Point* which refers to Captain Foley's ship *HMS ELEPHANT*. Foley was Nelson's flag captain at Copenhagen and when *HMS ELEPHANT* was broken up he obtained some of her oak timbers and had them made into a coffin which went with him on his subsequent voyages.

Sykes Island which lies in St. Vincent Bay is named after John Sykes, an able seaman who served with Nelson for many years and who is credited with saving his life in a small boat skirmish with the Spaniards in the Bay of Cadiz.

Nelson's "band of Brothers" is commemorated by several shore features in this area. *Mount Troubridge, Foley Head, Mount Foley* and the *Parker Range*. The latter is named after Vice Admiral Sir William Parker who was third in command at St. Vincent. The highest peak in this range is *Diadem Mountain* after *HMS DIADEM* which was a ship of the squadron under Jervis at this engagement.

At the entrance to Skookumchuck Narrows there is the small settlement of *Egmont*, named after *HMS EGMONT*, 74 guns, while at the entrance to Prince of Wales Reach *Goliath Bay* commemorates another ship which took part in the battle of Cape St. Vincent and later, under Foley, the battle of the Nile.

The final naval feature is *Saumarez Bluff* at a bend in the reach and named for Admiral James, Lord de Saumarez who was Nelson's second command at the Nile.

In the higher reaches of Jervis Inlet similar themes are followed with obvious connections between *Marlborough Heights, Mount Spencer* and *Mount Churchill*; also between *Mount Arthur* and *Mount Wellington*.

Then comes Prince of Wales Reach, Princess Royal Reach and Queens Reach (Victoria) the latter surrounded by her children *Victoria, Albert, Alice, Alfred and Helena* all of whom had a mountain named after them, while her mother, Princess Louisa is remembered by *Princess Louisa Inlet*.

This concept of applying names following a theme was common in areas where there were few inhabitants and no record of previous names and was carried on along the west coast until fairly recent times when all essential features had been named or were too widely separated for ready identification of any theme.

In some cases the date of the survey can be reasonably well fixed by finding the key to the toponomy. Sometimes general knowledge is sufficient e.g. in the Strait of Georgia, *Ajax and Achilles Banks,* the nearby *Exeter Shoal and Harwood Point* were named in 1945 but the survey was carried out in 1939 - the year of the battle of the River Plate.

Sometimes one can detect shipboard topics of conversation. Obviously some keen punters were with Captain Richards, *HMS PLUMPER,* in the 1860 survey of the Strait of Georgia when *Thormanby (Islands)* won the *Derby (Point)* for his owner Mr. *Merry (Island)*, a popular result as the news was *Welcome (Pass)*. *Buccaneer (Bay)* was no pirate but another racehorse. Other sporting names in the area being *Epsom Point, Oaks Point and Tattenham Ledge*.

The features in the vicinity of Queens Sound surveyed in the early 1940's recall grimmer days with their *Spitfire, Hurricane, Seafire, Stirling and Blenheim Islands, the Kittyhawk Group, Swordfish Bay* and flying types wouldn't be surprised if they didn't find some of the stinging pests in the nearby *Mosquito Islets*.

Given a free hand today it is interesting to speculate what social commentary the modern hydrographer would lay down for posterity.

An Accurate Log for Icebreaker Type Ships

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An accurate ship's log is more than just a convenient extra. Fishermen use a log to control trawl speed and hence trawl height above the seabed. In our work, we interface the log and gyro to Satnav to improve fix accuracy and operating convenience; we use the log in towing gear where speed is critical and in station-keeping; we can measure surface currents by comparing dead reckoning against fixes; and we discover that strange-looking gravimeter anomalies are in fact caused by the ship decelerating when it hits a big wave, as recorded by the log.

Our ships must be capable of working in ice, which means that the log sensor cannot protrude from the hull. This rules out pitot-tube types, and means that if we fit an electro-magnetic log, which measures water-speed right at the sensor face, the hull must be smooth and clean. By contrast, a high frequency Doppler sonar log measures by back-scatter from particles in the water a few metres from the hull. That is why four years ago BIO chose the Sperry 2MHz Doppler log, which has a steel-faced transducer only 6 cm. in diameter, having seen it work in the Woods Hole ship *KNORR*.

We soon had proof on the measured mile that we get high accuracy ($\pm$0.05kt.), and we found that the log works very well in ice. But we also found that operating a high-frequency acoustic log in an ice-breaker-type hull, with the added complication of a bow-thruster opening, runs into severe aeration problems in rough weather.

When a burst of bubbles passes the log transducer, the weak back-scatter from particles in the water is blanked off. You might think that this would result in a "No Doppler Measurement" reading which could be detected and eliminated from the mean of a number of readings that is accumulated before the log declares a speed measurement. However Kritz and Howard (1969) point out that a Doppler log actually measures the change in wavelength rather than the change in frequency; it behaves as an interferometer. Thus it measures distance travelled, and derives speed by differentiation. Not only is this a "noisy" process, i.e. differentiating an uneven distance record will produce a very ragged speed, but when distance measurement is lost through masking by aeration, the result is that the speed reading is systematically low.

Sperry had told us that the further forward we could put the transducer, the less "bubble sweep-down" we would get from the bow wave. So in *HUDSON* (90 m.) we fitted the transducer flush with the hull at the forward end of the hold. It works fine there in all ice conditions, and in seas up to about 3 m. When it gets rougher, we have to switch to a second transducer extended 1 m. below the hull on a retractable sword. Since it is never rough in the ice, we can always use one or the other.

In *DAWSON* (64 m.), the first flush-fitted transducer was installed in the Asdic compartment, about one third of the way aft from the bow. It was a bad sailor; it worked fine in harbours, but very badly at sea.

This year, Ship Division, at BIO, fitted two experimental transducer blisters on the *DAWSON's* hull, one at the bow extending 45 cm downwards to 1 cm above keel level from a point close below and abaft the bow thruster, and the other extending about 20 cm below the Asdic compartment. Both were tear-drop shaped, about 30 cm wide by 1 m long, with the transducer mounted in the flat lower face.

I tested these in a ten-day cruise last November. As soon as the ship encountered a 2 m swell on leaving harbour I found that both blister transducers did in fact work; I then wanted to know which worked better in bad weather. Arranging this test was no problem at all; we had 5 m seas for the next four days, and I found that the midships transducer tended to drop counts whereas the bow transducer did not (figure 1). But I still did not know whether the bow transducer was giving the correct speed, or whether it was merely doing a little better than the midships transducer. Since we were in the strong currents on the Gulf Stream I could not compare its water speed with the ground speed calculated automatically every 2 minutes by our Rho-rho Loran-C (shown by bars on figure 1.)

However *DAWSON* also has a SAL log, which works on the pitot effect and should not suffer from bad weather. A comparison between the SAL and the Doppler logs is shown on Figure 2. The SAL reads a little lower than the Doppler, but they agree in change of speed. Later that day the SAL log read consistently two knots lower than the Doppler, so it is not such a good sailor either. In figure 2 the Loran-C gives much the same speed as the two logs, so that either the logs were correct, or the current was compensating for any error.

I was surprised by the abrupt drop in speed, by three knots, when *DAWSON* hit a big sea. I never thought a 2,000 ton ship would be slowed that much, but of course a wave contains a good many tons of water. Note how much more faithfully this speed change is detected by the log than by the Loran-C, which has to be damped to get rid of the jitter caused by noise on a weak radio signal. The combination of a log to record detailed changes with Loran-C to remove the effect of current will give a very accurate and detailed measurement of speed over the ground.

Satnav accuracy depends far more on compensation for ship's velocity than on any other factor. A satellite fix calculated using a mean speed over the ten minute period 1514-1524 of figure 2 would probably be significantly less accurate than one which used a different speed for every 20 second satellite Doppler count, which is what happens when Satnav is integrated with log and gyro.

Reference

Jack Kritz and Morton J. Howard *Channel Navigation and Docking of Supertankers*. Navigation (U.S. Journal) Vol. 16 No. 1, Spring 1969.

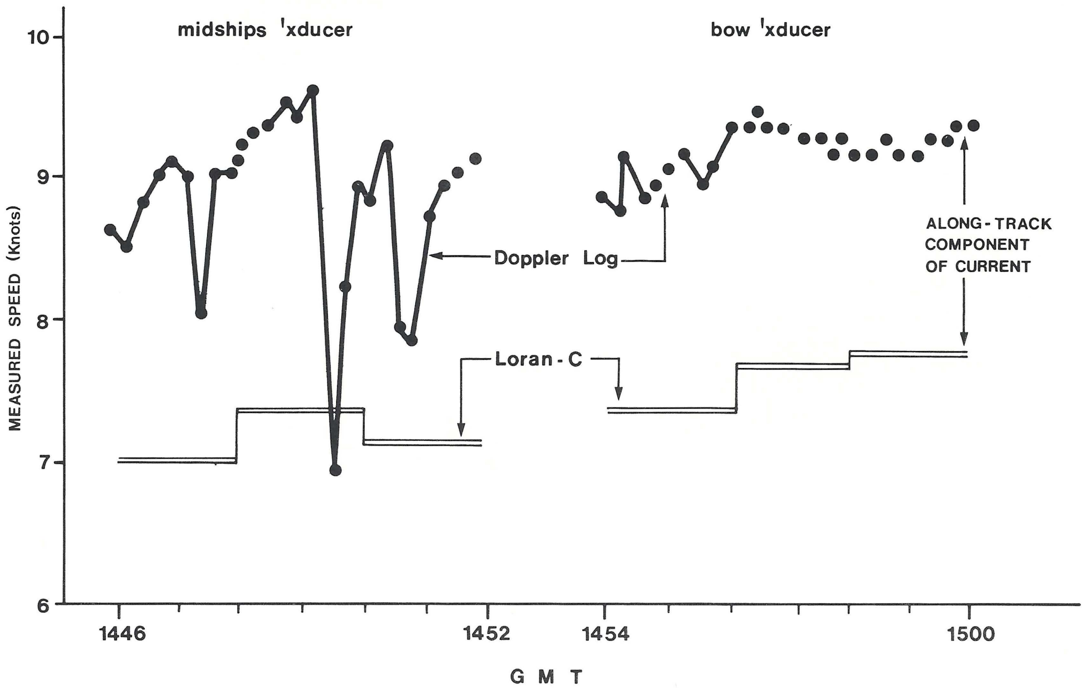


Figure 1. Comparison between Doppler log transducers in the midships hull-blister and the bow blister. The midship transducer shows several dropped counts whereas the bow transducer does not. As there was only one log electronics unit onboard simultaneous comparison of transducers was not possible, but this contrast occurred repeatedly in such series tests.

Ship was running in confused 4 m. beam seas, after 60 kt. gale.

Current measured when stoppedon station was 1.5 to 2 kts.

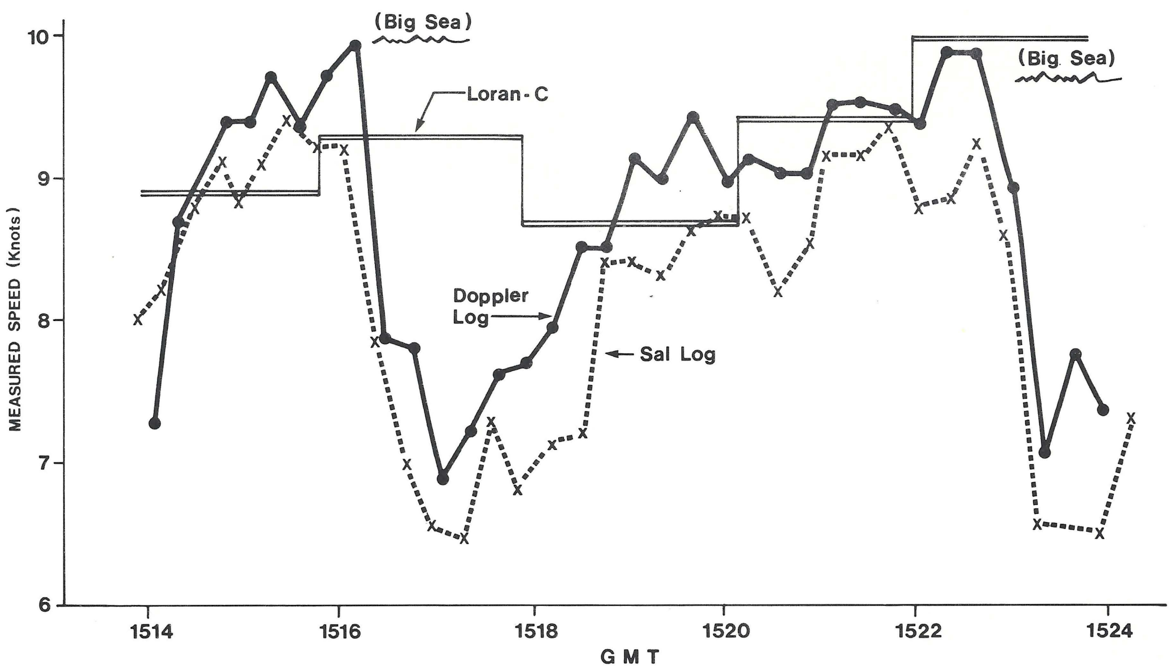


Figure 2. How a big sea slows the ship down. The Sal and Doppler logs record a drop of 3½kts., while, due to its damping, the Loran-C produces a smoothed average speed. Ship was heading homeward into 5 m. seas and pitching, corkscrewing. (Scientific staff hang on the rails when out of their bunks) Bow transducer used for the Doppler log.

News from Industry

The Hydrocarta Corporation, Houston, Texas

Hydrocarta has developed a range-bearning positioning system for use with their HYDROCARTA data collection system. The system called HYDROBAR is semi-automatic in that an operator is required to train a digital theodolite on the survey vessel. Range is derived from any microwave ranging system, such as Trisponder, while the angle is transmitted over a telemetry link at a rate of up to two readings per second. The angular resolution is one minute of arc equivalent to 0.3 metres per kilometre of range.

The system is particularly useful for river surveys where with conventional two-range systems short base lines must be used to achieve good geometry and maintain system accuracy. Odom Hydrographic International used the system late in 1976 on a survey of the Mississippi and Illinois Rivers and found that the required number of control stations was reduced by a factor of six over that required for two-range positioning.

New Hydrographic Data System from Morgan

Morgan Data Systems represented in Canada by M.S.C. Engineering Systems Ltd. of Toronto have added a dual frequency echo sounder to their line of hydrographic survey instruments. The line includes the Model N50 Boat Positioning System and the D80 series of Hydrographic Data Processor designed specifically for small boat applications. These Microprocessor controlled systems operate from a 12 volt D.C. power source, are light weight and packaged in splash-proof enclosures.

The N50 system accepts data from standard range-range positioning systems. The boat's postion is computed in x-y co-ordinates and the distance right or left of a designated track as well as the range to the end-point is calculated. Meters are provided on the front panel to indicate left-right distance and to-from position as a navigational aid to the helmsman. Optional peripherals include a graphic CRT, an incremental track plotter and a magnetic tape drive.

The D80 series of Hydrographic Data Processors automatically sample and record depth, position and up to 32 digits of operator controlled data. The depth digitizer includes a digitally generated tracking gate to minimize false echos. Data is recorded on a cassette recorder with an optional reader for off-line data dumping. The latest unit, the D83, includes a dual frequency echo sounder to provide greater information on the characteristics of the sediments. The 240 KHz signal will reflect off low density sediments (fluff) while the 40 KHz signal provides the depth of the harder underlying sediments. Analysis of return signal amplitudes provides information to determine the necessity of dredging the low density sediments. The unit is presently being tested by the U.S. Army Corps of Engineers, Waterways Experimental Station, Vicksburg, Mississippi.

News from C. H. S.

OceanCanyon Named After Canadian Hydrographer

An ocean canyon on the eastern edge of the Grand Bank of Newfoundland, 380 kilometres south-east of Cape Race, has recently been named in honour of a distinguished Canadian hydrographer F. Clifford Smith. Mr. Smith entered the Canadian Hydrographic Service in 1914 and served for over 40 years, retiring as Dominion Hydrographer in 1957. His long career has included World War I experience with the hydrographic department of the British Admiralty, surveys of Canadian coastal and inland waters ranging from the Atlantic to the Pacific Coasts, and many areas of the Arctic, and the compilation of "Sailing Directions" for the Hudson Bay route. Mr. Smith was appointed superintendent of charts in 1938 and Dominion Hydrographer in 1952. As Dominion Hydrographer he initiated surveys of the Newfoundland coast and the construction of *CSS BAFFIN*, launched in 1957.

Loran-C Calibrations

Pacific Region personnel, including Tony Mortimer, Rainer Schoenrank and Meiric Preece, are doing extensive Loran-C calibrations on the new Pacific Coast chain. Mike Eaton from the Atlantic Region and Dave Gray from Headquarters are involved in the initial stages of this project.

Vancouver Boat Show

Pacific Region shared an exhibit space with the Vancouver weather office of the Atmospheric Environment Service at this year's Vancouver Boat Show. The exhibit, manned mainly by field hydrographers, received considerable attention from the crowds as attendance at the show was expected to surpass last year's figure of 151,000. Featured were the relief model of Georgia Strait adapted to show the new continuous weather transmitter at Mount Tuam and also the new metric charts of Vancouver Harbour and the chart showing the new 200 mile fishing limit.

C. H. A. personal notes

Hans Pulkkinen retired from the Canadian Hydrographic Service in December but he did not leave his work as a hydrographic surveyor. This Spring he is back again flying in a helicopter and taking soundings through the ice in Viscount Melville Sound. As a man who looks and feels half the sixty-seven years that he is, Hans laughed at the idea of retiring. Born in St. Petersburg (now Leningrad) of Finnish parents, he early decided on the sea as a career and joined the Russian Department of Transport. There he served aboard the sailing ship *KARELIA*. In 1930 he enrolled in the Marine College at Leningrad and graduated as a ship's master.

Hans then joined the Hydrographic Service and in 1935 started his career as an Arctic hydrographer spending the next six years working with expeditions along the northern coasts of the U.S.S.R.

War interrupted his career and we next find him working at the Tidal Department of the Marine Observatory at Greifswald, Germany. Following the war Hans decided to come to Canada where he worked on the land and on the Great Lakes until, in 1955, the Pulkkinen family were granted their Canadian citizenship. The following year he joined the Canadian Hydrographic Service.

At forty-seven he was told he was too old for Arctic work! Consequently for the next few years he worked in the south. Thinking changed and in 1964 Hans was sent as hydrographer-in-charge of the icebreaker *JOHN A. MACDONALD* to the Eastern Arctic. In 1966 he joined the Polar Continental Shelf Project as a hydrographic surveyor and has continued to work with them to this date. During his years with that project he has done many interesting things from acting as a guide to visiting Russian scientists to working on the development of a hovercraft sounding system. Truly, an Arctic man for all seasons.

It seems that for Canadian hydrographers the road leads to the Arctic at some time during their career and *Gerry Wade* is no exception. Another one for the 'retired list', Gerry left the Canadian Hydrographic Service at the end of March but not to retire - rather to start a new career as a lecturer in hydrographic surveying.

Like many hydrographic surveyors in Canada, Gerry comes from the Maritimes. After returning from the war in Europe he joined the Topographic Surveys in 1950 but obviously finding that his maritime blood ran strong, moved to the Canadian Hydrographic Service the following year. In 1955 he became a hydrographer-in-charge for the first time and since then has been in charge of surveys in many parts of Canada. In 1959 his service during the historic opening of the St. Lawrence Seaway and the passage of the Royal Yacht *BRITANNIA* received royal recognition. In 1971 Gerry was seconded to the Polar Continental Shelf Project as Camp Commander of Beaufort Sea Ice Camp 200 and the associated AIDJEX (Arctic Ice Dynamics Joint Experiment). He also carried out surveys of Robeson and Kennedy Channels. In the following year he continued work in the channel between Ellesmere Island and Greenland. In particular he became involved in the matter of sovereignty of the small Hans Island which was claimed by both the Danes and the Canadians. In 1973 Gerry went again to the Arctic to co-ordinate field work for a detailed study of the propagation of Decca signals over the sea ice in Amundsen Gulf.

It seems almost as though Gerry's academic studies were pre-selected for his new career at Humber

Institute of Technology. He is a member of two provincial land surveyors' associations - Nova Scotia and Prince Edward Island. He is a Dominion Land Surveyor as well. During the sixties he studied hard in his spare time and obtained a B.Sc. in mathematics and physics from Carleton University. Finally, to add to his numerous credentials Gerry has instructed in hydrography at Algonquin Institute of Technology and Erindale College of the University of Toronto. A fine background to start the new course on hydrographic surveying at Humber.

In honour of these various achievements it was perhaps natural that the Canadian Hydrographers' Association should elect him as their President in March this year.

Pacific Region

A recent seminar in Pacific branch featured a film and talk by M.O.T. officials on the new Vessel Traffic Management Scheme for the Straits of Juan de Fuca and Vancouver.

Sid Wigen is still in Hawaii as Associate Director of the International Tsunami Information Centre; *Al Ages* recently co-chaired an oil spill conference in New Orleans sponsored by the American Petroleum Institute, the U.S. Environmental Protection Agency, and the U.S. Coast Guard; the Tidal and Current group recently welcomed *Bill Crawford* to their ranks; joining the Chart Construction and Revisions sections were *Bill Lyons, Michael Hohl, Peter Morton* and *Bob Parker; Charly Ryan,* a long service electronics technician, has won a competition and is now a radio inspector with Communications Canada; *Reg Pierce* hung up his seaboots and is now with the regional compilation section; *Gerry Wannamaker* has left the Hydrographic Service.

Central Region

Central Branch launched a very active seminar series last October which saw a total of 10 presentations by the end of March. A number of the seminars dealt with hydrographic topics, including the Senegal Offshore Survey, Hydrographic courses at Humber College and Integrated Navigation Systems. However, the remainder dealt with such diverse topics as tidal instrumentation, coastal engineering in Hawaii, a wave instrumentation tower in Lake Ontario, chemical lake surveys, Great Lakes shoreline erosion, and the Port of Hamilton.

Vern Crowley recently transferred to Pacific Region and will be in charge of a chartered vessel on the Mackenzie-Athabasca party this summer; *Sam Weller* will work with a firm of Ontario Land Surveyors based in Stratford, Ontario this fall as part of an exchange program; *Al Gris* recently transferred to the Cartography unit from the C.C.I.W. Drafting and Illustrating section.

Ottawa Region

Sev Crowther moved to the Pacific Region at the end of March to take up an appointment there as Production Chief; *Marty Frederick* will soon move to Central Region in the capacity of Checker; *Terry Tremblay* has been promoted to the position of Cartographic Publications Officer in Ottawa; *Jim Vosburgh* has transferred back to the Pacific Region from the Training section; congratulations to *George Yeaton* for completing French language training.

Atlantic Region

Gary Henderson has returned to Hydrographic after two years with Inland Waters Directorate, *Walter Burke* after an extended period with the Dominion Observatory, and *Ken Williams* after a one year special assignment with Staffing Branch, Halifax; *John Warren* has transferred to Ottawa, and *Renaud Pilote* to the Laurentian Region; *Percy Roberts* and *Dave McCarthy* have both left the Hydrographic Service; new hydrographers in the Atlantic Region are *Doug Frizzle, Greg Dwyer, Rob Webb, Dave Roop,* and *Dave Holt.*

C. H. A. Annual Meeting

The National Executive annual meeting was held on March 10, 1977 at the Holiday Inn, Burlington, with fourteen Executive members present and about 15 other members observing.

Many items were discussed, but two in particular were of vital interest to all C.H.A. members: Proposed amendments to our constitution, and the proposed affiliation of the Canadian Hydrographers' Association with the Canadian Institute of Surveying.

The first Constitutional Amendment was to Article 3 to allow Corporate Membership, to make provision as "International Members" for those people who do not reside in Canada, and to streamline our new-member-approval procedure.

Article 6 was amended to make the National President's term of office 3 years instead of the present 1 year.

Article 8 was amended to have the National Executive Meeting agenda circulated to all Branches six weeks prior to the meeting and to remove the 50% quorum requirement for Branch meetings.

These constitutional amendments will now be put to the general membership for ratification.

For some time now the C.H.A. has been contemplating some form of affiliation with the Canadian Institute of Surveying, and our National President in consultation with the C.I.S. has arrived at a set of terms which may be advantageous to both parties. These terms have been circulated to all Branches of C.H.A. and discussed at Branch meetings over the past several months.

Mike Bolton, Chairman of the C.I.S. Hydrographic Committee, briefly summarized the negotiations to date and after some discussion the meeting voted to instruct the National President to proceed with negotiations on the basis of the terms as outlined. Briefly, these terms would probably involve the C.H.A. paying an annual fee to the C.I.S., and taking over the job of nominating the chairman of the C.I.S. Hydrographic Committee. The C.H.A. would thus become a much stronger voice of Hydrography in Canada and internationally.

Before any final affiliation, of course, the terms would have to be accepted by our National Executive and ratified by the general membership.

Mr. Gerry Wade (Central Branch) was elected National President, and took over the chair from Willie Rapatz.

In February each year a band of intrepid helicopter pilots and engineers accompany the hydrographers and geophysicists to obtain soundings through-the-ice in Hudson and James Bay. This year the base of operations was Great Whale, on the south-east shore of Hudson Bay.

Great Whale Odyssey

FRED DEARE

Helicopter Pilot
Ministry of Transport

Way up on the shore of Great Hudson Bay
Is a place called Great Whale, our home for to-day
It's a tiny community, not much of a sight
A minuscule dot on this ocean of white.

Every morning we must go down to the ice
Sometimes the weather is not really so nice
But never an excuse from our lips is heard
As off we go in our rotary winged bird.

Check the Decca, did you see it jump
No, looks alright, just a little bump
How were the lanes when we stopped for that breath-er
Hell!! I don't know... wern't you watching either.

Better check in at a reference location
If not, we may lose all of these stations
Let's call the base and say Decca's no good
Get Ian upset and ruin his mood.

"44" to Great Whale, what's your weather back there
We can still see the trees, but the islands aren't there
Roger on that, I think we'll return
Point this stovepipe for home and burn baby burn.

The dreaded whiteout envelopes us in its grip
In this great bowl of milk we're just one tiny pip
Got to fly through this crud, don't have any choice
I wonder if we'll make it ... that's my quivering voice.

Something is wrong, my gyro is spinning
ADF's off, the horizon's not grinning
I'm sure that we're level, I don't see how ...
We're in a spiral, pull it out, RIGHT NOW!!!

Altimeter's unwinding and airspeed is high
She's coming around .. A chunk of ice went by.
Climb, climb, pull in the power
Or else we'll wind up as a metallic shower.

What's that shadow, the coastline, we made it
We were dealt a bad hand, but by God we played it
Keep your voice calm as you estimate arrival
At this point, we're all glad of survival.

Set the bird down and let's go have a drink
I don't even want to have time to think
But the thought comes to me as I walk away
I sure as hell earned my money to-day.

Pilots and engineers work as a group
We must work together or land in the soup
They all do their jobs, technicians and readers
And most of all Reg*, our long suffering leader.

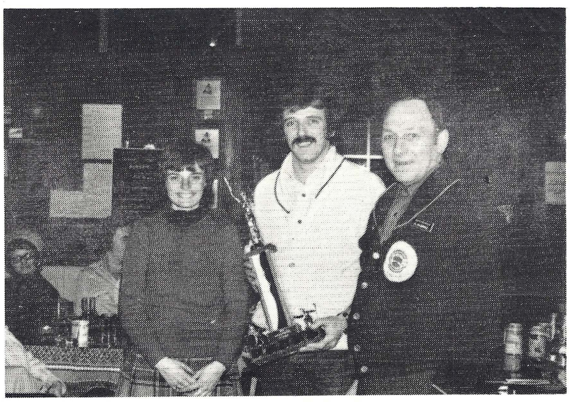
Tomorrow we'll go down to the ice once more
And rove many miles from the safety of shore
We'll do our job, there's no thought that we'll fail
It's part of the Odyssey, here at Great Whale.

* Reg Lewis, Hydrographer-in-Charge.

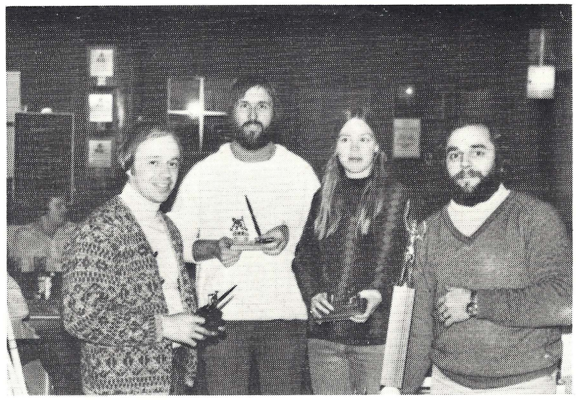
1977

H_2O Bonspiel

On January 15, 1977, Central Branch of the Canadian Hydrographers' Association sponsored the 5th Annual H_2O Bonspiel at the Humber Highland Curling Club in Etobicoke. John Gervais and his rink took the first prize and trophy.



(From left) Adam Kerr (absent), Barb Sinclair, Danny Mahaffy and Al Macdonald of the winning team of the "B" event.



(From left) Murray Brooksbank, Bernie Eidsforth, Cindy Medendorp, and John Gervais of the winning team of the "A" event.

Prizes for the 1977 H_2O Bonspiel were donated by the following:

- W.T. Chatham Associates Ltd., Hamilton
- Port Weller Dry Docks Ltd., St. Catherines
- Riviera Motor Court, Burlington
- Marinav Corporation, Ottawa
- Rapid Blue Print Ltd., Hamilton
- Marshall Macklin Monaghan Ltd., Don Mills
- RAB Engineering Ltd., Mississauga
- Kelvin Hughes, Don Mills
- Tellurometer, Canada Ltd., Ottawa
- Wild Leitz Canada Ltd., Ottawa
- J.H. French & Co. Ltd., Hamilton
- A-P Explorations, Oakville
- Canadian Applied Technology, Buttonville

P	O	L	F	H	L	A	R	E	T	A	L	I	R	D	A	U	Q	R	R
C	I	H	P	R	O	M	O	H	T	R	O	A	P	E	X	S	I	E	E
S	H	H	O	L	E	R	S	G	O	C	N	H	A	Z	E	V	L	A	T
H	K	S	S	G	O	E	I	T	O	O	O	L	E	V	E	L	B	L	E
O	E	E	N	N	X	T	A	Z	S	L	O	U	A	R	E	A	P	I	M
R	A	A	G	T	A	C	O	U	O	G	A	W	R	P	R	R	R	T	O
E	R	R	A	M	R	M	N	W	A	N	W	N	O	A	E	Y	E	Y	R
L	O	N	R	E	H	P	A	R	G	O	T	R	A	C	G	T	C	M	U
I	T	H	M	T	D	T	I	E	B	N	P	N	R	S	R	E	I	I	L
N	A	C	R	E	E	T	O	S	S	S	O	E	O	I	L	B	S	S	L
E	L	N	I	R	H	C	E	T	C	T	A	I	G	I	U	A	I	T	E
P	U	U	D	M	E	R	E	I	S	T	H	O	T	O	T	B	O	E	T
O	C	A	A	A	V	W	T	T	I	R	N	E	Y	A	E	U	N	H	O
L	L	L	N	A	A	E	C	O	M	O	O	R	O	A	U	I	L	C	S
Y	A	S	T	R	N	E	N	Y	M	A	E	H	U	D	L	D	I	O	G
C	C	I	T	R	J	C	S	E	E	D	E	F	C	D	O	M	A	M	S
O	O	R	E	O	I	R	T	L	N	V	O	T	A	E	O	L	F	R	D
N	A	B	R	G	E	R	G	U	P	R	R	E	O	N	D	D	I	O	G
I	Y	P	O	I	Y	N	O	I	T	A	L	U	G	N	A	I	R	T	G
C	E	L	P	M	A	S	A	F	E	T	Y	H	S	Y	K	A	T	S	E

All of these words are spelled out in the magic maze. They may be horizontal, vertical or oblique, forward or backward.

Circle the words as you find them, some letters are used in more than one world. When you have found all the words, the letters left over spell the magic word.

A. AID
ANALOG
ANGLE
APEX
B. BAR
BEAUFORT
BOW
BUOY
C. CALCULATOR
CARTOGRAPHER
COURAGE
CYBERNETICS
E. ECHO
F. FLOP
FOG
G. GNOMIC
GRADUATION
H. HAZE
HORIZON
K. KNOT
L. LAUNCH
LEADLINE
LEVEL
LOGARITHM
LOGIC

M. MERCATOR
METER
MIST
N. NADIR
O. OAR
OAR
OBSERVATION
OCEANS
ORTHOMORPHIC
P. PIERS
PLOT
POLYCONIC
PRECISION
PROJECTS
PROPELLER
Q. QUADRILATERAL
R. RANGE
REALITY
RECREATION
RIVER
ROD
ROSE

S. SAFETY
SAMPLE
SEA
SEAMANSHIP
SEXTANT
SHOALS
SHORELINE
SKEG
SOLUTION
SONAR
SOUNDER
STEWART
STORM
SUN
SURVEY
T. TAR
TEAM
TELLUROMETER
THEODOLITE
TIDE
TOW
TRIANGULATION
TRIGONOMETRY
W. WATER
WAVES