Lighthouse

JOURNAL OF THE CANADIAN HYDROGRAPHERS' ASSOCIATION

EDITION NO. 16, NOVEMBER 1977

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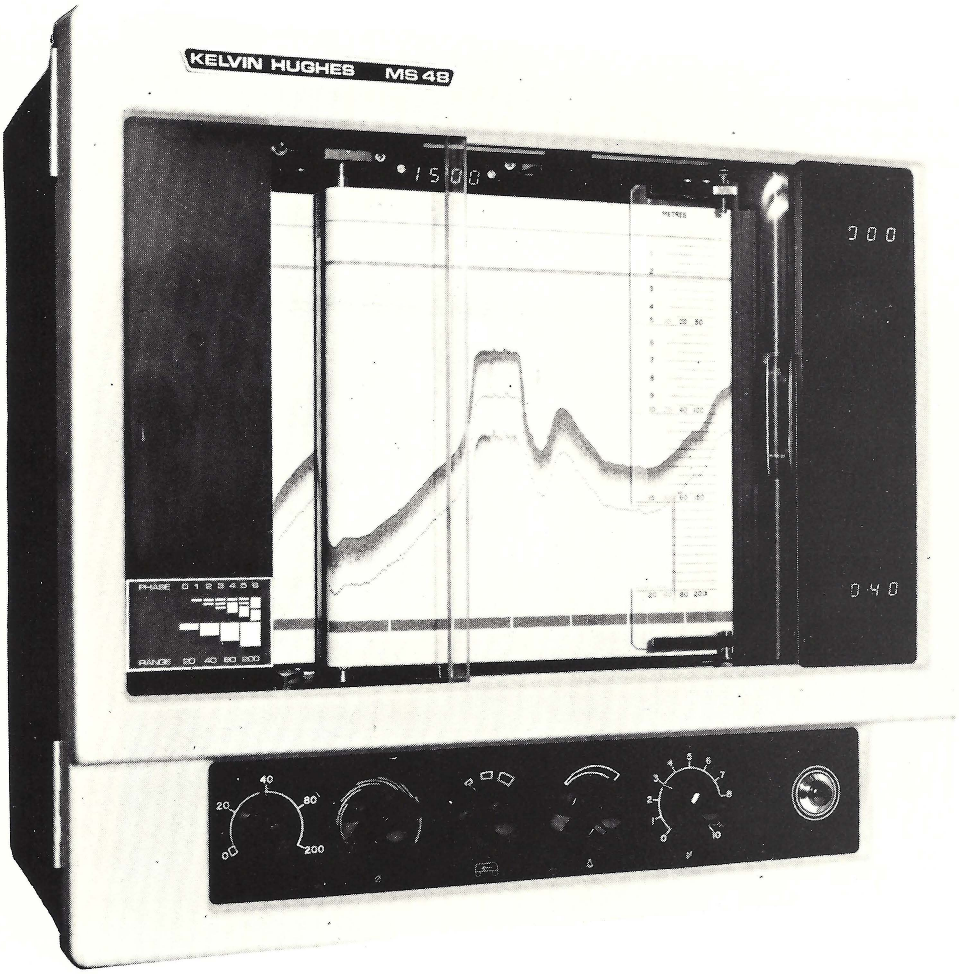

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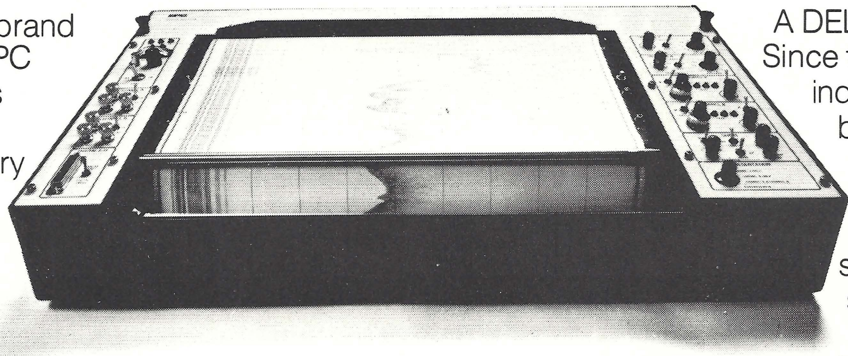

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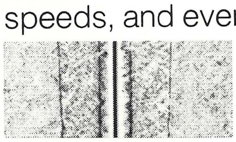

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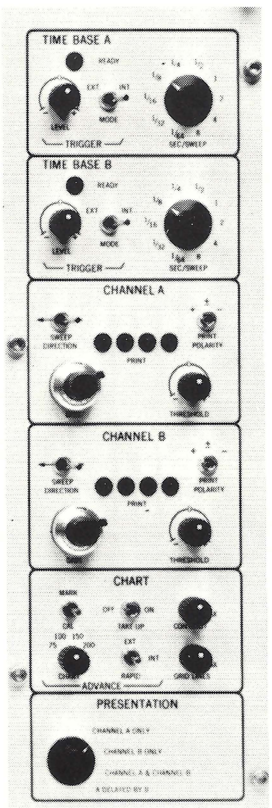

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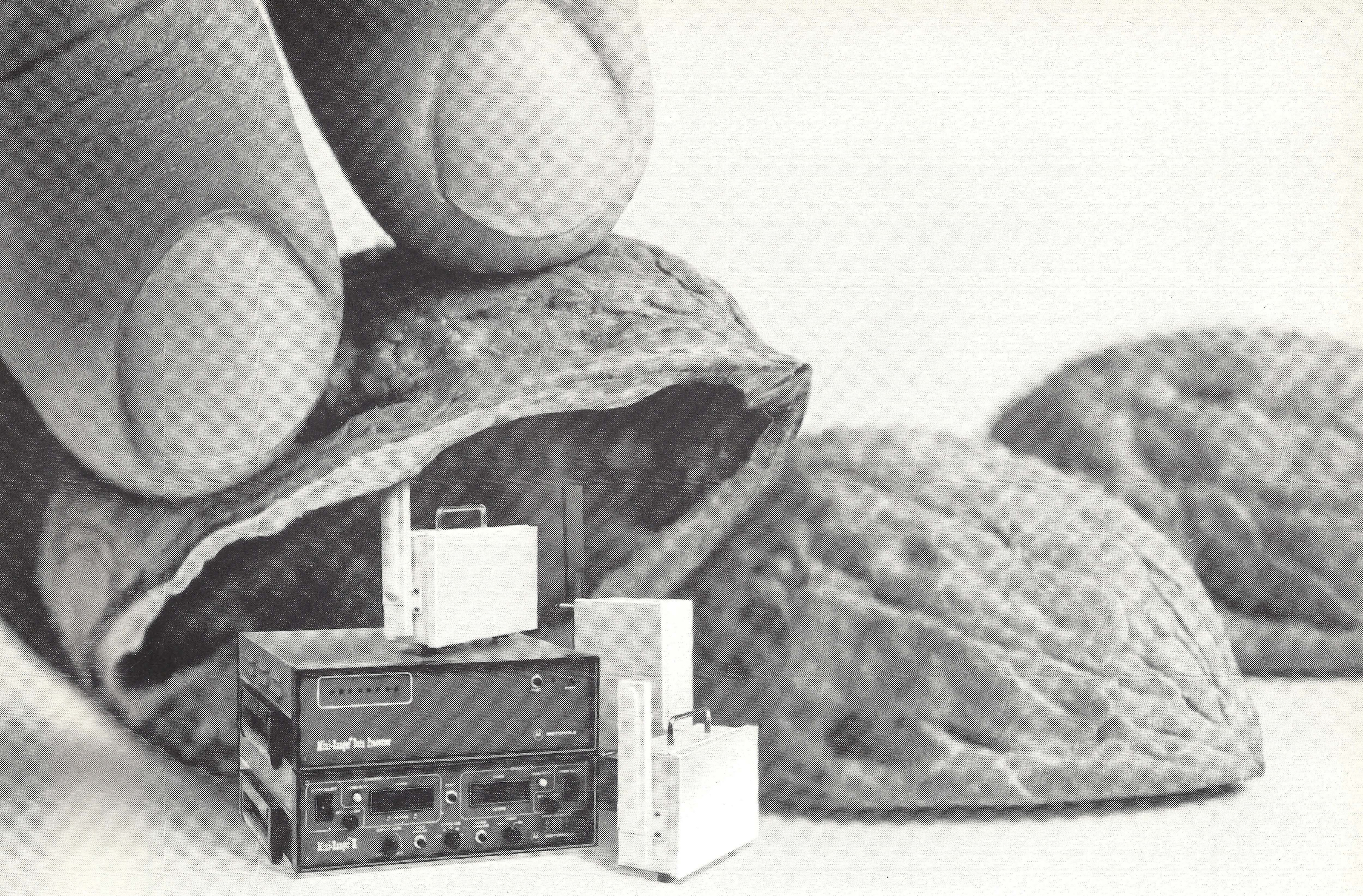

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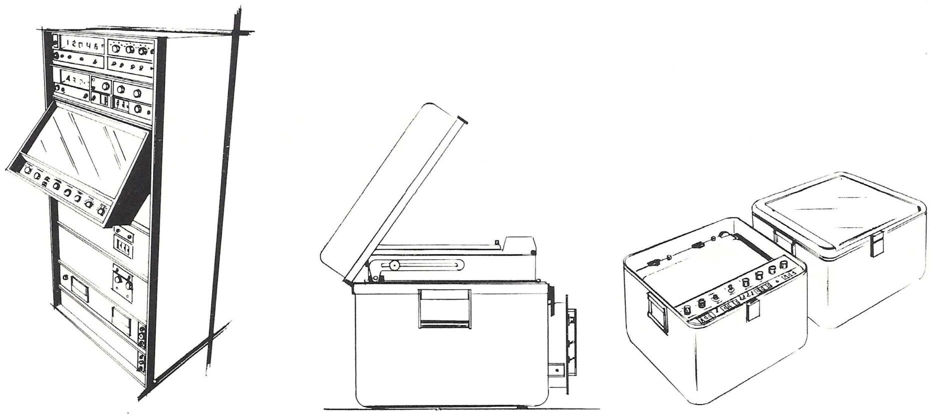

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Contents

EDITORIAL

Canada is perhaps best known for its vast natural resources and for its, at times, harsh climate. It is less well known as a country of originality and the setting of precedents. Yet in recent years Canada has become one of the few countries to unify its armed forces, and now it may become one of the few, if not the only country, to produce its nautical charts under commercial contract. Certainly not an earth shaking event to the majority of people but unprecedented in the field of national nautical charting where in most countries this is a program of the navy. True the data from commercial survey firms are incorporated in the charts of various nations and that close facsimiles of national charts are produced by private firms as yachtsmens' charts but nothing so major as is being contemplated in Canada today.

Over the last twenty years a number of studies have been carried out to examine the place of science and technology in the Canadian government. While earlier studies and policies seem to have been directed more at basic research and applied science the foxhunt has recently been tally-hoed in pursuit of scientific data collection. One of the major thrusts has been to transfer work from the government offices that can be done equally well by private industry. The stated reason for this is to put Canadian industry in a strong position where it can compete effectively in foreign and home market places. A more political reason is that it will reduce the size of a Public Service which the taxpayer sees as a horrifying burden on his shoulders. Unfortunately the growth of the Public Service in recent years has been more in the aid of a welfare state than in the direct pursuit of science and technology but this fine distinction is not readily apparent to the average taxpayer.

For some time now hydrography has been viewed as a potential area where some of the work now being carried out by government could be transferred to private industry. Earlier policies which might have affected this transfer did not have the teeth to bring it about but the most recent policy states that the onus is on the (government) department to show that it is inappropriate to contract out its work to the private sector. What is so special about hydrography and the production of nautical charts that they cannot be readily transferred from government to industry? Government hydrographers have no doubt that their work is special and that it is a gross over simplification to say that it is straightforward scientific data gathering. Senior hydrographers working in government are concerned that if such a transfer is made there will be a degradation of the high quality of Canadian charts. Taken to the extreme this may also make the government liable in the case of an accident brought about by negligent surveying or charting practices that may result from persons other than government personnel doing the work.

There is certainly no unanimous opinion on the interpretation of the legal responsibility of the government with respect to hydrographic surveying and charting. From time to time the government becomes involved in court cases where the aids to navigation and the charts are in question but certainly the type of legal actions that one hears about in other countries does not seem to be so apparent in Canada. It will unfortunately need more test cases before the complete question of legality is clear. With the introduction of the Charts and Publications Regulations of the Canada Shipping Act it seems that more weight has been placed on the government to assure that its nautical publications are as correct and complete as the state of the art and economics allow. One would expect that if a country legislates that all ships should use its charts or their equivalent then it is fair to expect that country to provide good charts.

There has been considerable discussion on whether or not charts made for small craft, in particular yachtsmen, will involve as much legal liability as those made for commercial traffic. Obviously since commercial vessels are much more costly one would assume the liability to be greater. These discussions have developed from proposals that perhaps the recreational charting program as a whole would be a good area to contract out.

Unfortunately Canada has not yet had its North Sea bonanza and there is little work for commercial survey firms except by taking over work that is at present done by government. No one likes to be dislodged from the status quo and so there are many good arguments raised against changing the system. Perhaps if Canada had a bonanza itself there would be more than enough work to go around. I am a firm believer that somewhere around our huge coast a bonanza exists and that rather than effect this artificial transfer of work from government to industry the most important task is to get legislation in motion that will reserve the offshore work for Canadian companies whenever that pool of black gold is found.

Message from the President

Since my April message several interesting events have occurred. Our affiliation with C.I.S. has been confirmed with a a few minor points still to be cleared up; LIGHTHOUSE has continued to gain in popularity with many subscriptions from outside Canada; and C.H.A. has added substantially to its International Membership.

At this time of year a large part of our membership have either completed or nearly completed the year's field operations. I sincerely hope that you have had an enjoyable and successful summer.

During the next few months there should be serious consideration given to the affairs of the association, particularly as regards proposed changes in the C.H.A. constitution and the term of office of the President. A longer term has been proposed for my successor - a suggestion with which I heartily agree.

The prediction expressed in April concerning interest in the Hydrographic Technologist course at Humber has become fact. Enrollment this fall is four times that of 1976/77, with students coming from as far away as England - a very encouraging situation.

All in all, hydrography appears to be in good shape.

Best regards to all,

Sincerely,

Gerry

* * * *

Lighthouse Editor Abroad

Mr. A. J. Kerr, Editor of LIGHTHOUSE and Regional Hydrographer for the Central Region of the Canadian Hydrographic Service, will be abroad for a year studying for a M.Sc. degree in Marine Law and Policy at the University of Wales, Cardiff, United Kingdom. During his absence *Mr. B. J. Tait* will be acting as editor and will be ready to answer any and all queries regarding the journal. Address all correspondence to:

Mr. B.J. Tait
A/Editor, LIGHTHOUSE
c/o Canadian Hydrographers' Association
867 Lakeshore Road
Burlington, Ontario L7R 4A6

International Membership in the C. H. A.

For some time now, the editor of the LIGHTHOUSE has been receiving enquiries from abroad from people interested in joining the Canadian Hydrographers' Association. This presented us with a problem as we were just not set up to accept members from outside our own close knit community. Not that we did not want these people as members, for without exception the enquiries were from people prominent in hydrographic circles in their own communities, and their membership and active interest in C.H.A. could do nothing but good for all concerned. Our problem was that the C.H.A. is administered through four Canadian Branches, Atlantic, Ottawa, Central and Pacific, each with its own fee structure and each with varying degrees of activity for the Branch Members.

At our last National Executive Meeting, we decided on an International form of membership designed to welcome people who have expressed an interest in joining the C.H.A. but who do not readily fit into one of our Branches or who are not Canadian residents. On a trial basis, the following conditions will be used:

1) *Annual Membership dues of $8.00 (Canadian)*
2) *Member receives the LIGHTHOUSE*
3) *Member receives an advance copy of the agenda for the annual National Executive Meeting (usually held in March during the annual Canadian Hydrographic Conference), and a copy of the minutes of the Meeting.*
4) *Member is kept in touch with Central Branch activities, and may present opinions, make motions, etc., at Central Branch or National Meetings either in person or by letter, and may take part in any other Branch meetings, should the member be in the area.*
5) *The National Executive of the C.H.A. will endeavour to keep the member in touch with any items considered to be of interest.*

If you - our Reader - are interested in joining the Canadian Hydrographers' Association, we would be very pleased to receive your membership application, and we would then put your name before our Membership Committee. If you have already paid the $6.00 annual subscription to LIGHTHOUSE we will require only the $2.00 difference to convert your subscription to the Member category, otherwise please enclose the $8.00 dues with your application.

An Evaluation of the Sea Beam System

S. B. MacPHEE

Planning and Development
Canadian Hydrographic Service
Ottawa

1. Introduction

During the latter part of May, I had the opportunity to spend some time on the JEAN CHARCOT in the Bay of Biscay during an evaluation cruise of the Sea Beam Precision Bathymetric Survey System. The JEAN CHARCOT is a French oceanographic research vessel, 70 metres long, operated by Centre National d'Exploration Oceanique (CNEXO) for the Centre d'Oceanographie de Bretagne (COB). The Sea Beam is a deep ocean swath surveying instrument developed by General Instrument Corporation, Harris ASW Division, of the United States.

The Sea Beam system is the commercial version of a product that has evolved from approximately fifteen years of work in the development of surveying systems for classified applications for the U.S. military. The first commercial system was developed for the Royal Australian Navy for installation on HMAS COOK. The system fitted on the CHARCOT is slightly modified from the Australian system but conceptually operates in the same manner.

Sea Beam is a high resolution bathymetric survey system combining a Narrow Beam Echo Sounder and Echo Processor to produce contour plots of the ocean floor in real time. The system is capable of operation over the depth range 40 - 11,000 metres with accuracies as discussed later in the report. Representatives from the hydrographic offices of France, the United States, the Netherlands and Canada attended the equipment demonstrations. There were also a number of geoscientists from the United States, the Netherlands and France. The trials were under the control of CNEXO personnel with technical support provided by software and hardware engineers from General Instruments Corp.

2. Description of System

The Narrow Beam Echo Sounder portion of the Sea Beam is capable of operation by itself and has been fitted on more than ten vessels for commercial and military applications. The Echo processor is an adjunct to the Narrow Beam Echo Sounder to produce online contoured bathymetric plots and to provide automatic operation.

Operations of the Narrow Beam Echo Sounder can be most easily understood by referring to Figure 1. The system employs the General

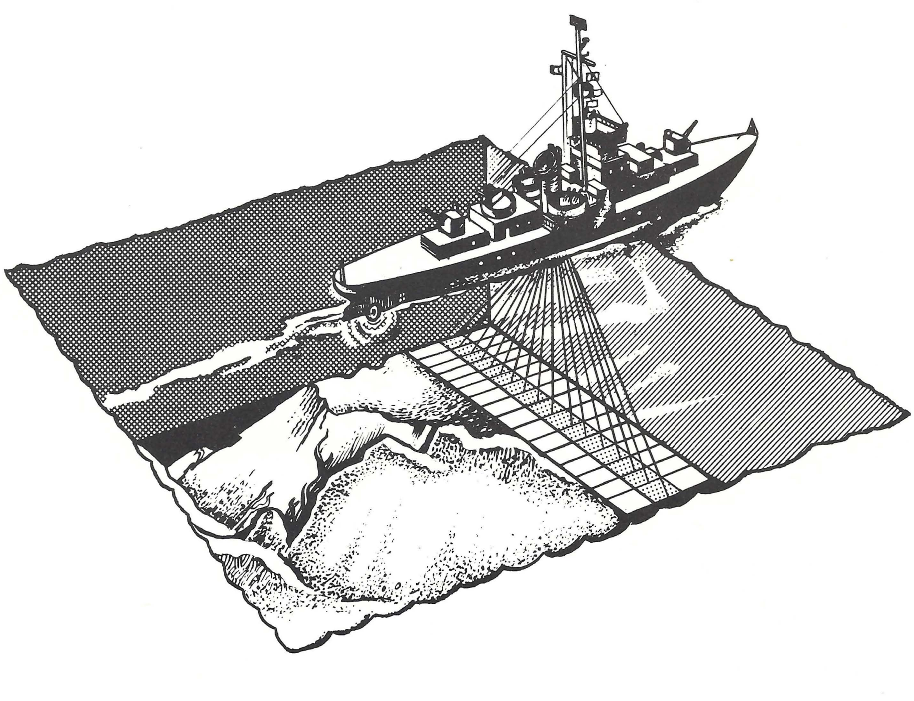


Figure 1. Pictorial representation of Sea Beam System

Instruments patented crossed fan technique wherein a multi-element projector is used as a transmitting transducer and a hydrophone array is used for receiving. The projector array, Figure 2, is mounted fore and aft along the ships keel and to ensure vertical projection of the sonar transmissions the beam pattern is electronically steered. This is accomplished by having the Sonar transmitter divided into twenty separate power amplifiers and having each power amplifier drive one of the twenty separate transducers in the projector array. The farthest forward transducer is designated as transducer number one and the signals fed to the other transducers are varied in phase in response to a pitch error obtained from a vertical gyro. The resulting sonar beam is 2 2/3^{0} fore and aft, and 54^{0} athwartships and is within 1/4^{0} of vertical for ship pitching up to ±10^{0}. Beam shading is accomplished by driving the projectors near the centre of array with higher power than those near the ends. The operating frequency of the system is 12. 158 khz and the projector array is more than four metres long.

The receiving array, Figure 3, consists of forty line hydrophone elements spread over an acoustic face approximately three metres long. The hydrophone array is mounted athwartships so that the transmitting array and the receiving array effectively form a cross or tee. The received signals from the forty hydrophones are amplified by forty separate preamplifiers and the preamplifier outputs are then resistively mixed to produce sixteen preformed beams each 2 2/3^{0} athwartships by 20^{0} fore and aft. The sixteen preformed beam signals are fed to the stator of a roll compensator. The rotor of the roll compensator is A.C. coupled to the stator and has fifteen segments. The roll compensator is coupled to the vertical gyro and is designed so that the signal appearing on the centre rotor segment is derived from the preformed beam looking vertically downward or it no beam is directly vertical, it is interpolated from the two most vertical preformed beams.

The rotor segments either side of centre, seven port and seven starboard, pick off the port and starboard preformed beam signals. These signals correspond to the sonar echoes returning along slant ranges along a swath symmetrically placed about the ship's bottom, if the ship is not heeled. In essence the transmitter via the pitch compensator and transmitting transducer insonifies an area with a beam pattern 2 2/3^{0} fore and aft and 54^{0} athwartships while the receiver discriminates and divides the insonified area into sixteen separate segments each 20^{0} fore and aft and 2 2/3^{0} athwartships. Because the roll compensator uses sixteen rotors and fifteen stators only fifteen received signals are actually processed. The Narrow Beam Echo Sounder part of the Sea Beam system therefore has an effective beam width of 2 2/3^{0} athwartships by 2 2/3^{0} fore and aft, while it has the ability to cover a swath up to 42 2/3^{0} wide, depending upon ships roll. In a water depth of 4000 metres, the swath width is approximately 3000 metres or slightly more than 75% of the water depth.

The Echo Processor part of the Sea Beam system is a later development than the Narrow Beam Echo Sounder and its primary purpose is to

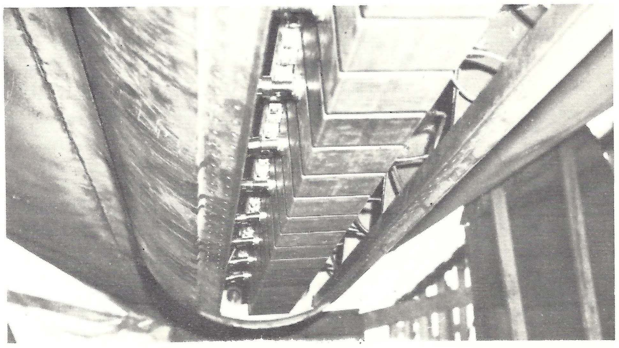


Figure 2. Projector array

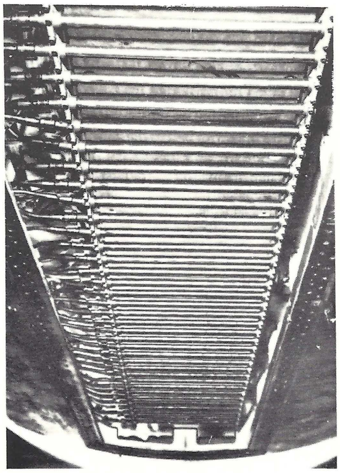


Figure 3. Hydrophone array

act as a centralized control and provide automated operation after the initial entry of the operating parameters. It is a computer based system that makes corrections for ray bending due to refraction, controls the ping period, controls receiver gain, provides timing, annotation data and input to the digital plotter, controls the depth tracker, processes the data provided to the data logger and performs numerous other housekeeping tasks. The Echo Processor consists of the following main sub-assemblies:

(1) Casette deck - The casette deck contains three transports and provides bulk storage for both the operating and diagnostic programs.

(2) Computer - Data General, Nova 800 with 32 K storage.

(3) CRT Display - The CRT display is a Tektronix model 603 storage monitor used to display crosstrack profile data.

(4) Digital Plotter - A Houston Instruments digital plotter is used to provide an online verification plot annotated under computer control with ship's heading, time of day, contour interval, depth, and tick marks on the contour lines in the direction of deeper water.

(5) Formatter for external data logger. External depth is provided for an external logging system. Included in the data output is time of day, heading and up to sixteen pairs of depth and crosstrack coordinates for each ping cycle.

(6) Facilities for providing information on selectable beams to a Universal Graphic Recorder.

(7) Other sub-assemblies include control panel, receivers, power supplies, and blower units.

3. Operation of System

The Sea Beam is a large and complicated system but likely the most impressive new development in sonar in a number of years. During the cruise, a canyon approximately 3,000 metres deep with steep sides was followed and the most impressive feature of the system, and a feature well demonstrated during this operation, was its ability for athwartships or crosstrack perception. By observing the graph on a ship fitted with a normal echo sounding system, it is easy to say that the water is getting deeper or shallower but it is very difficult to know whether to steer to port or starboard in attempting to follow a submarine canyon (not often of interest to hydrographers) or in attempting to find a deep or a shallow. With this system, by observing the CRT display, the operator could easily visualize the complexity of terrain over the entire swath being insonified.

During the trials, runs were done at speeds from 5kt to 12kt to assess operation under various conditions. Runs were also made under ATNAV (Acoustic Transponder Navigation) control in N.S. and E.W. directions and with 50% overlap to check outer beam degradation. In shallow water it was possible to produce one metre contour intervals while in depths in excess of 3,000 metres the lower limit is probably ten metres. The recorder and a Sea Beam strip chart are shown as Figures 4 and 5. In water depths of 3,000 metres, the design goal was to make the accuracy of the centre beam better than nine metres and the outer beam better than eighteen metres. From checks carried out during the cruise and from earlier trials, it appears that this has been achieved. Outer beam degrading is minimized by storing up to ten pairs of depth and velocity reading and correcting for refraction effects. No attempt is made to correct measured depth for changes in velocity. Corrections are made to eliminate as much as possible refraction effects while all depth readings are made at an assumed velocity of 1,500 metres/sec.

The Sea Beam system still requires development to merge navigation data and sounding data and to get rid of ships yaw and heave. All the data stored during the cruise was stored in terms of time and ping cycle only. The online plotter was really operating as a verification plot. It is planned that during the next year further processing will be done to eliminate the effect of ships yaw and heave and to develop software to recover a corrected plot representation as a post cruise operation.

The weather during the trial period was excellent with seas less than one metre for the entire period. The depth tracking system functioned flawlessly under these conditions. It is difficult to know what the tracking would be like under more adverse conditions.

4. Application of Systems to CHS

It is my belief that because of the complexity of the system, Canada could not utilize more than one. Since the swath mapping technique particularly for a system as large as the Sea Beam system is at its best in deeper water and in particular in the deep ocean, it is felt that the system would be most appropriate for offshore surveys and would find its greatest application in the geoscientific sphere. It is felt that the next Canadian hydrographic/ oceanographic ship for offshore operations should be fitted with a Sea Beam both for hydrography and geophysical applications.

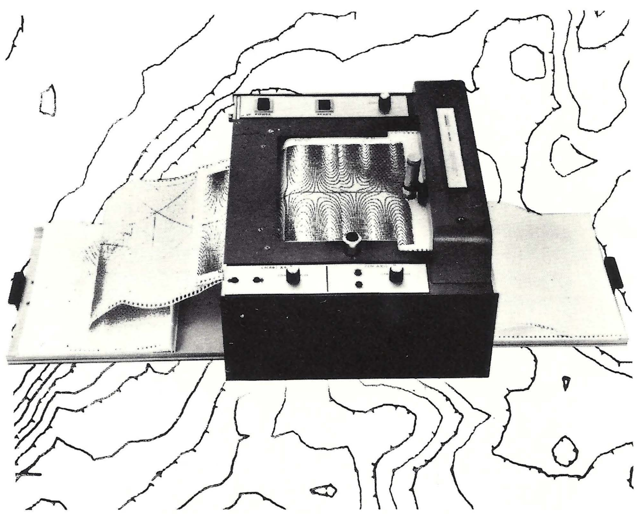


Figure 4. Recorder

The Bathymetric Sweep Survey System, a BO'SUN and on line PDP 11 computer is more applicable to inshore hydrography. An advantage of the BO'SUN system over the Sea Beam for inshore hydrography is the wider swath coverage. The Sea Beam swath is 0.75 X depth while the BO'SUN swath is 2.6 X depth. The BO'SUN is also less complicated. With the advent of deeper draft shipping and the increased fear of pollution due to tankers going aground, it is most important that CHS begin to investigate electronic sweeping systems. In the future, it is envisaged that there will be a requirement for clearance certification in many navigable channels and I am sure that there are few hydrographers who want to do wire drag sweeping.

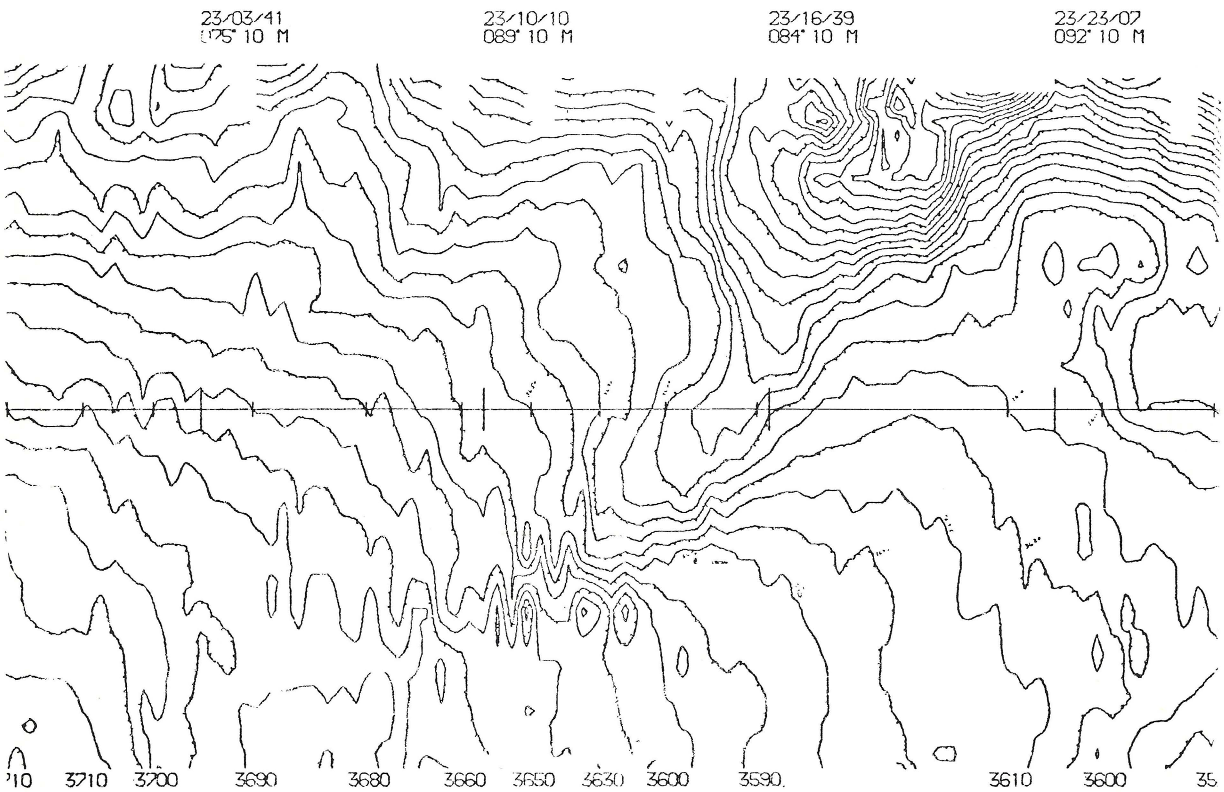
Because of the complexity of the Sea Beam system, it would be more advantageous to fit it on a new ship than to retrofit an older ship. The French spoke very highly of the system and of its geoscientific application. In discussion they described the sweep requirements in the project FAMOUS area where using conventional techniques it took thirty days to do a barely adequate survey while a ship fitted with a system very similar to Sea Beam swept the same area with better results in three days.

5. Miscellaneous Notes

The JEAN CHARCOT was a most interesting ship to sail on. Meals were excellent with delicacies such as couscous and stuffed artichokes. Wine was served at two meals daily and always available in the evenings. The cruise offered an excellent opportunity to try out my PSC French which did not rate as high as the meals or the wine but was passable in most instances.

Acknowledgements

I would like to thank Mr. Donald White of General Instruments Corp. for inviting my participation in this evaluation and supplying me the technical data on the Sea Beam System. I would also like to thank Dr. Renard, the cruise leader; M. Sciard, the manager of the CNEXO fleet and M. Allenou, the manager of the Electronics Equipment Divisions at CNEXO for the information they so willingly provided.



REALTIME BOTTOM CONTOUR STRIPCHART (10 METER CONTOURS) PRODUCED ABOARD THE FRENCH OCEANOGRAPHIC SHIP "JEAN CHARCOT" OF THE CNEXO FLEET ON MAY 26, 1977.

Figure 5. Sea Beam strip chart

Sailing Strategy in the Face of the Gulf Stream and North Atlantic Current

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During the past summer your editor and two other members of the C.H.A., Derek Cooper and Jim Bruce, took seven weeks leave to sail a 9 metre Hurley 30 sloop across the North Atlantic. The voyage lasted a total of 38 days from Mousehole, Cornwall to Newport, Rhode Island. An account of all aspects of the voyage has been given in talks and film shows at Ottawa and Burlington. This article deals specifically with the navigational strategy employed to make a reasonably fast passage. In particular, it discusses the tactics to counter the prevailing currents and winds, which are mainly adverse on an east to west crossing of this ocean. While strictly speaking this is not a hydrographic paper it does illuminate the relationship between marine science and practical small craft navigation.

It must be remarked at the start that although the voyage caused great interest in our research institute, sailing across oceans in small boats is no longer an unusual event or for that matter is it particularly dangerous if the voyage is made in a well found craft of modern design. Today, yachtsmen have sailed every ocean and in many cases they have sailed single handed. The North Atlantic, in particular, has become a yachtsman's highway. While the most favoured route is the traditional trade wind track to the West Indies, the OSTAR (Observer Single Handed Trans Atlantic Race) has made the more northerly routes as equally well known. This major event which started in 1960 with four competitors has now been run every fourth year since then and last year had well over a hundred entries. As a consequence, our knowledge of small boat behaviour and navigational tactics to make fast passages has increased enormously.

There are two major considerations to be made when planning the voyage. One of these is the time of year and the other is the route. The best references for examining the options are the U.S. Pilot Charts and the Admiralty Ocean Passages of the World. These references provide information on the prevailing winds, currents, temperatures and other environmental conditions on a monthly or seasonal basis. The data is provided in the form of statistics and is often criticized because it was not the condition when a certain passage was made. However, these references provide an excellent planning guide. Richey[1], Palmer[2] and many others have discussed their own personal strategy for making efficient passages but as the conditions vary from year to year there remains a good element of luck in every choice.

In considering the OSTAR course from Plymouth, England to Newport, Rhode Island, three fairly distinct routes have developed. The race is arranged to start in early June and, for most of the fleet, end sometime in July. This timing was also our choice. Before June there remains a fairly high risk of encountering depression-caused gales and after July the risk of hurricanes begins to increase rapidly. June and July may therefore be considered the 'weather window', although experience has shown that a crossing without encountering at least one gale would be unusual and the rare hurricane does occur in July. On the trade wind crossing the favoured time is the early spring although this presents the problem of leaving northern Europe in mid-winter.

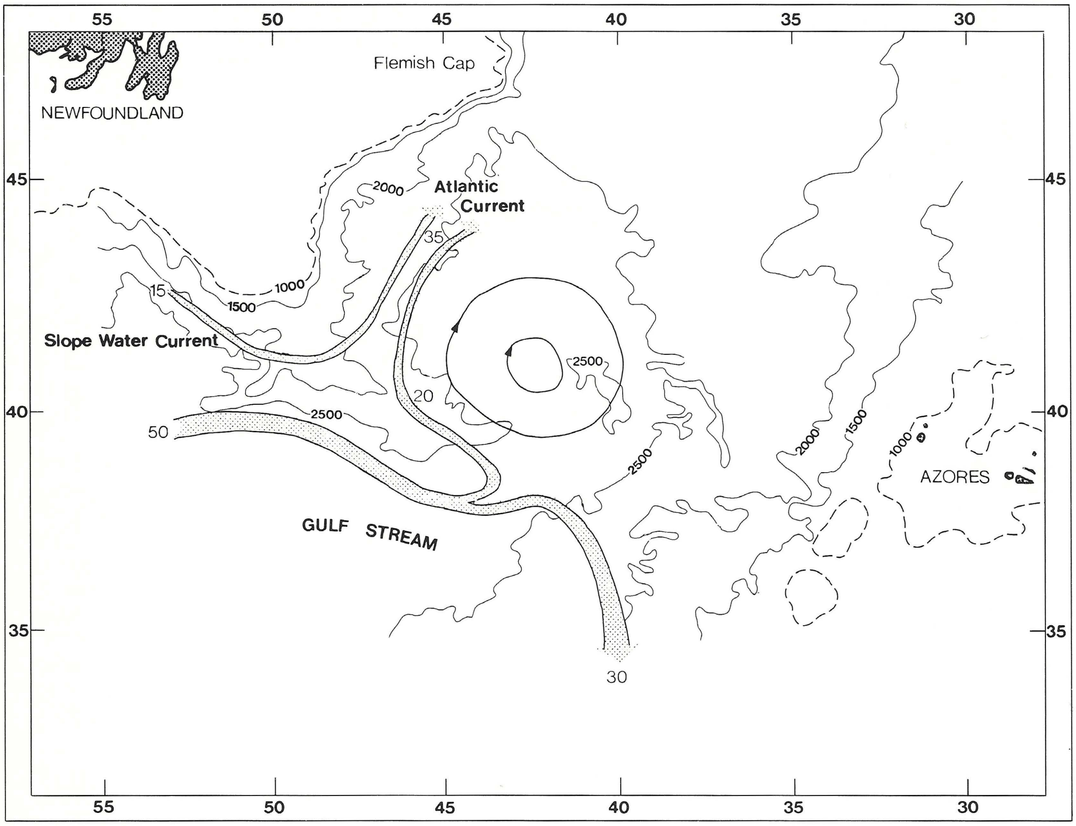
The three routes are The Great Circle route, 2,850 nautical miles in length; the Azores or Central route which is approximately 450 miles longer and the southern or trade wind route, which is over 5,000 miles in length. In 1968 Richey[3] explored the far southern route in his small boat *JESTER* (8 metres) and reported picking up the trade winds in 30° North. Although he made a good average daily speed of 92 nautical miles a day, the total time of passage was long. It seems that today only the Great Circle and Central routes are seriously considered by OSTAR competitors.

It has been said that the Great Circle route is not really a great circle since boats usually get beaten south and the route is closer to a rhumb line. Whatever it may be, it is cold with persistent head winds and passes through areas where fog, icebergs and fishing boats combine to make a serious obstacle for even the well crewed boat and certainly for the single hander. In spite of these disadvantages the Great Circle route has been favoured by the monohulls which point well into the wind and prefer the shorter overall mileage.

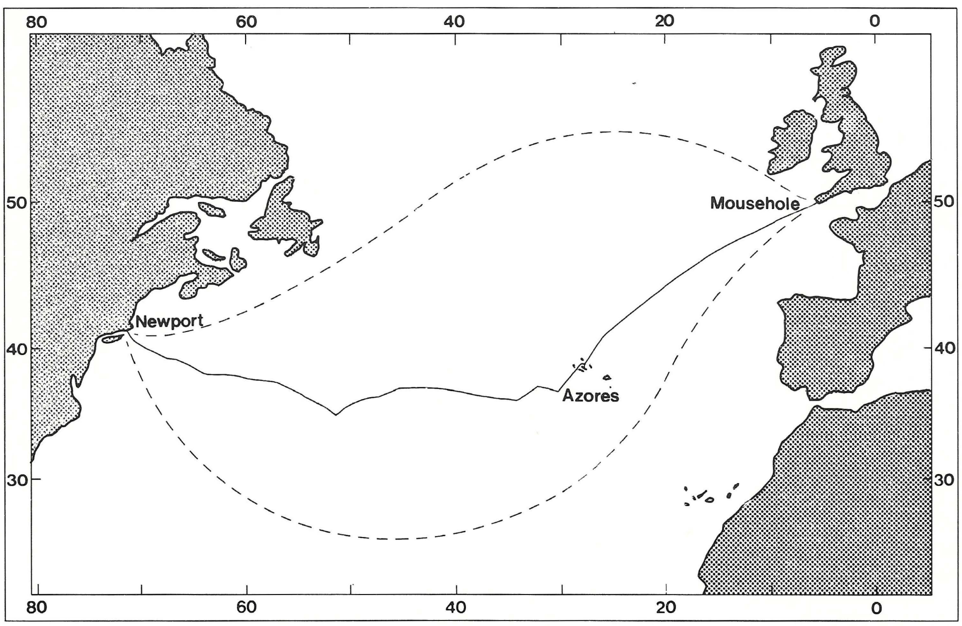
The Central route goes from the English Channel to pass by the Azores and then heads westward in about 36° North latitude to 60° West longitude when courses are made in a north-westerly direction to the point of destination. This route has a greater percentage of winds that are lighter and not from right ahead. As a consequence the route is favoured by multihulls (catamarans and trimarans) which do not normally perform so well to windward but are very fast in reaching winds. In making our own choice, while we were anxious not to exceed our leave, we were not racing and decided against the rugged northern route. Furthermore, since we were not racing we planned to use the auxiliary engine to get us through any calms which are a strong possibility in the area of the Azores and off the American coast in summer.

We had planned to leave England as the Jubilee bonfires burned down on June 7 but were delayed due to a gale and left the following day. The passage to the Azores was fast, direct and exhilarating, making Horta, Faial, in 10½ days at an average speed of 120 miles a day. It may be remarked that heavy monohulls seldom exceed their hull speed which in our case was about 6 knots so that a maximum day's run, short of surfing which permits you to exceed the hull speed, would have been 144 miles. On this sector of the voyage we encountered strong breezes from the north west, south east and back into the north west.

The voyage had been planned with the option to make the entire journey non-stop but in view of our fast passage we felt that a short stopover at the Azores was deserved. In fact it gave us quite a penalty as we entered the high pressure area south and west of the Azores which gave two weeks of calms and light headwinds. Clearly, if we had been racing



Diagrammatic chart of currents near the tail of the Newfoundland Banks, from Mann (1967)



The route of the 'A-OH-HA' showing alternative possibilities.

it would have been much better to cut the corner and pass to the north of Cortes and Flores even though this would have meant facing the half knot of current. The navigational strategy after leaving the Azores, of which more will be said later, is to keep to about 36°N until reaching 60°W when courses can be set for the destination. It was the westward leg that was the most frustrating as seldom were the winds favourable or strong enough. The one exception to that was when we were beginning to make northing again and encountered a force 8 gale about 250 miles north east of Bermuda. Finally we were lucky to have fine breezes when crossing the main thrust of the Gulf Stream before getting into fog off the Nantucket Shoals light vessel and eventually reaching Newport 25 days after leaving the Azores.

It was the avoidance of the North Atlantic Current and the Gulf Stream which introduced some of the more interesting navigational strategy. The Gulf Stream has been studied in detail by a number of oceanographers, dating back to the famous work by Mathew Fontaine Maury. Today there is even a small journal 'Gulfstream' published by the U.S. National Oceanic and Atmospheric Administration which discusses its condition on a temporal basis. In very general terms the Gulf Stream flows strongly north east up the American coast and in July has velocities of 1.5 knots in the area south east of Long Island[4]. It then trends eastwards and in the region of 50°W is reported[5] to split with the northerly branch being called the North Atlantic Current and the southerly branch going to the south to return water directly to the Sargasso Sea gyre. East of 40°W the U.S. Pilot Chart for July shows no currents in excess of 0.5 knots. In this part of the Atlantic the current flows directly against vessels following the Great Circle route but is transverse to the Azores route flowing in a south easterly direction.

Some of the more interesting strategy along the central route is involved in minimizing the contrary effects of the current westwards from the Azores. If the navigator can keep his boat in about 36°N he will hopefully be south of the east going current. Furthermore, it is possible that he may even pick up the occasional favourable eddy. On the assumption that our navigation was correct we were fortunate on several days of picking up westerly sets as much as 20 miles a day.

In about 60°W courses must be made to the destination and the Gulf Stream must be tackled. By going as far west as possible before taking this action the Gulf Stream can be taken reasonably perpendicularly and this minimizes the vector opposing the course direction. We had not looked forward to facing up to the Gulf Stream but in fact we over estimated for the north easterly set and ended up well to the south.

One of the difficulties of trying to skirt the Gulf Stream is that it is an area of very unstable weather with frequent thunderstorms and squalls. This is good for replenishing fresh water supplies but hard work as sails must be changed frequently.

In our earlier plans we had considered coming to Central Canada via the St. Lawrence River instead of the Hudson River and Erie Canal. In discussing this with Dr. C.R. Mann of the Bedford Institute of Oceanography he suggested that his scientific investigations had shown that it may be possible to cross the Gulf Stream with favourable rather than adverse currents. The key to this would be to take advantage of a branch of the Gulf Stream that actually flows in a north westerly direction for part of its path. To quote from one of his papers[6] "In the vicinity of 38°30'N, 44°W, the Stream divided. The main current continued southeast while a branch turned to flow northwest along the north side of the southeast Newfoundland Ridge. This branch current transported water of 14-16°C in the upper 400 m". Capitalizing on this feature it seems that if a small boat went due west from the Azores, facing only low velocity current, until reaching 44°W, it would be then possible to cross right over the Gulf Stream with favourable currents. In our case, where we had planned to head for the St. Lawrence the north westerly course could have been maintained but in the case of a vessel bound for Newport it is conceivable that having crossed the Gulf Stream it could bear off to the southwest, hopefully taking advantage of the Labrador current. But to quote Palmer[7] writing on the OSTAR "Yacht races, however, are not sailed on paper". In discussions with Dr. Mann on how we might have taken advantage of these various currents he suggested obtaining water temperatures at 200 metres since each water mass is apparently well defined by its temperature. For a while we mulled over the idea of lowering part of a bathythermograph on a fishing line to a depth of 200 metres but in the end decided that it would be very difficult. In the more southern parts of the Gulf Stream where surface temperature gives a clear identity of the current the author has noted that the large racing yachts are equipped with very sensitive in situ temperature measuring devices with an expanded scale covering only one or two degrees of temperature range.

A note may be made on our methods of navigation. We took with us two standard navigational sextants, a modern quartz crystal digital watch and two calculators besides various sight reduction tables. Dead reckoning was taken from a magnetic compass and a surprisingly accurate "electro log". This last operated with a small impellor that occasionally became fouled by weed but could be retracted into the hull and cleared. Without doubt modern solid state technology has brought about marvels for offshore small craft navigation. The quartz crystal watch, which although not of a particularly superior kind, was rated against time signals each day and had a rate of 0.8 seconds lost each day which is more than adequate. The two calculators were an unsophisticated SR7919D Commodore and a Texas Instrument SR 52 programmable calculator. The Commodore calculator had only the minimum trigonometric functions but with practice was easy and fast to use for working out astronomical positions. The T.I. instrument which had been programmed before the voyage, failed to read the program. During the voyage it was re-programmed but unfortunately exhaused its power supply before it could be put to use (the answer of course is that more power supplies should have been taken!).

Sun observations were possible every day except one on the crossing. Independent observations were made by two of us and on almost all occasions agreement to better than three miles, and frequently closer, was obtained. Star sights were a disappointment. This was either because of our lack of practice in recent years or because of low

Table 1. Daily Positions and Runs

DATE	POSITION		LOG (N.M.)	MADE GOOD COURSE	MADE GOOD DISTANCE (N.M.)	AV. SPEED (KNOTS)	REMARKS
June 8	Departure U.K.		5.1				
9	49° 27'.7N	7° 29'.1W	59.8				
10	48 20.2 N	10 36.4 W	137.2	241°	140	5.83	
11	47 15.6 N	13 49.0 W	145.9	244	144	5.76	- 25 hour run
12	46 11.8 N	16 26.8 W	118.2	239	125	5.2	
13	45 04.0 N	18 56.0 W	122.8	237	124.5	5.19	
14	44 04.5 N	20 21.7 W	99.5	226	85	3.54	
15	42 49.4 N	22 22 W	123.4	230	116	4.83	
16	41 33.8 N	24 15.5 W	117.6	228	113	4.7	
17	40 15.2 N	26 41.5 W	130.4	234½	135.5	5.65	
18			115				
19	At Horta						
20	" "						
21	37 22.0 N	29 41.0 W	78.9	216	76.3	4.1	
22	36 43 N	30 27 W	88.6	221	57	2.3	
23	36 53.6 N	32 15 W	94.1	240½	100	4.2	
24	35 50.5 N	34 29 W	100.6	268½	108.7	4.52	
25	35 51 N	36 31 W	102.2	270	99.0	4.13	
26	36 06.5 N	38 01.9 W	65.5	282	75.1	3.13	
27	36 22.8 N	40 09.8 W	66.3	284	106.3	4.43	
28	36 31 N	42 49.6 W	131.0	269	128.5	5.35	
29	36 38.5 N	45 16 W	124.0	273	117.8	4.71	
30	36 07.1 N	46 54.2 W	100.6	248½	85.1	3.54	
July 1	36 06.4 N	48 16.0 W	49.7	270	66.0	2.75	Counter current
2	35 44.1 N	49 59.3 W	80.7	255	86.5	3.60	
3	34 48.6 N	51 30.6 W	74.4	233	92.9	3.87	
4	35 30.5 N	53 00 W	90.6	300	84.2	3.50	
5	36 17.9 N	54 32.3 W	101.1	302½	88.5	3.69	
6	36 51.0 N	56 02.8 W	85.1	294½	79.9	3.30	Gale
7	37 11.0 N	56 45.0 W	33.9	300½	39.0	1.63	
8	37 29.4 N	58 00.6 W	60.8	287	62.9	2.62	
9	37 35.4 N	59 39.1 W	94.6	274½	78.3	3.26	
10	37 42.7 N	61 20.0 W	60.8	275	80.2	3.34	Enter Gulf Stream
11	37 50.0 N	63 45.0 W	124.0	273½	114.9	4.60	
12	38 31.6 N	65 29.0 W	101.6	297	91.7	3.82	
13	39 14.8 N	68 01.9 W	125.4	290	126.6	5.27	
14	40 32.0 N	69 56.6 W	118.7	311	117.0	4.87	
15	Arrival - U.S.A.						

Note: Comparisons between distance logged and made good should bear in mind that at times a direct course was not steered during the day.

powered telescopes in the sextants

Our radio communication consisted of a single side band radio which unfortunately we could not get tuned in Cornwall and a V.H.F. radio which worked well. Both were kindly lent to us by the MARINAV Corporation. Messages home were sent by contacting passing ships on the V.H.F. radio and all the ships that we spoke to were most cooperative. One contact is worth commenting on. The vessel was the U.S. roll-on roll-off freighter *PUERTO RICO*. After agreeing to pass our message the mate on watch called us back to say that he had just received a satellite fix and would we like it. We accepted the offer and afterwards said that we would check it against our 'sights' in the morning. To that there was no response!

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The Application of LANDSAT-1 Digital Data to a Study of Coastal Hydrography

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Abstract

Digital apparent radiance data from the LANDSAT-1 spacecraft, collected along the coastline of Nottawasaga Bay in southern Georgian Bay, have been used to effect a study of the application of such data to coastal bathymetry. These data have been compared to existing hydrographic charts for areas which have been well-defined in terms of depth contours. The result of such comparisons is that the Band 4 (0.5 - 0.6μ) MSS data clearly delineate the bottom contours in coastal regions for which the surface turbidity is substantially less than 1 FTU (i.e. very clear water as determined from the Band 5 (0.6 - 0.7μ) MSS data). Under such conditions of lake water turbidity, the maximum optical penetration defining the Band 4 response appears to be ~14 meters.

The energy return from a relatively clear inland lake is discussed in terms of volumetric and bottom effects and attempts are made at comparing the LANDSAT-1 digital data with "in situ" measurements of optical parameters. An iterative technique for estimating bottom reflectivity coefficients is also discussed.

Introduction

Pattern recognition studies of the digital four band apparent radiance data collected by the LANDSAT-1 satellite over inland lakes are being performed at the Canada Centre for Inland Waters on a routine operational basis. Results of these studies have shown (Bukata, Harris and Bruton 1974; Bukata and Bruton 1974) that:

(a) The Band 5 (0.6 - 0.7μ) digital data display a linear correlation with the turbidity (suspended particulate matter) measured at or near the surface of the water down to turbidities as low as ~1 FTU (~5 mg/ℓ concentration)

(b) The Bands 6 (0.7 - 0.8μ) and 7 (0.8 - 1.1μ) digital responses have been correlated with the measured surface chlorophyll a concentration for concentrations ≥ ~4 mg/m³.

(c) Mid-lake patterns in the Band 4 (0.5 - 0.6μ) digital response appear to be related to internal dynamic features occurring within the lake itself.

In this communication we discuss another property of the Band 4 satellite data, namely, the penetrative capability of impinging solar illumination of this wavelength into non-turbid nearshore waters, and the utilization of this penetration to determine information regarding both the coastal hydrography of the area and the optical nature of the water column.

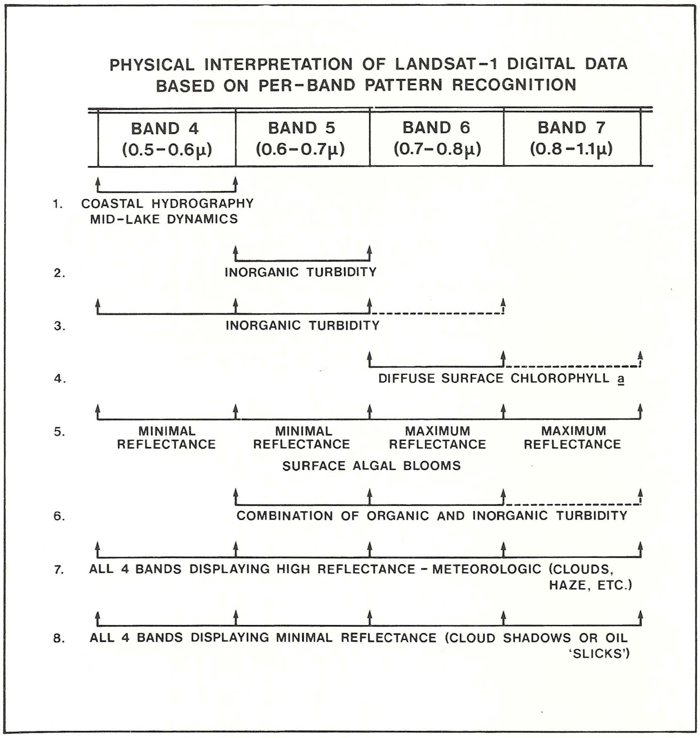

Figure 1. Results of pattern recognition studies of LANDSAT-1 digital data obtained over the Great Lakes.

As a summary of both published and unpublished work performed at CCIW in the pattern recognition studies of the LANDSAT-1 digital data collected over the Laurentian Great Lakes, Figure 1 reviews the results of the physical interpretations ascribed, to date, to the patterns observed in various combinations of the radiance Bands while absent in others. Per-Band limnological interpretations of the patterns observed in the digital printouts of the LANDSAT-1 apparent radiance data appear to be as follows:

(a) Patterns observable solely in the Band 4 data appear to be related to coastal hydrography in non-turbid waters (as discussed in this paper) or mid-lake dynamics in open waters.

(b) Bands 5, 6 and 7 respond to surface turbidity with Band 5 responsive primarily to inorganic turbidity and Bands 6 and 7 responsive primarily to organic turbidity. Excessive amounts of inorganic turbidity (as evidenced by high radiance response in Band 5) may overwhelm small to moderate values of organic turbidity (as in the case of oligotrophic and mesotrophic waters) with the result that the patterns observed in Band 5 may be duplicated in Band 6 and even Band 7. For specific types of inorganic turbidities such as $CaCO_3$ or mine-tailings of sufficient concentrations the Band 5 patterns may possess counterparts in the Band 4 data. In the case of the $CaCO_3$ "whitings" (precipitation caused as the result of a sudden chemical or physical change in the status of a lake which is supersaturated with dissolved calcium carbonate), the patterns are quite noticeable in the Band 4 data (Strong 1975). Such "whitings" generally occur as extensive mid-lake phenomena, and as such provide an excellent "tracer" material to delineate the dynamical processes occurring within the lake at the time of satellite overpass. Under such circumstances a natural large area dye-plume experiment is readily available to the LANDSAT-1 Band 4 data channel.

(c) Because of the strong chlorophyll absorption which occurs in the visible wavelengths, surface algal blooms will produce patterns in Bands 4 and 5 which display very low radiance values (the greater the chlorophyll concentration, the darker the pattern compared to the ambient radiance value of the lake) while Bands 6 and 7 will display the same patterns with higher radiance values compared to the ambient radiance value of the lake in those Bands. An excellent example of this feature of surface algal blooms may be seen in the LANDSAT-1 imagery acquired over Utah Lake on September 12, 1972 (Strong 1974).

(d) Consistently high radiance values recorded simultaneously in all four Bands are usually indicative of intervening meteorological phenomena. Consistently low radiance patterns simultaneously recorded in all four satellite Bands are interpretable as cloud shadows, or as in the case of the LANDSAT-1 image over eastern Lake Ontario on July 27, 1973, the presence of oil slicks on the water surface. This satellite observation of an oil slick in the Great Lakes will be discussed in detail elsewhere.

LANDSAT-1. Observations over Nottawasaga Bay

Figures 2(a), (b) and (c) illustrate the Bands 4, 5 and 6 computer print-outs of the digital apparent radiance data obtained by the LANDSAT-1 space vehicle over Nottawasaga Bay (southern Georgian Bay) on September 3, 1973. The data have been displayed as the average radiance values recorded from an area 6 pixels on a side, and thus represent a spatial resolution of ~470 m x 470 m. It is immediately seen that the internally cohesive optical patterns depicted in Nottawasaga Bay are mutually independent of one another (with the exception of a segment of the coastal region along the north shore in which the Bands 4 and 5 patterns display near-equivalence). Consistent with our pattern recognition studies, we interpret the Band 5 response as representative of the surface turbidity and the Band 6 response as representative of the surface biomass (chlorophyll a) distribution at the time of the satellite overpass. From the correlations of Bukata, Harris and Bruton (1974), all the water in Nottawasaga Bay is considerably less turbid than the current threshold of interpretation (i.e. concentrations << 5 mg/ℓ), and the maximum surface chlorophyll a concentration is not substantially greater than 4 - 8 mg/m^3. Figure 3 illustrates a schematic map of the main shallow hydrographic features of the Nottawasaga Bay area. Note the excellent correlation between these hydrographic contours and the Band 4 digital patterns displayed in Figure 2, particularly in the areas around the Mary Ward Ledges, the eastern shore of Nottawasaga Bay, Christian, Hope and Beckwith Islands, and the shallow waters in the Eastern Straits. Clearly, the Band 4 LANDSAT-1 digital apparent radiance response appears to have applications to coastal hydrography in non-turbid waters. It is interesting to note that the dissimilarity in coastal patterns displayed by the Bands 4, 5 and 6 responses suggests the ability to study nearshore zone phenomena from an approach based upon three simultaneously observed parameters, viz. bottom-depth contours (Band 4), surface turbidity (Band 5) and surface biomass (Band 6). This aspect of the LANDSAT-1 data to lakes research has recently been discussed elsewhere (Bukata 1975).

The Band 4 (0.5 - 0.6μ) apparent radiance I, recorded by the LANDSAT-1 space vehicle over lake water is comprised of four components:

$$I = I_a + I_s + I_v + I_b \qquad (1)$$

where

I_a represents the energy return from the intervening atmosphere

I_s represents the energy return from the surface of the water

I_v represents the energy return from the volume of the water column

I_b represents the energy return from the bottom of the lake.

Considering that the atmospheric and surface contributions remain relatively constant over the area depicted in Figure 2, equation (1) may be rewritten as:

$$I - (I_a + I_s) = I_v + I_b$$

$$I' = I - \text{constant} = I_v + I_b \qquad (2)$$

It is not unreasonable to assume that this constant is approximately given by the recorded radiance over the open lake waters free from coastal turbidity and bottom effects. (see Appendix I). In the case of the September 3, 1973 Nottawasaga Bay data, this correction would have a value of 15 (on the 0 - 63 scale). Thus I' would be obtained by subtracting a value of 15 from each of the recorded Band 4 pixel values.

Consider, further, that the impinging solar radiation in the 0.5 - 0.6μ range at the surface of the water is I_o. At a depth z, this radiation would assume a value of I_z given by

$$I_z = I_o e^{-\alpha z} \qquad (3)$$

where α is the vertical attenuation coefficient in the 0.5 - 0.6μ region resulting from both absorption and back-scattering within the water column, i.e.

$$\alpha = a + b_b$$

where

a and b_b are the absorption and back-scattering coefficients for the water, respectively.

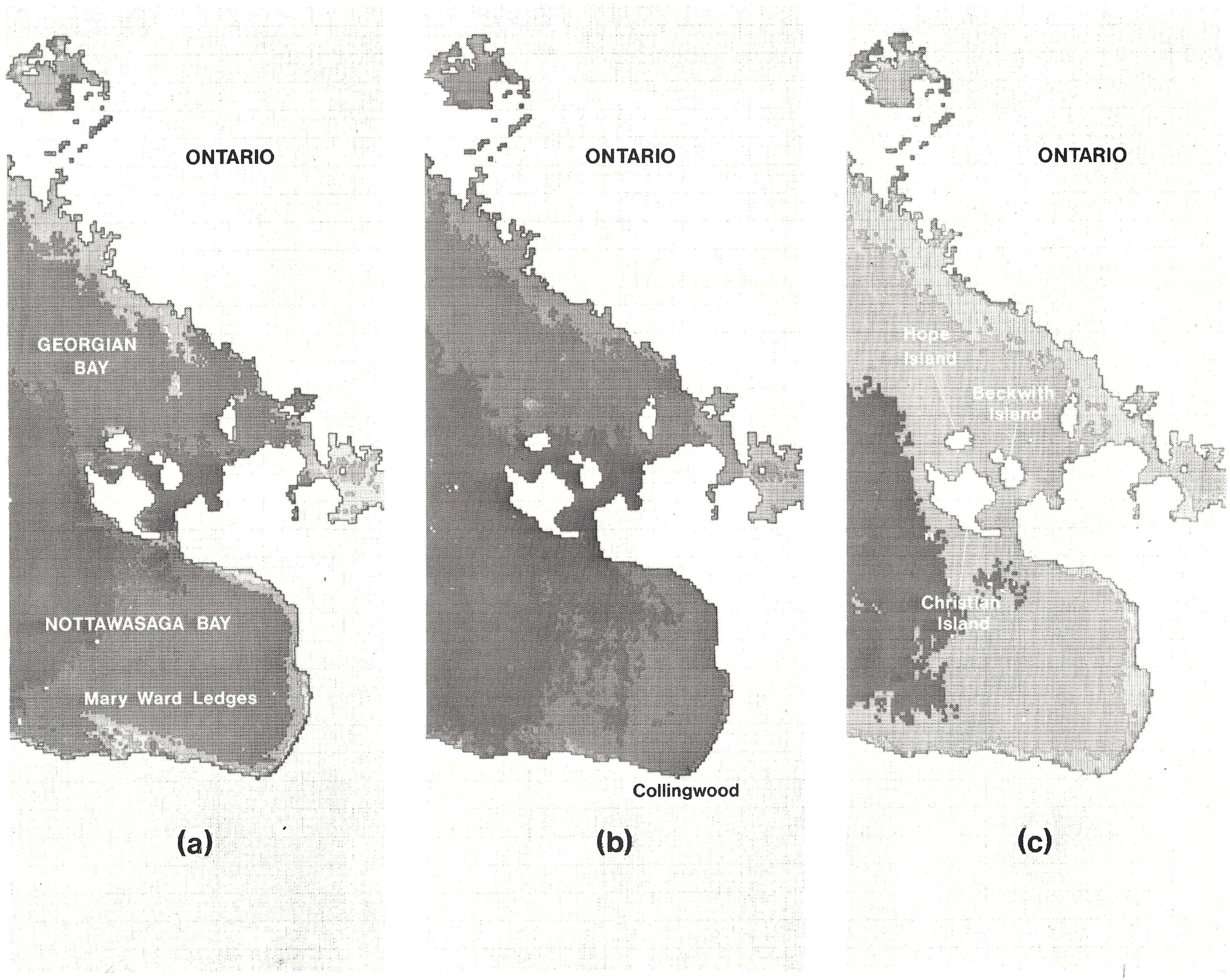

Figure 2. LANDSAT-1 digital apparent radiance data obtained over Nottawasaga Bay on Sept. 3, 1973 (a) Band 4 (0.5-0.6μ) (b) Band 5 (0.6-0.7μ) (c) Band 6 (0.7-0.8μ)

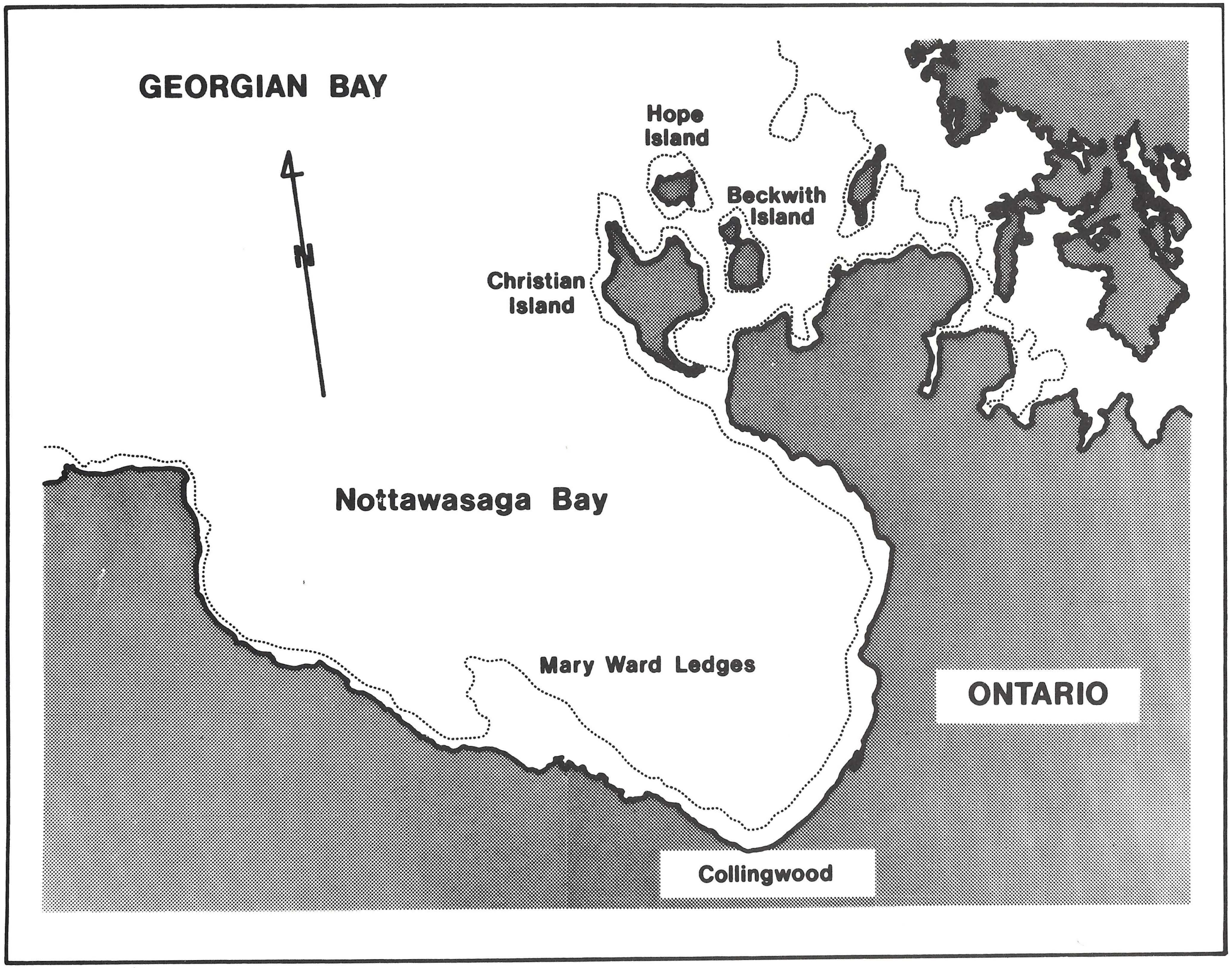

Figure 3. Main shallow water hydrographic features of the Nottawasaga Bay area.

The upwelling contribution to the recorded Band 4 beam due to backscatter within the elemental water column dz immediately below depth z would be given by

$$dI_z = b_b I_z \, dz$$

$$= b_b I_o e^{\alpha z} \, dz \qquad (5)$$

This backscattered flux would be further attenuated by the water column on its way back to the surface, so that the flux observed at the surface would have the value

$$dI'_z = b_b I_o e^{-2\alpha z} \, dz \qquad (6)$$

Integrating equation (6) from the surface (z = o) to the bottom (at depth $z = z_b$) yields

$$I'_z = \frac{b_b I_o}{2\alpha} (1 - e^{-2\alpha z_b}) \qquad (7)$$

$$\simeq I_v \text{ from equation (1)}$$

Equation (7) therefore represents the volumetric term from equation (1), i.e. the upwelling contribution to the recorded Band 4 response resulting from backscattered radiation within the water column.

The downwelling radiation at the bottom of the lake is given by

$$I_{z_b} \downarrow = I_o e^{-\alpha z_b} \qquad (8)$$

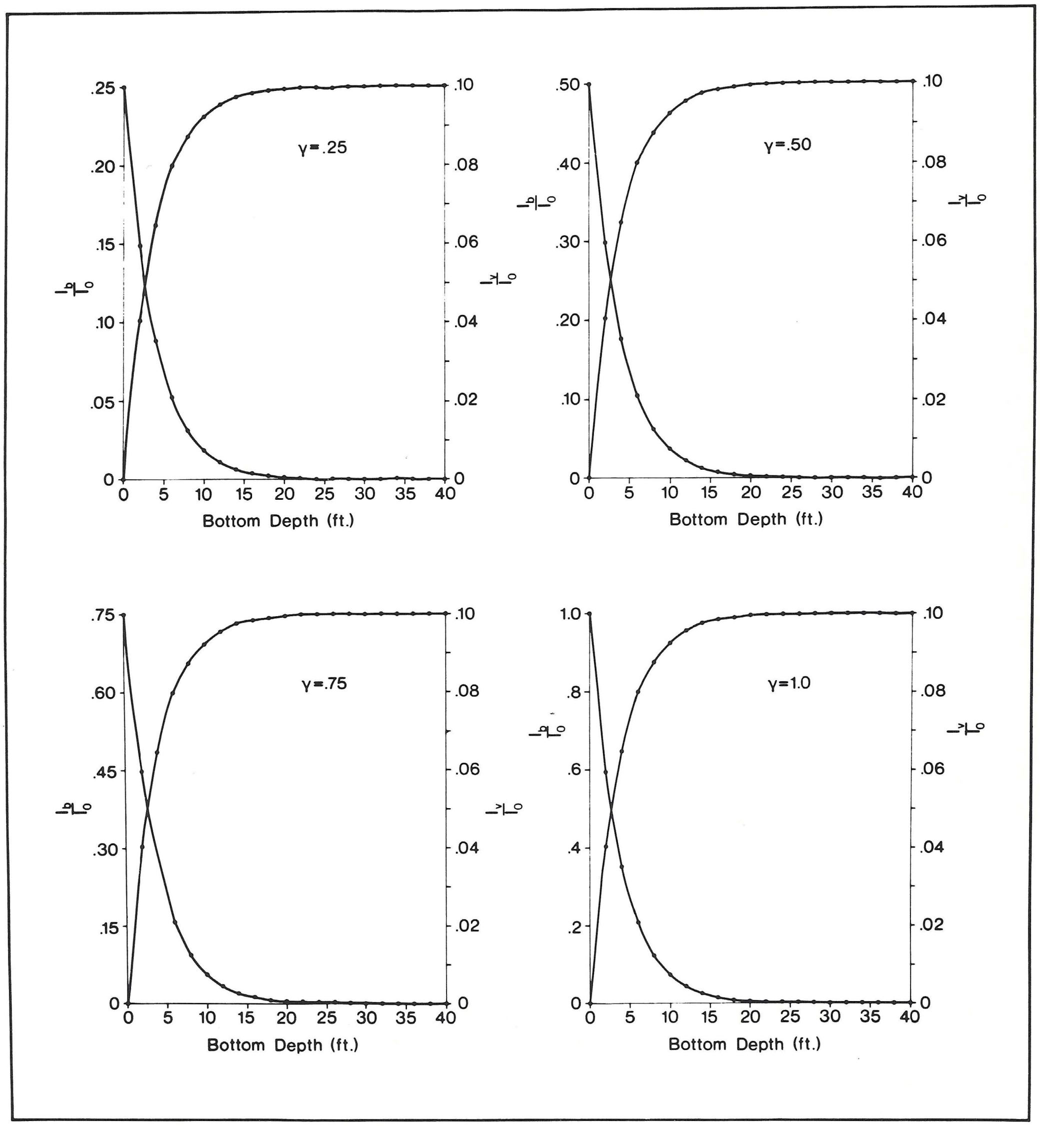

Figure 4. Volumetric energy return I_v and lake bottom energy return I_b as a function of bottom depth for several values of γ.

Consider the bottom surface to be characterized by a bottom reflectivity coefficient γ ($0 \leq \gamma \leq 1$) which indicates the fraction of incident radiation which is returned from the bottom surface. Thus, at depth z_b, the upwelling radiation due to bottom reflection would be of the form

$$I_{z_b} \uparrow \gamma I_o e^{-\alpha z_b} \quad (9)$$

which subsequent to further attenuation within the water column would appear at the surface with a magnitude given by

$$I_{z_b}' = \gamma I_o e^{-2\alpha z_b} \quad (10)$$

$$\simeq I_b \text{ from equation (1)}$$

Equation (2) may then be rewritten as

$$\begin{aligned} I' &= I_v + I_b \\ &= I_z' + I_{z_b}' \quad (11) \\ &= \frac{b_b I_o}{2\alpha}(1 - e^{-2\alpha z_b}) + \gamma I_o e^{-2\alpha z_b} \end{aligned}$$

Note that for small values of z_b, the influence of I_b becomes greater while the influence of I_v diminishes. For large values of z_b the opposite effect holds. Beyond the penetrative limit of the Band 4 response (or for black bottom surfaces for which $\gamma \sim 0$) the I_b term vanishes. That is, for a fixed value of γ, the I_b term asymptotically approaches zero, while the I_v term asymptotically approaches the value

$$\frac{b_b I_o}{2\alpha}$$

These relative contributions to the Band 4 apparent radiance response as a function of bottom depth are depicted in Figure 4 for assumed values of γ ranging from 0.25 to 1. For consistency of comparison, a value of 0.1 (Jerome et al. 1975) has been assumed for

$$\frac{b_b}{2\alpha}$$

and the I_v and I_b contributions plotted as a fraction of I_o. To further show the differences in relative contributions of the bottom and volume radiance terms as a function of γ, a family of curves is depicted in Figure 5 in which the percentage energy return from the bottom is plotted as a function of bottom depth for the four values of γ shown in Figure 4.

Figure 6 illustrates a computer printout of the Band 4 response over the Collingwood area near the base of the Mary Ward Ledges. The data are depicted with the maximum LANDSAT-1 spatial resolution (~79 metres square) after the so-called "sixth line" banding has been removed. The hydrographic features are delineated in Figure 6 with the deepest areas depicted by the lightest grey tones (minimal digital radiance response) and the most shallow areas by the darkest tones (maximum digital radiance response). A pixel by pixel comparison was made between the

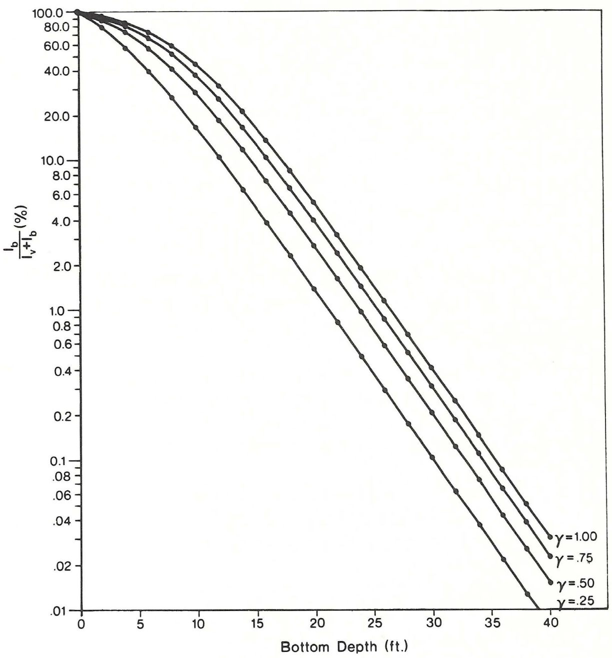

Figure 5. The relative contribution of I_b as a function of bottom depth for several values of γ.

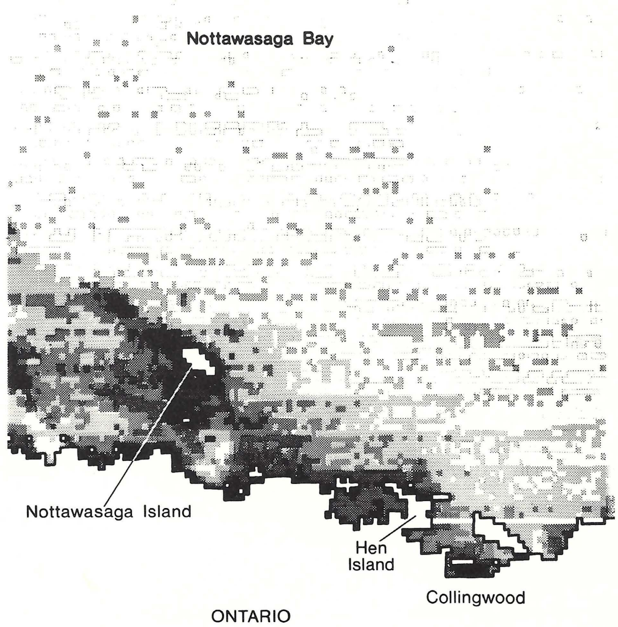

Figure 6. Band 4 digital printout of LANDSAT-1 data collected over the Collingwood area on September 3, 1973.

hydrographic chart data (map 2271 published by the Canadian Hydrographic Service) and the Band 4 digital response of Figure 6. An additional 4 feet was added to the chart data to compensate for the above datum water level correction applicable for September 3, 1973 (J. Gervais, private communication). A semi-logarithmic plot of I' (Band 4 response - 15) versus depth of bottom is shown in Figure 7. The salient features of this figure are:

(a) A linear relationship is seen between the logarithm of the corrected Band 4 digital response and the depth of lake bottom.

(b) The scatter of depth with radiance increases with increasing depth suggesting a greater reliability of the satellite data at shallow waters than at deep waters.

(c) The Band 4 digital data collected over the non-turbid waters of Georgian Bay may provide bottom contour detail down to depths of ~42 feet (14 metres).

Such a correlation as shown in Figure 7 is, of course, inappropriate as it considers only the contribution of the recorded Band 4 response of the lake bottom (the I_b term of equation (11)) and completely ignores the volumetric response of the water column (the I_v term). For example, the vertical attenuation coefficient α suggested by Figure 7 has the value

$$0.093 \begin{smallmatrix}+.024\\-.021\end{smallmatrix}\ m^{-1}$$

The CCIW lake optics program in southern Georgian Bay provided "in situ" spectrometer measurements at various depths on September 4. These results for a station located just north of the Mary Ward

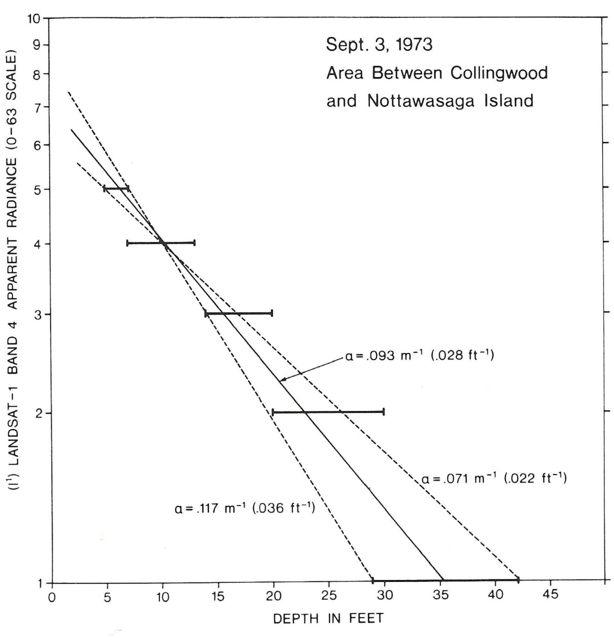

Figure 7. Plot of I'(Band 4 response - 15) versus bottom depth.

Ledges are shown in Figure 8. Herein it is seen that the measured value of the vertical attenuation coefficient α has the value

$$0.133 \begin{smallmatrix}+.006\\-.002\end{smallmatrix}$$

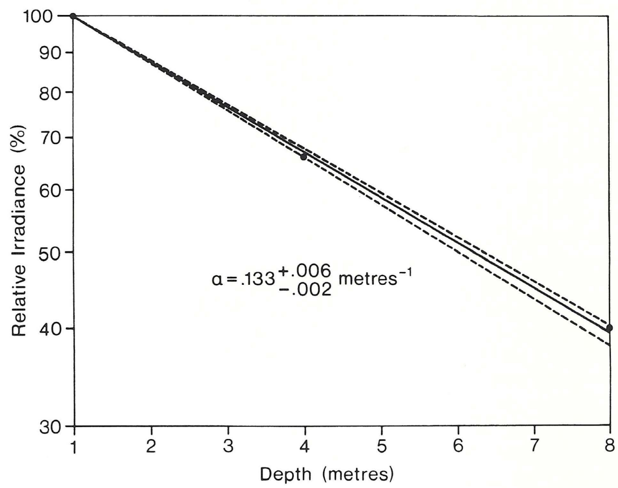

Figure 8. Spectrometer measurements in southern Georgian Bay, September 4, 1973.

Clearly, correlations such as shown in Figure 7 yield values of α which are too small since the contribution to the Band 4 response due to backscattering within the water column has not been considered. Such contribution to I' must be removed before the corrected value of I' (i.e. $I' - I_v$) is plotted against depth.

It is extremely difficult to directly apply equation (11) to the satellite data since it contains five unknowns, b_b, α, I_o, γ and z_b. However, two of these parameters are amenable to direct measurement by associated ground-based lake optics techniques, namely the attenuation coefficient α, and the backscattering coefficient b_b. I_o may be directly measured or the radiance data may be considered as a fraction of I_o. Also, where available, hydrographic charts may assist in the determination of z_b. Thus, equation (11) provides a mean of estimating γ (i.e. the bottom reflectivity coefficient) for various bottom surfaces utilizing the iterative technique discussed as follows:

$$I' - \frac{b_b I_o}{2\alpha}(1 - e^{-2\alpha z_b}) = \gamma I_o e^{-2\alpha z_b} \qquad (12)$$

Clearly, a plot of the logarithm of the lefthand side of equation (12) against z_b will yield a line of slope 2α. It should also be noted that the volumetric term subtracted from I' will result in a line of steeper slope than that shown in Figure 7 bringing the value of α as determined from the LANDSAT-1 vehicle into closer agreement with the value of α determined by the ship-board spectrometer. It is now required to estimate the magnitude of the subtrahend

$$\frac{b_b I_o}{2\alpha}(1 - e^{-2\alpha z_b}).$$

For the Nottawasaga Bay data, a value of $\alpha = 0.133$ is taken, along with a value of

$$\frac{b_b}{2\alpha} = 0.1,$$

consistent with the spectrometer measurements of September 4. This enables the ratio between the

$$\frac{b_b I_o}{2\alpha}(1 - e^{-2\alpha z_b})$$

term and the

$$\gamma I_o e^{-2\alpha z_b}$$

term to be determined for various bottom depths as a function of γ; i.e. the relative contributions to the upwelling irradiance I' of both the volumetric component I_v and the bottom component I_b may be determined as a function of γ. The iterative process then consists of obtaining the appropriate value of γ which will generate a slope yielding an α equivalent to the experimentally measured value of α. The results of such iteration (i.e. utilizing a measured value of α to determine γ) applied to the area between Collingwood and Nottawasaga Island are shown in Figure 9. It is seen from this curve that:

(a) A value of $\gamma = 0.5$ (i.e. a bottom surface which reflects half the 0.5 - 0.6μ radiation impinging upon it) satisfies an α of ~0.13 m^{-1} in the Collingwood area. This area is comprised of limestone bedrock overlaid by fine grained mud-like sediments which may be readily transported by nearshore circulation.

(b) At depths > ~20 feet (7 metres) a break in the linearity between the corrected Band 4 LANDSAT -1 data and the bottom depth appears to occur. This is interrpretable as the depth at which the volumetric contribution to the upwelling radiance becomes dominant over the contribution from bottom reflection. However, at this point, the contribution to the upwelling radiance from the volume of water below this depth is also asymptotically approaching zero which would manifest as a rapidly decreasing

$$\frac{b_b}{2\alpha}$$

ratio with depth, i.e. dramatic reductions occur in the total back-scattered upwelling radiance beyond this depth. Smaller values of

$$\frac{b_b}{2\alpha}$$

will tend to reduce the I_v correction term and thereby raise the deeper depth $(I' - I_v)$ values into agreement with the curve for more shallow waters. An example of this deeper depth correction is shown in the dotted curve of Figure 9 in which a value

$$0.05 < \frac{b_b}{2\alpha} < 0.1$$

is used. That is, it appears that $\frac{b_b}{2\alpha}$ is itself a function of z_b, sharply decreasing with increasing depth, i.e. in most cases as distance from shore increases. This may be due, in part, to smaller concentrations of scattering particles encountered in offshore waters than in the nearshore zone waters.

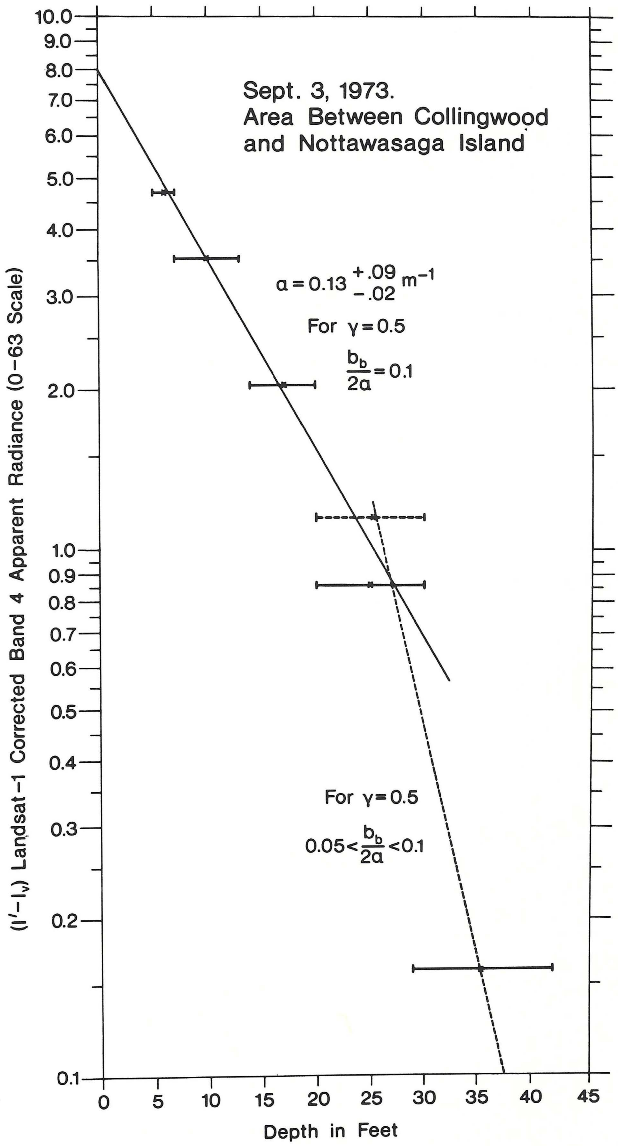

Figure 9. Iterative technique applied to the area between Collingwood and Nottawasaga Island.

Figure 10 depicts the pixel by pixel digital Band 4 data acquired over the Mary Ward Ledges on September 3, 1973. Figure 10 is similar to Figure 6 in that the deepest areas in the scene are depicted by the lightest grey tones (minimal digital radiance response) and the most shallow areas by the darkest tones (maximum digital radiance response). The resulting iterated curve for the Mary Ward Ledges is shown in Figure 11 wherein the similarity to the Collingwood area is immediately seen. Once again, a value of $\gamma = 0.5$ satisfies the reflectivity from the limestone bedrock Ledges, and a departure from linearity is seen at a bottom depth of ~8 metres.

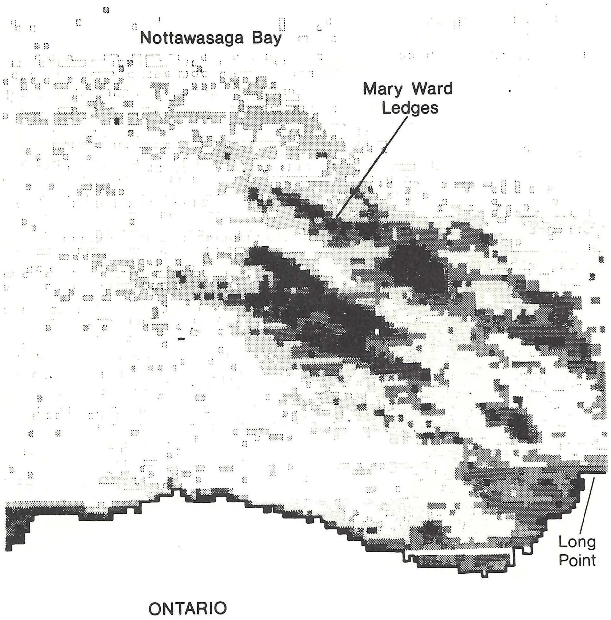

Figure 10. Band 4 digital printout of LANDSAT-1 data collected over the Mary Ward Ledges on September 3, 1973.

Conclusions

Although the analysis presented in this paper is preliminary in nature, it is clear that the Band 4 (0.5 - 0.6μ) digital LANDSAT-1 data may be directed towards studies of the coastal hydrography in inland lakes for non-turbid waters (as determined from the Band 5 (0.6 - 0.7μ) digital data). This paper further underlines the value of conducting "in situ" measurements of optical parameters in conjunction with the analysis of apparent radiance data collected above the surface of the water to produce a viable program for the remote sensing of lake systems. Knowledge of the optical properties of water such as the attenuation and backscattering coefficients enables iterative techniques to be employed to determine information on the type of bottom material present in the nearshore zone. For the limestone bedrock bottom present in southern Georgian Bay, such iterative techniques suggest a $\gamma = 0.5$ indicative of about half the incident radiation being reflected from the limestone. In principal, satellite and optical data could be utilized to catalogue γ for a variety of surfaces enabling a classification of inland lake bed material to be performed once the hydrographic features are known. Conversely, knowledge of the nature of the bedrock material would enable hydrographic classification to be performed on uncharted waters.

It should be noted that we have assumed γ to be essentially constant over the field of view, which is a reasonable assumption for the limestone ledges in southern Georgian Bay, but need not be reasonable for areas which are characterized by non-homogeneous lake bottoms. In such conditions a degeneracy arises between attributing changes in Band 4 apparent radiance to changes in depth of bottom or changes in γ.

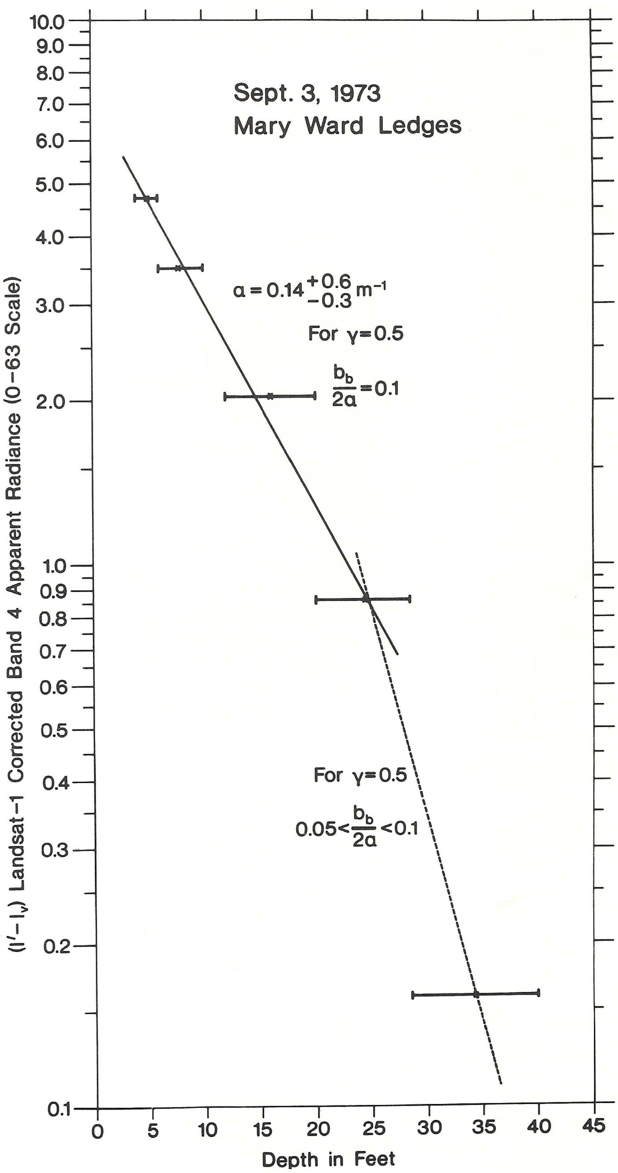

Figure 11. Iterative technique applied to the Mary Ward Ledges.

Appendix 1 — Discussion of Open Lake Atmospheric Correction

The Band 4 digital response over mid-lake waters contains energy return from the atmosphere, the volume of the water, and the surface, but not the lake bottom, i.e.

$$I(\text{Band } 4) = I_a + I_v + I_s \qquad (13)$$

Subtracting out a constant (on the 0 - 63 LANDSAT-1 scale) for $I_a + I_s$ neglects the contribution of I_v to the mid-lake response. From equation (6), the upwelling volumetric return from an elemental volume of water dz below depth z is given by

$$d\, I_z = b_b\, I_o\, e^{-2\alpha z} dz \qquad (6)$$

Integrating equation (6) from the surface (z = 0) to large depths (z = ∞) yields

$$I_z = \frac{b_b\, I_o}{2\alpha} \qquad (14)$$

The correction term subtracted from the Band 4 digital response in this work is therefore in error by the amount

$$\frac{b_b\, I_o}{2\alpha}$$

As seen from the direct measurement of "in situ" optical parameters discussed herein the value of

$$\frac{b_b}{2\alpha}$$

It is strongly dependent upon distance from shore decreasing rapidly from a value of 0.1 near shore to nearly zero beyond coastal influence. Therefore, the magnitude of the overcorrection to the data by assuming the mid-lake atmospheric and surface correction is considerably smaller than 10% of the incident radiance at the surface of the water.

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C. H. A. Crest Contest

At the 1976 National Executive Meeting in Burlington it was decided that we should try to devise a new Crest or Letterhead for general use by the C.H.A.

If you have an idea for a Crest and/or Letterhead for the C.H.A., please send it before 31st March, 1978 to:

Mr. J. Elliott
Canadian Hydrographic Service
P.O. Box 5050
Burlington, Ont. L7R 4A6

All entries become the property of the Canadian Hydrographers' Association, and a prize of $25.00 will be awarded for the chosen design. The C.H.A. does not bind itself to using any of the submissions. All entries will be acknowledged.

An Assessment of the Permanent Water Level Stations in the Canadian Arctic

F. STEPHENSON

Canadian Hydrographic Service
Pacific Region

Introduction

To monitor sea level fluctuations in the Canadian Arctic a number of permanent water level stations were constructed in the early 1960's*. In 1962 there were five permanent stations in operation (Table I). This network has grown slowly since then and presently there are thirteen permanent stations (Fig. 1), being operated by Water Survey of Canada on behalf of the Canadian Hydrographic Service.

It requires a large expenditure of manpower and money to maintain these sensitive instruments on a continuous basis. Subzero air temperatures and sea ice present problems which must be battled almost year round. Most of the stations are in isolated locations which can only be visited by trained technicians once every few months. Because of this, gauge malfunctions often go undetected for long periods and much valuable data is lost.

The average data return from the Arctic stations between 1962 and 1974 was 78% (Table 1). This is remarkably high considering the recording instruments being used and the conditions under which they are required to operate. But is it high enough? The technology now exists for a complete renovation of the Arctic gauging network. The form this renovation should take depends on what we see as the major requirements for an Arctic gauging network - now and in the future.

The Requirements

Records from permanent water level stations are required for the following:

(i) harmonic analyses of suitable time series for use in the prediction of tides;
(ii) the accurate determination of chart datums;
(iii) vertical control for charting and navigation;
(iv) marine engineering;
(v) for the use of geophysicists and geodesists in measuring eustatic changes;
(vi) oceanographic research; and,
(vii) input for numerical models of tidal progression and storm surges.

The main requirement for this data has for years been in meeting the needs of charting and navigation, however, the importance of this data for scientific research is increasing rapidly. Canada claims sovereignty over the vast Arctic Archipelago but it is an area about which we still know very little. Reliable long term water level records are required as input to many of the studies which must be done.

* Churchill has been in operation since 1940.

Arctic Water Level Gauges. 1962 - 1974

Since 1962 four types of recording instruments have been used at the permanent stations. They are the OTT float gauge, the OTT potentiometric gauge, the OTTBORO gauge and the Leupold-Stevens manometer activated bubble gauge. None of these instruments has ever been used exclusively at all of the stations. Each has disadvantages which makes it unsuitable for use in certain locations.

Common disadvantages are:

(1) The recording instrument must be placed in a shelter near the water and this shelter must be kept heated year round. If the heat source is interrupted when the outside temperature is below 0°C the water level gauge becomes inoperative. The station relies on electricity, diesel oil or propane for heat. These all require that the station be located near a settlement so that there is either a direct electrical connection or a runway so that diesel oil or propane gas can be brought to the station. This greatly restricts the choice of gauge sites.

(2) A lack of time control to the limits specified by the Canadian Hydrographic Service is inherent in all of the above instruments, especially if attendants visits are infrequent or nonexistent. Because of this much of the Arctic water level data is of limited use.

The four instrument systems can be further assessed as follows:

OTT float gauge

The OTT float gauge has been the most reliable of the gauges used in the Arctic during this period. However, the construction of the stilling well facility is very costly and time consuming. Stilling wells can only be constructed at sites having deep water right to the shore so that ice does not form around the inlet in winter. This makes it almost impossible to construct this type of gauge in the Western Arctic. At Tuktoyaktuk and Cape Parry attempts were made to connect the open water to a stilling well on shore by horizontal pipes, but these attempts failed due to the difficulty of keeping the connecting pipe ice free. Once in operation, these gauges require a heat lamp in the stilling well most of the year to prevent ice from forming on the surface of the water. The chart on the OTT is only long enough for one month of operation so a gauge attendant must be hired to change the paper.

OTT potentiometric gauge

This system uses a bottom mounted pressure transducer connected by electrical cables to a punch tape unit in a house on shore. The potentiometric gauge can be used in locations where shore ice freezes to the bottom in winter. The transducer is placed as far from shore as required to reach a location open to the tide year round. Problems occur when ice moves, breaks or shorts the cable. If portions of the cable freeze in the ice during the winter the cable and the transducer will


ARCTIC OCEAN
BEAUFORT SEA
GREENLAND
ELLESMERE ISLAND
Axel Heiberg I.
Kane Basin
3765
Ellef Ringnes
PARRY ISLANDS
Prince Patrick I.
Melville Island
Bathurst I.
Jones Sound
Devon Island
5560
Lancaster Sound
M'Clure Strait
VISCOUNT MELVILLE SOUND
Banks Island
6424
Somerset I.
Prince of Wales I.
M'Clintock Channel
Bylot I.
BAFFIN BAY
BAFFIN ISLAND
DAVIS STRAIT
AMUNDSEN GULF
VICTORIA ISLAND
6240
GULF OF BOOTHIA
6485
6360
6150
Coronation Gulf
Queen Maud Gulf
6290
NORTHWEST TERRITORIES
FOXE BASIN
ALASKA
Mackenzie River
Great Bear Lake
YUKON
Great Slave Lake
Southampton I.
5180
4140
4205
Hudson Strait
4379
HUDSON BAY
5008
5010
Ungava Bay
4575
PACIFIC OCEAN
Chichagof I.
Queen Charlotte Is.
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
JAMES BAY
ONTARIO
QUEBEC
LABRADOR
NEWFOUNDLAND
Vancouver I.
180° 160° 140° 120° 100° 80° 60° 40° 20°
80° 70° 60° 50°

Figure 1.

PERFORMANCE OF ARCTIC GAUGING STATIONS

PERCENTAGE OF DATA COLLECTED (INCLUDING INTERPOLATED DATA)

STATION NO.	LOCATION	62	63	64	65	66	67	68	69	70	71	72	73	74
								YEAR						
3765	ALERT	98	99	99	56	30	39	100	100	63	96	61	100	81
4140	FROBISHER		26	28	5			11	20	16	33	17	63	
4205	LAKE HARBOUR									45	33	91	79	100
4379	KOARTAC									93	27		32	33
4575	INOUCDJOUAC								91	95	38	30	38	100
5008	FORT CHURCHILL											98	100	66
5010	CHURCHILL	94	97	100	100	93	83	100	100	100	100	100	100	75
5180	CORAL HARBOUR									100	8	81	33	58
5560	RESOLUTE	100	100	98	75	93	90	100	99	84	97	100	84	100
6150	SPENCE BAY										69	47	75	68
6240	CAMBRIDGE BAY	61	47	100	100	100	100	100	100	100	100	100	100	25
6290	COPPERMINE												84	46
6360	CAPE PARRY					100	100	100	100	100	80	72	61	37
6424	SACHS HARBOUR												87	90
6485	TUKTOYAKTUK	100	100	97	92	88	98	54	52	46	80	20	90	85
	AVERAGE	91	78	87	71	84	85	81	83	77	63	68	75	69
	AVERAGE(1962-1974)	78												

Table 1.

PERFORMANCE OF ARCTIC GAUGING STATIONS

PERCENTAGE OF DATA <u>MISSING</u> - 1973

STATION NO.	LOCATION	1	2	3	4	5	6	7	8	9	10	11	12	A*	B**
							MONTH								
3765	ALERT	.	.	.	.	.	.	.	.	.	.	.	.	0	5
4140	FROBISHER	100	11	.	.	.	100	100	90	.	.	.	55	3	4
4205	LAKE HARBOUR	.	.	.	.	.	50	100	93	.	.	.	.	1	45
4379	KOARTAC	100	100	100	100	100	100	100	100	17	.	.	.	1	9
4575	INOUCDJOUAC	100	100	100	100	100	100	100	52	.	.	.	.	1	1
5008	FT. CHURCHILL	.	.	.	.	.	.	.	.	.	.	.	.	0	48
5010	CHURCHILL	.	.	.	.	.	.	.	.	.	.	.	.	0	22
5180	CORAL HARBOUR	48	100	100	100	100	100	100	77	.	.	.	74	3	13
5560	RESOLUTE	19	14	.	.	100	57	.	.	.	.	.	.	3	3
6150	SPENCE BAY	42	.	.	10	45	.	.	.	.	.	100	100	4	0
6240	CAMBRIDGE BAY	.	.	.	.	.	.	.	.	.	.	.	.	0	16
6290	COPPERMINE	68	21	42	17	.	.	.	.	.	.	.	48	3	0
6360	CAPE PARRY	.	.	61	.	16	43	.	.	47	100	100	100	3	37
6424	SACHS HARBOUR	.	.	.	:	68	47	19	.	.	.	.	10	5	1
6485	TUKTOYAKTUK	.	.	.	.	.	.	81	10	.	26	.	.	2	0

* Column A lists the number of periods of missing data in 1973 (periods too long for interpolation).

** Column B lists the number of days of record which were partially or completely interpolated.

Table 2.

probably be lost or damaged when the ice moves out in the summer. Trenching to bury near-shore portions of the cable beneath the effects of ice scour is too expensive to be practical.

The OTT punch unit is theoretically able to run unattended for up to six months, but unfortunately the gauge has proved to be unreliable for prolonged use in remote locations. When repairs are required they can seldom be done in the field.

Leupold-Stevens A71 water level recorder

This instrument is presently used in conjunction with a water stage manometer at all permanent stations in the western Arctic. The manometer system forces small amounts of nitrogen gas out of an orifice at the underwater end of a length of polyethylene tubing. The pressure required to force this gas out of the tubing is equal to the pressure head over the orifice and is measured by the recorder. An advantage of this system is the low cost of the polyethylene tubing. Since there are no underwater electronic or mechanical sensors, a line which is lost or damaged by ice can be easily and economically replaced.

Unfortunately lines must be replaced several times a year because every time pressure is lost in the line in winter water travels up the tubing and freezes. Each time the tubing and orifice are replaced the zero of the gauge changes. This means that each block of water level record receives only one or two sets of levels for vertical control - the accuracy of which depends on the sea state at the time of each levelling. The accuracy of the gauge zero is therefore often no better than ±0.1 feet.

For economic reasons these instruments are being run at half the minimum paper speed of 24 cm per day requested by the Hydrographic Service.

OTTBORO gauge

Although the OTTBORO was originally designed as a temporary gauge it has seen limited use at Arctic permanent stations. The instrument uses a closed air system to transmit the pressure exerted on an air filled rubber diaphragm in the water through capillary tubing to a pressure sensitive element in the recording unit on shore.

The OTTBORO is simpler in design than the bubbler gauge and the potentiometric gauge and is therefore less prone to instrument failure. However the instrument does not have the resolution of the other systems, is slightly temperature sensitive and suffers from a drift in gauge zero if sediment collects in the diaphragm housing.

In 1973 the total data return from the Arctic stations was 75% (including 4% data either partially or completely interpolated). This is very close to the thirteen year average of 78%.

Table 2 shows the percentage of data lost at the permanent stations for each month of 1973. During this period all of the previously mentioned instrument systems except the OTTBORO were being used in the gauging network. The minimum number of instrument breakdowns in a month was two in September, October and November. The maximum number was eight in June and in the remaining eight months there were a minimum of five stations inoperative for at least part of each month. There were a total of 29 instrument breakdowns in 1973. This is an average of approximately two breakdowns per station - not a very high degree of reliability.

Towards Increased Reliability

There are three ways by which the reliability of the Arctic gauging system could be increased.

(1) Modernize the existing gauges.

(2) Set up a real time water level acquisition system.

(3) Establish a network of self-contained bottom mounted pressure gauges.

Instrument reliability could be increased by replacing the current mechanical clocks with electronic clocks. Timing accuracy on mechanical clocks is seldom better than 1 minute a day. This means that at stations without gauge attendants timing accuracy is sacrificed because of a lack of proper time checks. An electronic clock using a quartz crystal timer is currently available to drive OTT and OTTBORO gauges, and could be adapted to the Leupold-Stevens. This clock has a maximum timing error of 3 minutes per month. It has the additional advantages of operation off a small battery pack for up to 12 months and operation in temperatures as low as -20°C. This makes it much less dependent on heat or electricity than the present clocks.

An electronic clock would definitely increase the quality of the data collected but it is doubtful if it would significantly increase the amount of data collected. Clock stoppages account for only about a third of the instrument breakdowns.

Since many of the stations are in remote locations most of the remaining breakdowns would still go undetected for long periods. This problem could be eliminated by adapting a real time data collection system to the instruments. Data could be fed into a computer daily and compared with predictions to immediately identify gauge malfunctions. Although this would increase the data return it would have no effect on the number of instrument breakdowns. An optimum data return with electronic clocks and real time data retrieval would only be about 90%. Current fiscal restrictions also make a real time Arctic water level system prohibitive.

A third alternative is to set up a network of in situ gauges. Although the data could only be recovered once or twice a year it would be possible with presently available pressure gauges to obtain a data return of very nearly 100%.

This alternative is in fact already being used at some of the Arctic stations. In 1975 Water Survey of Canada began replacing gauges in the eastern Arctic with bottom mounted Aanderaa pressure gauges. There are presently five stations equipped with these instruments. Atmospheric pressures are obtained from AES stations at or near the gauge site. These are received in tabular form and are keypunched onto cards for input to the computer. In the western Arctic the Hydrographic Service is now operating Aanderaa gauges at three stations in tandem with the WSC bubbler systems. Atmospheric pressure is measured by a second Aanderaa gauge in the AES office at each station. The atmospheric pressure is therefore immediately available in a form compatible with the tidal data.

Even though these instruments are highly reliable they are not perfect. To assure a near 100% data return two instruments should be installed at each station in moorings similar to that shown in Fig. 2, with a third instrument ashore as a barometric recorder. The instrument illustrated is an Aanderaa but it could just as easily be an Applied Microsystems gauge or any other unit of proven design and compact size.

Both the Aanderaa and the Applied Microsystems gauge are manufactured in Victoria and use the same quartz crystal pressure sensor. Both units are capable of recording pressure, time and temperature unattended for one year, although the increased tape capacity of the Applied Microsystems gauge means that it can sample more frequently or can be programmed to burst sample occasionally.

Each mooring would be installed in a location considered safe from ice scouring. The two instruments would be separated by about a hundred meters so that in the event of unexpected ice conditions only one instrument would be moved or damaged. A one year pinger on each mooring would allow divers to locate and recover the instruments each year even at locations where water visibility is poor. Each pinger would be a different frequency to allow positive identification of an instrument. The pinger and the pressure gauge would both sit in either PVC pots or PVC troughs and so could be quickly and easily removed or installed.

The mooring block is almost entirely non-metallic and will last indefinitely with little or no maintenance, thus providing a stable platform for an accurate long-term determination of gauge zero.

The high initial capital expenditure of equipping fifteen stations this way would be recovered in only two or three years through reduced operation and maintenance costs. A proposed schedule would involve only two visits to a station a year - once in the spring for levelling and once in the summer to level and exchange instruments.

Conclusions

The present Arctic permanent stations are not meeting all the requirements. There is a serious need for reliable, continuous water level information throughout the Arctic. There is also a need to expand the present network. In large areas of the Arctic Archipelago, particularly along the Arctic Ocean, there is no long term tidal data. A network of bottom mounted pressure gauges is the best means of meeting these requirements.

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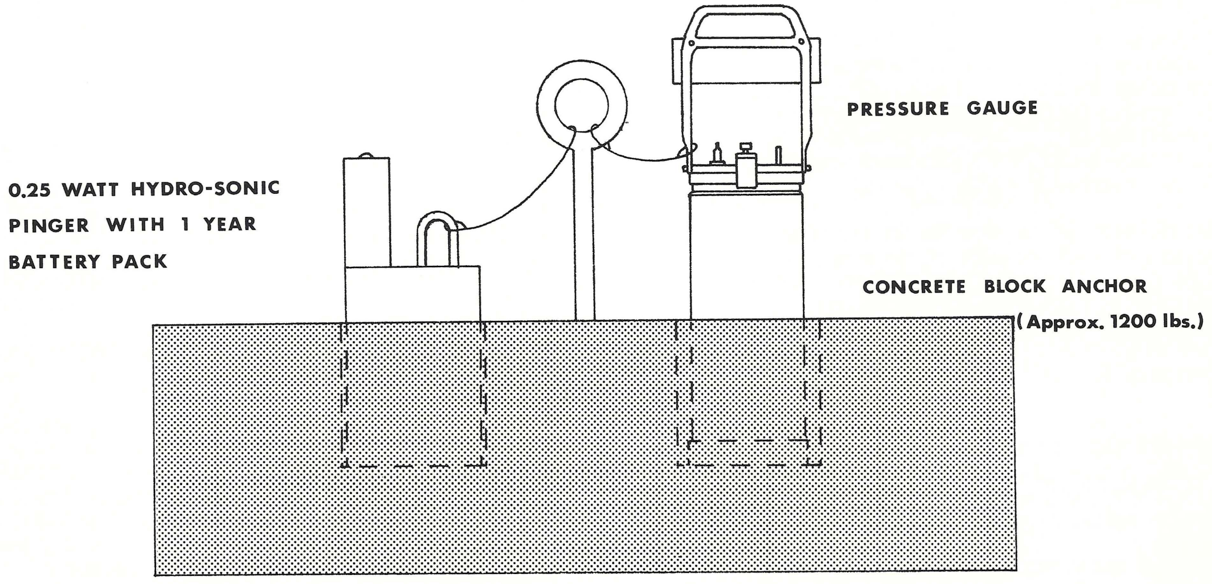

Figure 2.

Maxiran Trials on the Scotian Shelf

N. STUIFBERGEN

Canadian Hydrographic Service
Atlantic Region

Introduction

From August 16th to 22nd a MAXIRAN positioning system was tested in the vicinity of Sable Island on board the *Mary B. VI*, an offshore drilling support vessel operating out of Halifax.

The trials were organized by Marinav Corporation of Ottawa, and supported by Mobil Oil Canada Ltd., a company which is continuing the exploration effort to search for oil off the east coast of Canada. Participating in the tests were representatives from Navigation Management Inc., of Ocala, Florida, the company which developed the Maxiran System, and representatives from McElhanney Surveying and Engineering Ltd., Vancouver, B.C., who provided and operated a MiniRanger III System coupled to a desktop computer for calibration checks. Observers from other oil companies, NORDO, and the Canadian Hydrographic Service were also invited.

System Description

Maxiran is a multi-user, active-ranging system of positioning, which evolved from the Shoran/Hiran development of previous decades. Modern electronic circuit innovations have been incorporated in the design to make it a lightweight, solid-state system of medium range and high precision. Ranges of 300 km were demonstrated using the low power version of the system. With boosting amplifiers, ranges of 500 km have been achieved. The accuracy claimed is of the order of 10 m in distance. The cost of the basic system with three shore stations is about $100,000.

The Transmit and Receive operating frequencies are factory-set to values between 420 and 450 MHz. The transmissions are long modulated pulses (12.7 μs) which are detected in the receiver by a correlation technique, producing sharp compressed pulses whose time of arrival can be accurately measured. The pulse compression technique makes it possible to detect faint signals almost buried in noise, so that the transmitters can operate at relatively low power levels and use solid-state components in a compact design.

The pulses are transmitted in pairs; the time interval between the pair of pulses differs for each of the shore stations so that the receiver can identify each measured range.

The shipboard mobile unit (Monitor + Interrogator) can track any three selected base stations simultaneously. Acquisition of the stations is done manually and is easily performed in less than a minute; the distances are then displayed automatically without ambiguity (i.e. without lane count or cycle identification problems). In outward appearance, the acquisition and pulse-matching action is very similar to that of a modern Loran-A receiver. The returns from the shore stations are displayed on a large oscilloscope so that the operator can judge the quality of the measurement. The ranges are presented in metres on a numerical display and are updated continuously in the auto-track mode. Additional readouts show the time, day number, fix number, and line number. All of the displayed items are made available in digital form in both parallel BCD and serial format for recording on data loggers or to be fed to a small computer for on-line fix computation, steering guidance, and plotting.

Maxiran is a multi-user system; up to six mobile units can share the base stations. This limitation is imposed by the interrogation rate of 50 Hz of each mobile unit. If the interrogation rate were reduced, a larger number of vessels could operate together without saturating the base stations. No additional circuitry or modifications are necessary for multi-user applications, selection being made by one front panel control which effectively varies the interrogation coding.

The base stations are compact units, easily transported and manhandled, and two men can set up a station in less than an hour. The antenna is a directional array which is pointed to the working area and mounted on a 24 ft aluminum frame mast. It is important that the antenna be placed low above the water level (about 20 m) because the transmissions are propagated by a surface ducting effect.

The base stations are interrogated by the mobile units and respond with pulses transmitted at a power level of 200 W, running 2A from a 12 V battery. Linear amplifiers are available by which the transmissions can be boosted to various levels up to 20 kW, using about 5 A at 115 V ac. The shore stations can be run unmanned.

Various types of antenna are available, including a high-gain 48-degree beamwidth log-periodic array, a 135-degree beamwidth Yagi antenna, and an omnidirectional rod antenna. The shipboard antennas are interchangeable with the shore stations.

The shipboard antenna is mounted on a rotator unit and can be oriented by the operator using a remote control box which indicates direction relative to ship's head. A dual antenna system is available which will provide better reception when the shore stations are separated by a wide angle or when baseline crossings are run.

The Maxiran signals are received at distances beyond line-of-sight by a ducting mode of propagation, an effect which is dependent on meteorological conditions. Ducting occurs when the refractive index of radio waves decreases with height in the lowest 200 m of the atmosphere, causing the signal paths to curve downward. When the ray-bending curvature equals or exceeds the curvature of the earth, the signals are channelled along the surface. A favourable gradient of refractive index develops when the temperature increases and humidity decreases with height. Thus warm dry air over relatively colder water will result in excellent ducting propagation. It is the ducting effect along with the sensitive signal detection in the receiver that makes the extended range performance of Maxiran possible.

Field Tests

For the trials at Sable Island, five base stations were deployed along the coast of Nova Scotia between Halifax and Louisburg. One of these was later moved to Sable Island for baseline crossing tests. On the first run out, the *Mary B. VI* was moored to the *Gulf Tide*, a fixed drilling platform operating near Sable Island and positioned by Satnav. By an offset measurement of bearing and distance to the rig a calibration value was determined for the ship's antenna and the adjustment applied. The receiver has adjustable delay lines, set by thumbwheel switches so that 'locking constants' can be applied to each of the three channels. The measured distances are displayed in metres based on an effective propagation velocity of 229,700 km/s - a fixed value set by the frequency of a crystal oscillator.

Comparison checks were carried out at three stations near Sable Island using a MiniRanger III with transponders located on control points of a Tellurometer traverse along the island. The traverse was oriented by sun azimuth observations and tied to the mainland by Aerodist.

The observed Maxiran distances were compared with the distances computed by MiniRanger fixes. The field calculations indicated differences of the order of 10 m in lines varying in length between 180 and 280 km. Similar values were found on the baseline-crossing tests.

A second Maxiran mobile unit was installed on the *Gulf Tide* as a stationary monitor. It was found that the receiver gave usable results but was severely affected by electrical noise of welding and by power fluctuations caused by heavy machinery cutting in.

The trials raised a number of questions, mainly concerning the durability of ducting propagation, particularly in northern waters. It would be of great value to be able to predict good ducting conditions from meteorological data. It is thought that the signals would propagate poorly over sea-ice and over snow cover. With accumulated field experience and additional trials a better knowledge will develop of where and when adverse propagation conditions exist. Because the extended range performance of Maxiran depends on ducting propagation, one can expect that it might not always work in all hydrographic operating areas in all seasons.

From the trials at Sable Island, however, one gains the impression that propagation over the horizon is more prevalent and robust than the textbook explanation of the ducting phenomenon suggests.

The maximum ranges measured were at 295 km with a fairly distinct signal. Time did not permit a range test to the limit of reception. On trials conducted earlier this year off the west coast of Australia, ranges of up to 500 km were reported.

Conclusions

The most impressive aspects of the Maxiran system are the degree of precision attainable at distances far beyond the horizon, the absence of ambiguity in the measurements, and the ease of mobilizing the chain.

Hydrographic Surveying in the Context of the Surveying Engineering Program at the University of New Brunswick

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Preamble

The program in Surveying Engineering at the University of New Brunswick was initiated in 1960. During the period 1960 to 1965, it was administered by the Department of Civil Engineering as a two-year specialization program after successful completion of three years of Civil Engineering. The Department of Surveying Engineering was founded in 1965, and since that time has administered a full educational program in Surveying Engineering. In 1972 it was added to the list of accredited Canadian engineering programs by the Canadian Council of Professional Engineers.

Introduction

There are two objectives of this paper, with emphasis being placed on the second given below. They are:

a. To give a concise presentation of the undergraduate course of studies in Surveying Engineering at the University of New Brunswick.

b. To indicate to what extent this course of studies prepares a student for a career in hydrographic surveying.

To achieve these objectives, two items must first be given. The first is a complete definition of surveying engineering. The second is an explanation of the general educational philosophy adopted by the Department of Surveying Engineering.

Surveying Engineering can be defined as that discipline which is concerned with the measurement, analysis, and description of the physical features (natural and man-made) of the whole or any part of the earth, thus requiring a knowledge of:

(i) the physical properties of the terrain, the sea, and the atmosphere as they relate to the discipline;

(ii) the concepts and principles of measurement, processing and analysis of data;

(iii) the interpretation, representation, and transmission of surveying information for and to those who need it.

To prepare an individual, in four or five years of formal education, to meet the challenges offered by this discipline would appear to be an enormous task. In fact, the task would be impossible if the process was directed towards a "training" operation. However, if a person is presented with the basic concepts and principles of the subject matter pertaining to the discipline, and he or she has a sound understanding of them, subsequent formulation and solution of problems should presnt few difficulties.

The general philosophy of the Department of Surveying Engineering is that we offer an education as distinct from training. The definition of a university education was expressed well by Professor Jackson of McMaster University:

> "University teaching is not simply the imparting of information... but more important it is the tricky business of preparing the student to deal with what he (or she) comes to know, to discover how to ask the appropriate questions, to arrive at judgements, to develop methods, to construct models, to search and test and assess, to invent and to discover. For those abilities, rather than vast stores of knowledge, are the marks of an educated man,...".

Expressed in a comparative manner, A. Ingham wrote (in reference to North East London Polytechnic) [1977]:

> "... we are educationalists as distinct from instructors; we believe that our purpose is to develop the individual; to acquire the ability to evaluate and assess is as important as the training in certain skills in the making of a surveyor;...".

Adherence to this philosophy regarding education does not preclude the teaching of well-known and often used methodologies and training in certain fundamental skills. It is recognized that guidance in the application of concepts and principles is desirable, and often necessary, to impart a complete understanding of presented material.

Surveying Engineering Program

The undergraduate program can be split into two distinct parts - "core" and "elective". Within this context, the course requirements are then divided into seven groups. In Table 1, which gives an overview of the program, everything above the dashed line is part of the core, everything below is elective. The seven groups of subject material given in Table 1 are:

(1) Mathematics, Science and Computer Science;
(2) Basic Engineering;
(3) Surveying Engineering;
(4) Survey Camps;
(5) Cooperative Education;
(6) Humanities, Life and Social Sciences, Law;
(7) Technical Electives.

Each course listed is given in a three month (one term) period, and it is suggested that a minimum period of eight terms be taken to complete the requirements (e.g. as shown in Table 1). The letters in brackets with the electives indicate from what list a student may choose courses. The subject material of courses in these lists - A, B, C - are given in Tables 2, 3, and 4 respectively. It should be noted, however, that courses other than those given in these lists may, upon request, be accepted as electives.

The Cooperative Education program deserves some explanation at this juncture. Its start in 1972 was due, in large part, to suggestions by practicing surveyors and engineers that prospective surveying engineers should have some professionally supervised practical experience during the course of their formal studies. To date, this part of the program has served several purposes. It has given students the opportunity to come into contact with various branches of the surveying discipline while undergoing professionally supervised training. Equally important, employers participating in the program have had an opportunity to assess the potential of surveying engineering. In many instances, students have been able to begin apprenticeship programs such as those required by Land Surveying Associations/Corporations in Canada. Of course, the cooperative employment is only one part of this portion of the surveying engineering program. Two technical report courses are associated with it. These are designed to enhance a student's abilities in written and oral communication of technical information. Thus, Cooperative Education has become an important facet of the Surveying Engineering program, particularly in the areas of specialized training and continuing contact with the various branches of the surveying profession.

Undergraduate Specialization

The Surveying Engineering program of studies was not designed to fulfill the requirements of any subset of the surveying engineering discipline. However, since the change in 1972, from a set 5 year program of studies to a more flexible, credit-hour program, some undergraduate tailoring is possible where desired. It should be noted that any specialization undertaken by a student does not alter the degree he or she receives. In addition, since the Surveying Engineering curriculum is an accredited Canadian engineering program, no undergraduate specialization is required for graduates to obtain professional status with any of the provincial associations of professional engineers.

The process of specialization is best illustrated with some examples. The first shows how students might tailor their education to meet the future requirements of the Land Surveying Associations in Atlantic Canada. The second indicates how a student might obtain the education required of a Hydrographic Surveyor, using as a model the information given in the Report to the XI International Hydrographic Conference on Education and Standards of Competence for Hydrographic Surveyors [Ewing,1977]

For students wishing to become registered Land Surveyors in Atlantic Canada (New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland), to take maximum advantage of the Surveying Engineering program, they should proceed as follows: First, all course material of the Surveying Engineering program designated as "core" (Table 1) must be successfully completed. Secondly, in the course of fulfilling the Surveying Engineering degree requirements, the student should choose electives 10 and 11 and one of 2, 3, 7 or 9 (Table 2) from List A; 3, 4, 6 and 7 (Table 3) from List B; and 2 and 3 (Table 4) from List C. Thirdly, students are advised to use the Cooperative Education program to their advantage by seeking employment with registered Land Surveyors, possibly beginning required article time during periods of employment. Upon graduation, a prospective Land Surveyor is then left with having to complete the required article time, and to write any professional examinations required by the particular association.

The second example is that of tailoring the Surveying Engineering program to fulfill the suggested IHO/FIG requirements for a Hydrographic Surveyor Category A* [Ewing, 1977]. In this instance, it is easier to indicate the specialization route by showing what elements of the Surveying Engineering program satisfy the subjects given in the IHO/FIG syllabus. An abbreviated version of the latter is given in Figure 1. For the purpose of this example, specialization for Nearshore or Offshore and Oceanic Surveying are not considered (items 10 and 11, Figure 1). The groups of subject material listed as BASIC (elements 1, 2, and 3, Figure 1) are covered jointly by the core of the Surveying Engineering program and electives 3, 4, and 7 of List A (Table 2). A combination of Surveying Engineering core courses, electives 3, 4, 10 and 11 from List A (Table 2) and electives 1 and 2 from List B (Table 3) satisfy the SUPPORT group of subjects save for a deficiency in Oceanography. At this time, no courses in Oceanography are available at the University of New Brunswick. Course groups 6 and 7 (CORE, Figure 1) are covered by the Surveying Engineering core course material plus electives 3, 4 and 5 from List A (Table 2) and electives 1 and 2 from List B (Table 3).

Within this group, a course in Physical Oceanography is suggested [Ewing 1977]. The statements made above regarding Oceanography apply here as well. Finally, the PERIPHERAL subjects must be dealt with. The elements of item 8 are given in the Surveying Engineering core material and elective 9 from List A (Table 2). In subject group 9, the courses listed are Navigation, Pilotage and Seamanship, and Meteorology. No formal courses in any of these subject areas are offered at the University of New Brunswick. In closing the discussion of this example, several important points must be noted. First, all subject material is treated as per the general philosophy previously outlined. This implies that whenever and wherever a practical knowledge of the operation of a particular set of instruments is required, the details of all operations of a particular type of hydrographic survey are needed, etc., it is expected that a student will obtain the required training during Cooperative Education employment periods and after graduation under the supervision of persons who are knowledgeable in that particular field of interest. Finally, a comment regarding subject

*Ewing, (1977). "Hydrographic Surveyor, Category A. A comprehensive and broad based ability in all aspects of the theory and practice of hydrography and allied disciplines. With appropriate experience, to be able to plan and direct any type of hydrographic operation and take responsibility for its accurate and thorough execution. To be able to develop new approaches to hydrographic operations and assess recorded data."

GROUP	Term 1	Term 2	Term 3	Term 4	Term 5	Term 6	Term 7	Term 8
1	Calculus I, Introduction to Computer Programming, Fundamentals of Physics	Calculus II, General Chemistry	Linear Algebra, General Geology	Advanced Calculus, General Geology, Light and Sound (Physics)	Differential Geometry, Numerical Methods (Computer Science)	Complex Variables and Partial Differential Equations		
2	Applied Mechanics I	Applied Mechanics II, Engineering Graphics, Electricity & Magnetism	Descriptive Geometry		Electronics for Surveyors			
3	Elementary Plane Surveying		Advanced Plane Surveying, Analogue Photogrammetry	Theory of Measurements, Cartography I, Cadastre I	Introduction to Adjustment Calculus, Map Projections	Geodetic Surveying, Advanced Adjustment Calculus, Geodesy I, Analytical Photogrammetry, Astronomy	Geodesy II, Aerotriangulation, Cadastre II	Geodesy III, Cartography II, Survey Systems
4	Participation in two two-week survey camps is required following Advanced Plane Surveying and Geodetic Surveying							
5	A minimum of six months employment approved under the Department's Cooperative Program				Technical Report I		Technical Report II	
6	Elective (C)	Elective (C)	Elective (C)		Economics	Economics	Real Property Law	Commercial Law
7				Elective (A,B)			3 Electives (A,B)	3 Electives (A,B)

Table 1. Requirements for the BScE degree in Surveying Engineering – Suggested Eight Term Schedule

1. Engineering Surveying	7. Remote Sensing
2. Mining Surveying	8. Digital Mapping
3. Hydrographic Surveying I	9. Special Studies in Cadastre
4. Hydrographic Surveying II	10. Land Economy
5. Special Studies in Geodesy	11. Surveying Economics & Management
6. Special Studies in Photogrammetry	

Table 2. Elective List A

1. Exploration Geophysics I	7. Site Planning
2. Exploration Geophysics II	8. Introduction to Outdoor Recreation
3. Urban Planning I	9. Topography and Photo-Interpretation
4. Urban Planning and Design	10. Advanced Scientific & Engineering Programming
5. Route Design	11. Introduction to Computer Graphics
6. Municipal Engineering	

Table 3. Elective List B

1. Man and the Biosphere	6. Introductory German
2. Management of the Enterprise	7. Canadian History
3. Management of Human Resources	8. Canadian Government & Politics
4. Survey of English Literature	9. Provincial & Municipal Government
5. Introductory French	

Table 4. Elective List C

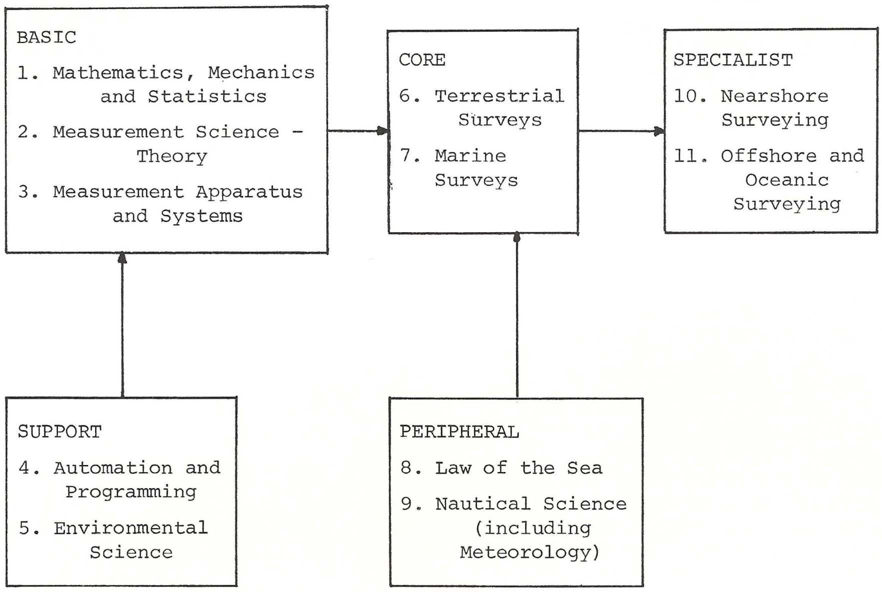

Figure 1. IHO/FIG Syllabus–Grouping of Subjects

material that is not covered by the Surveying Engineering program, namely Oceanography, Meteorology, Navigation, Pilotage, and Seamanship. These areas of study can be considered to be similar to the professional elements of a Land Surveying education - they are subjects which are important only to one branch of the Surveying Engineering discipline and thus should be dealt with by experts within that particular branch. Thus, expertise in the above mentioned subjects can be obtained after graduation in Surveying Engineering.

Courses in Hydrographic Surveying

The Surveying Engineering curriculum includes, as has been seen earlier, two undergraduate courses in Hydrographic Surveying (Table 2). The content of the courses demands a broad interpretation of the title Hydrographic Surveying, such as might be found in papers entitled The Role and Training of the Hydrographic Surveyor [Ingham, 1971] and The Multi-Faceted Education of the Hydrographer [Kerr, 1974]. As with all other Surveying Engineering courses, these have been designed and are presented with the departmental philosophy of education in mind. With particular regard to the teaching of hydrographic surveying subject matter, this is consistent with the philosophy put forward by other teachers of this material [Ingham, 1971]: "As much as possible, all forms of instruction should be founded on a knowledge of basic principles and never on procedure".

Hydrographic Surveying I is an introductory course designed primarily to give the student an appreciation of the challenges facing a sea-surveyor and the knowledge required to properly address those challenges. Detailed subject matter includes an explanation of the objectives and basic principles of hydrographic surveying as they apply to the needs of hydrography, oceanography, marine biology, marine geology and geophysics, coastal and offshore engineering projects, natural resource exploration and recovery, offshore international and intranational boundary determination, etc. The specific requirements of geodesy, photogrammetry, land, legal and engineering surveying, and cartography for hydrographic surveying are presented. The real-time determination of horizontal positions is dealt with extensively for inshore, coastal, offshore and oceanic surveys. Included in this is a study of the various types of instruments used (e.g. optical, electronic, satellite, hybrid systems), and associated observables (e.g. directions, angles, distances, distance differences), the mathematical models required for position computations, instrumental error sources (systematic and random), the effects of the atmosphere, land, and sea paths, and the determination and expressions of the accuracies of positions. Depth determination for inshore and coastal zones is dealt with. The establishment of a vertical datum is treated. The propagation of acoustic waves, with all of the associated effects (e.g. propagation losses, noise) are presented. The basic principles of echo sounding - instrumentation, reduction of measured depth, the accuracy of soundings - are given. Associated with the formal lectures are computational laboratory exercises and the preparation and presentation, by students, of brief but in-depth papers on course material. The total time allotted to present this material is thirty hours.

Hydrographic Surveying II is conducted in a manner similar to that of the previously described course. The time allotted here is forty-two hours. The three main topics of study are tides, underwater acoustics, and position determination. For each of these, the sequence of study is to first examine the underlying physical phenomena involved (e.g. tide producing forces, physical properties of seawater, earth's gravity field) and then analyze well-known mathematical models used to represent the physical situations (e.g. harmonic tidal formulae, acoustic equations, observation equations for position determination). Studies of each of the three topics also includes the reasons for the need of collecting certain data (e.g. prediction of tides), and an overview of certain devices used for data collection (e.g. tide gauges, echo-sounders, electronic distances measuring devices), and the processing, analysis, and representation of hydrographic information.

Summation

Of the two objectives stated at the outset, only the second requires some concluding remarks. Seventy-two hours of elective classroom time are devoted to the study of hydrographic surveying. Under the present circumstances, this is seen as being adequate since most of the knowledge required by hydrographic surveyors (e.g. Ewing,[1977]) is presented in several other core and elective Surveying Enginering courses. Combined with professionally supervised cooperative employment and external studies in oceanography and meteorology, Surveying Engineering provides a sound basis for those aspiring to enter the field of Hydrographic Surveying. Finally, it can be seen that this broad-based education program fulfills the needs of future hydrographic surveyors [Kerr, 1974]:

> "It appears to be generally accepted that a hydrographic operation requires a number of generalists who will coordinate and manage the work. These generalists cannot be expected to learn in detail every facet of the specialists' work but it is essential that they comprehend enough of their work that there be a satisfactory communication. The survey manager may even be a specialist himself but it is essential that he understands enough of everyone else's work aboard that he can make effective management decisions."

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INTERNATIONAL HYDROGRAPHIC TECHNICAL CONFERENCE
CONFÉRENCE INTERNATIONALE TECHNIQUE SUR L'HYDROGRAPHIE
INTERNATIONALE HYDROGRAPHISCH-TECHNISCHE KONFERENZ
CONFERENCIA INTERNACIONAL TECNICO-HIDROGRAFICA
OTTAWA 1979

The Canadian Hydrographic Service, the Federation internationale des Geometres and the Canadian Institute of Surveying will jointly host an International Hydrographic Technical Conference in Ottawa at the Government Conference Centre May 14-18 inclusive, 1979. The theme of the Conference is "Development of Ocean Resources". In addition to invited papers on Hydrography, Ocean Engineering and Surveying, the Conference will include a major Exhibition. Further information may be obtained by contacting :

The Organizing Committee,
International Hydrographic Technical Conference,
Room 209, 615 Booth Street,
Ottawa, Ontario, Canada.
K1A 0E6

Laser Ranger Evaluation

GEORGE FENN

Canadian Hydrographic Service
Central Region

Introduction

In June, 1977 Marinav Corporation of Ottawa, Ontario, made available to the Canadian Hydrographic Service, Central Region, a short range precision distance measuring device known as "Atlas Lara 10 Laser Ranger". This equipment is manufactured by Eumig Camera, Austria and distributed by Krupp Atlas Elektronic, Bremen, West Germany. The "Laser Ranger" is quoted as being capable of measuring distances to 500 m with a beam width of 0.57^{o} (1 m at 100 m) and an accuracy of $\pm$10 cm $\pm 1^{o}$/oo of the measured distance. The unit is powered from a 12 v dc or 115 v ac supply. It is light and small enough for one man operation. The instrument consists of two parts:

1) An optical head measuring 10 cm x 15 cm x 20 cm and weighing 3 kg, and
2) A distance display unit measuring 10 cm x 20 cm x 30 cm and weighing 3.5 kg.

The optical head can be placed on a tripod or can be hand held with the use of a shoulder harness. A gunsight telescope is also included.

Operation

Distances are measured through the use of a laser diode which transmits an infra-red light pulse through an optical sender lens and receives a return pulse through an optical receiver lens. An electronic circuit measures the pulse travel time and displays the computed distance. When the laser is triggered on a target, the measured distance appears on the display. If the transmitted laser pulse fails to return to the unit, the previous reading will be displayed along with a small red warning light indicating that the reading has not been updated.

Target Test

The working range is dependent on the type of reflective surface used for the target. Most test surfaces such as trees, ships, automobiles, building surfaces, and pavement returned a signal up to 110 m away. With a 1 metre square board covered by a special reflective tape (Scotchlite SL 5270) measurements up to 422 m were obtained. Readings in excess of 422 m using the 1 metre square board proved unreliable. Another test target used was the prism from a H.P. 3800 distomat. This target gave reliable measurements up to 520 m, while measurements in excess of this were unreliable.

Tests and Results

Tests were carried out at the Canada Centre for Inland Waters, Burlington, Ontario, during June, 1977. Initial tests were designed to evaluate accuracy and repeatability across land and water. The following results were obtained from groups of 10 readings at each station. The instrument was set up, on a tripod, at known points. The targets were then set up at a series of known distances from the instrument. Each distance was initially measured using a H.P. 3800 Distomat.

Target Orientation

A test was conducted to determine the sensitivity of the system to target orientation. The square board, with reflective tape, was set at various distances and then rotated about the normal to the laser beam until signal was lost. It was found that, at a distance of 180 metres, the board could be rotated 40^{o} in either direction before signal was lost. At 300 m the angle was cut down to 30^{o} in either direction, while at 422 m the board had to remain perpendicular to the laser beam. With other targets such as trees, walls, and cars, the range was dependent on the target being large and reflective enough for full beam width contact.

Beam Width and Sensitivity

The next test was to determine the beam width. Targets were set up at various distances and the laser focused directly on their centre. The target was then moved in a plane perpendicular to the laser beam. At 185 m the square board, with reflective tape, was moved a total of 3 m across the beam giving constant readings. Beyond 3 m, the unit would not update any new readings. Similarly at 300 m the board was moved a total of 2.75 m across the beam with constant readings. At a distance of 517 m the board had to be precisely in the centre of the beam to obtain readings. If the board had any lateral movement the unit would display the warning light and the previous reading. To examine the beam width at greater distances the prism was set 517 m away from the Laser Ranger. It was found that the prism could be moved a total of 6.5 m across the beam with constant updates. The results, using both the board and the prism targets, verify that the beam width is approximately 1% of the range specified.

Atmospheric Effects

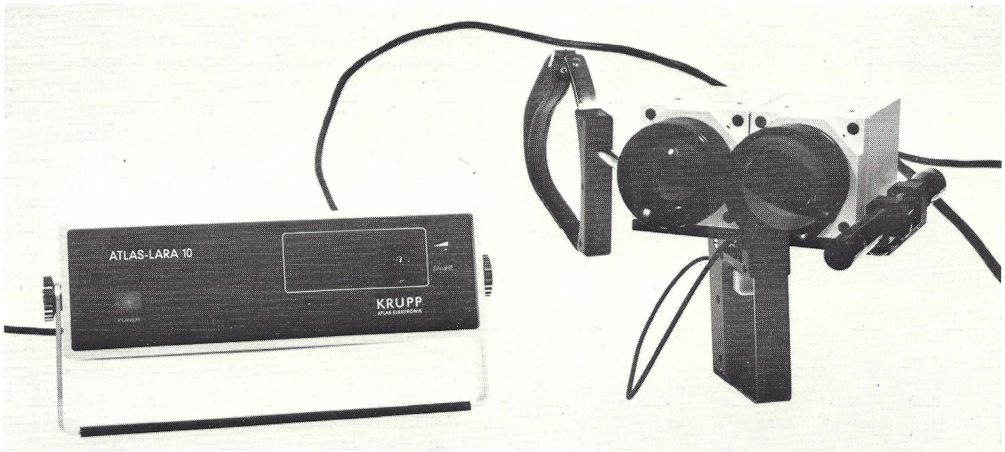
A test was set up to observe atmospheric effects on the unit. It was first noted that the position of the sun, relative to the laser beam, had no observeable effect on the accuracy or repeatability of the unit. Performance was unaffected by the beam crossing a land-water interface.

The instrument case leaked slightly causing the lenses to fog up during wet weather. Subsequently, the maximum range decreased depending on the severity of the weather. Fog and haze also decreased the range of the unit, again depending on their intensity. At one point, with the visibility at about 100 m, the unit would not pick up objects further than 27 metres away. One annoying part of the unit was the polarized screen over the output display which, under survey conditions, made the distance display extremely difficult to read.

Simulated Survey

To simulate a hydrographic survey, the unit was placed in a Boston Whaler with the targets located ashore. One person stood over the echo

Measured Distance	Average Reading	Error	Standard Deviation	Target Type	Conditions
91.44 m	91.67 m	+0.23 m	0.052	Reflective Board	Good, over land
45.72 m	45.85 m	+0.13 m	0.303	" "	" "
27.43 m	27.69 m	+0.26 m	0.032	" "	" "
9.14 m	9.36 m	+0.22 m	0.084	" "	" "
624.046m	615.2	-8.85 m	0.000	Prism	Good, over water
517.354m	517.5	+0.146m	0.067	"	" "
421.636m	421.8	+0.164m	0.000	Reflective Board	" "
303.661m	303.9	+0.239m	0.000	" "	" "
188.270m	188.25	-0.020m	0.050	" "	" "
517.354m	513.62	-3.914m	5.024	Reflective Board	" "
530.871m	No update			" "	
639.374m	No update			Prism	



sounder transducer with the unit held like a rifle. The first target used was a 1 metre square board painted white. The boat was steered away from and toward the target and distances of up to approximately 90 metres were measured. Past this distance, because of the action of even small waves on the boat, the unit could not be accurately aimed at the target. The board was then turned so that a reflective surface was shown, and the same results were obtained. The prism was then installed ashore instead of the board and the measured distance was extended to 165 m.

The weight of the unit made it difficult to hold rifle-style in the boat for any length of time. As an alternative the unit was set up on a tripod on shore and the target in the boat. This system also proved difficult to use as the Laser Ranger could not be rotated on the tripod in a vertical plane. However, by manually tipping the unit the tests were carried out. Using the square board securely fixed in the boat as a target a distance of 450 m was measured. However, since it was necessary that the board face directly towards the Laser Ranger, the boat could only be steered on one bearing. The board also tended to act as a sail, making it difficult to run on line. The prism was mounted in the boat as the target and, since it could rotate 360^0 in the horizontal plane, allowed more flexibility in running range lines. Distances of 610 m were measured using the prism target.

Conclusions

The "Laser Ranger" worked well within its stated limitations. When used with a prism, its range and accuracy under hydrographic survey conditions were high. On most large scale or wharf surveys the unit would work satisfactorily. Using a theodolite mounted with the unit, these surveys could be turned into very useful and accurate two-man operations.

Recommendations

From the test results, the unit was found to need some modifications. A ball joint on some other mounting device is necessary to give greater flexibility of movement in all planes. For shots up to 500 m a directional prism is a preferred target. The instrument case should be made weatherproof to protect the electronic components. An improved sun screen should be installed to facilitate reading the output display during daylight hours. A more convenient trigger mechanism, other than the remote camera shutter release, should also be available. Anti-fog lenses could also be added to make the unit more functional.

There is no new thing under the sun. (Ecclestiastes I. ix.)

R. W. SANDILANDS

Canadian Hydrographic Service
Pacific Region

In recent years there has been much discussion on the reliability of charts and various national charting agencies have, in different ways, attempted to classify the reliability of their surveys.

The following letter from Captain John Richards, RN to Rear Admiral Sir William Wharton, Hydrographer of the Navy, shows that this problem was being considered over eighty years ago.

10 February 1893

"It would greatly facilitate safe navigation if the value and character of charts were to be engraved on their margin by a note or letter. Thus, for example, A might signify that the Hydrographer feels satisfied that the chart is scientifically constructed, the necessary land features, or sailing marks, complete and correctly done.

A.1. might be understood to include all the former points together with the Hydrographers belief in the general correctness of the survey below as well as above the water mark.

A. 2. would certify to the former but imply doubts on the latter points to be explained by a marginal note or in the Sailing Directions.

A. 3. construction and landmarks good, insufficiently sounded or some of the features below low water mark doubtful.

B.1. would imply that the Hydrographer does not possess evidence of scientific construction but from the general style of the work believes it to be trustworthy, and so forth to C - untrustworthy charts.

To illustrate the above I would mark our charts of the Channel Islands A. 1. because they are practically perfect in construction and execution, but my chart of Morecombe Bay A.2. for the reason that although scientifically constructed and correctly executed, the very extensive sand banks bounding the ship channels are continually shifting."

Captain Richards served under the irascible Captain Belcher and was one of the few officers ever to receive a good report from him. He had charge of the Channel Island and west coast of England surveys from 1861 to 1872.

Obviously the problem wasn't solved then and is still before us today.

* * * *

Back issues of **LIGHTHOUSE**
Editions 13, 14 & 15 are available
at a cost of $3.00.
Order through the Editor.

CSS Baffin Mid-Life Refit

R. GILBERT

Canadian Hydrographic Service
Atlantic Region

BAFFIN was delivered to the Canadian Hydrographic Service early in 1957 and has worked steadily ever since. Most of the work has been hydrographic surveying in the Arctic, off the East Coast, and as far south as Guyana. She has occasionally been used for oceanographic research projects and has shown herself capable of collecting water samples in winds in excess of 30 knots, but her forte has always been Arctic surveying. The hull is designed to work in ice, but has very shallow draft for her size so that she can work comfortably in shallow water. She carries five 31 ft. survey launches (originally six) and has an endurance of about four months. She is the biggest of the fleet of ships which are dedicated to Canadian Hydrographic Surveys. The dimensions of *BAFFIN* and other Canadian oceanographic research and hydrographic vessels are given in Table 1.

Canada is unusual in that Hydrographic surveys are carried out by a Government Service which is associated neither with the military nor with the regulation of commercial shipping. The Canadian Hydrographic Service is directly associated with research oceanographers, and for many years the hydrographers on *BAFFIN* have obtained gravity and magnetic data at the same time as they measure water-depths, type of bottom, etc. Indeed, it is fair to say that the precision of the navigation of *BAFFIN*, which is as necessary for good gravity measurements as it is for hydrographic surveys, ensures that the final results are of outstanding quality.

BAFFIN has given outstanding service since she was built, but there is no denying that she is no longer in the first flush of youth. She was designed in an age when manpower was still cheap, and the design details show it. Her layout and decor are showing signs of age; spare parts for some of the machinery are getting very difficult to obtain. In 1974, Institute Facilities started to consider her future - when should she be scrapped and replaced with a modern vessel? Was her design the best that we could achieve today, or would the new ship have different characteristics? In particular, should the new ship be designed solely for Hydrography, or should there also be an oceanographic capability?

The first point which was resolved was that there was hydrographic work in abundance for a ship of *BAFFIN's* capability. Even though the drive into the Arctic would demand either really heavy ice-breaking capability, or alternatively working from the ice, for some areas, the need for surveys in moderately ice-infested areas was seen to continue for many decades to come. At the same time, there is a growing belief that, with today's fiscal restraints, there is an urgent need to make the maximum possible use of all our resources. In the past, there have been too many winter seasons when *BAFFIN* has not been in use, and this led to the concept that, while the ship should be primarily hydrographic, she should also have a capability to carry out oceanographic research. This belief was reinforced by the Senegal project, which showed that oceanography and hydrography could be combined into a single, highly-successful cruise.

The cost of a replacement vessel was estimated, with figures of 20 and 30 million dollars being bandied about. With costs like these, it was recognized that a replacement could not reasonably be expected for many years. The thought gradually developed that maybe we should thoroughly overhaul the *BAFFIN* instead of replacing her. How much would it cost to convert *BAFFIN* into a modern ship, equivalent (or nearly equivalent) to the 20 or 30 million dollar dream? The hull was good - needing some stiffening at the bows, to be sure - and would last at least another 20 years. Much of the machinery was good and the purchase of a limited quantity of spares would ensure operation for another 20 years. Should we perhaps plan on replacing the engines to give an increase in driving power and so increase her ice capability, buy quantities of spares for all other machinery, upgrade the living accommodation, install all possible labour-saving devices (especially the launch davits), and provide limited laboratory facilities? The estimated cost was 4½ million dollars and the end-result would be sufficiently close to the "dream-boat" that it looked a very

NAME	YEAR	LENGTH	BEAM	DRAFT	DISPLACEMENT	MAX SPEED
[1] CSS DAWSON	1967	211.75'	40'	15.25'	1966 Tons	12 knots
[1] CSS HUDSON	1962	296.5'	50'	20.58'	4660 Tons	16.5 knots
CSS BAFFIN	1956	285'	49.5	18.25'	3700 Tons	15.5 knots
CSS MAXWELL	1961	115'	25'	7'	230 Tons	12.6 knots
[2] CSS LIMNOS	1968	147'	32'	8'	650 Tons	10 knots
CSS PARIZEAU	1967	211.75'	40'	15.25'	1966 Tons	12 knots
CSS RICHARDSON	1962	66'	16.8'	6.8'	75 Tons	9.5 knots
[1] CSS VECTOR	1967	130'	31'	11'	650 Tons	10 knots
CSS WM. J. STEWART	1932	228'	35'	13.5'	1845 Tons	10 knots

[1] Oceanographic Research Vessels
[2] Limnological Research Vessel

good bargain. So, we discussed the concept with the staff at BIO, at a series of seminars, and firmed up the concept into a proposal.

The proposal was included in the program forecast submitted in the fall of 1975. So, of course, were many other proposals. As the months went by, there was no positive word on any of the proposals; we became resigned to another year with costs rising, but dollars fixed. Imagine, then, the astonishment of seeing in the blue book - the Parliamentary Estimates - the *BAFFIN* Mid-Life Refit, the only new item for the entire Department. And what was more, half a million dollars in the upcoming fiscal year. What had, up till now, been an idle fancy had become an urgent reality - and we had to get moving.

Now that the refit had become a reality, all sorts of people who had not previously been very interested came pounding on the door, insisting that their particular requirements were absolutely vital. The basic yardstick against which all the requests were measured remains fixed. The primary purpose of the ship is hydrographic survey - including multiparameter surveys and launch operations - and oceanographic research is to be carried out only if it does not conflict with the survey. Nevertheless, it is anticipated that there will be winter seasons when there is no hydrographic survey work to be done, and also that we will perfect the ability to combine hydrographic and oceanographic programs during years to come.

It was February, 1976, when we knew that we had half a million dollars to spend in 1976/77 fiscal year, and two million in each of the two succeeding years. The first thing which had to be done was to tie down the broad definition of the work scope. Studies showed that the original idea of replacing the engines, and upgrading the performance in ice, was not feasible without enormous cost. Replacing the whole drive system, including shafts and propellors, would require re-building the stern section of the ship. Variable pitch propellors were not feasible, for similar reasons. Therefore, it was proposed to keep the existing engines and drive-train, and purchase 20 years' worth of spares, while they are still in production. Investigations were carried out into a bubbler system which had been developed by a Finnish yard. A large quantity of air is blown from a series of nozzles mounted in the sides of the hull, deep below the surface. The air stirs the water and ice vigorously, and reduces the friction of the slush on the ship. It also appears that, in unbroken ice, air gets trapped under the ice ahead of the ship, enabling it to be broken more easily. The system has become almost a standard fitting to ships built for Baltic service in winter. It was determined that the system could be applied to *BAFFIN*, and that it would not affect sounding capabilities. A review was carried out of all mechanical, electrical and electronic equipment on the ship to determine what should be replaced and what spares should be bought - and requisitions promptly raised for items which could be bought quickly. Half a dozen crew cabins were upgraded, changing from the old-fashioned double berth cabins to modern single-berth, brightly decorated cabins-smaller than old ones, it is true, but obviously preferable. A concept was developed whereby the oceanographic capability would be directed towards continental-shelf capability for geological work to avoid the cost and complexity of a deep-sea heavy coring winch; laboratories are to be modular so that they can be outfitted on shore, and then installed on the ship - with substantial reduction in turn around time. The long standing problems with clutches was analyzed and found to be largely due to incorrect installations, twenty years previously, of the hydraulic couplings. A system was devised to convert the davits from manual to power operation and one test system was ordered. A system to permit partial control of the propulsion system from the bridge was devised, upgraded electrical generation systems designed, and logging system for the engine room.

Seminars were held from time to time with the staff at BIO, and the first year's budget was met - largely used to purchase spares. When the major requisition was forwarded, for the bubbler system, a train of events was initiated which resulted in the formation of an advisory committee for the Mid-Life Refit. The committee reviewed all aspects of the refit proposals and approved all but the bubbler system, which was considered to be not adequately proven for Arctic work. This in turn has reduced the demand for funding in the 77/78 fiscal year, so that once again there is strong pressure to find items which can be delivered quickly. A series of proposals initiated by the Hydrographic Service has covered a range of equipment, including 45 ft. launches, data-logging systems, multi-beam sonar, etc. These in turn have been reviewed by study groups to determine their desirability and availability. At present, it looks as though the expenditures this year will come close to 2 million dollars but there is still some uncertainty as to the cost and precise timing of many items.

The refit items have changed quite appreciably since the original ideas were formed but the basic concept and drive have not changed at all, and at the end of the project we will have a ship which is ready for another twenty years' work, from equator to pole, with facilities which are unequalled in the world. The mechanical systems of the ship will be redesigned to cut down costs - simpler, more reliable, less manually-intensive systems. The hull will be strengthened in one or two areas of weakness. Accommodations will be upgraded, including individual cabins, dining areas, galley, and washrooms, to result in a ship with fully up-to-date standards. The ship will be fitted with a comprehensive navigation system (including Sat-Nav, Range-range Loran-C, etc.) and a shipborne computer which will match in detail the data-gathering system. The requirements for launches, launch sounders, and data-loggers have been defined by special task forces, and manufacturers are being approached concerning the supply of these items. Facilities are being added for oceanographic work, including modular laboratories, winches and equipment handling systems, and a bow-thruster.

The final scope of the ship is rapidly becoming clear. *BAFFIN* will continue to be, primarily, a Hydrographic survey ship. She will carry a helicopter, four 31 ft. launches and two 40 ft. launches. She will be equipped to collect and process data using an integrated data-gathering and data-processing system, which is designed so that the output of data is increased, while the staff required is reduced. Labour-saving systems will be introduced throughout the ship, in an effort to reduce the costs of collecting data.

Navigation systems include Satellite Navigation, Rho-rho Loran C, Hi-Fix or Mini-Fix, Radar transponder systems, and Decca Lambda; and there is no doubt that in the not-too-distant future, the inputs from all these systems, and perhaps more, will be used to automatically determine a single "best" value for the ship's position at any given instant. The ship's computer is provided with plotters so that plots can be quickly made of the ship's track; CRT displays will facilitate the work of hydrographers checking that track-crossings indicate that quality of data is being maintained, or will assist in locating areas of suspected shoals, to be examined by the launches next day. Experiments are to be carried out in the near future in an attempt to find out more about the air bubbles which get carried under the hull in rough weather, and it is hoped that an echo-sounder system will be devised and installed which will overcome the rough weather limitations. Side-scan sonar is to be evaluated, and it is confidently predicted to be of great value in the unsurveyed Arctic waters. New recreational facilities will provide relief to both hydrographers and crew during the long and isolated surveys in the North. Even though the ship makes a port call every three or four weeks, the facilities available at Northern posts are very limited.

The number of ship's crew and hydrographers required to operate ship, launches, and equipment will be reduced by labour-saving devices. The number of berths will remain about the same, however, so that we can get even more out of each voyage of the ship. It is not uncommon to find that there are times when the ship could be utilized more fully than is now the case. There is considerable potential for measurements which can be made while the ship is underway to be combined with Hydrographic Surveys, and there are occasions when the ship and/or launches are not fully occupied by Hydrography. Laboratory facilities will be built so as to give the ship maximum versatility. The laboratories will be based on the container module of 20 ft. x 8 ft. x 8 ft.; they will be more robust than containers, and the ship will be designed so that they are an integral part of the structure. Access to the labs will be totally under cover, and doors can also be provided to interconnect adjacent modules.

Each module will be a "shell", provided with standard connections for power, water, drainage, and heat. It can be outfitted and used on shore, and then transferred (rolled-on) to the ship. A module can be outfitted for Decca Lambda, Chemical Oceanography, etc., or even equipped with an oceanographic winch. A module can also be equipped and shipped via standard container carrier to another country, if cooperative work is to be carried out.

The ship's bow will be strengthened, in order to enable the ship to work in heavier ice. Manoeuverability will be improved with a bow thruster which, coupled with the bridge control, will enable the ship to hold station under the most adverse conditions. The recently-installed air conditioning system will enable staff to work in comfort on cruises similar to those to Senegal or Guyana. Recent engineering developments have substantially reduced the noise level in the survey launches, and further work will be carried out to continue the improvements. Safety will continue to be a major concern and emphasis will be laid on making all operations as safe as possible - from improved methods of launching and retrieving the survey launches to the continuing device for safety consciousness on the part of all staff.

An article such as this can only touch briefly on a few of the hundreds of different items in such a massive project. However, while it is the intention of everyone that the end-result will give the user the maximum satisfaction, there's many a slip'twixt the cup and the lip.

Individual crew cabins were built, on a trial basis, in the winter of 74/75. The reports on these were enthusiastic, so a further batch of old-fashioned double cabins were converted to the new single-berth pullman type during the winter of 75/76. Again, the reports from the ship were enthusiastic - until a labour management meeting revealed that the crew, or the majority of the crew, emphatically preferred the bigger two-berth cabins to the new single-berth cabins. Clearly, big brother was not watching very closely in this instance, or perhaps father does not know best. At any rate, this particular error was caught in time and we hope that it is the only error which needs catching.

*   *   *   *

Laughin' on the Baffin

FRED DEARE

Helicopter Pilot
Ministry of Transport

Laughin' on the Baffin is what we call
Our shipboard tour between spring and fall
Nearly three hundred feet of wood and steel
She's a stoutly built ship from mast to keel.

They still call her "she" as in days of steam
She needs paint to be pretty and is broad in the beam
She's a nice looking gal and a good place to be
As she proves herself worthy when we take her to sea.

Gear stowed away, All the visitors ashore,
We're ready to sail...There's a woman aboard?
So why the big fuss, it's not something that's new,
For several years now, they've been "one of the crew".

One hundred miles out and we're into huge swells
Baffin is rolling and pitching like hell
The weak stomachs among us are dropping like flies
As first sharp end, then blunt end, points to the sky.

"Bring her head to the wind" Captain Majors commands
And Baffin responds to capable hands
Just hang tough awhile 'till we get where we're goin'
It's more sheltered there and the wind isn't blowin'.

Two days later we're where the work is to be,
The sick have recovered and calm is the sea.
In goes the tide gauge and mini-fix stations
Hop to it men, Good weather's a - wastin'.

Down goes the weather and we're hung up once more
So we throw out the hook and sit just offshore.
Ask Jerry which station's not working to-day?
Well, Master is off and the tide gauge blew away.

Where the hell is that buoy now Mr. Greek
Better find it soon or we'll be here all week
Five points to starbord and 3 miles away
Can't see it yet....Is the radar OK?

I sees it Cap'n, dead on the bow
Well for Crissakes you're right, I sees it now
Give me half speed or we'll run the thing down
Not that I give a damn, but Rene might frown.

Thirteen days out and we all need a break
In spite of the Chef's excellent offerings of steak
Head her sou'west, down the coast, wind is fair,
Six hours from now we'll be in Havre St. Pierre.

Our majestic approach is just marred by one quirk,
Can't get the stern in, The capstan won't work.
When one stops to think, We're all nervy as heck
A boatload of anglos, deep in Quebec.

O, what the hell, Quebec beer is OK,
The women are pretty and we're ready to play
So ashore we all go, up the hill to the bar
To parlez vous lamely amid thunderous guitars.

Newfonese and Francais, what a helluva combination
Whoever said we're a Two language nation
Could be it's good we don't know all that's said
That probably prevented a lot of broken heads.

After hours of dancing and drinking and shows,
We come back down the hill to our waiting bateau
There are some on their hands and some on their knees
And some nervously looking behind as they flee.

To-morrow we'll sail and we'll all do our jobs
Despite aching bodies and a head that throbs
Well, get it all to-gether, no good being half-in
We're back on the Baffin, but some sure ain't laughin'.

News from Industry

New Dynamic Position Fixing System

The new MRD-1 position fixing system from Tellurometer was unveiled in June at the FIG Conference in Stockholm, Sweden. The MRD-1 utilizes the patented Tellurometer principle and incorporates several improvements over previous systems. Crystal control of the carrier frequencies eliminates tuning and facilitates switch selection of remotes. The remotes remain in a standby mode until activated by the master signal, resulting in reduced battery drain. A single omni-directional antenna serves two master units simplifying antenna installation. A multi-user option enables up to three users to share the same remote station.

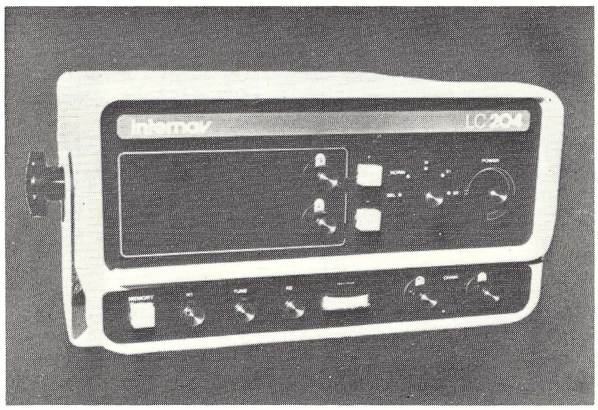
System operation has been greatly simplified and the unit can be easily operated by one person. Measurement frequency switching, range measurement and display are all handled automatically in the new system.

Tellurometer claims the MRD-1 has a repeatability of better than 1 metre under dynamic conditions and a range of 100 km subject to maintaining line-of-sight. The 3GHz carrier frequency is reported to be less susceptible to phase cancellations, resulting in improved performance over water.

Enquiries should be addressed to Tellurometer Canada, 1805 Woodward Drive, Ottawa, Ontario, Canada, K2C 0P9.

New Marine Navigation Plant Opens in Nova Scotia

Internav Corporation, a leading manufacturer of Loran-C receivers, has opened a manufacturing and engineering facility in Sydney, Nova Scotia. Internav's President, Mr. John Currie, has taken up residence in Canada to manage the new operation. The plant will allow the company to respond to the increased demand for Loran-C receivers and related engineering services created by the Loran-C expansion program. Under the program coverage will be extended over the entire Canadian West Coast, the majority of the East Coast and the Great Lakes region. The principal product of the plant will be the LC 204 receiver. Further information can be obtained from Internav Ltd., Point Edward Marine & Industrial Park, Sydney, Nova Scotia, Canada.



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Graphic Recorder Uses Wet or Dry Paper

In addition to the conventional wet paper, used with its Side-Scan Sonar, Klein Associates (USA) now offers a dry paper that can be used without making changes to the recorder. The paper prints shades of grey on white background and is reported to offer dimensional stability and a high resistance to smudging. This paper reduces the problem operators previously experienced trying to annotate the wet paper. The paper is available in 100 ft. rolls both 11 and 19 inches in width from Klein Associates, Salem, New Hampshire, U.S.A.

News from C. H. S.

Cartographic Training Course

In 1976 a Cartographic Training and Standards Unit was established at Headquarters in Ottawa to develop cartographic standards, and to develop and present cartographic training courses. In June of this year the unit offered its first course, one dealing with the compilation function of chart production and lasting 9 weeks. A total of 11 candidates, representing Headquarters and Central and Pacific Regions, attended the course.

Course topics included the elementary principles of map projection, the sources and types of data used in the construction of charts, the preparation of chart formats, compilation mosaics, sounding selections, the generalization of chart data, revision compilation techniques and the compilation of supporting data. Lectures reflected the requirements of both traditional and contour-style types of chart presentation.

For assessment purposes the candidates were required to write two examinations and prepare a compilation drawing.

It is planned that the next course will offer instruction in both the compilation and drafting functions of chart production. Also planned is a more advanced cartographic course aimed at the senior cartographers.

Attendees at the 1st Cartographic Training Course

Front row (left to right): G. Chan, M. Wolfe, R. Haas and J. Cookson (Instructors), R. MacDonald, H. Nepomuceno. Back row: A. Gris, F. Miller, R. Melbourne, D. Fleming, J. P. Séguin, P. Hopkins, C. Fisher. Absent: A. Lyon.

Pacific Region Moves to New Location

The Regional staff of C.H.S. have just completed their move from their downtown locations in Victoria to the new Institute of Ocean Sciences, Patricia Bay near Sidney, some twenty miles from the heart of Victoria.

After the initial chaos of unpacking and setting up shop, things are gradually becoming shipshape and Bristol fashion despite the cacophony of earthmoving equipment laying roads and landscaping.

Why not plan on attending the 17th Annual Canadian Hydrographers'Conference 18-20 April, 1978 and seeing the new Institute?

Atlantic Region Arctic Surveys

C.C.G.S. LABRADOR had an excellent season in the Byam Martin-Austin Channel area this summer. Ice conditions were relatively good and most of the route survey from Cape Cockburn to Cameron Island has been completed.

However, farther south in Victoria Strait, *BAFFIN* encountered severe ice conditions. The ship suffered some hull damage and had to return home earlier than anticipated to undergo repair. As a result of this, it was not possible to commission this Region's new HiFix-6 chain. This event will probably now take place next spring in the Gulf of St. Lawrence and hopefully should produce an interesting operational report for a future edition of LIGHTHOUSE.

New American Director at International Hydrographic Bureau

Following the elections at the XIth International Hydrographic Conference in April, Captain James E. Ayres, U.S. Navy, took up his appointment as a Member of the Directing Committee of the International Hydrographic Bureau on 1 September. The other two Directors, Rear Admiral G.S. Ritchie (UK) President and Rear Admiral D.C. Kapoor (India) were re-elected by the Conference to serve for a second five-year term.

Captain Ayres, lately Commander of the U.S. Naval Oceanographic Office in Washington, D.C., has resigned from the U.S. Navy to take up this important appointment. Aged 50, he holds an M.Sc. degree from the George Washington University as well as a B.Sc. in Oceanography from the University of Washington. His hydrographic surveying career started in 1946 with coastal surveys in the Pacific Islands, Persian Gulf and Red Sea, and he has since then been constantly concerned to enhance international cooperation in oceanographic and hydrographic operations and research.

C. H. A. personal notes

Samuel Gill Gamble (1911 - 1977)

Sam Gamble died suddenly the 31st of July, 1977. He was 66 years old at the time, but he looked and acted ten years younger. There will be some of you who never met Sam and some who never heard of him, but to those of us who go back a decade or so he was Canada's Mr. Surveying and Mapping.

Sam was a graduate of the Royal Military College, Kingston, and after a few years with the mining industry, returned to the Army, where he attained the rank of Assistant Director of Surveys, 1st Canadian Army, 2nd World War. Within a few years of joining the Department of Mines & Technical Surveys, he became Chief Topographic Engineer, Surveys and Mapping Branch, and in the late fifties Director, Surveys and Mapping Branch.

It was as Director, Surveys & Mapping that most of us knew him. He was our boss! In those days the Hydrographic Service was a division of Surveys and Mapping, and he took an intense interest in all that we did. *Sam's* wide ranging interest and his energetic support of new ideas and concepts ensured that we were early into tellurometers and other electronic measuring systems. On a personal note, he also ensured that the Arctic continued to get high priority, firstly through his strong support of the Polar Continental Shelf Project, and secondly by his unwavering commitment to the building of *"RICHARDSON"* - the essential first step in a Canadian hydrographic effort in the Western Arctic. He encouraged me to take *"RICHARDSON"* into the far north at a time when most of management were cool or even hostile to the idea.

When we left Surveys & Mapping Branch we continued to maintain close links with Sam and his concerns. His "Senior Survey Officers" Course was the breeding ground for future hydrographic management and a very successful attempt to cross-fertilize ideas, techniques, concepts between the various survey disciplines. His support of the Canadian Institute of Surveying was total and uncompromising. Whether acting as an official, as President or as an ordinary member, he flung his enthusiasm and all the resources he could muster into CIS activities. He brought the 12th Congress of the International Society for Photogrammetry to Canada, and until 1976 was the President of that august body. He was awarded an honorary Doctor of Science from the University of New Brunswick and an honorary Doctor of Geodetic Science from the University of Laval.

This man was an engineer, a surveyor, a soldier, a photogrammetist, an educator, a scientist, but above all else he was a "leader of men". It was as a leader that *Sam* really shone. He was very sure of what he believed. His integrity and reliability were unquestioned. His code of ethics and morality and his sense of duty to the profession of surveying in the country were an example to all. He was a very great Canadian! I hope we have not broken the mold.

T.D.W. McCulloch

Pacific Region

New hydrographers joining Pacific Region in June were *Tony Manley, Ernest Seargent* and *Michael Ward;* recently transferred to Pacific Region from H.Q. were *Sev Crowther, Austin Ross* and *Nick Said; Lou Prussner* has left the service; *Willie Rapatz* presented a paper on "The Pacific Ocean Offshore Tidal Programme", co-authored with *Stan Huggett* at the Stockholm F.I.G. Convention; *'Sandy' Sandilands* gave an invited paper on "Hydrographic Surveying in the Great Lakes during the 19th Century" at the recent Fifth Kenneth Nebenzahl Jr. Lectures at the Newberry Library, the Herman Dunlap Smith Centre for the History of Cartography, in Chicago.

Central Region

Bob Marshall has transferred to Atlantic Region on a one year acting assignment as Assistant Regional Hydrographer; *John Gervais* has left the Tides and Water Levels section to assume the duties of Training Officer at H.Q.; *Richard Lasnier* has left the service to accept a teaching post at Limoilon - a community college in Quebec; *Adam Kerr* has taken a one year sabbatical to study for a M.Sc. degree in Marine Law at the University of Cardiff in Wales; *Gerry Wade's* hydrography class at Humber College has grown to 30 students in this its' 2nd year.

We were very sad to hear of the death of *Jim McConachie* on 13th, October, in Toronto. One of our newer members, Jim was a student at Humber College and worked with us this past summer on the Winnipeg River Survey.

Ottawa Branch

Two Cartographic Development staff, *Mario Piamonte* and *Tim Evangelatos,* are on education leave this year; *Jim Kestner* has won a promotion to the EMR computing centre; *Sherman Oraas* is taking a lateral transfer to Patricia Bay in January; Chart Production decentralization is nearing completion, and the following personnel have transferred to their respective regions:

Atlantic	Quebec	Central
B. McCorriston	*J.P. Racette*	*B. Thorson*
L. Hunter	*M. Martin*	*M. Frederick*
R. Jones	*R. Lepage*	*B. Little*
E. Lischenski	*C. Chantigny*	*S. Chander*
C. Shipilow		*D. Mackenzie*
K. Crawford		*B. Hanson*
D. Fleming		
F. Miller		
R. Melbourne		

Atlantic Region

Bernadette Fleming, Atlantic Branch Secretary-Treasurer has left the service; new hydrographers in the region this year are *Michael Burke, Michael Ruxton, Michael Lamplugh* and *Frank Burgess; Keith White* has transferred to Research and Development; *Ross Douglas* and *Julien Goodyear* have returned to university this fall.

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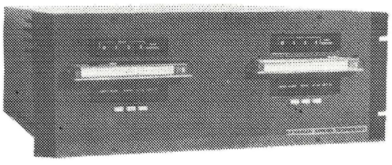

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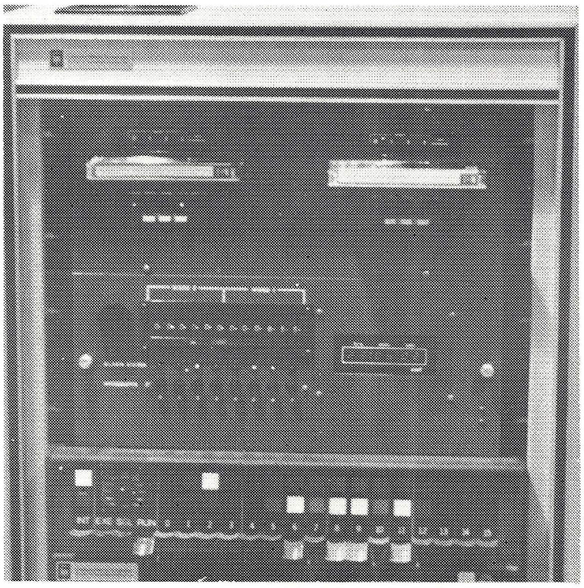

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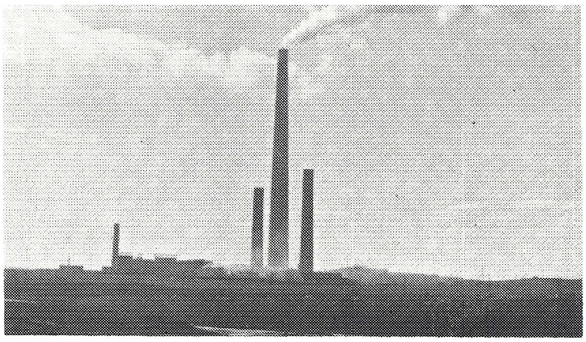

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