Edition No. 47, Spring 1993
Édition No. 47, Printemps 1993

ISSN 0711-5628

Lighthouse

JOURNAL OF THE CANADIAN HYDROGRAPHIC ASSOCIATION

REVUE DE L'ASSOCIATION CANADIENNE D'HYDROGRAPHIE

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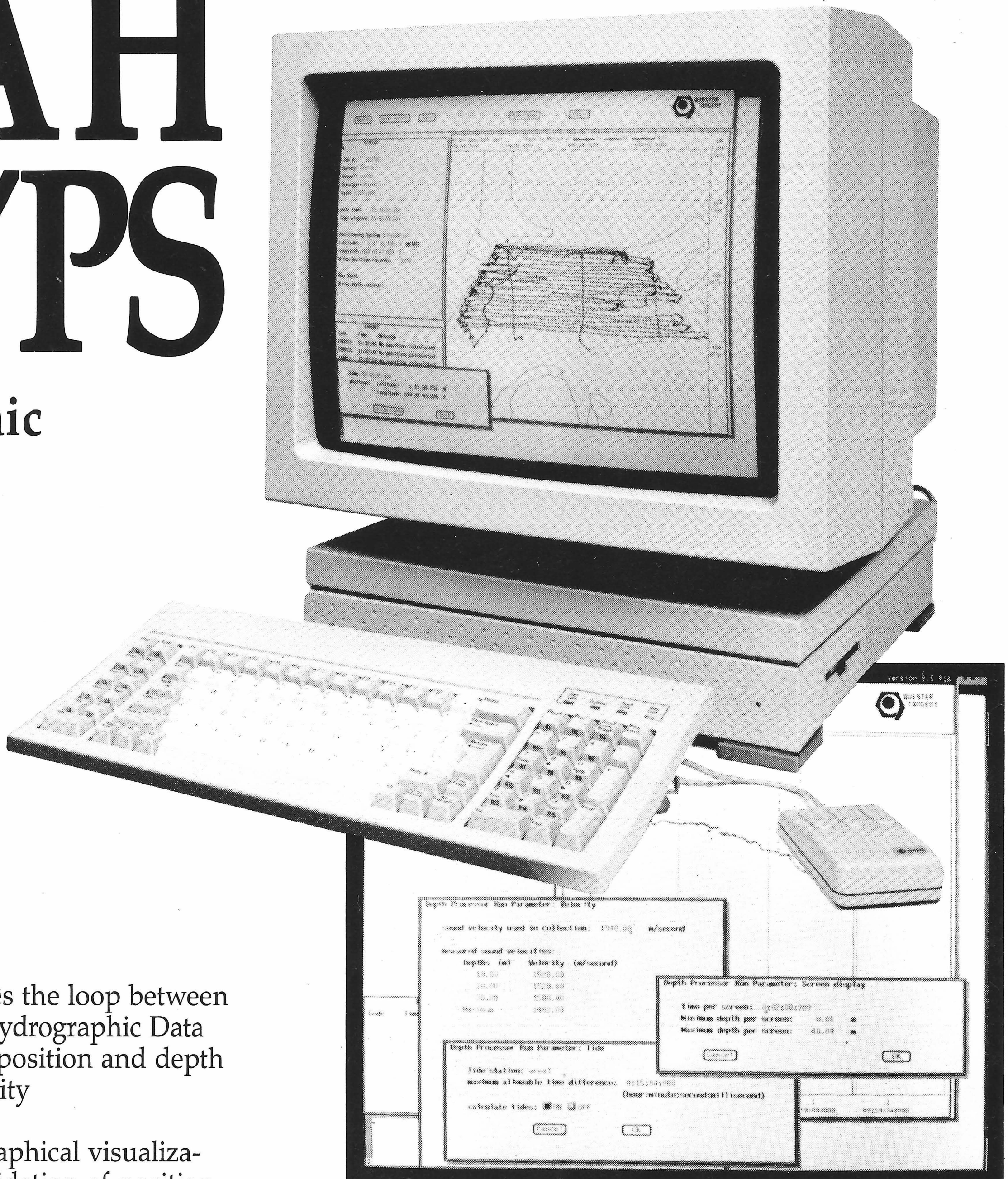

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LIGHTHOUSE

Spring / Printemps 1993

JOURNAL OF THE CANADIAN HYDROGRAPHIC ASSOCIATION
REVUE DE L'ASSOCIATION CANADIENNE D'HYDROGRAPHIE

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La revue LIGHTHOUSE est publiée deux fois par année par l'Association canadienne d'hydrographie et distribuée gratuitement à ses membres. Une formule d'adhésion se trouve en **page 4** de cette édition. Les tarifs annuels d'abonnement pour les non-membres sont de 20 $ au Canada et de 25 $ hors Canada, payable par chèque ou mandat-poste en devises canadiennes à l'ordre de l'Association canadienne d'hydrographie.

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Contents / Contenu

Regular Features / Chroniques

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

Les opinions exprimées dans les articles de cette revue ne sont pas nécessairement celles de l'Association canadienne d'hydrographie.

Closing dates for articles / Date de tombée des articles

Spring Issue	March 1 / 1er mars	Édition du printemps
Fall Issue	October 1 / 1er octobre	Édition de l'automne

Printed by / Impression par The Sinclair-Smith Press

Letters to the Editor / Lettres au rédacteur en chef

A Controversial View on EPNIS and Safety At Sea

Dear Sir:

In your Edition No. 46, Dr. F. Bianchetti explains what he calls "The ECDIS Paradox". As Hydrographer I want to make my comments on the author's proposals and affirmations.

A - Before discussing the relation between the use of ECDIS or EPNIS and safety of navigation, we must speak about the reliability of present charts and other nautical publications.

In coastal areas surveyed before the advent of radio-positioning systems the positional error in sight of the shore may reach 100 metres. Beyond the optical range, on the continental shelf, we can expect errors of 300 meters and even more. Inaccuracy on soundings shown on charts can reach 1 meter, especially in areas of the continental shelf where the geographical variations of the characteristics of the tides are great (English Channel for example). But the main risk comes from shoals which have escaped during the surveys, particularly in areas of irregular bottom.

The danger of 'forgotten shallows' at the time of the sounding lead was great. But it still exists with the vertical echo sounder. Today the careful use of side-scan sonars or multi-beam sounders, with a 100% coverage of the bottom, is the only method to warrant that all submerged dangers have been detected. But such comprehensive surveys have only been performed in limited areas to define recommended lanes.

Natural changes of the bottom may result in 'depth deficits' of 1 meter or more even some months after new surveys in areas with sandwaves (southern part of the North Sea).

Tidal predictions have their own limitations, especially in such areas as the English Channel or the North Sea. The meteorological tide is seldom predicted; "negative surges" may exceptionally create a tide deficit of 2 meters.

All these environmental factors must be taken into account, in addition to the characteristics of the ship, when the captain adopts an adequate under-keel clearance, which represents his vertical safety margin. The mariner must also deal with the surveyor's position errors, by adopting a reasonable horizontal safety margin. This is especially needed when he uses DGPS which gives a navigational accuracy far better than the accuracy of our old surveys.

B – Route Planning
Up to now the captain has the entire responsibility for the choice of a safe track. One of the major tools to perform this task is the conventional paper chart, supplemented by sailing directions, tide tables, ...

He must for that take into account:

1. Depth contours, shoals and obstructions shown on the chart.
2. Reliability of charted data. On recent charts he will find source diagrams and/or reliability diagrams.
3. Areas with changing bottom.
4. Tides and currents. A fairway with a well-known but limited depth may only be used when the height of tide exceeds a given value.
5. Weather conditions. A narrow channel may permit a safe passage in good weather and be dangerous otherwise.
6. Rule of navigation: traffic separation schemes, areas to be avoided, prohibited areas...

A convenient under-keel clearance (variable according to environmental factors) will be adopted in relation with items 2, 3, 4, 5. The sum of the draft and under-keel clearance must be smaller than the sum of the charted depth and the predicted tide, at any time (items 1, 4). The planned route must pass at sufficient horizontal distance from submerged hazards (horizontal safety margin).

C – Usable space
The concept of usable space according to ship and loading conditions is interesting but is not easy to be applied. Dr. Bianchetti clearly supposes that this space will be legally defined by others than the captain of the ship. This is indeed a major change. It would mean that in the case of grounding inside the usable space, the captain will have no responsibility. I doubt that a captain would be willing to navigate with an EPNIS without any depth information on the screen. This appears to be a kind of blind navigation where the captain has no idea about the depth under his keel. The new concept would mean that the usable space is defined, in advance, by professional mariners, in the name of IMO, with a great variety of 'safe-draft areas' (according to the classes of ships). But even if a captain could blindly trust in these safe-draft areas, there are other reasons for showing depth information on the screen.

1. Usable space will depend at any time on the height of tide at that time. For safety reasons it could be convenient to suppose the height of tide to be zero. So we could have a 'tide-independent usable space'.

   But in the case B4 this safe method would 'obstruct' well-known fairways. This case cannot be handled without depth information on the screen.

2. What will happen when inside a 'safe-draft area' a new shoal is discovered? This will change the shape of the safe-draft area for certain classes of ships and make no difference for other classes. In this case the immediate action for the safety of shipping will be to introduce the new shoal, via a depth contour shown on ECDIS or EPNIS. The same applies for a new wreck inside the safe-draft area.

3. If for any reason the ship drifts outside her usable space or must steer outside that space to avoid another ship,

the captain needs immediate depth information outside the usable space. The last-minute use of the back-up paper chart may not prevent from grounding. So it seems to be unsafe to have no depth information on ECDIS or EPNIS.

D - A Limited Comparison Between Air Navigation and Navigation At Sea

Dr. Bianchetti refers to air navigation to promote his ideas on EPNIS.

The well-defined airways are clear from any obstacle (except other moving aircraft). Anyway all natural features and man-made structures on land are well known in position and altitude; they are well charted. They can be seen in advance by the pilot's eyes or by his radar. Underwater hazards are not visible; they are only detected by the echo sounder when the ship is above them. It may then be too late. As stated in paragraph A, uncharted dangers exist outside the limited areas which have been comprehensively surveyed. This fact, and obviously the tides, are specific aspects of navigation at sea.

E – Conclusion

A hydrographer is obviously but not exclusively concerned with cartographic aspects; he is also interested in navigational and regulatory issues. There is no contradiction in defining a usable space with its limits on EPNIS and showing depth information on ECDIS or EPNIS. Reliable and permanently-available depth information on the bridge is essential for safety of navigation.

For the reasons given in paragraph A, comprehensive surveys of recommended lanes and areas on the continental shelf are, and will be, performed to make sure that inside those lanes and areas all shoals and obstructions have been found and properly investigated. The 'usable space' is then to be determined inside the 'comprehensive survey space'. These concepts should lead to a representation as simple as possible, which should facilitate route planning by the captain. Some kind of depth information will always be needed inside as well as outside the comprehensive survey space.

At the IAIN 7th Congress in Cairo (1991), I presented a paper on "Major Trends in Navigational Requirements of Shipping and How These are Met by Hydrographers". I extract the following sentences: "Nowadays mariners find it more convenient to be proposed safe channels or fairways with well defined characteristics (minimum depth, limits) rather than having to watch out for shoals or rocks". This seems to be close to one of the ideas behind the EPNIS concept. A kind of synthesis should be possible.

I would be glad if my opinion could be published in your Journal.

Yours Sincerely

Ingénieur Général JN PASQUAY
Hydrographer of the French Navy
Paris, France

Dear Mr. Richards:

I thank you very much for your flattering letter and for publishing my article in Lighthouse... I use this occasion for attaching to this letter my reply to Mr. Pasquay. It only reports my comments to his observations...

Thank you again for your interest in my work.

Yours Sincerely
Fosco Bianchetti

Dear Mr. Pasquay:

I have read with great interest your comments to my paper published in Lighthouse (#46) and I thank you for your attention. All through your letter I tried to discern if it was in favour or against my proposal.

In the end I have come to the conclusion that it supports most of my ideas, but it suggests a less radical approach which would lead to a compromise standing in between an ECDIS and an EPNIS.

You may be right. A pure EPNIS chart might be too empty. Some indication of key depths, and some other important information to be used in emergency situations, should be added.

The important point, though, is that this additional information should be added with this specific purpose in mind, and not with the purpose of letting the captain routinely decide his best obstacle avoidance strategy.

Most of the complexities of practical navigation (unreliability of the charts, imperfect tidal predictions, etc.) are, in fact, much better judged by local experts (Hydrographers, Coast Guard, Pilots, etc.) than by the captain himself. Especially considering the fact that the captain is not always as skilled as he should be, may be in a stressful situation and, anyway, can only offer a one-man solution conceived in a very limited amount of time.

One of the main purposes of my proposal was also that of creating a new electronic chart which, stripped by a team of experts of all unreliable or unnecessary information, could transform a very complex situation, as very well outlined in your letter, into one much simpler to understand and handle. Actually this simplification, implemented by experts using ample safety margins, should give the captain the feeling of more safety rather than less, considering (as you rightly say) that the completeness of current charts is not matched by their reliability.

Anyway, there is no doubt that my article contains only a broad outline and is only an indication of the direction to take. A practical implementation of the concept will require a much deeper analysis of the issues involved, some of which you have already clearly identified.

A last comment on air navigation. I am myself a pilot (fixed wing and helicopter) and I do not believe that there are as many differences between the two fields as you suggest.

It is true that airways are well outside any obstacle, but the opposite is true for the approach areas to airports. Visibility is often poor or nil, and there are no forward-obstacle-detecting radars on current civil planes.

Even more similarities hold. Radar altimeters, like depth sounders, can only detect the height underneath, when it is too late to correct the problem. Barometric altimeters are subject to changes in atmospheric pressure and, like what happens with tidal variations, can only be used if manually corrected with timely information supplied by the control towers.

As you are probably aware, many fatal accidents have happened involving airliners impacting high ground. Even recently. Many more would happen if an EPNIS type concept had not been applied to air navigation.

In the end I think that we could both underwrite the common conclusion that a team of experts examining the problem of marine navigation with a fresh look, unbiased by the load of the old tradition, could come up with a new set of rules capable of improving safety in a very substantial way. What should be the right mixture of EPNIS and ECNIS will certainly require effort and research far beyond my article, and your letter.

For the moment, I find that it is already great progress just to start talking about these issues.

Yours Sincerely
Fosco Bianchetti, C-MAP
Marina di Carrara, Italy

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Message from the National President / Mot du Président national

It is a great pleasure for me to be able to write my seventh President's Message to you in Lighthouse. I would like to take this opportunity, at the commencement of my second term as National President, to highlight some of the interesting activities currently underway in our organization, and to provide a glimpse at some of the international activities on the horizon.

While focusing on the activities as events, I would like to remind you that behind each of these events is an enthusiastic, dedicated (and sometimes overworked) group of volunteers, quietly working. These CHA folks deserve our heartiest appreciation for their exemplary commitment to the Canadian Hydrographic Association, and I hope that if you're asked to contribute some of your time or provide some of your expertise to help fulfill the CHA objectives that you, like these folks, won't think twice about it.

The CHA student award program is being well received by the first-year college and university students currently enrolled in hydrography-related courses. Student Award Program coordinator Mr. Barry Lusk will be announcing the inaugural student award program recipient shortly and that student will receive the $2000.00 award to be used to assist with continuing studies.

For those of us who have passed through the formal academic portion of our career but still desire to participate in education/training activities, CHA Central Branch in conjunction with the Geomatics Industry Association of Canada (GIAC) recently arranged a workshop on the use of geomatics in the marine environment, on June 8, 1993, immediately before the '93 Surveying and Mapping Conference in Toronto, Ontario. This workshop was designed to provide topical information and demonstrations of this emerging integration of skills and technology, with the contributing workshop participants being from academia, government and the private sector.

This jointly sponsored conference (CHS/CIG) also marked the official launching of the Central Branch Heritage Launch. This period reproduction of the 1792 survey launch used by Joseph Bouchette to conduct the first hydrographic survey of Toronto was used for a re-enactment of that survey. On hand to provide colourful commentary was Admiral Steve Ritchie, RN (ret.). The opportunity for us all to see and enjoy this living history was memorable.

On the horizon there is developing an opportunity for CHA and its Sustaining Members to participate in the 1997 International Hydrographic Organization symposium. This activity is being more fully explored and members will be informed as details become available.

In closing, I would like to say two things; firstly I extend sincere appreciation to the continuing efforts that Lighthouse Editor Bruce Richards and the Lighthouse staff bring to the publishing of this widely-read journal, and secondly; I echo Bruce's request for material for future issues. Please put pen to paper or, for the 90's, fingers to the keys.

Hoping you have an enjoyable summer and continue riding the wave,

Dave

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Abstracts / Résumés

Real-Time Acoustic Bottom Classification For Hydrography

A Field Evaluation Of Roxann

by
George E. O. Schlagintweit

A specific analysis of reflected acoustic signals enables real-time bottom classification during hydrographic operations using modern signal processing technology. Supplementary seabed data can be collected and portrayed for considerations such as groundfish habitat evaluation, shellfish distributions, oil spillage residue mapping, and pre-dredging analysis. In this paper, an instrument which performs this task is described and evaluated.

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Classification en temps réel des fonds par l'acoustique pour l'hydrographie

Une évaluation terrain de Roxann

par
George E. O. Schlagintweit

La technologie moderne du traitement des signaux acoustiques réfléchis et leur analyse spécifique permet la classification des fonds marins en temps réel lors de levés hydrographiques. De plus, les données du fond peuvent être recueillies et utilisées pour l'évaluation de l'habitat des poissons de fond, la distribution des mollusques, la cartographie des résidus de déversement de pétrole et l'analyse de prédragage. Cet article décrit et évalue un appareil réalisant cette tâche.

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Where Was Nootka In 1792 ? An Explanation Of Captain Vancouver's Longitude Error

By
Nicholas A. Doe

Captain George Vancouver surveyed the waters around Vancouver Island in 1792. Although he was a meticulous observer, the accuracy of his longitude observations was lower than expected. This paper explains Vancouver's method and reveals the unavoidable source of his error.

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Où était Nootka en 1792? Une explication de l'erreur de longitude du capitaine Vancouver

par
Nicholas A. Doe

Le capitaine George Vancouver hydrographiait les eaux autour de l'île de Vancouver en 1792. Bien qu'il était un observateur méticuleux, la précision de ses observations de longitude était inférieure à celle prévue. Cet article explique la méthode de Vancouver et révèle l'inévitable source de son erreur.

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Towards "IHOstat": IHO Approved Software Which Evaluates The Quality Of Bathymetric Data

by
Peter Kielland, Ken Burrows, Brad Ward, Michel Dagbert and Lt .Robert Velberg

The US Defense Mapping Agency and the Canadian Hydrographic Service are cooperating through the IHO Data Quality Working Group to focus their respective efforts on a single public domain program called "IHOstat". IHOstat evaluates both instrumental and interpolation errors and combines them into a single spatial uncertainty, providing a statistically valid error estimate for each point in the bathymetric data set. This paper describes the algorithm development behind IHOstat as well as efforts to ensure that the final software package can evaluate all types of bathymetric data sets.

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Cap sur "IHOstat" Le logiciel approuvé par l'OHI qui évalue la qualité des données bathymétriques

par
Peter Kielland, Ken Burrows, Brad Ward, Michel Dagbert et Lt. Robert Velberg

Les efforts respectifs de la US Defense Mapping Agency et du Service hydrographique du Canada via le groupe de travail de l'OHI sur la qualité des données se portent sur un programme public appelé "IHOstat". IHOstat évalue les erreurs instrumentales et d'interpolation pour calculer une zone d'incertitude fournissant statistiquement un estimé d'erreur valide pour chaque point de l'ensemble des données bathymétriques. Cet article décrit le développement de l'algorithme d'IHOstat et les efforts fournis pour s'assurer que le logiciel final puisse évaluer tous les types de données bathymétriques.

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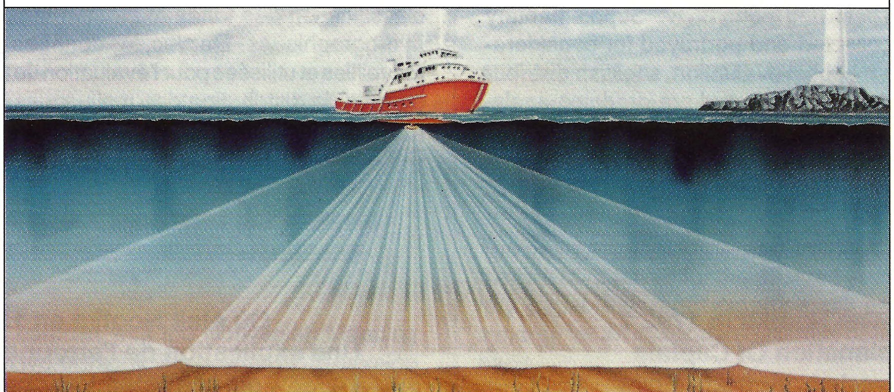

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Real-Time Acoustic Bottom Classification for Hydrography
A Field Evaluation of RoxAnn

by

George E.O. Schlagintweit

Introduction

Historically, hydrographic depths were determined with a leadline until the application of acoustics after World War I. Hydrographers always had a feel for what type of seabed they were charting, based on the responsiveness of the line as the lead struck the bottom. Bottom type was often inked alongside every depth. When acoustic depth sounding techniques were introduced, bottom classification was de-emphasized.

Recently, however, acoustic methods developed for classifying the seabed have re-kindled interest in this field. The motivation has been that technology advances have made acquisition of these data cost effective. Acoustic methods for seabed classification have been developed for sidescan sonar, multibeam sounders, and conventional monobeam sounders.

Seabed classification has many applications. These include:

- groundfish habitat areas;
- shellfish distributions;
- marine anchorage sites;
- oil spillage residue mapping;
- oil rig site investigations;
- dredging operations;
- pipeline and cable layout;
- scientific research; and
- areas that cause wear or damage to fishing gear.

The impact and scope of this technology is still being realized.

The results of an evaluation of RoxAnn, an instrument developed by Marine Microsystems Limited (Ireland), are presented in this report.

RoxAnn Description

RoxAnn uses the multiple-echo method of seabed classification. From some theoretical predictions and much experimental determination, a relationship evolved between the nature of the seabed and the first and second echos. The two parameters which RoxAnn uses for seabed classification are roughness and hardness. The initial portion of the first echo contains contributions from both sub-bottom reverberation and oblique surface backscatter from the sea bed. Because these cannot be discriminated easily, the first part of the echo is removed to minimize ambiguity. The remaining reverberation of the first echo is integrated to provide the first acoustical parameter, E1. This parameter is found to be a measure of the roughness of the seabed.

The second acoustical parameter, E2, is obtained by integrating the whole of the second echo to provide a measure of relative hardness (Figure 1). In both cases the integrations are performed after time varied gain (TVG) has been applied. Figure 2 shows the relative spread of E1 and E2 data. For a thorough description of the theoretical operation, consult references [1] and [2].

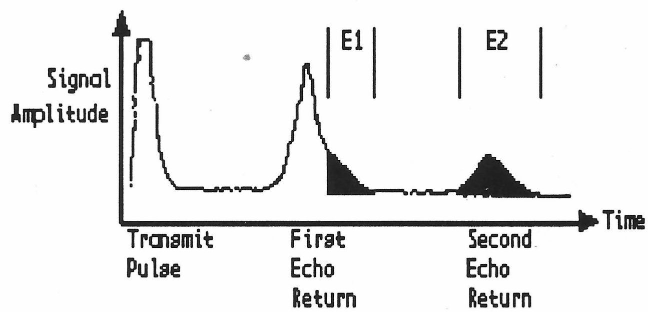

Figure 1: Gating of E1 and E2

E1 - roughness
E2 - relative hardness (acoustic impedance)

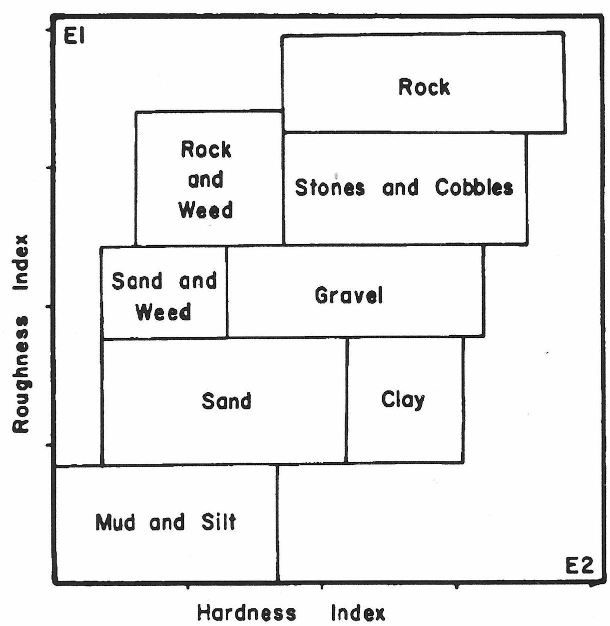

Figure 2: Empirical classification of seabed type with respect to E1 and E2

System Hardware

RoxAnn is an add-on to any conventional echo sounder; components consist of a head amplifier and a parallel receiver (Figure 3). The head amplifier is connected directly across the echo sounder transducer in parallel with the existing echo sounder transmitter, and is tuned to the transmitter frequency. Frequencies ranging from 20 to 250 kHz are acceptable according to manufacturer's specifications. The parallel receiver accepts the echo train from the head amplifier. It is designed to have accurate processing facilities, especially of TVG and filtering. The gating and integration of the first and second echoes are performed within this unit. Serial RoxAnn data are transmitted via RS232 to an external datalogger.

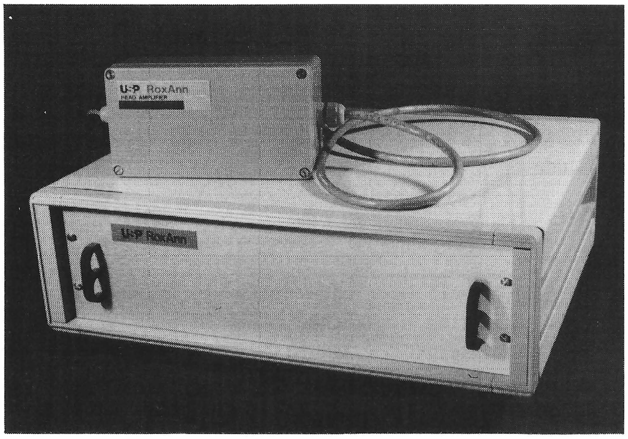

Figure 3:
RoxAnn: parallel receiver and head amplifier

System Configuration

For the purposes of this evaluation, a 7 m (23 ft) Hourston Glascraft survey launch was outfitted (Figures 4 and 5). The launch was positioned by differential GPS. Horizontal positioning accuracy was considered to be +/- 5 m at 95% confidence, +/- 10 m worst case. A Raytheon DSF6000 echo sounder was used with RoxAnn, and both the 40 and 208 kHz transmit frequencies were independently evaluated. A contract was let to the Quester Tangent Corporation to have the datalogger used by the CHS, ISAH (Integrated System for Automated Hydrography) integrated with RoxAnn. This modification entailed:

- decoding and logging of RoxAnn data;
- real-time E1, E2, and classification display; and
- an E1/E2 min/max classification table.

The table allowed the user to edit the minimum and maximum E values for a given seabed classification, and the seabed classification itself.

Installation And Calibration

The installation of RoxAnn was simple, as no additional hull fittings were required. Interfacing to a standard echo sounder was also easy. Each new installation of the system requires an initial tuning and calibration because pulse width, transmit power, and beam width are variables not accounted for within the parallel receiver. A portable oscilloscope was an essential tool for the optimization of the parallel receiver gain and signal-to-noise ratio. Once tuned, the min/max ranges of E1 and E2 for known bottom types were determined by ground truthing.

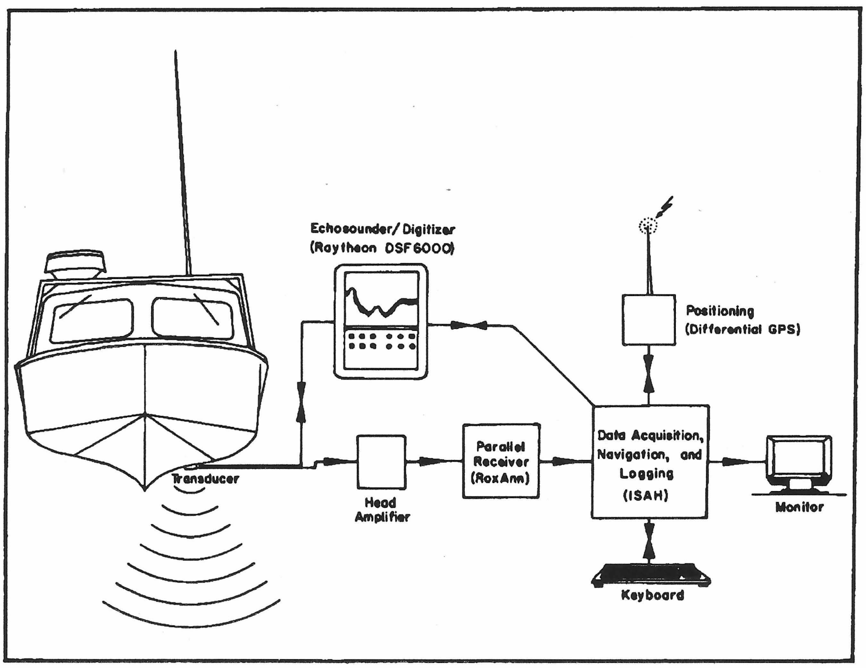

Figure 4:
System configuration for field evaluation

Figure 5:
Survey launch SNIPE used for evaluation of RoxAnn

Ground Truthing

"...The most difficult question to resolve is that of ground truthing..." [1]. The preferred testbed would be an artificial one, with geographically positioned zones containing gravel, sand, boulders, etc. Such a facility does not exist, nonetheless an intensive ground truthing effort was attempted in support of this evaluation using a convenient seabed.

The testbed chosen for this exercise was a 600 m^2 area approximately two miles northwest of the Institute of Ocean Sciences (IOS), near Sidney, B.C. (Figure 6). This area was last surveyed in 1989 at a scale of 1:4 000. Features such as rocky foreshore, mud/stone beaches and fine sand, as determined by conventional hydrographic bottom sampling, and proximity to IOS made this area ideal.

The prime method of qualifying seabed type was by visual inspection with divers, although both sidescan sonar and a mini-rov (remote-operated-vehicle) were also used. Sieves

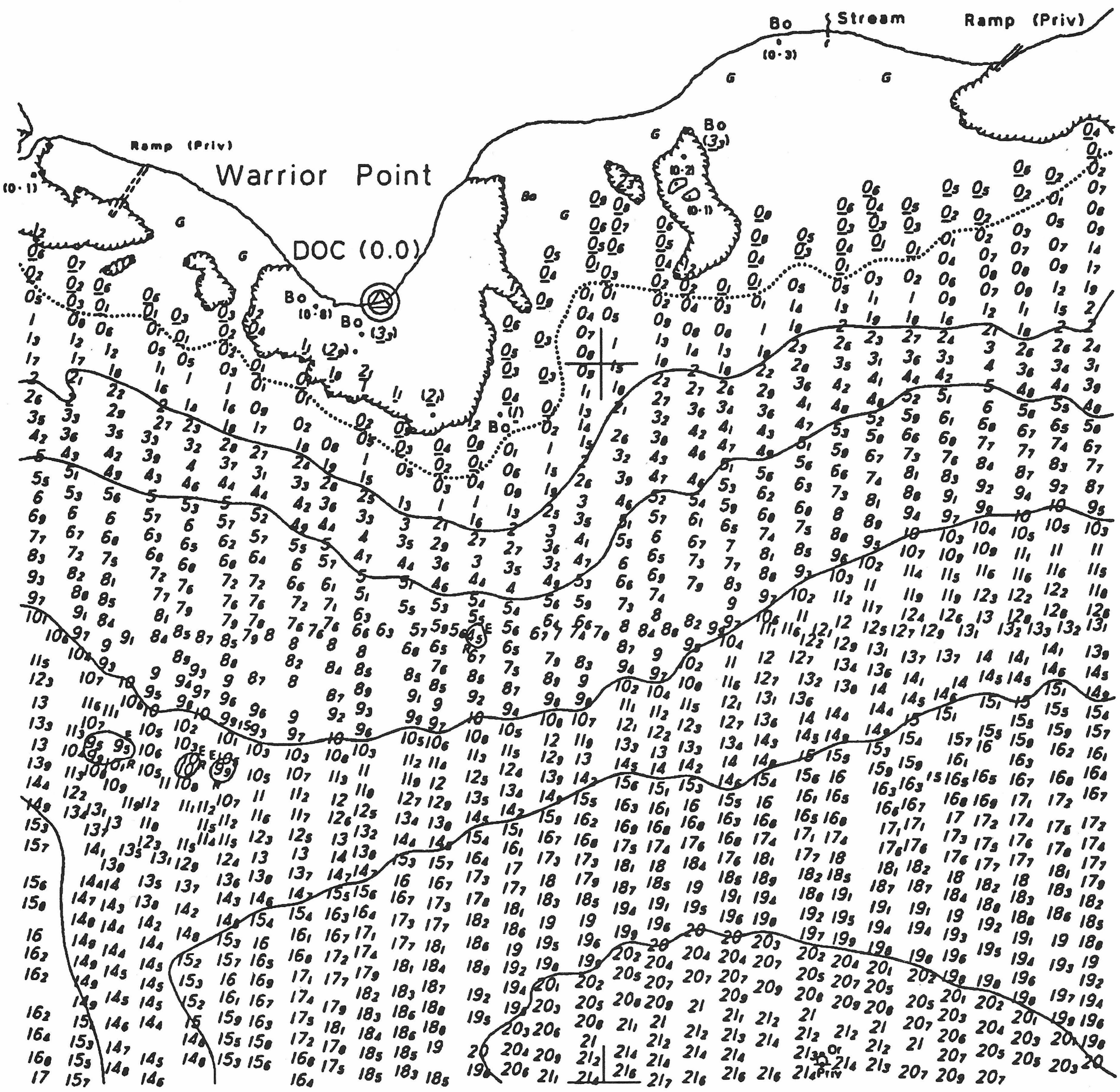

Figure 6:
Testbed for RoxAnn evaluation, at northern shore of Patricia Bay

or other devices for sediment classification were not used. Divers logged a total of 8 hours of underwater time, swimming compass-oriented grid lines approximately 100 m apart. When a boundary was determined, a small float with an attached message was released. The survey launch recorded the message and position of the float as it surfaced.

Five distinct seabed classifications were defined:
- mud/fine sand;
- mud/stones;
- mud/stones/shell/weed;
- stones/mud; and
- rock.

An approximate 'a priori' determination of the seabed's composition was established. Classifying the seabed into distinct groups was not trivial, because exceptions within groups usually existed. The only boundary that divers had no difficulty defining was the one between mud/fine sand and mud/stones. Due to the linespacing, typical six-metre visibility, local seabed discontinuities and boundary delineation uncertainties, the truth of the seabed is adequate for specific applications only.

Data Collection

The test data were collected at a scale of 1:10 000, with lines plotted five millimetres apart. All data were logged once per second and at constant launch speed (5 kn). During initial testing it was observed that repeatability was achievable only if constant speed was maintained. This was due to changes in aeration and engine noise.

The range on the echo sounder could not be changed when RoxAnn was operating; when the range is changed, transmit power into the water changes, thereby changing the relative strength of the return echos.

Interpretation Of Results

Some modifications to hydrographic data-processing software were required in order to portray RoxAnn data. The same operations that ISAH did with the raw data in real time were also done when processing. This way, a min/max table for E values could be iteratively fine tuned in the office from one dataset. The seabed classifications were coded as depth values so that CARIS (Computer Aided Resource Information System) software could be used for data manipulation and portrayal.

Figure 7 indicates a modest correlation between the 40 and 208 kHz datasets. The differences were primarily due to the fact that the shape of the acoustic envelope is frequency dependent. "...With low frequencies (e.g. 20 kHz), there is a tendency for the sonar to be reflected only by the underlying rock bed, while at high frequencies (e.g. 200 kHz) the sonar scarcely penetrates the silt..." [2]. Lower frequencies typically have wider beamwidths, thus insonifying larger areas and causing seabed classifications to be generalized.

This disagreement indicates that the user must choose the appropriate frequency for the required application. When planning a survey of an area that is to be dredged, lower frequencies must be considered. Conversely, for groundfish habitat evaluations where only the surface of the seabed is relevant, high frequencies are required.

Current bottom classification methods used by hydrographers are not objective. Although CHS Standing Orders do specify size criteria for bottom types, the use of educated guesses is more common in the field. What one hydrographer denotes as a mud/stone beach is labelled as a gravel beach by another, as is evidenced in Figures 6 and 7. Another problem observed with conventional bottom sampling is that bottom types are often incorrectly identified due to the sampling technique. Armed leadlines (those fitted with tallow so that specimens will adhere) can indicate a presence of sand or shell, but boulders and stones can never be determined with any certainty as they are never visually confirmed. Instead, hard bottom responses are almost always interpreted as rock, even if the seabed consists of boulders, stones, or cobbles. This is also the case with grab or core samplers, as the size of the sample is limited to the size of the sampler. Fine sand was determined by conventional sampling in Figure 6, while divers confirmed mud/fine sand. Presumably, sand bonded to the tallow on the lead, but the mud washed off before the lead surfaced, therefore only fine sand was concluded as the representative sample.

Checklines agreed very well with the 208 kHz configuration, and RoxAnn operated continuously in all depths. The 40 kHz did not work in depths less than four metres, and checklines were in poor agreement. Unfortunately, tests were not performed in rough seas.

An Alternative Classification Method

The results of this paper were obtained by the Supervised Classification method. The Supervised Classification attempts to best-fit a dataset to a ground truthed model. However, an 'Unsupervised Classification' may be a superior method. An Unsupervised Classification is an automated process that searches for natural groupings in the spectral properties of the dataset. The user allows the computer to select the class means and covariance matrices to be used in the classification. Once the data are classified, the analyst must then determine:

- if the algorithm has created a realistic number of classifications; and
- what type of seabed each classification represents.

The latter can be done by sampling representative sites within each classification zone. If more or fewer classifications are desirable, algorithm-dependent parameters must be modified and the program rerun.

The stochastic nature of a seabed (i.e. roughness parameter) permits semivariogram analyses to determine optimal line spacing. (A semivariogram is a graph of sample variance versus depth). Such analyses can only be possible if an unsupervised classification is implemented, whereby quality estimators can be associated with each data point.

Classification Accuracy

"...There must be a method for quantitatively assessing classification accuracy." [3]. In remote sensing, this is usually done by comparing classifications derived by ground truthing with a dataset generated from an unsupervised classification algorithm.

Unsupervised classifications derived from larger scales can also be used in absence of ground-truthed classifications.

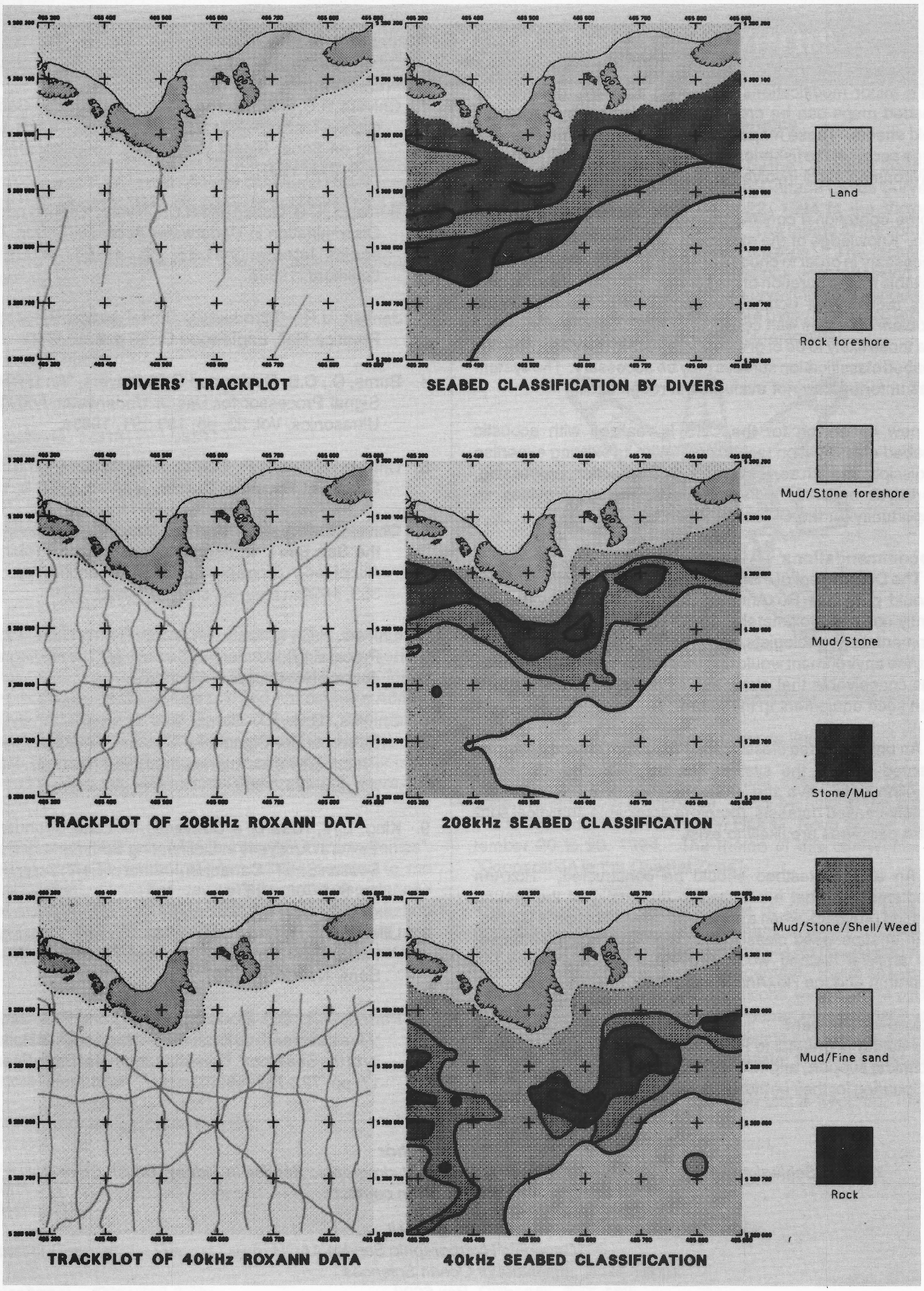

Figure 7:
Seabed Classifications as determined by divers and RoxAnn

Conclusions

The RoxAnn system interfaces easily with most echo sounders (20 - 250 kHz), is easy to install, and requires little space. Once calibrated, the system requires no operational support. With minor modifications to existing software, geomorphic seabed maps can be created to supplement hydrographic field sheets. These maps provide valuable information for a large sector of the fisheries industry, as well as engineers and environmentalists involved in the marine environment.

Some operational constraints were identified in the evaluation. Knowledge of the maximum depth to be surveyed was necessary in order to choose an echo sounder range that was suitable for the duration of the survey. Constant vessel speed was required for optimal results. This poses a potential problem for areas with coastline or high vessel traffic, which are those likely to be of greatest interest. In this case, specific seabed classification surveys may be necessary. The system was unfortunately not evaluated in rough seas.

A new dimension for the CHS is realized with acoustic seabed-classification technology. With its existing expertise in disciplines such as positioning; data collection, processing, portrayal; and field logistics, this technology provides an opportunity for the CHS to broaden its role.

Recommendations

1) The Department of Fisheries and Oceans (Pacific Region) should purchase RoxAnn equipment. The hardware currently costs approximately $15,000 (Cdn). Biologists, environmentalists, geologists, and most engineers working in the marine environment would find these data particularily useful. It is conceivable that every survey launch will be equipped with such equipment in the future.

2) An unsupervised classification algorithm should be implemented so that the system can be calibrated efficiently. RoxAnn data have the characteristics of many other remotely-sensed datasets, therefore applicable analytical software packages are likely to exist.

3) An artificial testbed should be constructed. RoxAnn produces data that are limited to the quality of the ground truthing provided, when a supervised classification is utilized. If an unsupervised classification algorithm is implemented, the artificial testbed would provide a check on both the algorithm and the RoxAnn system itself.

Acknowledgement

The author is grateful to R. Lindsay and B. Johnson for their technical support, and IOS divers E. Sargent, D. Sinnott and L. Spearing for their enthusiasm and commitment. J.B. Larkin must also be acknowledged for persisting with the scanner and versatec plotter to ensure that the graphics required for this paper were given justice.

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Where was Nootka in 1792? An Explanation of Captain Vancouver's Longitude Error

by

Nicholas A. Doe

Captain George Vancouver surveyed the west coast of North America and the waters around Vancouver Island in 1792, arriving at Nootka in late August. It was not the first time he had been there; he had sailed with Cook 14 years earlier as midshipman on Cook's third voyage to the Pacific. This experience entitled him to be regarded as the first European to have circumnavigated Vancouver Island, even though frigate captain Alcalá-Galiano, who completed a voyage from Nootka to Nootka arriving only a few days later than the British captain, might not have agreed.

Captain Vancouver was a very meticulous and thorough observer, but most of his longitude determinations were too far east, those at Nootka being no exception. The location of his observatory at Friendly Cove was 49°35.6' N, 126°37.1' W, but by his own calculations he was at 49°34.3' N, 126°28.5' W. This is a latitude error of only 1.3' (2.4 km), but a longitude error of 8.6' (10.3 km). Moreover, as he somewhat ruefully observed in his book, his calculated longitude was a full 20.5' (24.6 km) east of the position for Friendly Cove calculated from many hundreds of observations by Captain Cook. This was, for Vancouver, a worrying and puzzling discrepancy.

The Spanish were no help either. Commandant Bodega y Quadra, with whom Vancouver was negotiating the status of Nootka, placed the observatory slightly west of the usual Spanish position, and, quite fortuitously I am sure, almost exactly half way between Cook's and Vancouver's reckonings. In his journal, Bodega notes that Nootka is 21°23' W of the *Contaduría* at San Blas, i.e. at 126°39.5' W, which is about 2.4' (2.9 km) west of its true position.

The method that the British Navy used to measure longitude is known as the method of lunar distances. What they did was measure the position of the Moon in its monthly orbit around the Earth, and then use pre-calculated tables to determine the predicted time for the Moon to be at that position. This told them the time at Greenwich in England. By comparing this time with the local time as determined by the Sun, and noting that the Earth revolves 360° in 24 (solar) hours, they could calculate how far east or west of Greenwich they were.

The position of the Moon was determined by Vancouver by measuring the angle, or angular distance as it is known, between it and the Sun, using a sextant. At new moon, the angle is very small; but two weeks later, at full moon, it has grown to close to 180°. It is this slowly changing angular distance that 18th-century navigators used to determine Greenwich time, and hence their longitude.

In 1778, Captain Cook spent four weeks at Resolution Cove on Bligh Island, which is 6.6 kilometres ENE of Friendly Cove. While he was there, he and the astronomers on the expedition made over 600 observations of the position of the Moon. The resulting determination of their longitude was 10.8' (12.9 km) west of its true value. This was, by the standards of the day, and considering the accuracy of their sextants, a good estimate; yet it falls short of what might have been expected from such a prodigious amount of work.

Thanks to William Bayly, the astronomer travelling with Cook as a representative of the Board of Longitude, we have a good record of Cook's observations. Recently I completed an analysis of these observations, using data from an ephemeris of the Sun and Moon compiled by the Jet Propulsion Laboratory in Pasadena [1]. This analysis showed that if one neglects the measurements Cook made of the position of the Moon relative to the star Regulus, the longitude of Resolution Cove can be calculated from Cook's observations to an accuracy of 0.6 minutes of arc, or about 700 metres. The principal source of Cook's error was the Nautical Almanac of 1778 which contained the predicted positions of the Moon and Sun for that year.

The movements of the Moon are governed by the gravitational fields of all the other objects in the solar system. The principal fields, those of the Earth and Sun, have been fairly well understood since Isaac Newton's time, but in the late 18th century the influence of the planets on the Moon and the subtleties associated with the Earth's non-perfect shape were yet to be discovered. The tables of Tobias Mayer, which formed the basis of the Nautical Almanac's Ephemeris of the Moon, were derived from algebraic equations containing about 18 groups of terms. The 19th- and 20th-century astronomers Laplace, Hanford and Brown were later to expand this to over a 100 groups of terms, and then eventually to a large book-full of terms.

Algebraic analysis of telescopic observations has nowadays been largely replaced by computer modelling of the solar system. These models, which are many thousands of times more accurate than anything that has gone before, use information gathered from radar, laser ranging, and the movements of artificial satellites and spacecraft to plot the course of the members of the solar system.

Captain Vancouver made 106 sets of observations at Nootka, each involving six measurements of the Moon's position. Unfortunately, the full details of these observations have been lost and it is not possible to make the same detailed analyses of these results as was possible for Cook. Nevertheless, Vancouver's book contains a good summary of his results and it is possible to correct his results for errors in the Nautical Almanac for 1792.

The accompanying table shows the results of this analysis. The columns are the Julian day, the date in Vancouver's book, the observer (Vancouver or Joseph Whidbey), the number of sets of measurements made (each set comprised the result of six observations), the longitude in Vancouver's book in modern notation [2], the correction to be applied, and the corrected longitude. Julian days, for those who do not know, are used by astronomers and historians to label days unambiguously. Calendar reform applied at different times in different countries, and failure to change the date on crossing the international date line, make the more familiar calendar dates unreliable.

This table shows that Vancouver, using the same techniques as Cook, and making the same number of measurements as Cook, did in fact succeed in producing a result that was every bit as accurate as Cook's. Vancouver's corrected longitude for the observatory at Friendly Cove is 126°37.6' W, a mere 0.5' (600 metres) west of its true position.

For the record, and for those who are interested, the five-step correction procedure that I used is described in Appendix 1.

Julian Day 0400 PST	Vancouver's Date 1792	Obs.	No. of sets	Vancouver's Longitude	Correction	Corrected Longitude
2 375 808	Aug. 22	V	5	126°10.9'W	+ 4.6'	126°15.5'W
		W	5	126°23.9'W		126°28.5'W
2 375 810	Aug. 24	V	4	126°23.2'W	0.0'	126°23.2'W
		W	4	126°25.3'W		126°25.3'W
2 375 824	Sept. 7	V	2	126°37.5'W	+14.5'	126°52.0'W
		W	2	126°41.0'W		126°55.5'W
2 375 825	Sept. 8	V	8	126°21.3'W	+15.8'	126°37.1'W
		W	8	126°15.7'W		126°31.5'W
2 375 826	Sept. 9	V	8	126°28.5'W	+16.7'	126°45.2'W
		W	8	126°22.7'W		126°39.4'W
2 375 829	Sept. 12	V	6	126°32.9'W	+11.0'	126°43.9'W
		W	8	126°27.5'W		126°38.5'W
2 375 840	Sept. 23	V	8	126°33.4'W	- 1.9'	126°31.5'W
		W	8	126°46.9'W		126°45.0'W
2 375 840	Sept. 23	V	8	126°47.2'W	- 1.9'	126°45.3'W
		W	8	126°47.3'W		126°45.4'W
2 375 848	Oct. 1	W	6	126°24.6'W		
	collective mean =			126°30.1'W		126°37.6'W
						modern value is 126°37.1'W

Notes: Vancouver's collective mean was 126°28.5'W. This is probably an arithmetic error on his part as it is difficult to replicate by postulating typographical errors.

Oct. 1 results are based on lunar distance from Altair in the constellation of Aquila. All others are based on lunar distance from the Sun.

It is not clear why there are two entries for Sept. 23.

Table 1: Summary of Vancouver's Observations at Nootka,
corrected for errors in the Nautical Almanac for 1792.

Whilst the result of this analysis does show Vancouver to have been an observer of the highest calibre, it is a little disturbing that Vancouver himself seems not to have suspected his Nautical Almanac might have been in error. Yet there was evidence for this in that his observations did not agree with those of the Spanish. Galiano certainly was a very intelligent and competent navigator, well versed in alternative techniques for measuring longitude, and probably aware of the differences between the British and other Almanacs. Galiano even went so far as to tell Vancouver that he had found that tables could lead to longitude errors of up to three-quarters of a degree:

> "So we told Captain Vancouver, to whom our proposition was strange because of the ideas established in England by the best astronomers, who had predetermined, as an exact method of establishing longitude, the mean of many lunar distances." [3]

In general, Vancouver made many of his observations from land, so he was not prevented from using a high powered telescope to observe the moons of Jupiter. The beginnings and ends of the eclipses of these moons make a very good clock, although, to be fair, at the particular time Vancouver was at Nootka, Jupiter was setting only about an hour after the Sun and observations would have been difficult to make.

One of the questions that certainly interests me is whether or not it would have been possible for a late 18th-century astronomer to have corrected Vancouver's results on his return to England, by using observations made at the Royal Greenwich Observatory whilst he was away. The observatory records show observations on Aug. 23 and 27, and Sept. 2, 4, 26 and an incomplete observation (no declination) on Sept. 22.

The method I used to analyze these results was to concentrate on the error in the ecliptic longitude of the Moon. The calculation of the distance between Sun and Moon also involves the ecliptic longitude of the Sun and the ecliptic latitude of the Moon, but the relative contribution of these two quantities to the distance error is small. The Nautical Almanac of 1792 tabulated the Moon's ecliptic longitude every 12 hours.

The exact method of analysis is described in Appendix 2, and the results were as follows:

	ecliptic.long.error	longitude correction
Aug. 23	1.6"	+0.8'
Aug. 27	-5.2"	-2.6'
Sept. 2	20.6"	+10.3'
Sept. 4	23.2"	+11.6'
Sept. 26	-7.9"	-4.0'

The corrections to be applied to the (terrestrial) longitude determinations indicate that it would indeed have been possible for someone in the 18th century to have come close to the point we have, 200 years later. As it turned out, the magnitude of the errors attributable to the Nautical Almanac was not fully appreciated in Britain until the longitudes obtained by Matthew Flinders during his survey of Australia were re-computed in 1811 [4].

Appendix 1

The procedure that was used to correct Vancouver's longitudes was as follows:

1. From the JPL Ephemeris, take the RA (Right Ascension) and Declination of the Sun and Moon at Ephemeris Time 0000 hrs (approximately 1600 hrs PST) and compute the lunar distance.
2. Convert Ephemeris Time 0000 hrs to Universal Time (K8 in the Astronomical Almanac 1991). The difference between these time scales reflects the difference between atomic time and time based on the rotation period of the Earth. The length of our present 24 hour day is increasing at a long-term average rate of one hour every 200 million years because of tidal friction.
3. Convert the Universal Time of Step 2 to Apparent Time using the equation of time. Apparent time is true solar time and differs from mean time because the Earth's orbital speed is not constant throughout the year.
4. By inverse interpolation, from the 1792 Nautical Almanac, compute the Apparent Time at which the Moon was at the lunar distance calculated at Step 1.
5. From the difference between the times calculated in Steps 3 and 4, compute the correction to be made to Vancouver's longitudes.

Appendix 2

The procedure that was used to determine the error in the Nautical Almanac longitude for the Moon based on observations of the Moon's transit at Greenwich was as follows:

1. At the time of transit of the Moon's illuminated limb across the Greenwich meridian, determine the Sun's RA (Right Ascension) and the obliquity of the ecliptic. Neither of these figures is critically dependent on the time of observation. Also, 18th-century values are very similar to those computed from modern ephemerides.
2. Determine the apparent time of the observation by subtracting the RA of the Sun from the RA of the illuminated limb.
3. By interpolation determine the longitude of the Moon at the time of observation from the Nautical Almanac.
4. Calculate the observed longitude using the observed RA of the centre of the Moon's disc, the observed declination (90°-North Polar Distance), and the obliquity of the ecliptic of date.
5. Subtract the longitude obtained at Step 4 from the longitude obtained at Step 3.

Acknowledgements

The author gratefully acknowledges the help of Dr. Myles Standish of the Jet Propulsion Laboratory, Pasadena, who supplied an accurate Ephemeris for the Sun and Moon 1792 (DE-118 + LE-062). Thanks are also due to Mr. Adam J. Perkins, the Royal Greenwich Observatory archivist at Cambridge University in England, who located and sent the Greenwich observations.

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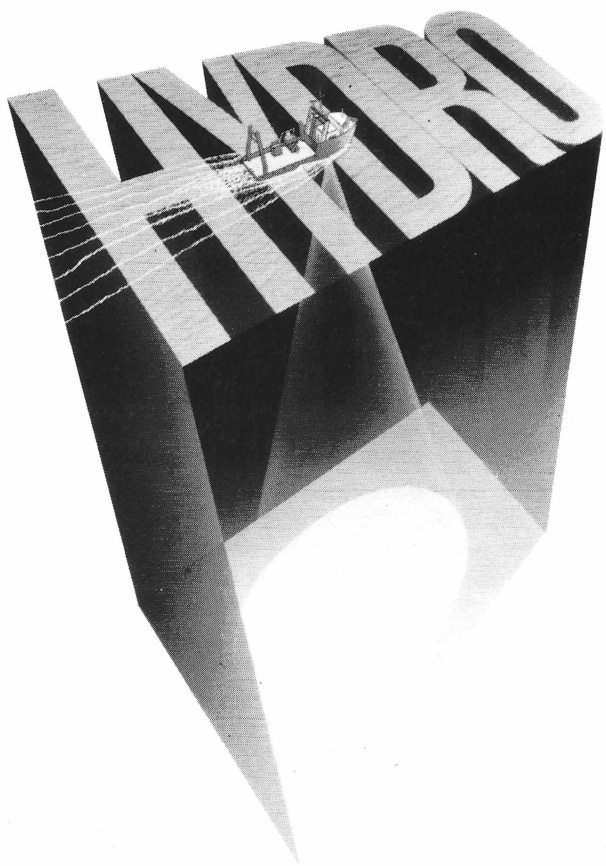

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Towards 'IHOstat':

IHO Approved Software Which Evaluates the Quality of Bathymetric Data

by

P. Kielland, K. Burrows, B. Ward, M. Dagbert, Lt. R. Velberg

Introduction

In essence, traditional hydrography has consisted of a series of graphically-portrayed operations. The path of documents it produces leads through various data collection and data manipulation operations and ends at the published chart. This scale-dependent way of doing things has been with us since the earliest days of chart making and has resulted in a massive document-oriented data base. Navigators continue to use the graphical data paradigm as they plot their course on the charts that hydrographers and cartographers have painted for them.

Hydrography is presently undergoing a radical move away from these traditional document-based techniques and products. Already many surveys are capturing and processing data digitally. Computerized tools for cartographic manipulation of these data files are being developed which will produce digital products suitable for viewing in an Electronic Chart (EC) environment. By marrying digital chart products to electronic positioning information (preferably from differential GPS), the Electronic Chart can provide far more utility and safety than when viewing the same information on a paper chart. Using both the vessel's current position and a geocoded bathymetric data file, the EC computer extracts and displays pertinent vector or raster data. The ship's position is thus automatically plotted and displayed with respect to the surrounding bathymetry and other chart-related features.

The evolution away from document-based hydrography is the challenge facing hydrographers today. In the future, hydrographers will devote far more of their energies towards managing a data base and extracting diverse digital products tailored to both traditional users and new applications. Traditional paper charts will continue to be produced, however more efficient semi-automated cartographic techniques will become possible. Other extracts from the digital data base will support a new and exciting range of EC products from electronic 'paper chart equivalents' all the way up to EC files capable of displaying high-density survey data. Specialized data base extracts will also support a variety of military, civil and scientific applications.

The challenge of digital hydrography has many facets; one of the most crucial is that of evaluating the quality of bathymetric data. In the old paper-chart world, data quality evaluation was far less of a problem. Chart scale was chosen to be small enough that survey errors appeared negligible compared to the other uncertainties facing navigators. Surveys were generally positioned with far greater accuracy than that available to the average mariner. The navigators' knowledge of their own position was uncertain enough that they were very cautious of approaching charted hazards. The high level of human intervention during the production of documents ensured that 'good judgment' was embedded in the products. While somewhat subjective, this process did indeed ensure that the quality and completeness of the survey data being compiled was appropriate for the intended use of the final document.

The situation is changing rapidly. Differential GPS (DGPS) will soon provide navigators with better positioning accuracy than that which was available to the hydrographers who collected the bathymetric data. This high-accuracy automatic position-updating on Electronic Charts will erode much of the safety margin that has existed in the paper chart world. The thinning of the traditional safety margin dictates that data quality be examined much more objectively than in the past. If accurate data error estimates are not readily available to navigators, then the power of the EC has the potential to do more harm than good. Without information to the contrary, a navigator might assume a uniform high data quality and be tempted to venture close to less reliable areas of the bathymetric image. This same lack of information might cause more-wary navigators to assume a uniformly poor data reliability. While caution is certainly the safer attitude to have, ignorance of data quality will prevent high-quality surveys from being fully exploited by deep-draft commercial shipping.

It's obvious that knowledge about bathymetric data quality is as important as the data itself. Totally unqualified data is essentially useless. The more accurately data is qualified the more useful it can be when exploited in an EC environment. Scale-independent error estimates must be woven into the fabric of the digital database as well as the products we extract from it. How can this best be done? To answer this question we should first ponder the nature of the errors we wish to quantify.

The true uncertainty of any bathymetric representation is continually varying and unique to every location on a chart. This is evident since both the accuracy of the survey measurements and the complexity of the bathymetry being sampled are unique at each charted location. Thus any view into the bathymetric data base can be conceptualized as two overlapping surfaces:

1. The continuously varying elevation of the marine floor as defined by our measurements (referred to in this paper as the bathymetric surface); and

2. The continuously varying fidelity of the above approximate image with respect to the true marine topography being charted (referred to in this paper as the stochastic surface).

Figure 1 shows different views of two bathymetric surfaces together with their corresponding stochastic surfaces. Both images were computed by the IHOstat software described in

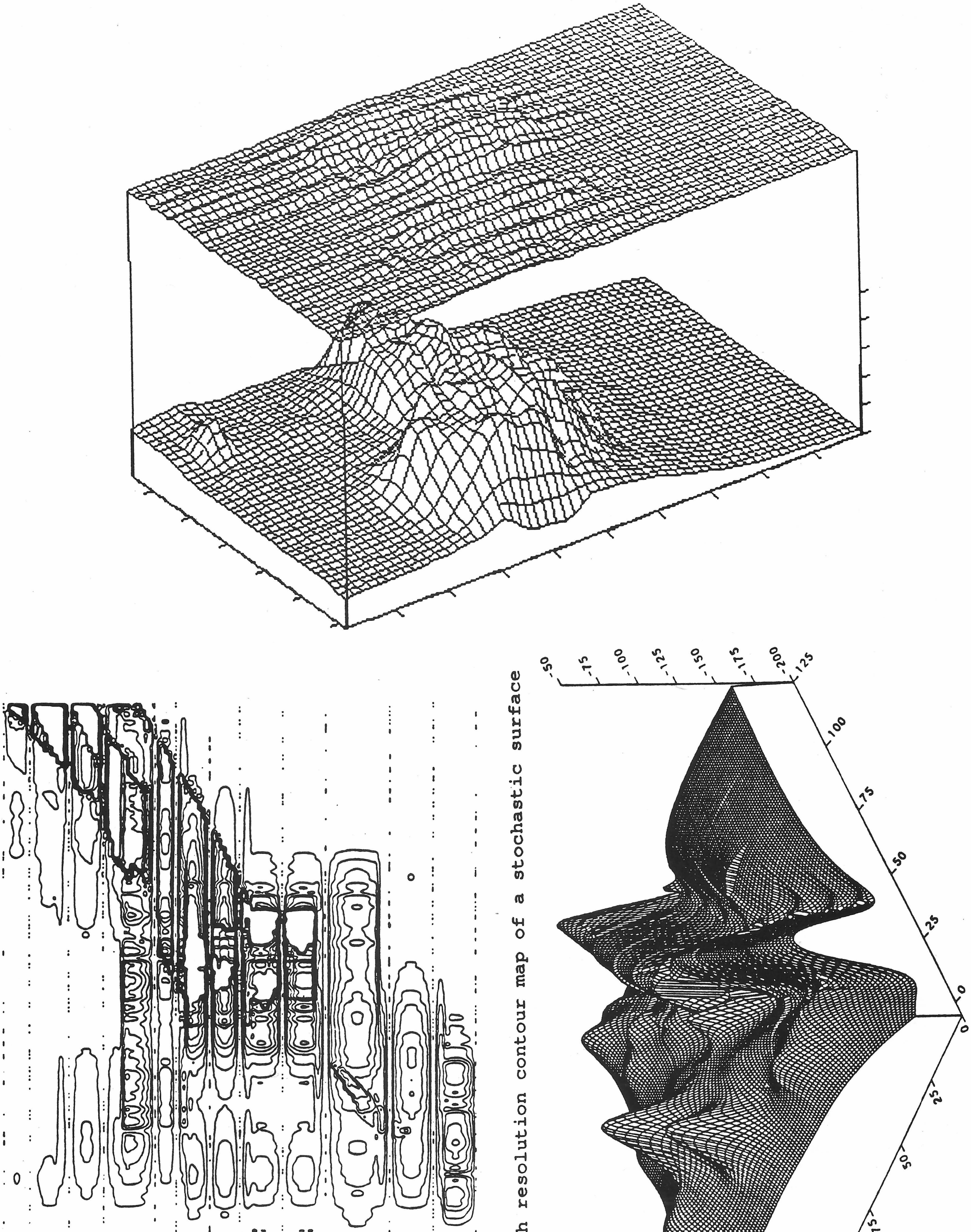

Figure 1: Different views of the bathymetric and stochastic surfaces

this paper. The bathymetric surface is simply the Digital Terrain Model interpolated from the observed sounding profiles. The stochastic surface is comprised of the vertical error estimates for every point on the bathymetric surface. For clarity in the perspective view of the upper image, the vertical scale of the stochastic surface has been exaggerated five times with respect to the vertical scale of the bathymetric surface depicted below it.

The stochastic surface exhibits some correlation to the bathymetry due to the fact that a fairly constant line spacing was used to collect the profiles. The location of these surveyed profiles can be seen on the stochastic surface since the uncertainty due to interpolation errors drops to zero where measured depths exist. The lower image in Figure 1, a contour plot of a stochastic surface shown above a 3D view of its corresponding bathymetric surface, shows this effect clearly. If more soundings had been measured in the regions of high uncertainty then IHOstat would have computed lower peaks on the stochastic surface. Thus we see that the stochastic surface which corresponds to a bathymetric surface is a function of both seabed texture and sampling density whereas the bathymetric surface itself is strictly a function of water depth.

To objectively describe the fidelity of the spatial bathymetric surface, the stochastic surface must also be expressed in the same spatial units. For example, one must be able to select an arbitrary location on the bathymetric surface (not necessarily where depths were measured) and find out for example that: "the total vertical uncertainty of the depth estimate at this point is +/- 0.8 m at the 95% confidence level". Such spatial error statistics are highly desirable since they are independent of the scale at which the data is viewed. This is an important consideration for an EC application since it permits both the bathymetric and stochastic surfaces to be viewed at various scales without disturbing their spatial relationship. Assuming for the moment that the stochastic surface can be accurately evaluated, how might the two surfaces be exploited to actually improve safety for navigators?

The most direct approach would be to view the stochastic surface exactly as the bathymetric surface itself is generally viewed; as a contour map. Figure 1 contains such a map of estimated standard deviation for each depth on a particular bathymetric surface. If this contour map of the stochastic surface were viewed as a separate image then it might conceivably be of some use to a sophisticated navigator, however, it would hardly be intuitive or convenient. If this contour map were overlaid onto its depth contour map, the two views would be poorly correlated. For example: at the interface between a zone sounded with modern swath techniques and one sounded with traditional profiling techniques there would be a sharp rise in the stochastic surface whereas the bathymetric surface itself might be quite continuous and smooth. The overall effect of this incoherence on the navigator would be one of visual confusion.

How could the navigator easily interpret changes in depth confidence when trying to lay out a safe course over the bathymetric surface? A better approach for transmitting the data-quality information would be to integrate both bathymetric and stochastic surfaces into a single coherent image. Since the two surfaces can't be superimposed or even viewed separately without a great deal of visual confusion we require some common graphical element which can simultaneously convey both types of information in an intuitive manner. The depth contours themselves present a convenient and easily implemented means of doing so. To produce contours of either the bathymetric or stochastic surfaces, the depth data must first be interpolated onto an arbitrarily dense mesh of estimated depths. This interpolated model can utilize either a grid structure or a triangulated network structure. On the interpolated grid model, nodes of equal value are then joined and smoothed to produce contour lines consistent with the graphical representation desired.

If the magnitude of the bathymetric and stochastic surfaces are simply differenced (added and subtracted at each grid node) then we obtain two nearly coincident bathymetric surfaces that have been both deep- and shallow-biased by the uncertainties represented on the stochastic surface. We can then contour these two new bathymetric surfaces to obtain a very useful graphical tool for viewing the full information content of the data. The area bounded by the deep-biased and shallow-biased contour lines is the zone in which the true contour is known to be located (within the statistical confidence level to which the stochastic surface was computed). For example: if the stochastic surface used is computed at the two sigma level, then the envelope between deep and shallow biased contour lines would represent the zone within which the true contour line must fall 95% of the time.

Figure 2 illustrates how this display method might appear to navigators. The display is simulated here for the sake of graphical clarity, however IHOstat currently has the capability to compute and draw similar graphics to portray any input survey file. In the lower area of Figure 2, a 20 m contour has been drawn through both the deep-biased and the shallow-biased bathymetric surfaces. The visual effect produced is that of a single contour which gets thicker and thinner depending on the magnitude of the stochastic surface. For clarity, the survey area has been divided into zones of different data fidelity and seabed topography. Data fidelity is dependent on two factors: the accuracy of the observations and their density with respect to the features being charted. In Figure 2 we see that the accuracy of the technology used to collect soundings and the complexity of the bathymetry both affect the width of the contour envelope. In this example (assuming the stochastic surface was computed at the 2 sigma level), the navigator would have a 95% assurance that the true 20 m contour lies somewhere within the boundaries of the variable-width contour envelope. The advantage this gives to the navigator is that a ship's course can now be easily laid out with due consideration to both the bathymetry and its uncertainty.

Another possible tool for integrating the bathymetric and stochastic surfaces would be to colour- code the contour line using the depth uncertainty at each grid node. The 10 metre contour line situated in the upper part of Figure 2 has been drawn using 3 grey-scales. IHOstat doesn't currently support this output mode. Each portrayal method has advantages and disadvantages. The contour envelopes have the advantage of actually showing the horizontal limits of confidence zones, however the visual effect can become complex under certain conditions. The colour-coding method maintains neat contour lines but doesn't explicitly inform a navigator where to plot a course in order to maintain a desired keel clearance. In an evolved EC system, different graphical representations of data quality could be toggled on or off as required. What is

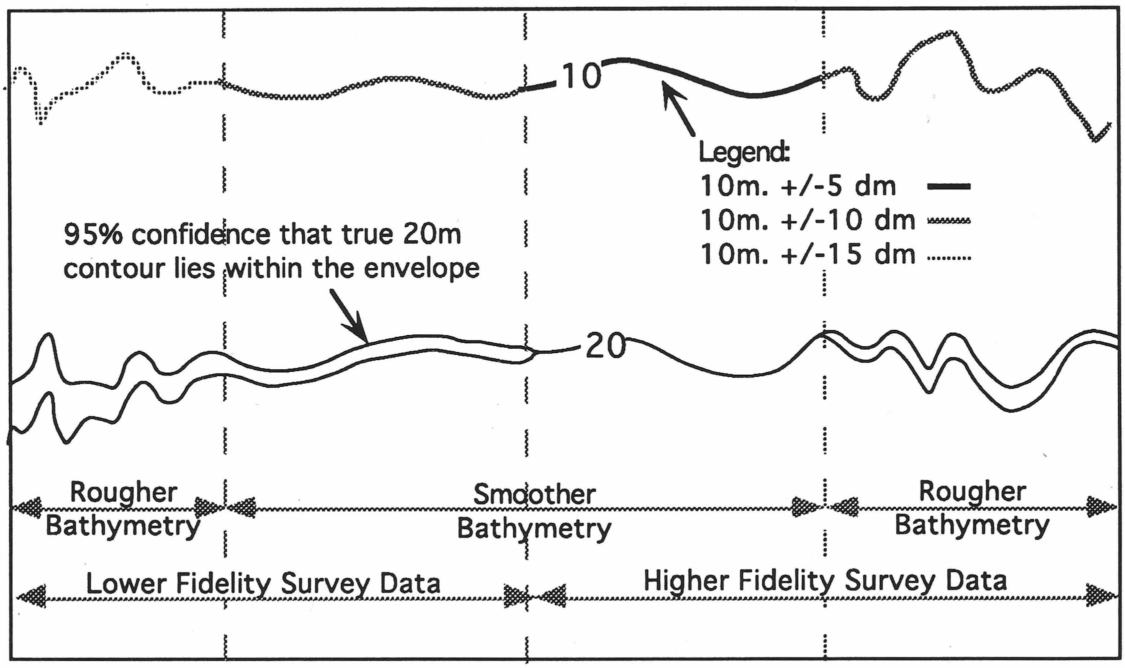

Figure 2: Methods of integrating both depth and uncertainty surfaces

fundamentally important, however, is that the bathymetric data uncertainty be statistically quantified and that these error estimates be made available together with the depth estimates themselves.

IHO AND THE DATA QUALITY ISSUE

In view of the importance of deriving good error estimates for digital data, the IHO is seeking to update the current IHO data quality standard (Special Publication 44). SP44 is a series of guidelines for obtaining data that is "sufficiently accurate for navigational purposes". Some of SP44's quality standards have to do with scale-independent factors such as instrument calibration. Much of the document, however, consists of fairly subjective survey guidelines which relate the quality of survey data to the scale at which it was plotted during the survey. This approach was adequate for guiding document-based hydrography but is clearly unable to compute a stochastic surface which qualifies a bathymetric digital data base.

To address this concern a Working Group was formed within the IHO Committee on the Electronic Chart and tasked with developing ways and means to assess digital bathymetric data in a manner that would complement the capabilities of the Electronic Chart. Member states have been working on various aspects of this task since 1989. The data-quality standard which governs document-based hydrography is itself a document (SP44). Similarly, it became obvious that to establish a quality standard for digital hydrography we should create a public domain computer program which can analyze and qualify the digital bathymetry. The Working Group has focused on producing such a program and has dubbed it "IHOstat". The balance of this paper is devoted to illustrating how Research and Development (R&D) efforts have resulted in a working program, what its strengths and weaknesses are, and what plans are being made for improving it.

IHOstat Algorithm Development

As we've seen, an ideal bathymetric data-quality estimator would be roughly analogous to the error ellipses geodesists compute for control points. Geodetic spatial statistics possess some features that would also be desirable for qualifying bathymetric data:

1. They are mathematically sound and thus provide a defensible means for portraying the quality of data to users;

2. They are quantified spatial statistics and thus well suited to exploitation in a digital environment such as the Electronic Chart; and

3. They can render survey procedures more efficient by permitting survey observations to be refined until a desired level of data confidence is achieved.

In order to succeed in computing a valid stochastic surface for bathymetry, a number of principles have guided IHOstat's development:

1. Wherever possible, the program should employ statistical analysis of the geocoded data itself rather than define a set of guidelines for how the data should be collected.

2. Statistical error estimates should be ground-truthed using test data sets. If possible, self-calibration algorithms should be developed to ensure the error estimates accurately describe the data being analyzed.

3. Wherever 'rules of thumb' or arbitrary constants are unavoidable in the program's algorithms, they should mimic the traditional ones used in document-based hydrography (SP44).

4. If possible, the program should permit 'what-if' analysis to guide surveyors during their survey towards

collecting data which provides a desired level of confidence.

5. The entire process should be as scale-independent as possible.

Early in development, three principal error types were identified which together form the total error budget:

1. Instrumental errors affecting the bathymetric observations;

2. Interpolation errors in the zone between the observation sites; and

3. Document-related processing and compilation errors.

IHOstat evaluates these three error types in sequence. Instrumental errors are analyzed first so that the uncertainty of the observed data can then be propagated into the interpolation error estimates. This two-step process computes total vertical error estimates for any point within a surveyed area (its stochastic surface). The density of the points where total errors can be computed is arbitrary and independent of the density of the survey points. In practice they are computed onto a grid of sufficient density to resolve the growth of uncertainty between the surveyed points. Two to three times the density of the observations provides adequate results without excessive computation time. A detailed discussion of this evaluation process is given below.

The third general error type will be modeled by an analysis module which is currently only in preliminary development. Document-related processing and compilation errors are the most difficult ones to evaluate since they are generally linked to a particular graphical interpretation of a sparse historical data set. A short discussion of the problems posed by these data sets and some proposed analysis methods is presented later in this paper (see 'Currently Un-modeled Errors').

Evaluating Instrumental Errors

Instrumental errors are the easiest to conceptualize. Given sufficient information they are also the easiest to quantify. Instrumental errors define the accuracy of each data point that has been measured during the survey. Bathymetric instrumental errors are of two types: positioning errors and depth measurement errors.

Positioning errors are often straightforward to evaluate since many modern surveys observe multiple Lines Of Position in order to over-determine the vessel's location. The misclosure statistics from each of these position computations provide good estimates of the positional errors. A less satisfactory situation arises on older surveys where redundant LOP's weren't measured. The Geometric Dilution Of Precision (GDOP) can, however, often be computed for each of these positions. Position error estimates can then be made by multiplying GDOP by an apriori error estimate for the observed LOP's. The apriori estimate of the typical LOP error is based on the characteristics of the technology that was employed for the survey. IHOstat currently supports both these scenarios for a range of popular survey positioning systems. The worst-case scenario for estimating position errors arises where the survey record only contains final positions and a brief description of how the data was collected. In these cases the best that can be done is to assign errors to the positions based on descriptive information about the positioning system. The IHOstat interface prompts users for input to qualify the data-capture technique by selecting through a hierarchy of descriptive menus. Figure 3 illustrates the root menu of this interface. Once the data has been described, a 'Look- Up Table' assigns appropriate typical error estimates to all the observations in the data file. The user can also input additional error estimates for global error sources such as horizontal datum uncertainty with respect to WGS'84. In other words, the error model fully evaluates any LOP redundancy where applicable but assigns realistic apriori estimates to all data points when necessary.

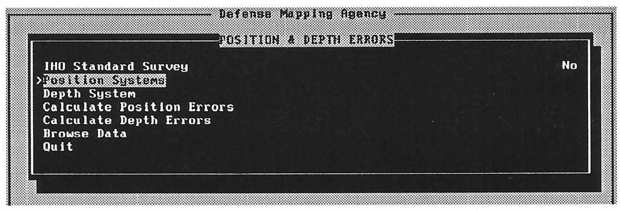

Figure 3: IHOstat Menu Structure for Instrumental Error Evaluation

Similarly, acoustic errors are modeled using whatever information is available about the depth measurements. IHOstat estimates the vertical errors caused by the acoustic footprint insonifying sloping terrain. The slope of the terrain at the measurement site is derived from its neighboring depth observations while the acoustic footprint is derived from the characteristics of the transducer. Additional computations are performed on multi-beam data sets. Comparisons of overlapping data are made to measure the internal consistency of the data set, thereby allowing the calculation of measurement noise. This technique is not used for single-beam data sets because there is insufficient overlap to provide reliable results, but in dense multi-beam data sets it provides an accurate noise measurement.

Currently IHOstat doesn't rigorously estimate any vertical uncertainty induced by chart datum errors, instrumental tide gauge errors, co-tidal chart errors, errors in acoustic calibration, depth digitization errors or heave noise. The composite of these errors is estimated based on a user input apriori error estimate for each variable. Another error source currently outside the scope of IHOstat is the dynamic nature of the seafloor. As the seabed shifts over time the quality of data deteriorates. In some critical waterways this is monitored by annual surveys however it is generally not feasible when trying to qualify an existing data set. Analysis procedures and guidelines for their use have yet to be developed for handling the general case of time sensitivity.

An alternate method of ascribing instrumental errors to data is available within IHOstat by selecting the 'IHO Survey' command. The scale of the survey can then be input by the user and its corresponding IHO SP44 depth and position error will be attributed to all observations in the data file. The scale is used to attribute 95% positional errors which correspond to 1.5 mm. on the survey document. Depth errors are independent of scale and correspond to 0.3 m for depths of 0 to 30 m and 1% of depth for deeper soundings. This approach to the problem assumes that the data set being analyzed was collected in accordance with IHO SP44 guidelines and that these guidelines correspond to a known bathymetric uncertainty in all the survey data. It is therefore less robust than that described above. It is, however, based on an accepted standard and is expedient given the large number of data sets which contain insufficient information to analyze the accuracy of each measurement.

Estimating Interpolation Errors

Instrumental errors exist at locations where depth measurements have been observed. Interpolation errors, on the other hand, are errors that pertain to those locations where depth measurements have not been observed. Owing to resource constraints, most surveys only measure depths over a small portion of the total area being surveyed (typically along discrete sounding profiles). As we move away from these depth observations we are forced to interpolate depths based on nearby soundings. Depending on the acoustic technology used and the effort expended on the survey, 'nearby' may be anywhere from a few metres to many kilometres away.

When continuous contour lines are interpolated through discrete surveyed depths, their portrayal of the true depth is contaminated by the interpolation errors. If the surveyed depths are 'far apart' then, depending on the topography of the sea floor, these interpolation errors can be much greater than the instrumental errors in the measurements themselves. Since chart users navigate with respect to charted contours, quantifying interpolation errors is therefore at least as important as quantifying instrumental errors. For this reason IHOstat development has focused considerable effort on statistical modeling of interpolation errors. These interpolation error estimates are combined statistically with the previously evaluated instrumental errors to define the best possible stochastic surface for a data set.

The locus of points which forms a contour line is interpolated based on simple assumptions about the local bottom morphology. The presumption of a linear slope between the depth samples is typically used to compute each interpolated depth value. Higher order mathematical models can be implemented in machine-contouring algorithms. Hand contouring also departs from linear interpolation since an expert cartographer will often subjectively bias the contour line towards the shallowest interpretation of the surrounding measured depths. Regardless of the method used there will always be interpolation errors which vary with the validity of the assumptions used for the interpolation. The only instance where no interpolation errors occur is when the data set provides continuous coverage of the bottom so that no interpolations are required. Swath sounding technology represents this optimal case since the bottom is completely insonified. In practice however, the majority of hydrographic data has been obtained using some form of discrete sampling. Cost considerations may dictate that many future surveys continue to directly measure only a representative sample of the total bathymetry.

If the bathymetry being surveyed is perfectly smooth between the observed depths then an errorless linear interpolation of depths can take place since the assumption underlying the interpolation is valid. If, on the other hand, the bathymetry is not perfectly straight and smooth between the observed depths then the premise for interpolation is somewhat false and the interpolated values will be somewhat uncertain. This uncertainty grows larger as the topography grows rougher. The uncertainty of the interpolated depth also grows larger with its distance from any observed value and reaches a maximum mid-way between measured depths.

<u>Variogram modeling</u>

An effective means of modeling this error growth is by constructing a variogram from the observed data. The variogram is the principal analysis tool in a field of statistics known as 'geostatistics'. It relates the distance between measurement sites to the variability of all the depth pairs separated by that distance. A variogram is a simple XY graph with average distance between observations along the X axis and the average squared difference between measured values along the Y axis. The variogram thus has the desired property of relating the depth uncertainty of an interpolated point to its distance away from any of the observations.

IHOstat relies heavily on variograms and computes them in the following manner:

1. A data sampling window onto the survey area is established (see Figure 4).

2. The distances between all soundings inside this window are computed and groups of all possible sounding pairs are formed according to distance (e.g. all pairs from 0-10 m apart, pairs from 10-20 m apart ... pairs from 990-1000 m apart, etc.)

3. Within each distance group, the average squared difference in depth among the member pairs is computed (the group's variability) as well as the average distance between the sounding pairs in the group.

4. The average squared depth differences are then plotted against the average distances between soundings to form the variogram which characterizes the spatial variability of the data within the window.

In Figures 5 and 6 we see examples of two windowed depth profiles on the left and their resulting variograms on the right. These graphics are screen dumps taken from IHOstat during the interactive modeling process described later in this paper. The rougher terrain in Figure 5 results in a variogram that is more than twice as steep as that computed from the subjectively smoother terrain in Figure 6. While this may seem trivial or merely common sense, it does illustrate the statistical basis for predicting estimates of uncertainty into the zones between sounding profiles. To do so, the major assumption is that the terrain roughness observed along the measured profile is statistically similar to that which lies between the profiles (presumption of isotropy).

There are a few constraints on the variogram worth noting. The first is that the general slope of the terrain (called the trend) will falsely exaggerate the roughness if it isn't removed. In Figures 5 and 6 we see that the bottom has a considerable slope superimposed on both the rough and smooth terrain samples. The straight line drawn over the profile is a linear regression IHOstat uses to remove this trend effect. Once detrended, the depth-differencing in the variogram computation is done, not on the absolute depths but on the residuals from

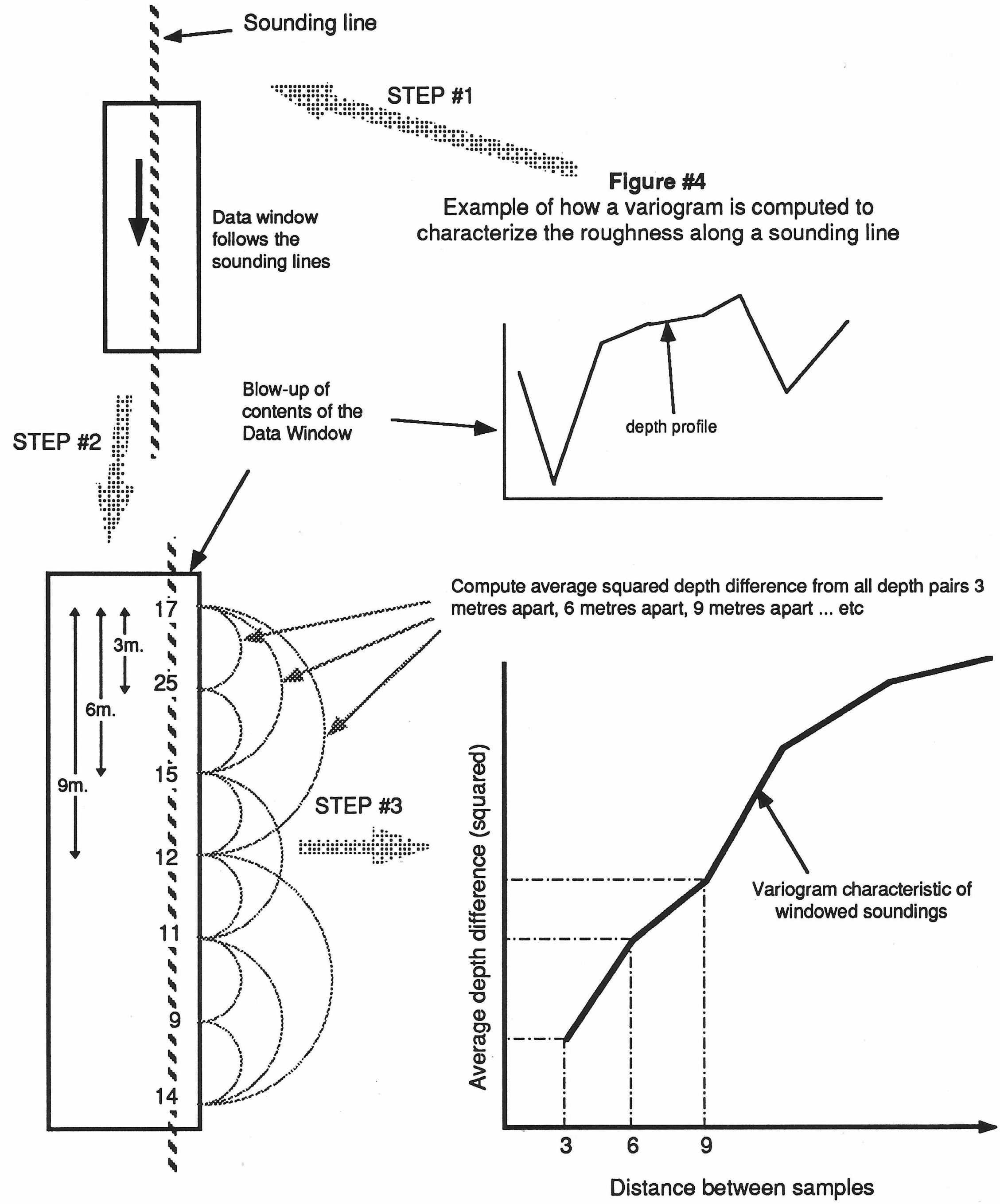

Figure #4
Example of how a variogram is computed to characterize the roughness along a sounding line

Figure 4: IHOstat's Variogram Computation

the line fit. The resulting experimental variogram is then modeled by a least squares fit to the form:

$$V(h) = ah^b$$

The analytical variogram model is required for the actual interpolation process described in the next section ('Kriging'). It also permits compact storage of the large number of local variograms that are needed to define the varying geostatistics of a digital bathymetric data set.

Another proviso for obtaining a realistic variogram model is that there needs to be at least 30 to 50 soundings in the moving data-sampling window. This ensures that the variogram curve will be defined by enough depth comparisons to have statistical significance. If too few soundings are used in its computation, then the graph of the experimental variogram will be too noisy for reliable modeling. This points to a weakness in the IHOstat process: it requires dense data samples in order to serve as a usable predictor of localized terrain variability. Fortunately, hydrographers generally collect data continuously along sounding profiles so this doesn't pose a major problem provided raw, un-decimated sounding data is input to IHOstat. It does, however, inhibit reliable prediction of interpolation errors when analyzing older data sets in which most of the raw soundings collected along profiles were discarded during document-oriented field processing. These sparser data sets must be evaluated by less statistically rigorous methods (see 'Un-modeled Errors' later in this paper).

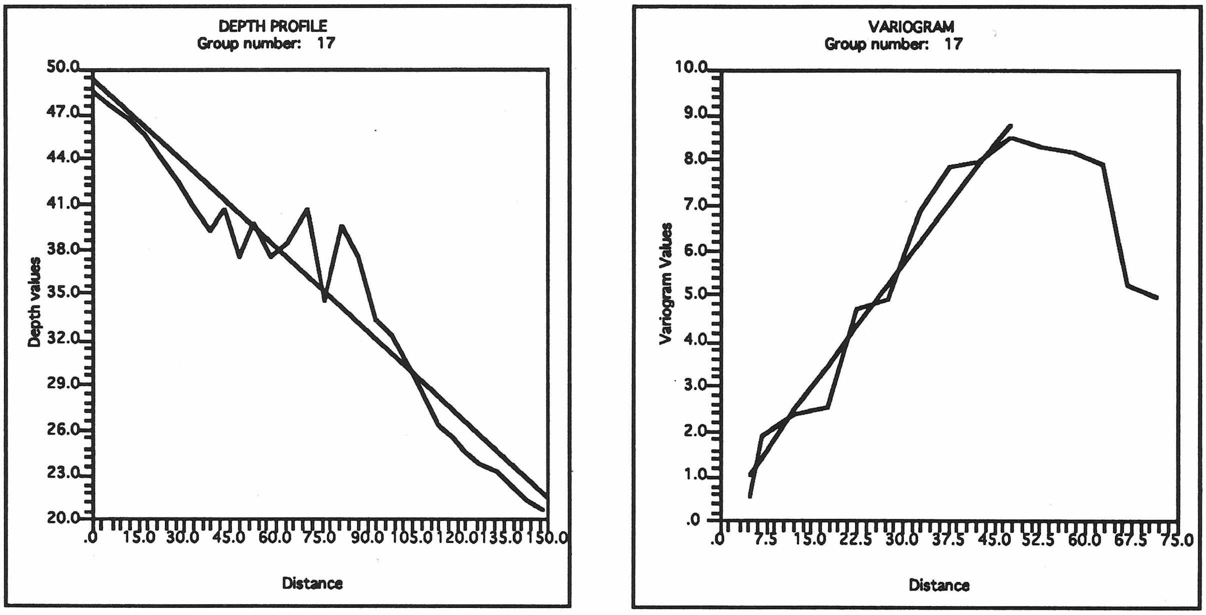

Figure 5: Rough Terrain and Resulting Variogram

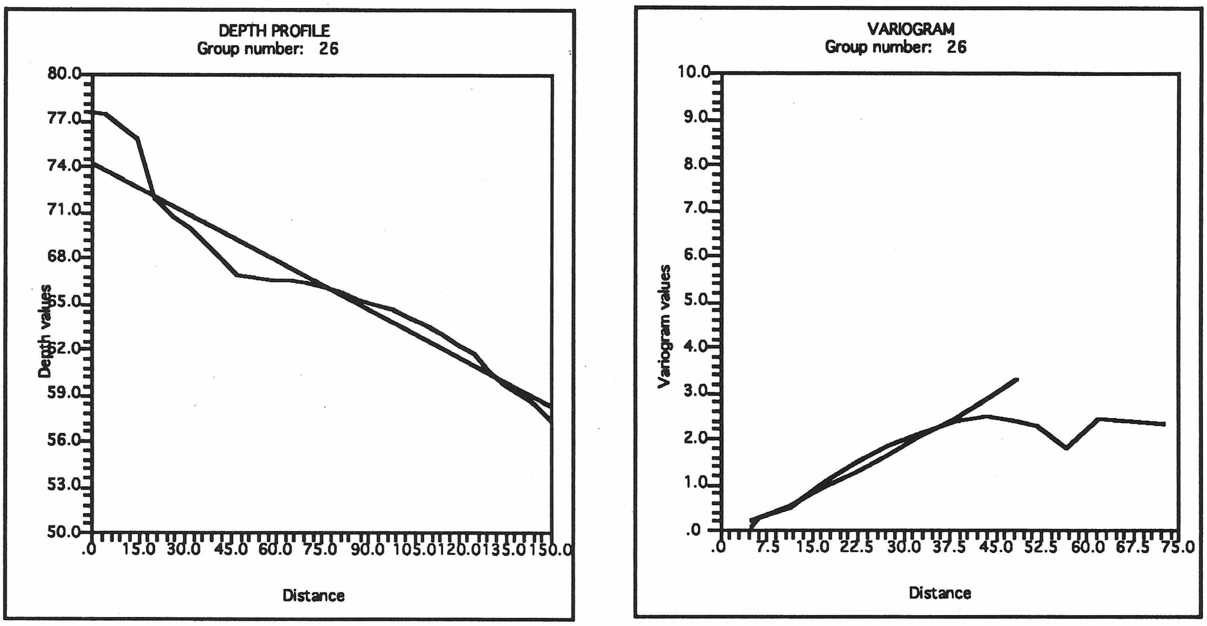

Figure 6: Smooth Terrain and Resulting Variogram

Since we wish to produce a map showing how interpolation errors vary over the ocean floor, variograms must be computed for many small zones so as to resolve these variations. The traditional approach to variogram computation has been to use the total data set to compute a single variogram which characterizes the entire area. This approach was tried early in development and found to be ineffective. IHOstat thus imposes a cell structure over the data, and a variogram model is computed for the data in each cell. The cell size is as small as possible while maintaining a statistically significant sample (30 soundings is the default value). The data window's size can be modified by the user, however the program will automatically suggest a size and orientation which is appropriate for the data density being analyzed.

Confidence envelopes

IHOstat initially presumes the seabed terrain is isotropic (the variability observed along sounding profiles is the same variability we would encounter in other directions). This assumption permits the variogram to be used to compute and plot out 'confidence envelopes' (see Figure 7). A confidence envelope is a lane of variable width centered along a sounding profile. The area inside these envelopes represents the zone in which depths can be interpolated within the error tolerance that was used to compute the envelopes. In Figure 7, given the profile spacing and the local bottom topography ,all depths within the confidence envelopes can be interpolated to within +/-2 m, 95% of the time. The depth contours have been overlaid onto the confidence envelopes to illustrate how the envelopes become narrower as the bottom gets rougher thus opening 'holes' in the interpolation confidence.

The width of the envelope at any position along its length is computed from the variogram of the data sample at that location. The envelope width is equal to twice the horizontal distance that corresponds on the variogram to the maximum allowable interpolation error. This confidence limit is input by the user and is presumed to refer to the 2 sigma (95%) level. Varying the allowable error tolerance will result in wider or narrower envelopes; large allowable errors result in wide envelopes and vice versa. To prevent graphical confusion, IHOstat can limit the maximum envelope width to the nominal line spacing (this was done for Figure 7).

The confidence envelopes serve two functions:

1. They assist hydrographers in determining an optimal sounding pattern with a permissible level of interpolation error. Line spacing can be adjusted such that confidence envelopes just overlap - no more, no less.

   This adaptive sampling function could be performed in real-time as the sounding vessel progresses.

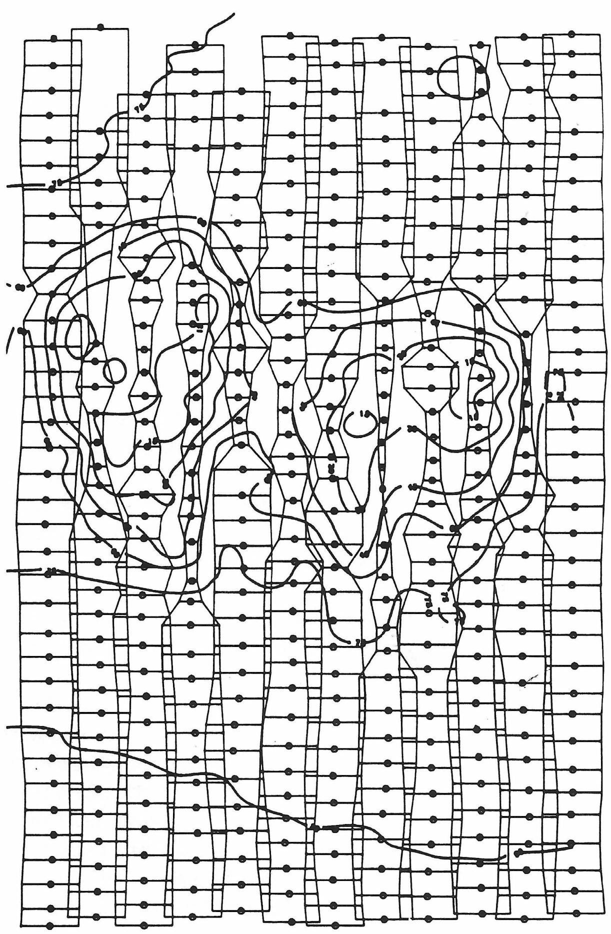

Figure 7: Confidence Envelopes

2. They give an overview of how bottom texture varies in the survey area. This knowledge aids in identifying homogenous texture zones. The utility of this knowledge is explained in the next section.

Kriging

Variograms are the fundamental device used for predicting interpolation errors. IHOstat's confidence envelopes are simply a useful graphical representation of the information contained in the variogram. No attempt is made to make use of soundings collected on adjacent sounding lines nor can the confidence envelopes be used to actually estimate qualified depths for points between the profiles. To do so, we must extend the use of the variogram to an interpolation process called 'kriging'.

Kriging is generally used as a method for automated contouring since it interpolates an arbitrarily dense grid of depth values. Contour lines can then be drawn between grid points of equal value to produce the contour map. One attractive feature of kriging is that it honours the data points. Honouring the data is desirable in hydrography where observed values must be preserved. Some gridding algorithms will deform the observations onto a 'best fit' grid surface. Kriging will not. If a grid point is interpolated at the exact location of a measured sounding then its value will be identical to that sounding and its estimate of interpolation error will be zero.

Kriging forms a linear combination of depth values from nearby survey lines to interpolate the depth estimates for each grid point. The weights used in the linear combination are derived directly from the variogram. This property permits unique error estimates to be made for each of the interpolated depth values. IHOstat also introduces the previously-estimated instrumental error estimates into the kriging equations and propagates them into the total error estimate for each interpolated point. Thus, the kriging algorithm computes both the bathymetric and stochastic surfaces for any set of depth observations.

The main advantage that computing the complete stochastic surface has over simply computing one dimensional 'confidence envelopes' around profiles is that soundings from adjacent sounding lines are also used in the computations. Since the presumption of isotropy which underlies the confidence envelopes is often false, using data from adjacent lines can greatly improve the variogram modeling and thus the reliability of the variance estimates which make up the stochastic surface.

<u>Calibrating the variogram models</u>

Experience with early prototypes demonstrated the need for a procedure to automatically calibrate the error predictions. This became apparent after biases were observed when comparing the computed estimation variances (predictions) to the actual interpolation errors observable in the data. In this testing phase, the true interpolation errors were observed by removing every second line from a survey file. Using the remaining data, depth values were kriged for the exact locations of the removed soundings. We could then difference the measured depths from the interpolated depths to obtain the true interpolation errors.

These observed depth misclosures should have agreed statistically with the predicted estimation errors from the kriging. In a statistically significant sample, the standard deviation of the measured errors should be equal to the average of the predicted errors. While in some test data sets this relationship was validated, there were many cases in which significant biases were being observed. These biases were the result of faulty assumptions in the algorithm regarding:

1. The isotropy of terrain;

2. The trend model used to compute the experimental variograms; and

3. The analytical models used to characterize the experimental variograms.

Whatever their origin, the composite of these biases had to be dealt with if the stochastic surface was to have statistical validity.

The solution implemented in IHOstat is a routine called XVALID. A bias ratio (C) is computed by randomly selecting 25% of the data points, then kriging depth estimates for each of these measurement locations using the remaining data. The observed depth misclosures and predicted errors are accumulated and used to compute C:

$$C = \frac{\text{Standard Deviation of observed misclosures}}{\text{Average of predicted errors}}$$

This ratio is an index of how statistically valid the error predictions are with respect to the observed interpolation errors. If the correction factor (C) is significantly different from 1.0, this indicates a bias condition. Once computed, this ratio can be used to adjust the slope coefficient (a) in all the variogram models previously computed for the data set [$V(h) = ah^b$]. By correcting the slope of all the variograms, the average predicted error will adjust accordingly. The XVALID procedure thus calibrates the variograms, forcing the interpolation error estimates to conform statistically to the actual predictability observed in the data.

The observed biases are due to the three faulty assumptions listed above. Experience in other geostatistical applications indicates that the biases are characteristic of a geologically homogenous zone. This being the case, more accurate correction factors are obtained by limiting the computation of C to such zones. This can be accomplished by using the ZONE function within IHOstat. This function permits the user to define any number of polygons within the survey data which bound geologically homogenous zones. A unique correction factor will then be computed and applied within each zone.

Before further explanation of the ZONE function, it's worth describing the IHOstat user interface. All tasks, including the definition of zones, are facilitated by the interactive graphics environment in which IHOstat operates. Bathymetric data points are displayed in one window as a hypsometric plan view (colour-coded by depth). A mouse is used to zoom and pan the display as well as to select sounding line segments for interactive analysis. Selected line segments are displayed in a separate window as depth profiles. The profiles can be interactively modeled and their corresponding variograms displayed. The XVALID procedure can also be performed on a line segment. A separate graphics window then illustrates the measured profile, the profile interpolated from the adjacent sounding lines, the misclosure (difference) between the two profiles and finally, the predicted error. The mouse is also used to orient and size the cell structure used in the windowing algorithm. A separate text window displays data numerically and permits keyboard input from the user. The visual feedback from this Graphical User Interface (GUI) aids users in viewing and understanding the significance of any given variogram, confidence envelope or correction factor.

To continue with an explanation of the ZONE function, on IHOstat's plan view of depths, the confidence envelopes can be viewed superimposed on the colour-coded soundings. This plan view allows zones of similar texture or structural orientation to be quite easily perceived. Using the mouse, a user can then trace out polygons which bound these zones. The XVALID procedure will then proceed to iterate using the data sets contained within each zone. After each correction factor is computed the user is asked if it should be applied to correct the variograms within that zone. This ZONE feature thus permits human perception to augment the robustness of the variogram calibration in IHOstat. Once the variogram models have been optimized, the gridding process itself can finally proceed knowing that the resultant bathymetric and stochastic surfaces will be as accurate as possible.

The actual gridding is accomplished within the KRIG menu. First, a default grid mesh is displayed over the survey plan image. This grid mesh can then be adjusted graphically to any density by using the mouse. The grid density chosen will greatly influence the time it takes to compute the two surfaces. Once the grid density is defined, the kriging algorithm proceeds to interpolate grid values using the observed depth data and the previously-computed set of local variogram models. Progress through the computation is monitored on-screen as each grid square is filled with the colour corresponding to its interpolated depth. A disk file of the grid nodes is also created containing position, estimated depth and estimation variance.

Two database implications of these two grids (rasters) are of interest:

1. The computed stochastic surface will be the most complete picture of the data uncertainty that can be derived from the data. These raster objects should be stored as such and used for a variety of survey planning tasks or graphical tasks such as the dual-purpose contours depicted in Figure 2.

2. The computed bathymetric surface will be incomplete. Since the measured depths from which the grid is derived are not exactly coincident with grid node locations, the actual measured values are not present in the raster objects. If the computed grid mesh is too coarse then peak soundings on shoals might not be stored in the database. This would have no impact on the generation of contours (since contours are interpolated, not measured). It might, however, affect the cartographic operation of selecting critical shoal soundings. For this reason, storage of the interpolated bathymetric surface must be augmented by storage of the observed data points.

Before describing the built-in contouring functions of IHOstat, one more gridding tool needs explanation. The kriging estimation at each grid point involves searching for neighbouring soundings. IHOstat uses 20 soundings found in the vicinity of the point to be estimated. If only the closest 20 measurements were selected then they would most likely all come from the same profile. A random selection of depths within the search pattern ensures that data from all profiles within the search area are used to estimate the grid value and error. Normally, the presumption of isotropic topography causes the data search pattern to be circular about the grid point being estimated. This search pattern gives equal weight to data in all directions.

If, however, non-isotropic structures such as rock ledges or sand waves are present in the zone being analyzed, since equal weights have been given to all directions, the interpolated grid values won't properly reflect the structural trend. For example: contours of a sand bank would portray a series of high spots where the sounding profiles traversed the structure rather than portraying the elongated structure we intuitively know it to be. Such graphical artifacts are a common problem with automated contouring algorithms. IHOstat addresses the problem in the following manner. Using the SEARCH option, the default kriging data search pattern can be modified by the user to suit the anisotropy's visible in the data (anisotropic: having different properties in different directions). This is accomplished by defining an arbitrary search ellipse which matches the orientation and magnitude of the structural trend perceived in the data. Each zone previously discussed under the ZONE function can have an ellipse assigned to it which the kriging algorithm will use when estimating points within the zone. Each ellipse is defined by using the mouse to draw its semi-major and semi-minor axes. By using this 'SEARCH' feature to pass knowledge about perceived bathymetric structure into the kriging algorithm, contours generated from the resulting grid file become more realistic.

The final operation currently supported within IHOstat is the actual production of contours from the computed grid. The 'CONTOUR' menu prompts the user to specify which variable should be contoured:

1. The interpolated depth; or

2. The predicted standard deviation of the interpolated depth.

This choice of variable is made by supplying coefficients A, B and C in the equation:

Variable to contour = A x Depth + B x Error + C x (Error / Depth)

This definition provides five contouring options:

1. If A=1, B=0 and C=0 then a contour map of the bathymetric surface will be drawn.

2. If A=0, B=1 and C=0 then a contour map of the stochastic surface will be drawn.

3. If A=0, B=0 and C=1 then a contour map of the relative error will be drawn. The relative error (error / depth) adjusts the stochastic surface to reflect the fact that navigators become less concerned with data uncertainty as the water depth becomes greater. The value of C can be any real number so as to scale the relative errors as desired.

4. If A=1, B=1 and C=0 then each error estimate will be added to its corresponding depth estimate. Thus, a contour map of deep-biased bathymetric contours will be drawn. If B=1 then a single standard deviation will be added. If B=2 then the 95% deep contour will be drawn.

5. If A=1, B= -1 and C=0 then each error estimate will be subtracted from its corresponding depth estimate. Thus, a contour map of shallow-biased bathymetric contours will be drawn. Overlaying plots of both the deep- and shallow-biased contours results in the variable-width contours which were simulated in Figure 2.

Each contour line is created using a bi-cubic spline function to join all grid values which fall on desired contour intervals. The smoothness of the spline curves can be controlled to some extent by the density of the grid that was chosen during kriging. Contour intervals and colour coding are adjustable and disk files of the contour graphics can also be created. Using an external utility, these plot files can be converted into .DXF files for use in a variety of GIS environments.

Currently un-modeled errors

The analysis of instrumental and interpolation errors just described is already functional in the IHOstat program. The process shows what can be done with a digitally-captured dense profile. Unfortunately the majority of hydrographic data sets don't lend themselves to this kind of statistical analysis. The world has over 100 years' worth of historical document-based data that must be digitally exploited if at all possible. The intended role of IHOstat is to provide a standard process for evaluating all bathymetric data, not just certain data sets that were captured in an optimal digital format. The 'digital data base' that was referred to at the outset of this paper becomes a nebulous concept indeed if all its possible inputs and outputs are considered. In this section we'll consider these possibilities, how they complicate the task of IHOstat and what solutions are feasible.

The legacy of document-based hydrography can be classified into two broad categories: survey documents and navigation documents. The survey documents are all the field sheets (fair sheets) that have been produced during surveys. The navigation documents are all of the charts that have been compiled from the survey documents. Both of these document types portray only the bathymetric surface.

<u>Problems Evaluating Older Survey Documents</u>

The appearance of these documents gives very little indication of the magnitude of either the instrumental or interpolation errors that exist within the zones they cover. Often the data on which these drawings were based is no longer readily available. Most older surveys were carried out using positioning and sounding methods that were quite dependent on the skill and judgment of the hydrographer. The subjective element involved in the older surveying methods means that in many instances it becomes a leap of faith to assign instrumental errors to the portrayed data. Interpolation errors can only be predicted if quite dense soundings along profiles are available for analysis. For the sake of graphical clarity, survey documents only portray a greatly decimated data set so it is difficult to make reliable statistical conclusions about interpolation errors.

Under these circumstances we are forced make some assumptions about the survey methods and extrapolate an apriori error estimate. The best parameter on which to base these assumptions is the scale of the survey (the approach taken in SP44). This approach can only assign the same typical quantitative error estimate to a wide array of data sets surveyed at a given scale. However, it is at least based on the fact that as the scale of the survey gets larger, hydrographers do indeed employ more accurate instruments. Also, regardless of the complexity of the bathymetry being mapped, a larger scale will produce smaller interpolation errors due to the greater density of the observed data.

This scale-dependent approach to defining the stochastic surface corresponds to the 'IHO survey' feature already implemented and described earlier under 'Evaluating Instrumental Errors'. Using the assumption that the survey was collected in conformation with SP44 guidelines this menu item assigns a flat stochastic surface of uniform height based solely on the scale of the survey. This uniform error estimate can only represent what 'typical' surveyors might achieve when surveying 'typical' bathymetry at a particular scale. Since instrumental errors are subject to a host of variables and the complexity of bathymetry is constantly changing from place to place, the stochastic surface assigned by this function will be approximate at best.

Experience has shown that interpolation errors are usually greater than instrumental errors, so assigning a global instrumental error to all survey data is less dangerous than assigning global interpolation errors to the same data set. As we have seen, variogram studies of the data provide an excellent way to evaluate bottom roughness and predict local interpolation errors. The problem we are facing is that survey documents generally lack sufficient data for carrying out such an analysis, and what data does appear on them must be digitized prior to processing.

Problems Evaluating Navigation Documents

When trying to evaluate bathymetric data quality, navigation documents (charts) pose an even greater challenge than survey documents. Charts represent a tremendous investment which must also be captured into the digital data base in one form or another. This brings us to a fundamental division in EC strategy—raster display versus vector display. Briefly: raster data capture from a document is fast and inexpensive but only provides a 'dumb' image, like watching television. Vector data capture, on the other hand, is relatively time consuming and expensive, however the result is an 'intelligent' image, like interacting with a computer. Separate bathymetric and stochastic surfaces can only be determined from vectorized input data. Once computed, the two surfaces can be viewed in either raster or vector format, however they can be more fully exploited in a vectorized EC environment.

Due to their cost effectiveness and 'paper-chart-equivalent' appearance, raster-based EC systems were the first to hit the marketplace. These EC systems are essentially automatic position plotters which display the same information as paper charts. Raster images contain some new error sources inherent to the scanning process, however these mechanical errors can be well controlled or modeled. Provided that the charts are scanned with reasonable care using modern equipment the dominant error sources will still be the instrumental and interpolation errors discussed so far in this paper.

For some EC applications the bathymetric data on navigation documents must be vectorized. Vectorized data permits different types of chart elements to be selectively viewed and scaled. Vectorized digitizing results in computer-intelligible chart data so that real-time safety analysis can take place to aid navigational decision making. For the same reason, survey documents must also be vectorized in order to carry out any statistical analysis of their content. Navigation documents are produced at a smaller scale than the survey documents from which they were compiled so the already sparse data portrayed on survey documents has to be further decimated. On top of that data decimation, the cartographic compilation process relies heavily on generalized contours to portray bathymetry rather than depth values. The result is that even if the depths appearing on a navigation document have been vectorized a meaningful local variogram analysis is not possible.

The data quality problem becomes even more complex if we consider all the other data types that navigators will be viewing on their EC. Floating aids, shoreline and on-shore topography are three such data types whose accuracy can vary significantly. These data types must also be qualified in order to fully and safely exploit a bathymetric image. Another factor to be considered is the subjective nature of many of the data-reduction steps that go into compiling a navigation document. Depth contours for example have always been generalized and safety-biased when transferred from survey documents onto navigation documents. Should these intentional graphical deformations be treated as a normally distributed error source like instrumental and interpolation errors? Obviously they represent a special case that is highly dependent on the scale at which they are viewed. Any 'error' statistics applied to intentional graphical deformations would have to be regarded as separate from the scale-independent stochastic surface described so far in this paper.

Some Possible Solutions

Bathymetric documents are a patchwork of many data sources, each with continuously varying data qualities. Whether these bathymetric images are in paper or digital format, some estimate of their stochastic surfaces should be made available to EC-equipped navigators. There is no easy solution to the whole problem. Time and money are needed to evaluate historical documents as they are rendered into electronic format. A statistical toolbox approach will be required which permits any type of data set to be evaluated as realistically as possible. While IHOstat has already prototyped some of the necessary tools, a lot of R&D remains before we have both the tools and the expertise needed to do the job.

The best overall strategy when qualifying any data set is to backtrack along the production chain as far as possible before attempting to map out data quality. The closer we get to the raw survey data the more objective the overall quality analysis will be. When dealing with historical data sets, if accessing or digitizing all source data is not possible then selective sampling is the next best means of determining the stochastic surface. This might involve digitizing a representative sample of the original sounding rolls then using that information to compute variograms that roughly describe the whole data set. In this way an approximate view of the variograms within the survey zone could be constructed. Once classified in this manner, the data density at each location in the historical data set could be used to predict interpolation errors.

Another approach to achieving the same end might be to collect a modern representative sample of profiles as part of revisory surveys. While collecting this data, selected areas could also be swath sounded and compared to the original data. This would enable us to draw some statistical conclusions which might be extrapolated throughout the older data set. Since interpolation errors must be taken into account when comparing non-coincident data coverage of the same area, the geostatistical tools already in IHOstat could be of assistance in performing this type of comparison.

Another approach for obtaining data closer to source is to digitize those depths appearing on survey documents. This vectorized data could then be analyzed just as we would for digitally- captured profile data. This analysis would of course be somewhat scale-dependent since the degree of data decimation on a survey document is inversely proportional to its scale. On larger-scale plans,however, the data density might be sufficient to produce meaningful maps of the stochastic surface using the geostatistical approach described in this paper. One obvious advantage of this approach is that the digitized source document would also serve its primary role of digitally defining the bathymetric surface.

Whatever approach is taken, extensive testing with real data will be required to develop guidelines for effectively using numerical analysis tools to qualify older documents. Any of the approaches for qualifying data captured from documents will be sub-optimal compared to a geostatistical analysis of dense, digitally-captured on board the survey vessel. R&D will consist mostly of trials with test data sets to identify good sampling and analysis procedures for a wide range of scenarios. Ground-truth swath surveys will be needed to determine what works and what doesn't. Once working procedures are identified, they could be standardized by implementing an expert system type of user interface for IHOstat.

Future Development

Currently the software described in this paper consists of two separate programs running under MS DOS. The program which evaluates instrumental errors is called 'XERROR' and was developed for the US Defense Mapping Agency. The program which evaluates interpolation errors is called 'HYDROSTAT' and was developed for the Canadian Hydrographic Service. The two programs communicate through a file sharing arrangement whereby the instrumental error estimates made by XERROR are written into a data file containing the XYZ bathymetric measurements together with their estimated standard deviations. This qualified data file is then used by HYDROSTAT to perform the kriging which defines the full stochastic surface.

Together these two program modules make up the current IHOstat. The intent is to merge the separate programs into a single application once they have been adequately tested and developed. It is hoped that other IHO member states can provide the needed beta test sites in order to find bugs in the software and propose enhancements based on testing with their own data. DMA and CHS will implement the tasks that are identified by beta test sites. A few tasks have already been identified:

1. The current implementation can be quite slow, even when running on a high performance 486 PC. The plan is to port the software into a UNIX workstation environment to get much better interactivity when working with large data sets. In keeping with the concept of promoting an open IHO standard, the PC version will also be maintained. A batch-processing capability will be added to the PC version to permit the interactive interface to build a macro file of control commands. This would permit large jobs to process unattended overnight.

2. The 'confidence envelope' concept will be packaged separately into a near-real-time application. This utility would operate in conjunction with a data logger/navigation display unit to facilitate adaptive sampling during surveys. There is considerable potential for optimizing survey efficiency using this approach. Survey specs could be specified in terms of a maximum permissible uncertainty in the bathymetric surface rather than the traditional 'survey scale' approach. As the sounding vessel collects data, real-time confidence envelope graphics could guide hydrographers in varying line spacing as required to meet the required level of bathymetric uncertainty.

3. Algorithm development will be extended towards the analysis of data from modern swath sounding systems. Swath data will be exploited such that the current presumptions about isotropy of the sea floor can be tested with much greater reliability. The result will be a tool for predicting the swath overlap requirement with respect to a desired level of confidence (less than 100%). The swath sounder coverage might then be opened up to less than 100% coverage to optimize use of the vessel. The goal here is to prevent 'over-sounding' of areas that don't require total swath coverage.

4. The complexity and novelty of the entire data evaluation task is such that professional training becomes a necessary issue to address. Tutorials and possibly an expert system interface to IHOstat will be developed.

The current Working Group schedule is aiming for most of the above work to be completed by the end of 1994. Progress will of course be subject to the level of participation by IHO member states. Any organization wishing copies of the current software and users documentation should contact the authors.

Conclusion

An evolved Electronic Chart system relies on an objectively qualified digital data base. International standards are required to ensure that an optimal evaluation methodology is adopted worldwide. IHOstat has demonstrated some geostatistical algorithms that give good results when used on dense digital profile data. These error-estimation tools can provide greater safety in future high performance EC systems due to their inherent scale independence. A statistical toolbox approach is the only viable approach to evaluating all modern and historical data sets. Further testing of the current software by the international community will be required in order to refine and expand the existing toolbox.

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1992 CHA Directors' Meeting

Ottawa, June 6, 1992

Present: Dave Pugh, National President
Bernard Labrecque, V-P, Québec Branch
Sean Hinds V-P, Central Branch
Frank Colton, V-P, Prairie Schooner Branch
George Pugach, V-P, Captain Vancouver Branch
Carol Nowak, V-P, Pacific Branch

Regrets: R. Mehlman, V-P Ottawa Branch

1. **Acceptance of Agenda**
The agenda as outlined was accepted (Appendix A).
Carried

2. **Receiving Minutes 1991 Annual Directors' meeting.**
The minutes of 1991 Directors' meeting held in Rimouski, Québec were accepted as circulated. (Appendix B)
Carried

3. **Report on Action Items 1991 Directors' Meeting**

1) Minutes of the 1990 Annual Directors' Meeting
Item 17 : CHA Pin : CHA lapel pins distributed to the Branches were well received by membership.

Item 19 : CISM : CISM does distribute the 25 copies of Lighthouse to their Technical, Provincial and Branch representatives. CHA will request that in exchange CISM distribute a copy of the Journal to each of the CHA Branch chairpersons: **Action: Pugh**

Item 20 : By-laws: The CHA Bylaws will be printed in a pocket size booklet form, with both languages in the same booklet, and distributed to each member through the Branches. In addition a copy of the Bylaws will be published in the next convenient issue of Lighthouse. 1,000 copies of the Bylaws will be printed.
Action: Pugh/Richards

3) GST: Nationally CHA is not required to be registered for GST as it is a non-profit organization with revenues under 30 K$ annually. Québec Branch has registered for a GST account as it is actively involved in commercial sales of charts and related navigation products.

11) Exchange of Proceedings: There has been no action on this proposal by the American Branch of the Hydrographic Society. The CHA National has solicited support for this exchange from CHS and will respond as requested.

13) Membership Lists: The National President reminded the Directors that Sharon Thompson (Pacific Branch) has continued her offer to maintain a membership list for CHA. This however requires that the Branches submit that information so "please continue if you already do and kindly start if you haven't."
Action: Branches

19) Other Business:
CHA Shirts, Hats & Ties: T-shirts, golf shirts and possibly hats with the CHA logo will be available from Central Branch. Sweatshirts and possibly ties, also with the CHA logo, are available from Prairie Schooner Branch. For further information contact the Branch representative.

4. **Auditor's Report on the 1991 National Account**
The 1991 Auditor's was accepted as circulated. (Appendix C)
Carried

5. **CHA National Dues for 1993**
The National Dues for 1993 will remain at $15.00 and therefore this will not be an agenda item at the 1992 Annual General Meeting.
Carried

6 **Nomination Committee**
Chairperson of the Nomination Committee for CHA National President will be Mr. Jake Kean. A request nomination announcement will be published in the Spring '92 issue of Lighthouse with the necessary nominating procedures (Appendix D). The nominations will close on October 1, 1992, with balloting to take place on December 1, 1992. The incoming President's term is for 1993-1996.

7. **Lighthouse Report for 1991**
Editor Bruce Richards, in a submitted report, is continuing his call for support from CHA members to submit &/or solicit articles for Lighthouse. He also mentions a drop in advertisers for the last two issues of Lighthouse which reflects the current economic environment. Also steady progression to make Lighthouse publishing more independent from appreciated government support is continuing with 90% of the necessary activities being performed by volunteers or through private sector contracts.

8. **Lighthouse Financial Statement for 1991**
The circulated 1991 financial statement was accepted. (Appendix E)
Carried

9. **Lighthouse Proposed Budget for 1992**
The amended Lighthouse Proposed Budget for 1992, by increasing the Lighthouse operating grant to $3,000.00 from $2,000.00 was accepted. (Appendix F)
Carried

10. **CHA Student Award Program**
Mr. Barry Lusk, Immediate Past President of CHA and CIDA/CHA Training Program Financial Administrator has proposed a Student Awards program be put in place utilizing accumulated management funds from the previous training programs. He suggested that an annual $2,000.00 student award be promoted through Canadian colleges and universities which have an active hydrographic academic program encompassing the many disciplines comprising hydrography. The proposal was accepted, and suggested rules for application were reviewed by executive. (Appendix G)
Carried

The National Executive applauds Barry for this initiative and gladly accepts his offer to implement this exciting program.

Action: Lusk

11. **Carnet de bord**
Bernard Labrecque presented a log book "Carnet de bord" which Québec Branch has produced. This book combines a myriad of information, both from government and private sector sources, which benefits the recreational boater. In 1992 the log book will be distributed free of charge, for 1993 and later it is anticipated to sell for approximately $ 3.00 with a circulated of 10,000 - 15,000 copies. This is an excellent publication which the directors will take to the Branches for discussion about replication in their Branches.

Action: Branches

12. **Workshops 1993**
Central Branch in conjunction with Geomatic Industry Association of Canada (GIAC) will host a one day workshop immediately prior to the CHS/CISM conference on June 8, 1993 in Toronto, Ontario. The workshop topic will be "Geomatics for the Marine Community" and will take the forum of lecture, hands on demonstration, and discussion with representatives from the private, academic and government sectors.

13 **Central Branch - Historical (1792) Hydrographic Survey Launch Project**
Sean Hinds presented an overhead presentation of the historical hydrographic survey launch project which Central Branch is presently implementing. The project involves construction of a functional hydrographic survey launch during the summer of '92, in public view, at Harbourfront in Toronto. Volunteers will be dressed in period attire while working or answering questions. When completed the launch will be provided to schools, commercial interests and ultimately reside at a marine museum. The launch will also be utilized at the '93 CHS/CISM conference.

This project has an estimated cost of $ 25,000.00. Funding for this project is being supported by the CHA, CHS, CHS/CISM conference committee, corporate and private sponsors.

The project received acceptance by the Directors. It was also noted that the professional manner in which Central Branch produced a thorough Business Plan for this activity could well be used by other Branches in subsequent projects.

14. **Liability of Board of Directors**
Dave Pugh reported that he has solicited information and cost quotes to provide the association with liability insurance. This is in response to recent changes in legislation affecting organizations. The information and quotes will be distributed as received and require further discussion by the Board of Directors.

Action: Pugh

15. **CIDA projects**
The CHA/CIDA training projects in Jamaica and Malaysia coordinated by Mr. Tom McCulloch have been successfully completed. Tom at the completion of the Malaysian project initiated a market survey to determine and demonstrate the effectiveness of this 5 year project. The results of the survey have reinforced the government, academic and private sector support for the requirement to continue a hydrographic training program under local initiative in Malaysia. Tom will continue to liaise with Malaysia and report to the CHA as appropriate.

Concerning Jamaica and the Caribbean in general Mr. Willie Rapatz will be assisting Tom to ascertain what new training initiatives can be sought with appropriate liaison with the CHA Board of Directors.

Action: McCulloch/Rapatz

16. **1992 AGM**
The 1992 Annual General Meeting will be held on December 16, 1992 via teleconferencing at a local time commensurate with 3:00 p.m. local time in Ottawa, Ontario. The Directors approved this forum and will moderate for the Branches and submit by December 1, '92, to National applicable phone numbers and appropriate reports for redistribution to the Branches. National will pay for the telephone expenses related to this Annual General Meeting.

Carried

Action: National, Branches

17. **CHA Supporting Member Consortium**
The National President has been approached by various CHA members with a request for CHA to take on a more active role in promoting hydrography in the national and international marketplace. In essence to allow a consortium to be developed for specific projects coordinated by CHA and associated members. Issues which the Directors felt should be addressed in preparing a response deal with funding, polices, insurance and reporting. Dave Pugh will relay these issues to the requesting members and report on their replies to the Directors.

Action: Pugh

18. **Memberships**
1992 Membership in CHA has generally remained stable. There is still no active participation at the Branch level from Atlantic Branch though individuals are maintaining memberships though the National Office. Dave Pugh will continue to interact with persons in Atlantic and see if the Branch can be reactivated functionally according to Bylaws of the association.

Action: Pugh

19. **Hydro '92**
The Board approved attendance at Hydro '92 by the National President.

Carried

20. **Proposed National Budget for 1992**
The proposed 1992 National Budget was accepted. (Appendix H) Carried

Meeting was adjourned.

1992 CHA Annual General Meeting

December 16, 1992 at 15:00 (EST)

Via teleconference call to 7 Branch-designated locations (Atlantic Branch - regrets).

Members Present: as per Branch registers

1. **Opening Remarks**
   Dave Pugh, CHA National President, called the meeting to order at 15:05. He welcomed everyone to the 1992 Annual General Meeting (AGM) and expressed his appreciation for the external financial support for this conference call.

2. **Agenda**
   Motion made to accept agenda.
   Hinds / Mehlman /Carried.

3. **Branch Reports**
   The Branches presented their Branch reports to the National President. Reports absent: Atlantic Branch. The National President thanked the Directors for their reports.

4. **1991 Financial Report**
   A motion for acceptance was made for the 1991 CHA financial statement which had been circulated to the Branches and was available at the meeting.
   Acheson / Hall / Carried.

5. **1992 Auditors**
   A motion to accept the appointment of Sheila Acheson and Jake Kean as auditors for the year 1992 was made.
   Herron / Hall / Carried.

6. **Minutes of the 1991 AGM**
   The Minutes of the 1991 AGM held on April 17, 1991 at the Congres Centre in Rimouski had been distributed to the Branches and were available at this meeting. A motion to accept the Minutes as presented was moved.
   Acheson / Colton / Carried.

7. **Other Business:**
   Mr. Weller (Central Branch) desired information on the number(s) and Branch affiliation(s) of Lifetimeand Honourary Membersof CHA. In responding, the National President indicated he did not have those details at hand and would provide a response to Mr. Weller in due course.

   Mr. Mehlman (Ottawa Branch) requested information on the status of the dormant Atlantic Branch and in particular the Branch's financial assets. The National President indicated that talks were currently on-going with a small group of people in the dormant Atlantic Branch and that the possibility exists that it will become active within the year. If this is not the case then the financial assets would be transferred to National to be held in trust, with a nominal accruing interest rate until such time as the Branch did re-activate.

   Mr. Hinds (Central Branch) asked if CHA would be receiving a DFO grant this year. The President replied that unfortunately, due to severe financial restraints, DFO was unable to provide a grant to CHA for 1992.

8. **1991 Lighthouse Awards**
   The National President announced the 1991 Lighthouse Awards: for best non-technical article "Canada's Lighthouse Stamps" by Roger Robitaille; and for best technical article "Impulse Radar Bathymetric Profiling in Weed-Infested Fresh Water" by Austin Kovacs.

The teleconference meeting was adjourned at 1540.
Acheson / Mehlman / Carried

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Canadian Hydrographic Association / Association canadienne d'hydrographie

The **Canadian Hydrographic Association (CHA)** is a non-profit, scientific and technical group of about 500 members with the objectives of:

- advancing the development of hydrography, marine cartography and associated activities in Canada;
- furthering the knowledge and professional development of its members;
- enhancing and demonstrating the public need for hydrography;
- assisting in the development of hydrographic sciences in the developing countries.

It is the only national hydrographic organization in Canada. It embraces the disciplines of:

- hydrographic surveying;
- marine cartography;
- marine geodesy;
- offshore exploration;
- tidal and tidal current studies.

The Canadian Hydrographic Association is formally affiliated with the Canadian Institute of Geomatics. It is informally associated with the Hydrographic Society.

<u>What the CHA Can Do For You</u>

- advance your knowledge of hydrography, cartography and associated disciplines, and keep you abreast of the latest development in these disciplines;
- enable you to develop and maintain contacts with others involved with hydrography, nationally and internationally.

These benefits are provided through the publication of LIGHTHOUSE (one of only three journals in the world devoted exclusively to hydrography), through the sponsorship of seminars, colloquiums, training programs, national conferences, and branch and national meetings.

<u>Lighthouse</u>

The journal of the Canadian Hydrographic Association, LIGHTHOUSE, is published twice yearly and distributed free to its members. Timely scientific, technical and non-technical papers and articles appear in the journal with authors from national and international academia, industry and government. Present circulation of LIGHTHOUSE is approximately 900.

<u>Membership</u>

Membership is open to all hydrographers, those working in associated disciplines, and those interested in hydrography and marine cartography.

<u>Branch & Regional Activities</u>

The Canadian Hydrographic Association has eight (8) branches located across Canada. National headquarters is located in Ottawa.

For further information write to:

National President
Canadian Hydrographic Association
P.O. Box 5378, Station F
Ottawa, Ontario
Canada
K2C 3J1

L'Association canadienne d'hydrographie (ACH) est un organisme sans but lucratif réunissant un groupe scientifique et technique de plus de 500 membres ayant des objectifs communs, comme:

- faire progresser le développement de l'hydrographie, de la cartographie marine et de leurs sphères d'activités au Canada
- permettre les échanges d'idées et le développement professionel de ses membres
- rehausser et démontrer l'importance de l'hydrographie auprès de public
- assister au développement des sciences de l'hydrographie dans les pays en voie de développement

Au Canada, l'Association est la seule organisation hydrographique qui embrasse les disciplines suivantes:

- levé hydrographique
- cartographie marine
- géodésie marine
- exploration extra-côtière
- étude des marées et courants

L'Association canadienne d'hydrographie est affiliée à l'Association canadienne des sciences géomatiques, et non-officiellement liée à la Societée de l'hydrographie.

<u>Ce qu'elle peut faire pour vous</u>

L'ACH vous offre des avantages tels que:

- parfaire vos connaissances de l'hydrographie, de la cartographies et des disciplines connexes, tout en vous tenant au courant des nouvelles techniques et des derniers développements réalisés dans ces domaines;
- établir et maintenir des contacts avec ceux qui oeuvrent en hydrographie, au niveau national et international.

Ces avantages sont transmis par l'entremise de LIGHTHOUSE (une des trois revues au monde traitant exclusivement d'hydrographie) et par la tenue de séminaires, de colloques, de programmes de formation et d'assemblées régionales et nationales.

<u>Lighthouse</u>

La revue de l'Association canadienne d'hydrographie. LIGHTHOUSE, est publiée deux fois l'an et distribuée gratuitement aux membres. Des articles scientifiques, techniques et non techniques, provenant du milieu de l'industries ou du gouvernement autant national qu'international, apparaissent dans cette revue. Le tirage actuel de la revue est d'environ 900 copies.

<u>Comment devenir membre</u>

Le statut de membre est offert aux hydrographes et à tout ceux oeuvrant ou ayant un intérêt dans des disciplines associées à hydrographie ou à la cartographie marine.

<u>Sections et activités régionales</u>

L'Association canadienne d'hydrographie possède huit (8) sections à travers le Canada. L'administration central se trouve à Ottawa.

Pour plus d'informations, s'adresser au:

Président national
Association canadienne d'hydrographie
C.P. 5378, station F
Ottawa, Ontario
Canada
K2C 3J1

Sustaining Members / Membres de soutien

In 1987 the CHA defined a new form of membership to allow companies, closely linked with the hydrographic field, to become more involved with the activities of the CHA and to maintain closer contact with users of their products. Through LIGHTHOUSE these Sustaining Members are also able to reach a world-wide audience of people involved with hydrographic work. The benefits of Sustaining Membership include:

- a certificate suitable for framing;
- three copies of each issue of Lighthouse;
- copies of the local Branch newsletters, where available;
- an invitation to participate in CHA seminars;
- an annual listing in Lighthouse;
- an annual 250 word description in Lighthouse; and
- discounted advertising rates in Lighthouse.

The annual dues for Sustaining Membership in the CHA are $150.00 (Canadian).

Current Sustaining Members are listed below.

Aanderaa Instruments Ltd.
100 - 4243 Glanford Avenue,
Victoria, British Columbia,
Canada V8Z 4B9
contact: Gail Gabel *(affiliation - CHA Pacific Branch)*

ATLAS ELEKTRONIK
1075 Central Avenue,
Clark, New Jersey,
USA 07066
contact: Karl Kieninger *(affiliation - CHA Central Branch)*

C-MAP / USA
P.O. Box 1609,
Sandwich, Massachusetts,
USA 02563
contact: Kenneth J. Cirillo *(affiliation - CHA Central Branch)*

Datasonics Inc.
P.O. Box 8,
1400 Route 28A,
Cataumet, Massachusetts,
USA 02534
contact: Paul Igo *(affiliation - CHA Central Branch)*

EG&G Marine Instruments
P.O. Box 498,
1140 Route 28A,
Cataumet, MA,
USA 02534 *(affiliation - CHA Central Branch)*

Garde Côtière canadienne
104 rue Dalhousie, Suite 311,
Québec, Québec,
Canada G1K 4B8
contact: Claude Duval *(affiliation - ACH Section du Québec)*

l'Institut maritime du Québec
53 St-Germain Ouest,
Rimouski, Québec,
Canada G5L 4B4
contact: Claude Jean *(affiliation - ACH Section du Québec)*

Quester Tangent Corporation
9865 West Saanich Road,
Sidney, British Columbia,
Canada V8L 3S3
contact: John Watt *(affiliation - CHA Pacific Branch)*

Racal Positioning Systems Ltd.
118 Burlington Rd.,
New Malden, Surrey,
United Kingdom KT3 4NR
contact: Paul Deslandes *(affiliation - CHA Central Branch)*

SEA BEAM Instruments Inc.
141 Washington Street,
East Walpole, Massachusetts,
USA 02032
contact: Steve Withrow *(affiliation CHA Central Branch)*

SIMRAD Mesotech Systems Ltd.
202 Brownlow Avenue
Dartmouth, Nova Scotia,
Canada B3B 1T5
contact John Gillis *(affiliation - CHA Central Branch)*

SURNAV Corporation
89 Auriga Drive,
Nepean, Ontario,
Canada K2E 7V2
contact: Harold Tolton *(affiliation - CHA Ottawa Branch)*

terra surveys ltd.
1962 Mills Road,
Sidney, British Columbia,
Canada V8L 3S1
contact: Rick Quinn *(affiliation - CHA Pacific Branch)*

Sustaining members of CHA are offered space in Lighthouse each year for a 250-word description of their services.

Aanderaa Instruments

Aanderaa has recently joined forces with Jon B. Jolly Inc. of Seattle to market several equipment lines to B.C. and Alberta. These include Alden Electronics, Benthos and Rees Instruments. The Alden Electronics' thermal printer is particularly useful for applications demanding photographic quality output.

Development of two new products is nearing completion: a soil moisture measuring instrument and a low cost, high accuracy flow sensor. Both of these products should reach the market by the fall of this year.

C-MAP / USA

C-MAP/USA is located on Cape Cod, Massachusetts and is a wholly owned subsidiary of C-MAP s.r.l. of Marina di Carrara, Italy, makers of the proprietary C-MAP electronic cartographic technology. Since its founding in 1988, C-MAP/USA has played a major role in establishing C-MAP as the most widely used electronic chart database worldwide.

C-MAP/USA develops, markets and updates electronic charts throughout North and South America and the Pacific Rim. In addition, the United States subsidiary acts as a liason between Original Equipment Manufacturers and C-MAP/Italy in the engineering and design of electronic chart display systems. C-MAP/ITALY is a leading designer and manufacturer of electronic charting systems in Europe and in conjunction with subsidiaries C-MAP/FRANCE and C-MAP/UNITED KINGDOM, develops, markets and updates electronic charts throughout Europe and Africa.

Datasonics Inc.

Datasonics, Inc., Cataumet, MA delivers SIS-7000 Seafloor Imaging System to the Atlantic Marine Branch of the United States Geological Survey.

The United States Geological Survey recently took delivery of a new deep ocean sea floor imaging system from Datasonics Inc. This system will be used for surveying areas in the US Exclusive Economic Zone (EEZ). This acoustic sonar system uses a swept frequency (Chirp) for generation of a sonar signature for side scan and sub bottom. An additional row of transducers for acquisition of swath bathymetry information is installed in the 17 foot 4000 pound tow vehicle. Additional features of this vehicle include a CTD system for measurement and logging of oceanographic parameters as well as real-time sound velocity corrections, a three axis magnetometer, a flux gate compass for two vehicle headings, pitch and roll sensors for vehicle motion tracking, a speed log for monitoring tow vehicle speed through the water and an acoustic altimeter for height above bottom. SIS-7000 Seafloor Imaging System is a full-ocean depth multi-sensor sonar system using linear swept-FM (Chirp) technology.

Digital sonar data and environmental data are telemetered to the surface at a 1 mega-bit rate via a UNOLS .068 inc coaxial tow cable. The system has been designed to operate over a fibre optic cable as well.

The sonar data is displayed with the environmental data and stored for further processing with an off-line sonar image processing system. A status and control work station handles the communication with the sub-sea electronics. Environmental data are displayed real time as well as power supply voltages, navigation information from an external navigation string and other information as to the status of a tow vehicle. The tow vehicle can be placed in a diagnostic/calibrate mode in order to test various component systems. These tests include: the injection of a chirp/signal at the sonar receivers, turning on and off sonar channels, calibration of the flux gate compass and other features.

Datasonics integrated a number of off-the-shelf components with in-house Chirp sonar technology and digital processing capability to achieve an innovative approach to a full ocean depth multi-sensor seafloor mapping system. This approach allowed Datasonics to rapidly develop a system capable of meeting the governments stringent specification and generate a base platform for future systems with various sensor configurations.

Quester Tangent Corporation

QTC has been awarded a contract for the supply, installation, and commissioning of **ISAH 5500** data acquisition platforms, **ISAH HYPS** processing systems, and CARIS systems by the Indian Ministry of Defense. The contract was signed in Delhi on May 17 and is valued at approximately $1.5M Cdn. By the end of 1993, a total of 30 **ISAH** systems will have been delivered to India. QTC has agreed to establish an Indian subsidiary to provide after sales support, software development, and local manufacturing to support the systems.

The **ISAH-S** bottom classification system described in an earlier Lighthouse is currently being field-trialed. Sweep data were collected over test sites in Victoria with the support of DREP and DPW during May using the prototype hardware. The system will be used in the Bay of Fundy with UNB this summer, and will be shown at the Survey and Mapping conference in Toronto in June.

Quester Tangent is expanding its client base to the offshore geophysical market in Australia. Tail-buoy tracking systems have recently been delivered for seismic surveys in the area, and an **ISAH HYDAS** is currently in use as an integrated nav system and data acquisition system on a swath system survey. **HYPS** with CARIS is being used as a position and depth editor QC tool on the survey. The data will be processed using **HYPS**, HIPPS, and CARIS.

Sea Beam Instruments

Sea Beam Instruments specializes in underwater acoustics, signal processing, beam-forming technologies and the design and development of transducers and complete bathymetric sonar systems. The company markets sophisticated multibeam survey systems to military, research and commercial organizations around the world.

Professor Darshan C. Kapoor
1923 - 1993

Memorial Tribute

by G. R. Douglas

The hydrographic world has lost a respected and valued member of its community - there are simply no other words to describe the recent passing of Professor Kapoor. But today I am going to refer to him only as Kap because that is how the hydrographers around the world knew him.

I want to trace for you some of the important steps in Kap's career that saw him rise from a young sub Lieutenant to a distinguished expert in international hydrographic affairs.

In 1942 Kap took his first naval training course and upon the completion of that course in '43 became a sub–Lieutenant. He progressed steadily through the officers ranks from Lieutenant to Lieutenant Commander to Commander to Captain and finally to Rear Admiral. Coincident with his progression in regular naval affairs, he began his climb as an hydrographer in 1948, when he took his first hydrographic specialist course. A review of all his accomplishments in hydrography would literally take hours but I think it can best be summed up by simply saying that the expertise Kap possessed was based on a very firm foundation because he had done it all. In 1966 Kap became the Hydrographer to the Government of India and as such headed the Indian delegation at the 9th International Hydrographic Conference. He was also very involved in many United Nations activities.

It is quite easy to see, with this sort of activity behind him, why he would be interested in the International Hydrographic Organization. On June 24, 1971 Kap made application to be a member of the Directing Committee of IHO. He was elected as a Director at the 1972 and 1977 conferences and served for 10 years in that capacity. It was during this period that Kap became known to the international community and indeed where I first began to know the man we all respected.

Those ten years at the Bureau were indeed interesting times in the world of hydrography for it was during this period that technology began to play a significant role in how we 'drogies' went about our business. Kap played a major role in the moulding and shaping of the standards, the techniques and the methods that allowed the hydrographic community to proceed on a steady but upward course towards the high-tech surveys and chart production of today.

And of course Kap was the eternal diplomat - always doing the right thing at the right time. Not that he couldn't put folks in their place if it was deserved. His eloquence and his choice of words was such that most people didn't realize they had been dealt a blow until much later. The President of the Directing Committee during those 10 years at the IHB was Rear Admiral Steve Ritchie. I received the other day a copy of Ritchie's new book, "No Day Too Long - An Hydrographer's Tale", and in that book there is a very nice photograph of Steve Ritchie and Kap with Their Serene Highnesses Prince Rainier and Princess Grace – surely a fitting remembrance of his ability to mix with sailors and royalty alike.

As part of Kap's responsibilities at the IHB, he was asked to set up the guiding committee for GEBCO. This was where the Canadian Hydrograpic Service first became involved with Kap on a regular basis. Through Kap's persistence and guidance, Canada published the fifth and current edition of the GEBCO series. This beautiful set of charts that describe the world's oceans is also a fitting tribute to Kap's contribution to a better understanding of the geography of this planet.

This association with Canada continued and finally Kap and Hildi moved here and became part of the Canadian hydrographic family. He was our father confessor, he was our consultant, and he was our friend. Even before the 14th IHO conference last May, I phoned Kap many times to ask "What do I do?" And I always got the right answer.

We have lost one of our hydrographic family that was full of wisdom and understanding and we shall certainly miss him.

We know that Kap will always have a strong wind in his sails and that he will always be watching our actions from his command position on the starboard side of the bridge.

Darshan Chander Kapoor died on January 19, 1993 after suffering a heart attack at Erindale College (University of Toronto). This tribute was given by Ross Douglas (Dominion Hydrographer, Canadian Hydrographic Service) at a Memorial Service held for Kap at the College on February 5, 1993.)

Editors Note: Kap was Editor of Lighthouse from 1985 to 1987. He was also a very active member of the Hydrographic Committee of the Association of Ontario Land Surveyors (AOLS) where I had the good fortune to work with him on various issues relating to the AOLS Certificate of Registration program for Hydrographers.

representing and serving the world hydrographic surveying community with individual and corporate members in sixty countries

The Hydrographic Society

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Lighthouse Puzzler / Casse-tête du Lighthouse

by
Beth Weller

Lighthouse Puzzler # 8

The Central Branch Heritage Launch was completed in good time and it is now the last day of the CHS/CIG Survey and Mapping Conference. Four surveyors (one of whom is with The Hydrographic Society of America) are preparing to re-enact Joseph Bouchette's 1792 survey of Toronto Harbour.

From Rear Admiral Steve Ritchie's notes, can you figure out who is doing what?

The clues:

1. Jack (who is not with the Toronto Branch of the Canadian Institute of Geomatics) is at the helm.
2. The person swinging the lead has a black hat.
3. The person with the Association of Ontario Land Surveyors is trimming the sails.
4. Jim has a blue hat.
5. Paola, who is with the Canadian Hydrographic Association, is not wearing either a red or black hat.

Surveyor	Affiliation	Hat Colour	Assignment

	AOLS	CIG-TB	THSOA	CHA	Red	Blue	Black	White	Helm	Lead Line	Sails	Sextant
Gabriella												
Jack												
Jim												
Paola												
Helm												
Lead line												
Sails												
Sextant												
Red												
Blue												
Black												
White												

Solution to Fall Puzzler

By Clue 1, Jackie is married to John or Jim, Barbara is married to Bill, and Craig is married to Cathy (Clue 5). The McCullochs (Clue 2), Andersons (Clue 4), and the Sandilands (Clue 5) are not going to PCS, so the Eatons must be going there. Craig and Cathy can't be Sandilands (Clue 5), Anderson (Clue 4 and 7) or Eaton, so must be McCulloch, and going overseas but not to Bali, therefore to Rockville.

Jim is not going to Bali, nor is Bill (Clue 3), nor Craig (Clue 6), so John is, and by elimination must be Sandilands. Caitlin is not Sandilands so must be married to Jim, so by elimination Jackie is married to John.

Caitlin and husband are not the honeymooners (Clue 5) so must be the Andersons, and Barbara and Bill Eaton are the honeymooners.

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Coming Events / Événements à venir

Geographic Information Seminar & Exhibits

This seminar is co-sponsored by the Canadian Institute of Geomatics and the Ontario Ministry of Natural Resources. It will be held October 19 to 20, 1993, at the Royal York Hotel in Toronto, Ontario.

For more information contact the Canadian Institute of Geomatics at:

Canadian Institute of Geomatics
Box 5378, Station F
Ottawa, Ontario
Canada
K2C 3J1

Telephone: (613) 224-9851
Fax: (613) 224-9577

U.S. Hydrographic Conference '94

The Sixth Biennial International Hydrographic Conference will be held at the Omni International Hotel, in Norfolk, Virginia, April 19 to 23, 1994. This conference is jointly sponsored by the National Oceanic and Atmospheric Administration (NOAA) Coast and Geodetic Surveys, The United States Coast Guard, The Oceanographer of the Navy (U.S.), the U.S. Defense Mapping Agency, the Hydrographic Society of America, and the International Federation of Surveyors (FIG).

The conference theme is "Marine Information Partnerships". A portion of the technical program will be devoted to the electronic chart. Three half-day workshops are also planned to run concurrently with the technical sessions. Workshop topics include: marine geographic information systems, and customer views on nautical information product characteristics.

Papers are invited for presentation. Abstracts from 100 to 300 words must be submitted by October 15, 1993.

For more information please contact:

U.S. Hydrographic Conference '94
P.O. Box 732
Rockville, MD
U.S.A.
20848-0732,

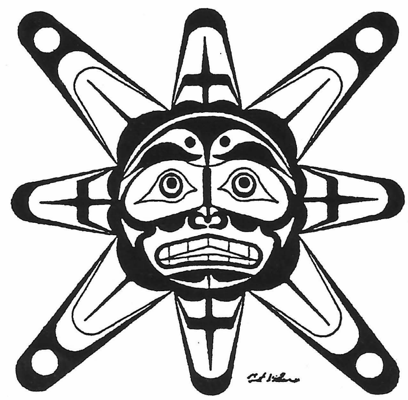
Or contact Commander George Leigh, NOAA at:

Telephone: (301) 713-2783
Fax : (301) 713-4019

(see advertisement on inside back cover)

1994 CIG Conference

This conference, jointly sponsored by the Canadian Institute of Geomatics and the Association of Canada Lands Surveyors, is scheduled for April 20 to 22, 1994 in the Victoria Conference Centre in Victoria, B.C. The theme of the conference is "New Boundaries - New Horizons". The technical program will consist of plenary sessions encompassing the technical and scientific aspects of surveying and mapping in a digital environment. Workshops are being organized for the three days preceding the opening ceremonies.



Coastal Zone Canada '94

Coastal Zone Canada '94 is a major international coastal zone management conference. It will be held at the World Trade and Convention Centre in Halifax, Nova Scotia, September 20 to 23, 1994. The theme of this conference is "Cooperation in the Coastal Zone".

The purpose of the conference is to provide an exciting opportunity for participants from many different disciplines and areas of interest to explore strategies for developing new partnerships in coastal zone management. Panel sessions, workshops and round-table discussions will examine cooperative approaches. Concurrent paper presentations will focus on the sharing of new and existing knowledge, experience and technologies related to coastal and marine issues.

The deadline for submission of abstracts is Sept. 30, 1993.

For further information please contact:

Coastal Zone Canada '94
Conference Secretariat
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

Telephone: (902) 429-9497
Fax : (902) 429-9491

1993 Advertising Rates / Tarifs publicitaires

POSITIONING
The acceptance and positioning of advertising material is under the sole jurisdiction of the publisher. However, requests for a specified position will be considered if the position premium of $25 has been included in the insertion order.

MECHANICAL REQUIREMENTS
Advertising material must be supplied by the closing dates as camera-ready copy or film negatives (Colour ads must be film negatives). Copy preparation, including colour, bleed and photos will be charged at the printer's cost plus 10%. Proofs should be furnished with all ads.

Single-page inserts will be charged at a full page body rate. Material must be supplied by the client. Page size must conform to the single page insert trim size (below).

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Standard Ad Sizes
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CLOSING DATES
LIGHTHOUSE is published twice yearly in Spring and Fall. The closing dates are **March 15th** and **October 15th** respectively.

PRINTING
Offset screened at 133 lines per inch.

RATES
All rates are quoted in Canadian Funds. Sustaining Members receive a 10% discount.

	B & W	Colour Spot*	Colour Four
Outside Back Cover	NA	NA	$1025
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*Spot Colour (Orange, Red or Blue)

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EMPLACEMENTS
L'approbation et l'emplacement de l'annonce sont à la discrétion de l'éditeur. Cependant, toute demande d'emplacement spécifique sera considérée si une prime de 25 $ est ajoutée à la demande de parution.

EXIGENCES MÉCANIQUES
L'annonce publicitaire doit être un prêt à photographier ou sur film négatif (les couleurs supplémentaires doivent être sur film négatif) et être fournie aux dates de tombée. La préparation de copie couleur, à fond perdu et de photos sera chargée au tarif de l'imprimeur plus 10 %. Les épreuves devraient être fournies avec tous les suppléments.

Les insertions d'une page seront chargées au tarif d'une pleine page. Le matériel devra être fourni par le client.

DIMENSIONS DE LA PUBLICITÉ

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Publicité à fond perdu:	8.75"	x	11.25"
Insertion d'une page:	8.25"	x	10.75"

Grandeurs standards des suppléments
Pleine page: 7.0" x 10.0"
Demie-page: 6.875"x 4.75" ou: 3.375"x 9.75"

DATE DE TOMBÉE
LIGHTHOUSE est publiée deux fois par année, au printemps et à l'automne. Les dates de tombée sont **le 15 mars** et **le 15 octobre** respectivement.

IMPRESSION
Internégatif tramé à 133 lignes au pouce.

TARIFS
Tous les tarifs sont en devises canadiennes. Les membres de soutien ont droit à un rabais de 10 %.

	N & B	Couleur Une*	Couleur Quatre
Couverture arrière	SO	SO	1025
Couverture intérieure	300	400	825
Pleine page	275	375	675
Demie-page	200	300	675
Insertion d'une page	275	375	675
Carte d'affaire	125	225	SO

*Une couleur (orange, rouge ou bleu)

Les tarifs sont assurés aux termes des contrats publicitaires jusqu'à concurrence d'un an. Les annulations ne sont pas acceptées après la date de tombée.

Tout le matériel publicitaire doit être acheminé à:

Monsieur K. Weaver ,Directeur de la publicité
LIGHTHOUSE
P.O. Box 5050
867 Lakeshore Road
Burlington, Ontario
CANADA L7R 4A6
Téléphone: (416) 336-4538 Télécopieur: (416) 336-8916

CHA News / Nouvelles de l'ACH

Section du Québec

La Section du Québec a participé, pour la première fois au Salon du livre de Rimouski. Cet événement tenu au Centre des congrès du 29 octobre au 1er novembre 1992 fut une occasion privilégiée pour faire connaître son Carnet de bord, la revue Lighthouse publiée par l'Association canadienne d'hydrographie et les différentes publications du Service hydrographique du Canada. Ce fut aussi une très belle opportunité de rejoindre le public ayant le goût d'acquérir de nouvelles connaissances par la lecture.

Un nouveau conseil d'administration a été élu pour l'année 1993 lors de l'assemblée générale annuelle de la Section du Québec qui s'est tenue à l'Institut maritime du Québec à Rimouski le 5 décembre 1992. Il se compose de:

Vice-président	Bernard Labrecque
Secrétaire-trésorier	Pierre Pagé
Conseiller	Sylvain Guimont
Conseiller	Jean Proteau
Conseiller	Denis Proulx

Quatre nouveaux membres se sont joints à la Section du Québec depuis l'automne dernier. Il s'agit de René Langelier, Mario Couture, Stéphane Lauzon et Olivier Ayotte. Nous leur souhaitons la bienvenue.

Julie Bellavance, agente de communication, et Hélène Aubut, graphiste ont beaucoup travaillé pour faire connaître aux publicitaires le Carnet de bord 1993 et pour améliorer la présentation du contenu de la deuxième édition. La page couverture de l'édition 1993 représente le bateau de sondage HERITAGE LAUNCH construit par la Central Branch et l'on retrouve une publicité du Lighthouse sur la couverture intérieure arrière. Cela démontre qu'il y a un très bon esprit d'entraide entre l'Association et ses Sections.

Marie-Andrée Jobin, commis de bureau, nous a quitté en décembre parce que le programme sur lequel elle était engagée se terminait. Chantal Fiola, agente administrative, a été engagée en janvier grâce au programme provincial "PAIE". Elle s'occupe de la gestion des affaires de la Section, de son magasin et de son Carnet de bord. Ces deux personnes ont contribué à alléger la charge de travail du conseil d'administration, surtout celle du secrétaire-trésorier et du vice-président.

Notre conseiller Denis Proulx, chargé des activités, a préparé et expédié un questionnaire aux membres de la Section pour connaître leurs attentes et leurs suggestions sur les types d'activités à organiser. Le conseil d'administration est dans l'attente du retour des questionnaires pour en compiler les résultats.

La Section du Québec a de nouveau été présente à l'Expo-Nature de Rimouski tenue du 22 au 25 avril 1993. Ces présences répétées font connaître de mieux en mieux l'Association, si on se fie aux remarques des visiteurs. Le conseil d'administration a hâte de pouvoir participer à d'autres expositions, ailleurs sur son territoire car c'est un des meilleurs moyens de rejoindre le public.

Ottawa Branch

The 1993 Branch Executive was acclaimed at the December 1992 annual general meeting :

Vice President:	Sheila Acheson
Se.-Treasurer:	Gunther Schuetzenmeier
Past VP:	Rick Mehlman
Directors:	Ilona Monahan
	Tom Cassidy

Retirements

Two familiar faces at 615 Booth Street have recently decided that it's time to enjoy the retired lifestyle; Jim Bruce retired in March and John O'Shea left in early May.

Jim Bruce joined the CHS in 1957 after serving as an officer in the British Merchant Navy. Jim originally joined the CHS as a field hydrographer and spent his first full survey season in Pike-Resor Channel in Frobisher Bay along with D'Arcy Charles, Harvey Blandford and Derek Cooper. He then switched to the cartographic side in time to compile the first charts of the St. Lawrence Seaway.

While serving in Ottawa as the Chief of the Notices to Mariners section, from 1962 to 1989, Jim still managed to return to sea occasionally and earned his Master's ticket. He also joined Adam Kerr and Derek Cooper for a jaunt across the Atlantic in a 36-foot sail boat.

CHA was lucky in 1984 when Jim took office as the National President for a three-year term. Jim's considerable energy brought about several major changes to the organization, which became the foundation for our present strength. Under Jim's leadership the CHA developed a new constitution and took the first steps towards involvement in international projects in Asia and the Caribbean.

From 1989 to his retirement Jim was the Chief of the Sailing Directions unit in Ottawa. He continued his interest in sailing, and now has his own sailboat, which he keeps on the St. Lawrence River. We wish Jim many happy years of smooth sailing.

John O'Shea was one of the founding members of CHA. He joined the CHS as a hydrographer in 1960 after working with the Ontario Government doing legal surveys. John worked on surveys in almost every part of Central Region, including Georgian Bay, James Bay, Lake Winnipeg, Lake of the Woods, Red River, the Ottawa River and the St. Lawrence River. He was also HIC in the Western Arctic on the Polar Continental Shelf Project.

John joined the Planning Office in Ottawa in 1971. He didn't spend all of his time there though. In 1971 he was on a Coast Guard icebreaker in Victoria Strait and M'Clintock Channel. In 1976, he was off to Senegal for a three-month offshore survey on the Baffin. His fluency in French came in handy in 1978 during his one-year secondment to Québec City where he helped to establish the new Québec regional office.

John moved on to the position of Technical Assistant to the Dominion Hydrographer in 1985 and served both Steve MacPhee and Ross Douglas.

Now that he is retired John can devote even more time to his pursuit of physical fitness.

General
Ottawa Branch is happy to welcome Denis Pigeon who has just joined us here as a Quality Control Officer.

Congratulations to two Branch members on their recent marriage. Ilona Hilbert-Mullen and Dave Monahan were married on February 19, 1993. Ilona Monahan is spending the summer on the Lake Ontario survey while Dave gets to organize the move to their new home near Ashton.

Anna Singerff is also working in the field this summer; she is a member of the Port Elgin, Lake Huron survey party.

George Medynski, Ocean Mapper Extraordinaire, hit a three-run homer in the bottom of the 5th, on May 6th, 1993. George is a star player on the True Brews who play out in Carp.

Don Mitchell is now only semi-retired. He has returned to his true home in the CHS where he is working, under contract, with the Tides, Currents and Waters Levels Division.

Ottawa Branch will be holding its annual picnic at noon on June 29 at Mooney's Bay Park.

Pacific Branch

The annual election of branch officers was held on December 15, 1992. There was strong interest and all positions were filled by secret ballot. Elected to serve on the 1993 executive were:

Vice - President	Rob Hare
Secretary -Treasurer	Mike Bolton
Executive Members	Doug Cartwright
	Dave Gartley
	Michael Jennings
	Fred Stephenson
	Dave Thornhill.

H20 Bonspiel
At the end of March, when most Canadians were looking forward to yet more snow, Victorians were enjoying the outdoors (sailing, skiing, golfing, gardening etc.). Out of sympathy for our fellow CHA members in the rest of Canada many Pacific Region members chose to forego these traditional springtime activities for a day of curling. On March 28 more than 50 CHA members and guests participated in the sixth annual CHA H2O Bonspiel at the Glen Meadows Golf and Country Club.

The curling was grueling and the competition ferocious, but the rewards were great, thanks to the generousity of our many sponsors and the culinary skills of the staff at Glen Meadows. The winning team, skipped by Willie Rapatz, included worldclass stone tossers Carol Nowak, Linda Burgess, and Dave Thornhill. This is the second year in a row that Willie Rapatz has skipped a team to victory in this event. Is it a coincidence that he and Barry Lusk developed the handicapping system for this year's event?

General
On April 3 the Business section of the Victoria Times-Colonist featured an article on Quester Tangent Corp. and their recent shipment of hydrographic survey equipment to India. As part of the article, John Watt and Paul Lacroix were pictured with one of their ISAH units. While neither one of them quite matches up to the SUNshine girl, they both had good reason to smile.

On April 15 the branch hosted a luncheon seminar at Glen Meadows Golf and Country Club. Dilsher Virk of D.V. Digital Videosystems Ltd. gave an excellent presentation on Optical Disk Technology in Mapping. D.V. Videosystems Ltd. has collected video images of all the highways in B.C. and stored this information on optical disks. These images and other supplementary information are used for highway planning, contract preparation etc. As part of this presentation Dilsher also showed us samples of the CHS charts presently available on optical disks produced by EMR.

As a result of last minute changes in ship schedules and unexpected barge repairs the CHS field surveys were a little late getting started this year. While our CHS members were forced to cool their heels for a while, Jim Vosburgh of Terra Surveys Ltd. was busy carrying out surveys on the Fraser River above Hell's Gate. Jim briefly contemplated shooting the rapids in Hell's Gate in his survey boat, but fortunately was able to get the motor restarted.

Denny Sinnott had to forego a one week field trip recently to ensure he would be home when his second child was born. Although the baby didn't arrive during the week of the field trip, Denny was much more relaxed when the baby arrived several days later. Congratulations to Denny and Alisha on the birth of their daughter Shaelyn.

A number of our members have either recently been away or are presently away. Bill Crawford spent two weeks in the Irish Sea in March aboard the RRS Challanger. During this trip Bill was able to make short visits to both Scotland and Wales. Ken Halcro is participating in the CHS Central and Arctic Region winter survey in Coronation Gulf. Can Ken bring home a soapstone carving that will generate as much discussion around the coffee table as Ernie Sargent's did several years ago? Carol Nowak is working with CHS Central and Arctic Region in Burlington this summer. If all goes according to plan Ken and Carol will eventually be in the same city at the same time. Willie and Marg Rapatz left recently for a month in Europe. On the way home they will be stopping in Toronto for the CIG/CHS conference.

Central Branch

The first half of 1993 has been extremely busy for Central Branch. Counting down the days until the Surveying and Mapping Conference begins, the Heritage Launch is ready for the conference and the reenactment team is practicing rowing techniques, the registration committee is busy processing registration forms for delegates and answering information requests, the CHA/GIAC Workshop is taking shape and LIGHTHOUSE is in the final stages of production. We will all need a vacation sometime after the middle of June!

Rear Admiral D. C. Kapoor
It is with sorrow that Central Branch heard of the untimely death of Rear Admiral D. C. Kapoor. A valued member of CHA, he had a great interest in Hydrography and the Law of the Sea. 'Kap.' was Editor of Lighthouse for several years, and in recent years was a professor on the Survey Science faculty of University of Toronto. He passed on his knowledge to the many students he taught, and he will be missed by his many colleagues in the hydrographic community.

A private family funeral was held January 23, and there was a memorial tribute held in the Faculty Club Room at Erindale College on February 5.

Meetings
We have had four meetings so far this year. The first meeting was held January 28th and was hosted by Keith Weaver. At the end of the meeting we settled back and enjoyed an interesting talk and slide presentation by John Summers, Assistant Curator of the Marine Museum of Upper Canada.

The second meeting was hosted by Brian Power on March 10. Our speaker that evening was Andrew Leyzack who spoke on the Electromagnetic Scanning Profiler and his pipeline location work with Wimpole of Houston, Texas. He also showed how an ESP survey can give the buried depth of a pipeline as well as its location, and can even pin-point some kinds of damage to a pipeline.

Our third meeting on April 21 was hosted by Sam Weller at his home. We adjourned for a beer break, then watched the video *Ships of Shame*, a BBC Panorama production exposing some of the outrageous dealings that have resulted in sunken ships and drowned seamen. The classic note was surely the episode of the modern tanker whose bow fell off. Altogether, this was an enlightening view into the world of Flags of Convenience, less-than-exacting Classification Societies, and surveyors who seem to miss serious defects.

The last meeting was an invitation to join the Company of Master Mariners of Canada in the Wardroom of HMCS York, in Toronto, on May 18. The speaker was Ray Gibson, recently-retired Marine Adviser for the Ontario Government.

H2O Bonspiel
Grimsby Curling Club was the scene for Central Branch's 22nd Annual H2O Bonspiel, held on Sunday, March 28. Fifty-six curlers, some experienced, some first-timers, all enthusiastic, competed for the prestigious H2O Bonspiel Trophy. Winning rink was the family team of Don, Colleen, Jeff and Sue Kennedy; Don finally took the trophy after many years of trying. Second place was won by David Goodger, Chris Vogel, Simon Illingworth and Weili Xu. Congratulations!!!

This 'prestigious event' attracted a curling team of hydrographers from Pacific Branch: Brian Wingerter, Doug Cartwright, Patti Dew and James Wilcox, as well as Sheila Acheson, representing Ottawa. Paola Travaglini from Central Branch won the prize for the most pigs (i.e. short of the hog line).

Central Branch H_2O Bonspiel

Pacific / Ottawa Branch Team: Brian Wingerter, Doug Cartwright, Patti Dew, James Wilcox and Sheila Acheson

Prizes for all participants, thanks to generous donations by the bonspiel contributors, were greatly appreciated by all. The Bonspiel co-ordinators would like to acknowledge and thank the following for their generous contributions:

Canadian Helicopters	Edmonton, Alberta
Geodimeter of Canada	Toronto, Ontario
Klein Associates Inc.	Salem, NH, USA
Knudsen Engineering Ltd.	Perth, Ontario
Norman Wade Company Ltd.	Hamilton, Ontario
Quester Tangent Ltd.	Sidney, B.C.
terra surveys ltd.,	Ottawa, Ontario
Canadian Hydrographic Service,	Burlington, Ontario
Canadian Hydrographic Association - Central Branch	

Co-ordinators Rick Sandilands and Earl Brown also thank Brad Tinney, Jackie Miles and Brian Power for their contributions to this very successful bonspiel.

General
Several of our members, Sean Hinds, Paola Travaglini, Andrew Leyzack, Mike Johnston and Pete Wills, recently completed CHS Cartographic Training. Denis Pigeon has left us for greener pastures with Ottawa Branch.

Wedding Bells rang for Joe Delle Fave and Betty Virgilio on the 24th of April. The happy couple was married in Toronto. Congratulations! We wish you every happiness.

CHA Central Branch Heritage Launch Update

Desperation, sacrifice, anticipation, and satisfaction are all words to describe past days of the CHA/CB Heritage Launch Project. Today the most appropriate is 'pride'.

What began in earnest on June 14, 1992, as a public exhibit on Toronto's Harbourfront has culminated into one, classy, 1792 hydrographic launch. It is a tribute to all of CHA that this Project has reached this point. On behalf of the CHA/CB Heritage Launch Project I sincerely thank all the sponsors and all the volunteers who pulled together to bring this piece of history to life.

Over the past few weeks volunteers have spent hours putting the final touches to the Heritage Launch at the Gill Bibby boat shop in Binbrook, Ontario. Many more hours in recent days have been filled with water trials and re-enactment practice.

A very successful 'Official Launching' took place on the last day of the Survey and Mapping Conference held in Toronto June 9-11. Rear Admiral Steven Ritchie RN (Ret'd) , well known hydrographer, author and historian acted as narrator for the occasion.

Numerous dates and locations have been set for this coming summer. On these occassions members of the CHA, Central Branch, will tell the story of a hydrographic survey 200 years ago.

Sean Hinds

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Advanced Sonar Survey and Exploration Techniques (ASSET)

A research programme to produce the next generation of seabed mapping systems has been launched by a consortium of British companies led by Dowty Maritime Ocean Systems. Called ASSET (Advanced Sonar Survey and Exploration Techniques), the project looks to combine the techniques of swath bathymetry and high resolution sidescan sonar to produce a competitively priced system which would become the standard tool for seabed mapping, pipeline surveys, search and salvage, harbour surveys, and seabed mineral prospecting.

Conventional sidescan sonar transmits a single broadside beam from each side of the towfish. The new sonar will use combined interferometry and imaging sonar techniques and will form up to five variable focus and steerable beams on each side of the fish. The beams "look" slightly ahead of track and will be electronically steered in order to image a group of parallel swathes on the seabed.

The sonar will have the operational flexibility that will allow the user to trade off performance parameters in the field. For example, in its most advanced configuration the sonar may be towed at continental shelf depths at speeds of 12 knots using all five beams. By loading different software the operator will be able to switch to a three knot, single beam survey focused at a particular range of interest of, perhaps, between 10 and 20 metres, to get extremely high resolution of around five centimetres.

A further feature will be the ability to change tow depth to gain the required sidescan/bathymetry tradeoff - the higher the fish is in the water the better the bathymetric results; a lower tow gives better sidescan data.

On the surface a digital signal processor based on a UNIX workstation will crunch 200 million-plus instructions per second of data while performing a wide range of functions such as beam forming, beam steering, making corrections for gain with range, calculating interferometry results and so on. Menu-driven, the UNIX workstation with the user-friendly window-type displays, will be configured so that it is a simple matter to re-boot the system to initiate a different type of survey pattern.

Costs will be held to a minimum by removing all processing from the fish itself and taking the data to the surface on a wide bandwidth link via a fibre-optic tow cable. An attitude package for towfish orientation and heading is also being developed.

The other collaborators in the project are Swath Sonar Techniques Ltd., Marine Acoustics Ltd., and Gardline Surveys Ltd. The project is backed by the UK Department of Trade and Industry's Wealth from the Oceans programme.

Del Norte Technology Inc

Del Norte's latest products incorporate features previously unavailable in low-cost GPS receivers and brings them within reach of a broad spectrum of GPS users. Del Norte's latest entry into the market, the Model 3006, offers a variety of data recording options, as well as the integration of echo sounder, compass, and tide gauge data, in a small, light-weight and affordable package. Sensor integration, resident navigation software, logging options and the ability to run PC-based packages from other vendors are offered in the entire range of Del Norte's GPS products.

Del Norte's efforts are aimed at remaining a technology leader in precise positioning features and migrating them into affordable GPS receiver systems. Early response to Del Norte's campaign indicates that the GPS market is ready for feature-rich low-cost DGPS, with personalized product and application support.

Klein Associates Inc.

Klein Associates is pleased to announce that they are the recipient of the 1992 Compass Industrial Award. The Compass Industrial Award is awarded annually by the Marine Technology Society and is presented to a firm for outstanding contributions to the science and engineering of oceanology and marine technology.

Klein was presented this award for the significant contributions made to marine technology through the design and development of a physically manageable, simple-to-operate, multi-beam focused side-scan sonar, the new Multi-Scan High Speed High Frequency Side-Scan Sonar System. The developments achieved in multi-beam focused technology significantly improve resolution and area coverage compared to the single beam sonar.

Through the use of five side-scan sonar beams, operating at a frequency of 390 kHz, the technology permits a speed of 10 knots and a maximum operating range of 150 metres per side, while maintaining 100% coverage of the sea bottom. The resolution of the Multi-Scan system is higher than that of a single beam sonar at all operating speeds due to the creation of the multiple dynamically-focused beams.

The comparison rate of a single beam and a Multi-Scan system operating at 100 metre range at the optimum speed of 4 knots for the single beam sonar and 10 knots for the Multi-Scan shows that the area coverage rate of the Multi-Scan is 2.5 times better than that of the single beam, unfocused sonar at double the resolution.

Laser Plot Inc.

Laser Plot announces the appointment of Bruce Angus to the position of President and C.E.O. of Laser Plot Incorporated.

Bruce M. Angus, 41, has been Vice President, Sales and Marketing for Laser PLot Inc. since joining the Company in July 1992. Previously, he was Product and Marketing Manager at Sperry Marine Incorporated and has many years of marine experience in Europe and the USA. Mr. Angus is an experienced mariner and holds a Bachelor of Science Degree in Marine Electronics. William Reisner, Chairman, commented "Bruce Angus brings to the position direct experience and skills in building Commercial, O.E.M. and Recreational business volumes and has already made significant contributions in his prior position. Additionally, Laser Plot is now stabilized and positioned to target strategic sales growth."

Laser Plot is a leading supplier of electronic chart display systems and is the market and technology leader in digitized chart publication for marine markets.

Seatex

Seatex has signed a contract with the Norwegian Mapping Authority, Norwegian Hydrographic Service (NHS) to develop a high-precision Differential GPS positioning system based on the US Navstar GPS satellite navigation system. NHS intends to use the system for their hydrographic and bathymetric survey work along the Norwegian coast and on Svalbard.

Seatex AS was selected as the supplier of this system based on the broad range of experience within the company in a wide variety of GPS applications directly related to the requirements of the NHS. The NHS has very high requirements for system performance including high accuracy, ease of operation and reliability. Once in operation, it will represent one of the most advanced systems for this type of application on the international market.

The system will utilize differential GPS and comprises an on-board vessel unit and a portable reference station sending differential corrections to the survey vessel on a dedicated radio link. The on-board unit receives these corrections and calculates the position of the vessel with a very high degree of accuracy.

The system will be used along the Norwegian coast and on Svalbard. Significant design effort has been expended to ensure that the reference station is easily portable for one man under a wide variety of conditions. The station will operate uninterrupted under the harsh climatic conditions found along the coast of Norway. The reference station can operate from either battery or mains suppply. The transmission of reference data is controlled from the vessel, thereby saving battery life and enabling the station to work for long periods unattended.

The specifications for the system include: position accuracy better than two metres, possibility to apply LOP from terrestrial radio navigation systems, L1 and L2 (dual frequency), 9 channel GPS receivers, full remote control of reference station, man-portable reference station and control of the reference station to be easily transferable between vessels when operating several vessels within range of a single reference station.

The DGPS system will undergo a series of test procedures before it is finally approved by the NHS. The ultimate goal is to verify that the system complies fully with the initial requirements of NHS and confirming that the system can completely satisfy the operational requirements of the NHS. The test procedure comprises a factory test, a seatest and finally a system acceptance test which will be carried out under fully controllable field conditions.

Subsea Offshore Ltd.

Aberdeen based SubSea Offshore Ltd. has acquired the interests and assets of Brown & Root Survey from its parent organisation, Brown & Root. The new entity becomes a division of SubSea Offshore and will be known as SubSea Survey.

The deal consolidates a close working relationship between the two companies for the past ten years. Their complimentary capabilities and expertise will provide the necessary synergy for an integrated business operating on a worldwide basis.

This is an integration of Brown and Root Surveys' offshore survey operations with SubSea Offshore's own established position in offshore inspection, repair and maintenance markets.

SubSea Survey will continue at present to operate from its existing premisess at Wellheads Crescent, Wellheads Industrial Estate, Dyce, Aberdeen AB2 0GA.

The Hydrographic Society

Proceedings of Hydro 92, the Eighth Biennial International Hydrographic Symposium, held in Copenhagen last December which was attended by delegates from 26 countries, have been published by The Hydrographic Society.

They comprise 29 papers presented by leading speakers drawn from all sectors of the world hydrographic community. Topics covered include Quality Assurance and Control, Navigation and Positioning, ECDIS, Acoustics, Engineering Construction Projects, Coastal Zone Management, Special Sensor Platforms and Hydrography for Developing Countries.

Copies are available at £35 each for Society members or £50 for non-members from, The Hydrographic Society, University of East London, Longbridge Road, Dagenham, Essex, U.K., RM8 2AS.

Canadian Hydrographic Service (CHS)

Scotia-Fundy Region (Dartmouth, N.S.)

Ocean Mapping Activities

During 1992 representatives from the main federal departments responsible for ocean mapping related activities established a committee to foster closer collaboration in conducting ocean mapping projects. These included Fisheries and Oceans, National Defense, Energy Mines and Resources, Environment Canada, Transport Canada, Public Works and also the NSERC Chair in Ocean Mapping. Expanding on DND's ocean mapping requirements, a comprehensive list of Objectives and Deliverables under the general data model (Data Acquisition, Data Management, Data Transformation and Information Dissemination) was prepared. Within the framework of alliances or partnerships involving government program agencies, academic institutions, the private sector and funding sources, these requirements would be addressed. Several projects and initiatives were completed under this umbrella during 1992/93. A few of the more significant projects are described below.

Ocean Mapping Surveys:

Two surveys were completed by the Canadian Hydrographic Service (CHS) and the Atlantic Geoscience Center (AGC) that contributed significantly to the ocean mapping objectives. One was the MATTHEW multi-parameter survey on the inner Scotian Shelf covering an area of 1000 km^2. It was an 8-week project collecting EM100 bathymetry, pseudo sidescan, gravity and magnetic data. The other was the FCG SMITH sweep survey of Halifax Harbour. It was a 5-month project covering Halifax Harbour from McNabs Island in to the Narrows at the MacKay Bridge. Both surveys collected complete bottom coverage data sets, from which spectacular seafloor images similar to high resolution satellite imagery were produced. The images generated significant interest in the scientific community and were requested by interest groups during the recent public hearings on the Halifax Harbour Cleanup project.

Ocean Mapping Project

Following a public Request For Proposals (RFP) in November, 1992, a contract was awarded to a private consortium led by McElhanney Geosurveys to complete a seven task Ocean Mapping Project. These tasks included:

1. Existing Data Bases.
2. DOLPHIN/EM100 Survey.
3. Hardware and Software for Route Survey Office.
4. High Speed data acquisition Study
5. Ocean Bottom Magnetometer.
6. Acoustic properties of Sedimnets.
7. HIN Points and Lines Database.

This project produced hardware, software, instrumentation and seafloor images of an area near St. John's, Newfoundland.

Chair in Ocean Mapping:

Several research projects were conducted leading to the development of software tools. These included: swath editing software tools SwathEd and DelayEditor; integration of airborne/spaceborne and acoustic datasets; 3D visualization tools; and sediment classification algorithms.

The more significant project was the Hydrographic Ground Truthing Experiment (HYGRO-92). Multiple data sets were collected over several test sites and targets in the Bay of Fundy region and then analysed using the new software tools to study the relationships between actual seabed characteristics (topography, texture and composition) and acoustic measurements of these same characteristics. Actual seabed data was collected using photogrammetry, underwater photography with BROWSER, airborne remote sensing with CASI, satellite remote sensing with ERS-1, bottom samples from cores & grabs, terrestrial surveys, and placement of known targets.

Acoustic data was collected using Navitronics Sweep, Simrad EM1000, acoustic altimeter on BROWSER, Chirp sonar and SEISTEC subbottom profilers, Mesotech and Klein sidescan sonars, RoxAnn acoustic sediment classification instrument, and a vertical beam echo sounder.

Other Activities

There were two invited presentations on ocean mapping activities during the year. One was to the Atlantic Geoscience Society annual meeting titled *"New Frontiers in Ocean Mapping"* and also included a media briefing. The other was to the Marine Technology Society (Eastern Canada) annual meeting. The new seafloor images of Halifax Harbour and the Inner Scotian Shelf, the technologies involved and the interpretation of the images were the focus.

As part of the Maritime Coastal Defense Vessel (MCDV) project, the Department of National Defense (DND) has established a Route Survey Office at the Bedford Institute of Oceanography (BIO). This is a cooperative effort to work more closely with DFO and EMR in order to meet the Navy's increasing ocean mapping requirements.

Tides Currents and Water Levels

The eleven Permanent Water Level Network (PWLN) sites continue to operate despite major operational budget reductions. Scotia-Fundy Region also has two experimental sites, although one site (Nain) may be closed this year as a cost savings measure.

As part of a long-term program for the establishment of vertical control at hundreds of Atlantic small craft harbours, approximately 12 sites were completed. This is a significant reduction from last year's total of 47 sites.

Development of several tidal information databases continued. Spatially indexed data such as station histories, datums, chart tidal blocks and lunitidal information are now readily available on a PC workstation. Plans are proceeding to migrate these data to a multi-user UNIX environment for wider area access. A software utility to use CARIS for plotting information from these databases was completed.

Nautical Publications

The cartographic work area has been restructured and centralized to the fifth floor, Polaris at BIO. Two people from Quebec Region, Anne Frenette and Andre Hardy, have been on assignment in Scotia-Fundy Region's cartographic unit to become familiar with CARIS. Jim Ross has left the CHS for Management Training and Judy Lockhart has returned from studies at University.

Headquarters (Ottawa, Ont.)

Planning and Development

The Nautical Geodesy and Tides unit has been recently split into two sections: the Nautical Geodesy unit, and the Tides, Currents and Water Levels unit.

Nautical Geodesy:
Rick Mehlman has been involved with the readjustment of the Great Lakes and Newfoundland onto NAD83. As well, he continues to maintain both the CHS horizontal control data bank and CHS's list of lights data bank. Rick is also monitoring a contract with Geosurv Inc for the formation of a "Handbook for GPS Control Surveys" to meet CHS control survey requirements.

Since December Dave Gray has been verifying the Loran-C lattices in Dixon Entrance and the St. Lawrence River. Dave continues to investigate CHS's off-datum charts; he had already calculated the datum adjustments for the charts to be digitized under the Electronic Chart Pilot project.

Tides, Currents and Water Levels:
This unit now consists of Peter Richards, Manager, and Marilyn Van Dusen, Tidal Officer. As well as continuing existing tasks the unit is assuming new duties. The TCWL unit is now also reponsible for the complete production of the Canadian Tide and Current Tables and for the entire operation of the IHO Tidal Constituent Data Base service, which is provided to the international community. All of this will be done directly within CHS. The data and methodology are now being transferred to the unit with the assistance of Don Mitchell who has joined the staff on a contract basis. The Marine Environmental Data Service continues to povide its expertise in archiving tidal data.

Planning:
The unit has been coordinating CHS participation in interdepartmental projects and programs. Jake Kean has been negotiating with the Department of Indian and Northern Affairs for funding for a major multi-year hydrographic survey of the southern Northwest Passage based on a study by Canarctic Shipping. CHS input was provided for the preparation of the 1991/92 roll-up of the Brander-Smith I Green Plan activity and for Environment Canada years 1 and 2 public report card. Since December there has been on-going activity on the Brander-Smith II Memorandum to Cabinet for funding of hydrographic surveys on the southwest coast of Newfoundland. At the request of the Department of National Defence, surveys have been planned for three areas in the eastern high Arctic. A DND/DFO Memorandum of Understanding on Marine - Related Science and Technology Activities is being prepared. Jake Kean is also serving as a DFO Science coordinator for an Emergency Preparedness Canada national exercise

Training:
Dave Pugh co-ordinated cartographic training courses in Central and Arctic Region and Scotia-Fundy Region. He is developing training material that is based on multi-media techniques.

Electronic Chart Pilot Project:
There have been important developments within the CHS Electronic Chart Pilot Project. Canada Steamship Lines Inc. has purchased 11 ECPINS systems from Offshore Systems International Ltd. for their self-unloading bulk carriers operating in the Great Lakes and the St. Lawrence Seaway. This is the first fleet purchase of ECDIS systems in the world. Although CSL was not originally included in the EC Pilot Project, agreement has been reached to include this major installation of systems in the project. A total of 166 ENCs (Electronic Navigation Charts) must be created to meet CSL's needs.

Other installations of OSL's ECPINS included in the project are:

- on both bridges of the double-ended British Columbia ferry operating between Horseshoe Bay and Langford. (This installation is completed and was demonstrated to CHS management in mid-May.);
- another B.C. ferry in Georgia Strait running between Tsawwassen (south of Vancouver) and Swartz Bay on Vancouver Island;
- an Atlantic Marine ferry running between Digby, N.S. and Saint John, N.B.;
- an ARCO supertanker running between Valdez, Alaska and Cherry Pt., Washington;
- a Great Lakes bulk carrier operating from Thunder Bay to Windsor;
- a SOCONAV crude oil tanker running between Montreal and Quebec City;
- Ontario Northland's ferry travelling between Tobermory and Manitoulin Island; and
- the Marine Training Institute in St. John's, Nfld.

Marine Cartography

Chart Maintenance and Distribution:
The unit has been busy as usual; since December it has produced 27 Reprints, one New Edition, 6 Overprints/Reruns and 25 Patches. During this time a total of 374 Notices to Mariners were processed and over one million correction values were applied to existing chart stock. Over 60,000 charts and over 100,000 nautical publications were distributed during this period. Chart actionable notices on all current editions of CHS charts are being entered into the Notices to Mariners data base by contract help. Over 8,000 Notices have been entered to date; 2,600 remain to be entered.

Three members of the unit are in the field this summer as part of the multi-disciplinary hydrographer career development programme. These are: Anna Singerff, Ilona Monahan, and Aurèle Rochon.

Peter Heinrichs, a long-time member of the Notices to Mariners section, has officially retired from the CHS.

Chart Maintenance and Distribution cooperated with the Sailing Directions unit to develop and staff a successful display at the Ottawa Boat and Sportsman Show in February.

Sailing Directions:
Jim Bruce, the Chief of the Sailing Directions Unit since 1989 retired in March after 36 years with the CHS. Yves Bouchard is now the acting chief of the unit. Nicole Paquette has been occupying the Assistant Sailing Directions Officer position in an acting capacity.

Since December the Sailing Directions Unit has been working on both English and French versions of a number of volumes. Both the English and French versions of the Great Lakes Sailing Directions, Volume 2, are scheduled to go to press in early summer. Work continues on both versions of Arctic Sailing Directions, Volumes 1 & 3, and the Small Craft Guide Saint John River, Volume 1.

Cartographic Development:
Cartographic Development continues to support production, for both paper chart and electronic chart production environments. Several contractor's kits have been delivered to private industry and direct support for the EC pilot has and continues to be provided (eg Offshore Systems International Ltd., EHDC, Matrix), and a platform independent data format was created in order to facilitate interaction with data providers and suppliers (NTXALL). The NTX Toolkit developed by Paul Guibord enabled an application to be written which would provide and accept this type of data. This toolkit has also been used in CHS Regions for translating field data to NTX and by Lewis Boone for generating NTX graphics from Source Directory System (SDS) queries.

The second version of the Chart Distribution System was deployed in Ottawa and at IOS. The Notices-To-Mariners (NTM) data base system was deployed to all Regions and training was provided to users in Ottawa. Version 1.0 of the Names Data Base System was also delivered to René Lepage of the Nomenclature section. Version 1.0 of the Digital Chart Management System (DCMS) has also been implemented, and the design documents are presently being reviewed by the Limits committee. In addition, we have carried out a study into the use of Internet and AIR (Apple Internet Router) to link all Regional mailcenters without the use of modems. The same Internet pad will be looked at for fixed-cost Client-Server database applications.

Ocean Mapping:
Since December 1992, work on the Natural Resource Map Database (NRMDB) has continued. Work is on-going for maps covering the west coast, Great Lakes, and Grand Banks.

A total of 56 maps have now been digitized for the Grand Banks, with nine maps completed since December and 11 maps currently in progress. These maps will be used in the CHS Electronic Chart Pilot programme as part of an installation aboard a DFO surveillance vessel early in 1994.

Since December four maps have been finished for the west coast. All maps have been digitized and work continues on approximately 10 required to complete this part of the database.

Two Great Lakes NRMs (western Lake Ontario and western Lake Erie) are now in progress.

Work in the Electronic Chart (EC) field and related issues included responsibility for the majority of topology training and user support for topology across the CHS. The Electronic Chart Pilot program, including the Canada Steamship Lines (CSL) purchase of ECPINS has kept Ocean Mapping busy performing digital quality control, providing CARIS support (mostly related to CARIS topology), assisting with the implementation and use of the Digital Chart File Standards (DCFS), and customizing chart data for ECPINS installations.

In the area of bathymetric mapping, the on-going production of digital Natural Resource Maps is currently focusing on the west coast, as part of CHS participation in a co-operative effort with the Department of National Defense (DND) and Energy, Mines and Resources (EMR) called Vector Smart Map Canada (VMap-C). The goal of this project is to produce a 1:250,000 map data base for all of Canada which will be part of a world-wide database called VMap. The world-wide VMap is being produced by DND, the US Defense Mapping Agency, and the United Kingdom Ministry of Defense. Thirty-one NRMs covering the Great Lakes are being produced as part of a joint mapping program with NOAA.

Joel Box has joined Ocean Mapping as a term employee. He will focus on the development of the CARIS Object Manager software, and participate in other electronic chart work.

Two summer students will be working on bathymetric mapping and the creation of a data base of ASF Chartlets (Additional Secondary Factor) for Loran corrections. Existing chartlets will be scanned and vectorized using Applescan and CARIS SAMI.

Two Ocean Mapping staff, Mike Turgeon and Bob Farmer, are on field assignment for the summer, under the Multidisciplinary Hydrographer training programme.

Quality Control and Services:
Félicitations to Ray Chapeskie who has just returned after successfully completing his French language training. The Quality Control unit was finally brought up to full strength when Denis Pigeon joined the unit in mid April as a quality control officer. Denis was formerly with the Nautical Publications Section in Central and Arctic Region. Dave Black has assumed the duties of the Production Monitor on a permanent basis.

Data Management:
The Source Directory System is now being used by all Regions, with Scotia-Fundy Region finalizing the loading of their data, and Quebec and Pacific Regions beginning to load their data. Central and Arctic Region has been fully operational for several years and uses this system to catalogue sources and record chart maintenance decisions.

Central and Arctic Region (Burlington, Ont.)

Field Surveys
The 1993 Arctic winter survey, with HIC (hydrographer-in-charge) Al Koudys, recently completed two months of work out of Coppermine, NWT, using TIBS (Through-Ice Bathymetry System) and spot sounding to conduct a reconnaissance survey in Coronation Gulf. Al and Jon Biggar are now working out of Cambridge Bay for two months, using TIBS for a reconnaissance survey in Queen Maud Gulf, Icebreaker

Channel and Victoria Strait. An Arctic summer survey, with HIC Bruce Wright, will conduct a survey from the CCGS SIR JOHN FRANKLIN, and will examine any shoals found with TIBS, primarily in the area of Victoria Strait. The CSS TULLY, operated by Pacific Region, will examine shoals in the other areas covered by the winter surveys. The proposed survey in Hudson Bay out of Churchill has been canceled since external funding support was not available.

The southern surveys on the Great Lakes have just left for the field. The Lake Huron survey under HIC John Medendorp is based in Port Elgin and using Syledis to survey the area between Stokes Bay and Point Clark. The Lake Ontario survey with HIC Jack Wilson is working out of Oshawa to complete the sounding program on Lake Ontario by surveying the area between Cobourg and Toronto using our new Sercel GPS system. The Revisory survey under HIC Paul Davies is visiting various sites in the Region to resolve queries for new charting, to conduct harbour surveys, and to correct some off-datum charts.

Nautical Publications

Several Nautical Publications staff were recently assigned to Field Surveys, with a corresponding number of field staff moving to assignments in the chart production units. Sean Hinds, Mike Johnston, Andrew Leyzack, Paola Travaglini and Pete Wills have just completed the six-week Cartographic Module of the Basic Hydrography Course that was held in the Region. Four CHS staff from Pacific Region and one from Ottawa also attended the course. Denis Pigeon recently left the Region to take a Quality Control position in Ottawa.

Charting projects completed in the last six months include New Charts 1436 and 1437 (St. Lawrence River) and New Edition 6247 (Playgreen Lake), and numerous Notices To Mariners chart correction patches. Current charting projects nearing completion include New Charts 7578 (Pelly Bay, NWT), 5640 (Churchill Harbour, Hudson Bay), 5720 (Approaches to Chisasibi, James Bay) and 2215 (Collingwood, Georgian Bay), and a New Edition of Chart 2021 (Murray Canal to Healey Falls Locks, Trent-Severn Waterway).

Development

A new TIBS digital bird was successfully tested in Coppermine and showed better noise and drift results than the analog system. Mike Crutchlow will soon be joining Al Koudys in Cambridge Bay, NWT, to evaluate the GPSNet satellite differential correction system. If successful, this transmission of GPS corrections via a communication satellite will be used for the Arctic summer survey instead of operating our own reference sites. Paul Millette and Tony Natolino have been conducting local field trials with the new Sercel GPS system to get it ready for the Lake Ontario survey.

In collaboration with Offshore Systems International Ltd. (OSI) and Canada Steamship Lines, the Region has decided to accelerate its program of providing Electronic Navigation Charts (ENC). The program will involve the production of 78 Central and Arctic Region charts in the Great Lakes and St. Lawrence River. The program will be implemented in the following stages:

1) The creation of 22 ENCs consisting of shoreline, navaids, channel limits and a depth contour (either 10 m, 30 ft or 5 fathom) in-house by May 15, 1993.

2) The creation of an additional 56 ENCs in-house by September 1993.

3) Quality control of digitizing and ENCs produced at OSI.

4) Upgrading the ENCs to the recommended data content for the Display Base and Standard Display proposed by the International Maritime Organization.

Seven CHS staff from Development, Field Surveys and Nautical Publications Divisions have formed a team to tackle this challenge.

The Electronic Chart Pilot Project to demonstrate the OSI Electronic Chart System on the Tobermory/South Baymouth ferry (CHI CHEEMAUN) and a Great Lakes bulk carrier this summer is making good progress. CHS staff have been involved with Coast Guard to install GPS differential telemetry systems at the Port Weller and Killarney LF beacon sites.

Pacific Region (Sidney, B.C.)

Field Hydrography

All of the field sheets and survey data from last year's Nootka Sound, Queens Sound, and Wales Island surveys have been delivered to the Hydrographic Data Center (HDC). On the Wales Island survey major differences in the coastline from the 1888 US C&G survey adjacent to point "B" on the A-B line (Dixon Entrance) have been found and reported. The Dixon Entrance Navigation Systems project yielded several reports and provided a very useful basis of information for proposed DGPS inplementation by the CCG. Other local surveys were also completed and delivered to HDC before the end of March. These included surveys of Patricia Bay, Sidney, and Ganges.

This year's surveys will see the R.B. YOUNG (K. Czotter HIC) on the west coast of Vancouver Island near Zebellos, the PENDER (G. Eaton HIC) on the central B.C. coast near Bella Bella, the JOHN P. TULLY (B. Lusk HIC) in the Western Arctic, hopefully in Dolphin and Union Strait, and a revisory party in Canoe Pass on the Fraser River (V. Crowley HIC).

Arctic Sailing Directions Volumes 1 and 3 have been delivered to the editor for formatting and publication. A national meeting of Sailing Directions personnel was held in Ottawa in March. A number of recommendations affecting Pacific Region were made including discontinuance of Small Craft Guides, adoption of a 120 page booklet format for Sailing Directions, and inclusion of supplementary information in charts 3312 and 3313.

Manual digitization of field sheets continues slowly. A pilot project has been initiated with the province of B.C. to investigate the addition of hydrographic survey information to TRIM topographic files.

G. Eaton continued his work with CHS's EC demonstration and customer survey project and gave numerous presentations to the public. A. Raymond assisted the department in Fraser River stock assessment projects by making reconnaissances of the central portion of the river and by monitoring a contracted survey of a potential fish counting site.

Chart Production and Distribution

The main emphasis in present production activities is the reconstruction of Small Craft Chart 3311. This package containing five sheets and a cover, that is in hand for a major New Edition. Production staff are recompiling from source material to portray the new standards of presentation and symbology. The results of this exercise will be the production of complete digital files including text.

Human resources in Chart Production have remained greatly diminished with assignments of staff members to both Field Hydrography and Tides and Currents. The recent involvement of Pacific Region in the 1993 Carto course has also taken its toll on production with staff attending to either lecture or learn (two students and four instructors).

The conversion of data for the Electronic Chart Pilot Project is nearing completion. For this project Standing Offers were arranged with five companies. The initial call-ups were for seven charts and five field sheets, and these were later increased to a total of sixteen charts and five field sheets. Six charts contained insets and/or compartments which were kept as separate files, and three of the field sheets where each split in two and kept as separate files. These thirty five files were ranked in accordance with demonstation schedules and are being checked as resources permit.

CHS attended the Vancouver Boat Show in February. The "theme" of our booth was Client Services - advising the public as to the services and products available from the CHS. Display board sudjects included horizontal datum adjustment (NAD 83), the Electronic Chart, and the TENYO MARU oil spill.

Tides and Currents

Spring and field surveys came early to Tides and Currents this year. Three field programs were either carried out or started in March.

The field portion of a PERD-supported research project to profile the Fraser River with precise GPS was successfully completed. The purpose of this project is to test the feasibility of using DGPS as a means of establishing chart datum along the Mackenzie River (the target is a vertical accuracy of 0.1 metre or less). The field work was carried out over a period of five days using four Ashtech PXII receivers (one on the REVISOR and three at control points), two levelling crews, and quite a few cellular phones. The University of Calgary participated in the field program and is presently processing the data collected.

Pressure gauges were serviced by divers at six locations in Active Pass. These instruments were serviced in preparation for a current survey being carried out in April and May. This is a launch-based survey using the empirical hydraulic technique.

Bill Crawford spent two weeks on the Royal Research Ship CHALLENGER in the Irish Sea making turbulance measurements as part of a program to study coastal currents in the Irish Sea and the influence of turbulence on those currents. The results of this program will be used to improve our own current prediction models in shallow coastal seas such as Hecate Strait.

Reconnaisance surveys were carried out in the Courtenay and Campbell rivers to select locations for the installation of temporary water level gauges. The water level data collected will enable the CCG to determine the required levels for dredging in these rivers.

Engineering Services

In January, T. Curran was assigned the duty of responding to the Fraser River priority, as identified in the Larkin report. This implied reviewing the Larkin recommendations, hosting a conference call with government participants, investigating potential riverine fish-counting technology, discussing requirements with industry, and presenting the results in a Fraser River workshop. This work has been completed, but involvement in the Middle Fraser fish monitoring continues. Projects carried out since then include video taping selected sections of the river, and assisting with site surveys. There has also been some involvement in the Flowmeter-for-Fish in the lower Fraser River. Following completion of the civil works and the re-establishment of power, the hydroacoustic system was installed at Annacis Island in March and is now operational. A final report investigating the relationship between fish count data at Mission and the acoustic amplitudes incidentally acquired at Annacis Island in 1992 is anticipated shortly.

Several ISAH modifications were made prior to the start of the field season. The direction of the cooling fan was changed to keep the unit (especially the Targa drive) cleaner, and the CPU cards were modified to accept EEPROMs. The keyboards appear to be getting rough treatment in the field as mechanical repairs were required on a number of them.

G. Worthing and D. Gartley spent some time packaging the reference station and launch installations of HPC/DGPS. They also determined the cause of some of the datalink parity and data latency faults we have experienced. The faults were caused by sloppy timing on one of the serial interface lines (RTS) from the PC to the radio modem.

The operation of the new UHF DGPS store and forward repeater was tested. Power consumption of the DPGS reference station is now low enough that solar panels can power the complete station. Some software was also obtained from DataRadio to develop an easy-to-use and thorough test precedure (bit error analysis) for the UHF DGPS communication links while in the field.

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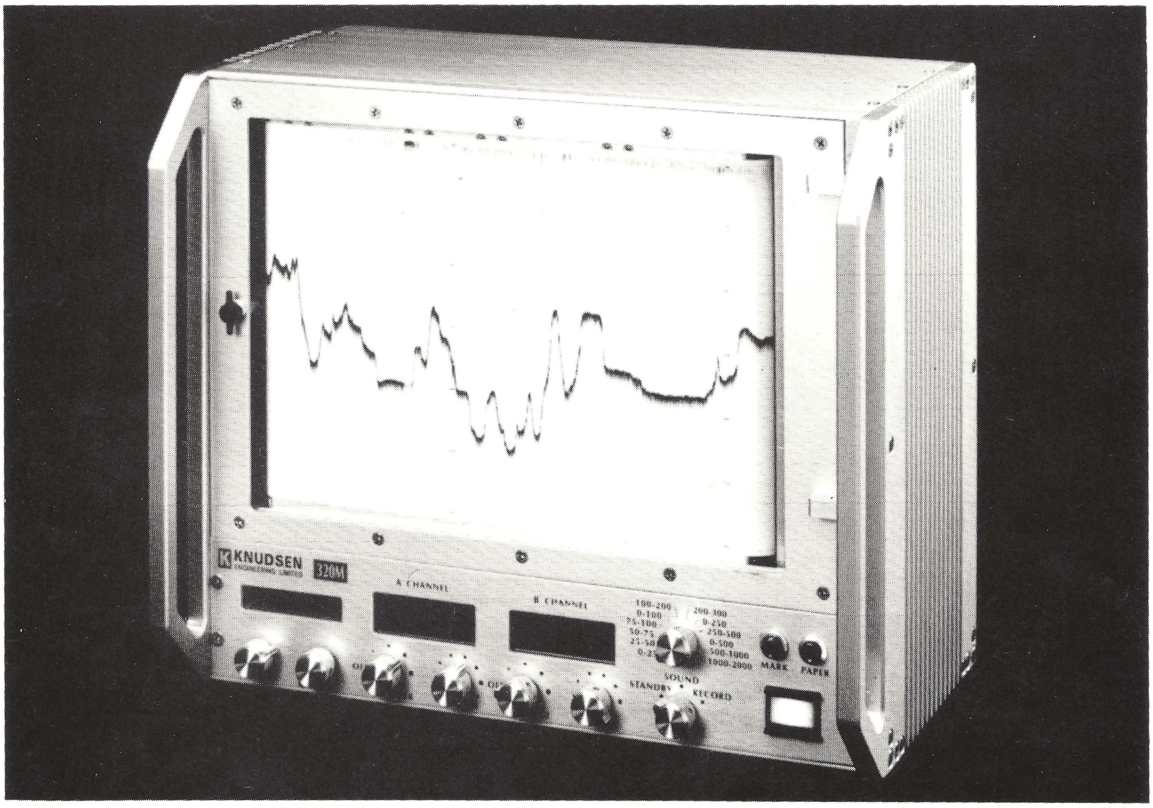

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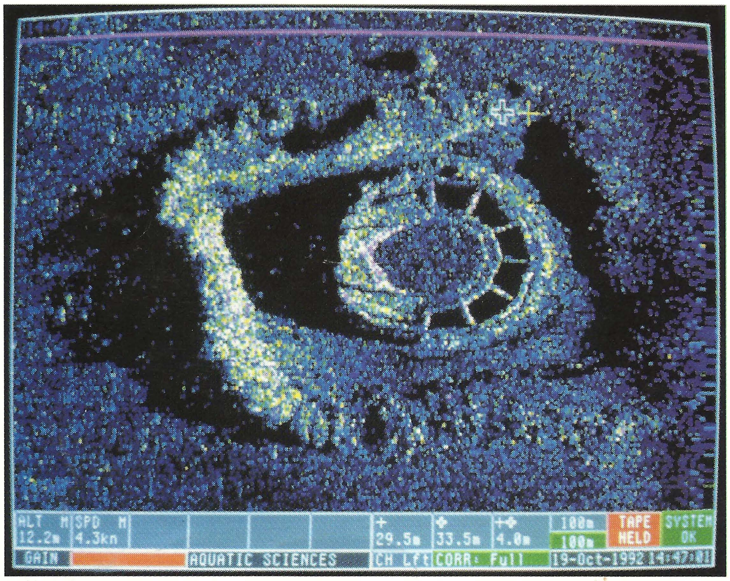

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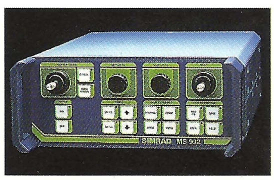

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