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Lighthouse

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The Tsunami Warning System in the Pacific

G. C. Dohler

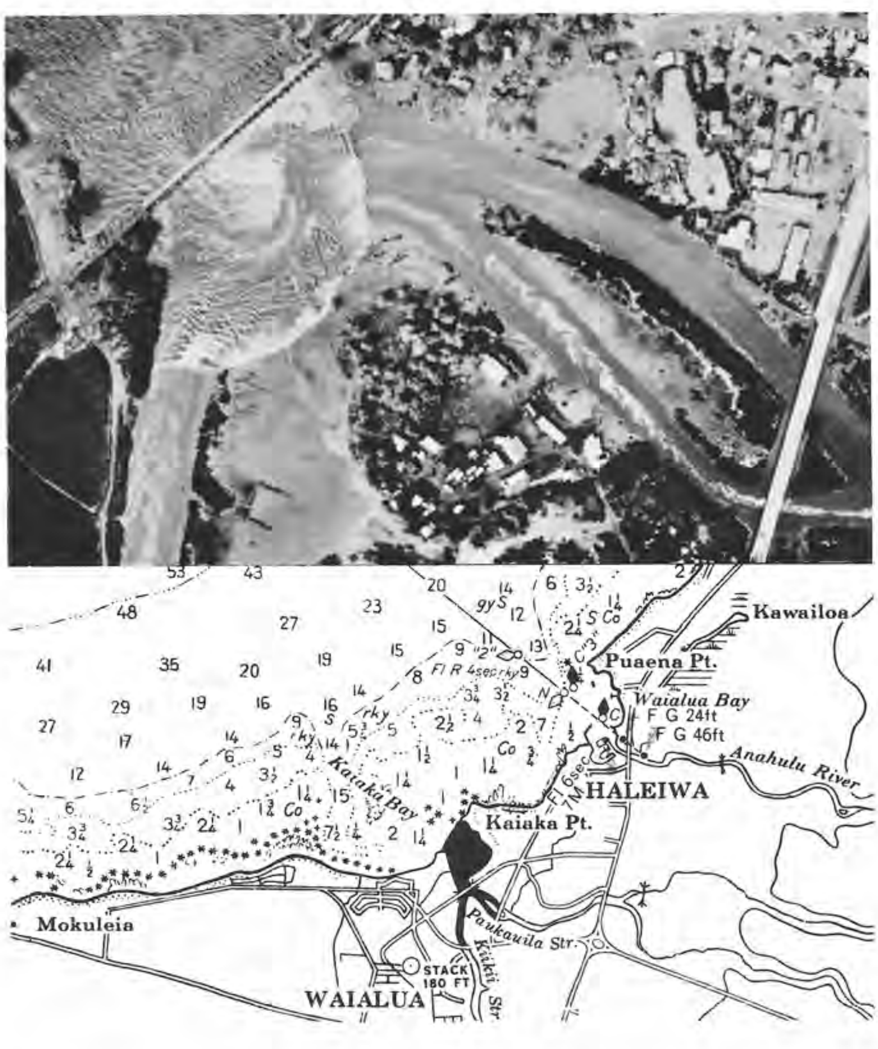
1983

2. Introduction
Over the past two decades all the coastal areas in the Pacific experienced a rapid growth in population and industrial and harbour facilities. A firm estimate is not available of the number of potentially endangered persons in each country bordering the Pacific, however many miles of coastline are exposed to tsunamis in North America, the east coast of Asia, the Pacific Islands, and South and Central America.

At least seven near-shore seismic events causing tsunamis, having occurred in the last ten years, resulting in loss of life and property (29 November 1975, Hawaii, 2 lives lost; 17 August 1976, Philippines, 8,000 lives lost; 19 August 1977, Indonesia, 189 lives lost; 18 July 1979, Indonesia, 540 lives lost; 12 September 1979, New Guinea, 100 lives lost; 12 December 1979, Colombia, an estimated 500 lives lost; and 26 May 1983, Sea of Japan, approximately 100 lives lost). Tsunami Warning Centers were unable to provide tsunami warnings to these areas in time to be useful. Losses such as these from future tsunamis can be minimized if a denser network of warning centers, reporting stations and better communications existed, and if better programmes of tsunami preparedness and education were in effect.

Tsunamis always produce a threat close by, but not always one far afield. Only if the energy produced is sufficiently great, will the resulting wave cross the open ocean as a very long and low amplitude wave, reappearing depending on the coastal bathymetry as a highly destructive wave thousands of miles away from its source.

The most destructive Pacific-wide tsunami of recent history was generated along the coast of Chile on May 22, 1960. No accurate assessment of the damage and deaths attributable to this tsunami along the coast of Chile can be given; however, all coastal towns between the 36th and 44th parallels either were destroyed or heavily damaged by the action of the waves and the quake. The combined tsunami and earthquake toll included 2,000 killed, 3,000 in-



THE NOVEMBER 1952 TSUNAMI ON THE NORTH SHORE OF OHAU, HAWAII jured, 2,000,000 homeless and $550 million damage. Off Corral, the waves were estimated to be 20.4 meters (67 feet) high. The tsunami caused 61 deaths in Hawaii, 20 in the Philippines, and 100 or more in Japan. Estimated damages were $50 million in Japan, $24 million in Hawaii and several millions along the west coast of the United States and Canada. Wave heights varied from slight oscillations in some areas to ranges of 12.2 meters (40 feet) at Pitcairn Island; 10.7 meters (35 feet) at Hilo, Hawaii; and 6.1 meters (20 feet) at various places in Japan.

Destruction from tsunamis is the direct result of three factors: inundation, wave impact on structures, and erosion. Strong tsunami-induced curents have led to the erosion of foundations, the collapse of bridges and seawalls. Flotation and drag forces have moved houses and overturned railroad cars. Tsunami-associated wave forces have demolished frame buildings and other structures. Considerable damage also is caused by the resultant floating debris, including boats and cars which become dangerous projectiles crashing into buildings, piers, or other vehicles. Ships and port facilities have been damaged by surge action, caused even by weak tsunamis. Fires resulting from oil spills or combustion from damaged ships in port, or from ruptured coastal oil storage and refinery facilities, can cause damage greater than that inflicted directly by the tsunami. Other secondary damage can result from sewage and chemical pollution following destruction. Damage of intake, discharge, and storage facilities also can present dangerous problems. Of increasing concern is the potential effect of tsunami drawdown when receding waters uncover cooling water intakes associated with nuclear power plants.

More people are attracted to the sea shores for their livelihood and for recreational and other purposes. The damage caused by a tsunami now or in the future will be much greater than in the past, if existing technology is not utilized in providing the most effective and efficient warning system for those living along the shores of the Pacific.

Present techniques of tsunami prediction are severely limited. The only way to determine, with certainty, if an earthquake is accompanied by a tsunami, is to note the occurrence and epicenter of the earthquake and then detect the arrival of the tsunami at a network of tide stations. While it *is* possible to predict when a tsunami will arrive at coastal locations, it is *not* yet possible to predict the wave height, number of waves, duration of hazard, or the forces to be expected from such waves at specific locations.

During the last few years, new operational concepts have been developed for warning systems utilizing updated technology and instrumentation. The objective of these new operational systems are to reduce the time needed to evaluate the tsunami hazard, make decisions, and disseminate the warnings, on a Pacific-wide or on a regionalized basis. These new systems can use shore and off-shore based seismic and tsunami sensors transmitting data in real time, to the Pacific Tsunami Warning Center and/or to Regional Warning Centers throughout the Pacific making use of synchronous meteorological satellites for communication relay. The systems can also make use of conventional communication facilities and reduce the time necessary to communicate tide and seismic information, as well as to transmit warning messages. Utilizing such technology, the operational response of the Pacific Tsunami Warning Center and that of the Regional Tsunami Warning Centers could be greatly enhanced for the protection of life and property.

3. Present Tsunami Warning Centers

3a. The Pacific Tsunami Warning Center:
In 1948 the Seismic Sea-Wave Warning System was put into operation at the Seismological Observatory near Honolulu. The Intergovernmental Oceanographic Commission (IOC) approved in 1966

THE PACIFIC TSUNAMI WARNING CENTER

the offer made by the United States of America to strengthen these facilities by establishing on a permanent basis the International Tsunami Information Center (ITIC). At the same time, the IOC established the International Coordination Group for the Tsunami Warning System in the Pacific (ITSU).

On the recommendations by this Group, the facilities at Honolulu have been identified as the Pacific Tsunami Warning Center (PTWC). Its main responsibility is to issue warnings to all participants having designated appropriate civil defense organizations within sixty minutes of a tsunamigenic earthquake.

Appropriate communications and computer facilities as well as trained staff are available on a 24-hour basis to carry out this task at the Center.

The Communications Plan of the Tsunami Warning System, Ninth Edition, September 1980, prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administrations (NOAA), National Weather Service, gives information on the guaging and seismic stations in operation, the participating agencies, the procedures to be followed in the event of a Tsunami and other information of importance and interest.

The Present Warning Process:
The tsunami watch process is triggered by seismic signals received in almost real time at Honolulu from selected seismic stations, seismic observatories and Regional or National Warning Centers.

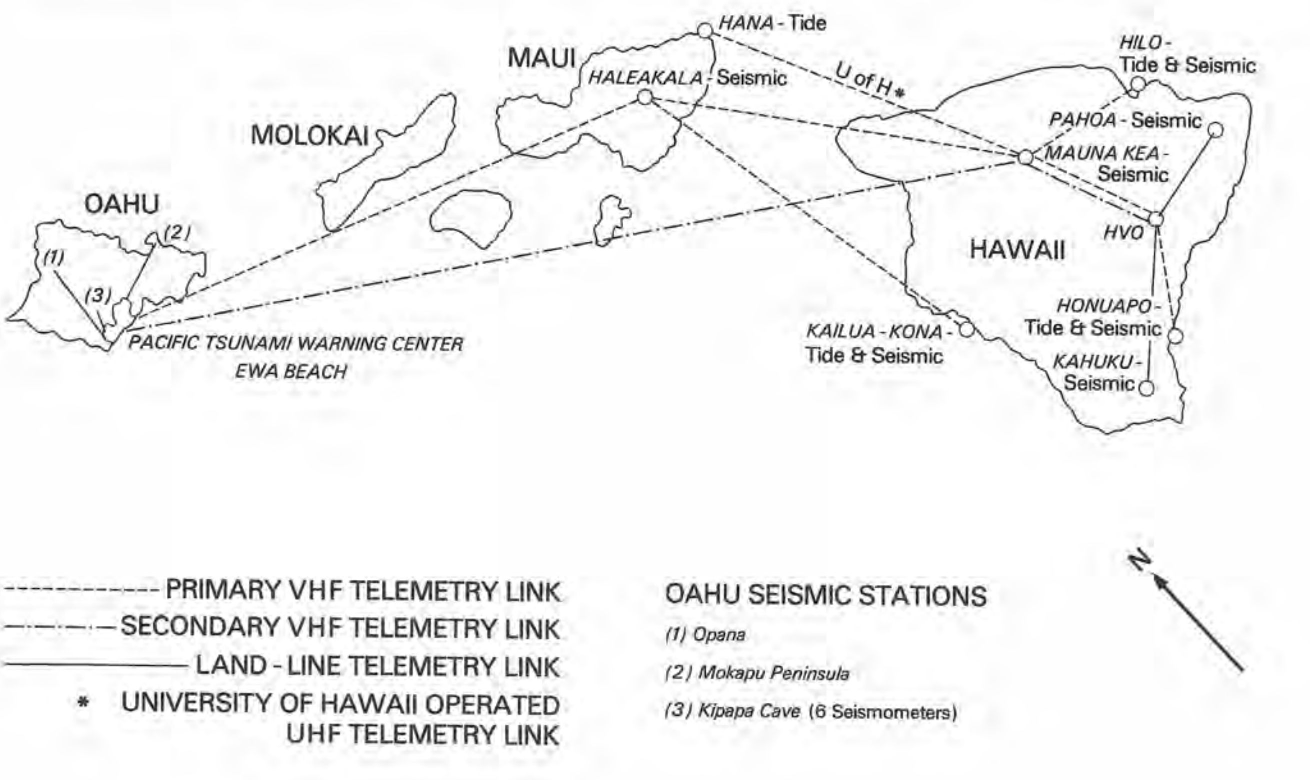
Tsunamigenic earthquakes occurring in the region of the North Pacific can be verified presently at the Pacific Tsunami Warning Center in Honolulu within 20 minutes. During this time frame all participating nations in the area are advised that a possible tsunami threat exists. However, the confirmation of the actual tsunami can only come from properly located and instrumented water level recorders. Within the North Pacific area several water level gauges have good communication links with Honolulu or other warning centers. Confirmation of a dangerous tsunami within 20 minutes is therefore only possible where these facilities exist and are being maintained for this purpose.

Present operating limitations prevent actual warnings to be disseminated in less than one hour to most countries within the Southwest Pacific and along the South American coast. However, given the technology, warning center distribution and communication facilities as available for the North Pacific, warnings to the population within the equatorial area and the Southern part of the Pacific could be activated also in less than one hour.

Regional or national warning centers are in existence within the United States of America, the Union of Soviet Socialist Republics and Japan. The Centers are located at Honolulu and Palmer (U.S.A.), Petropavlovsk-on-Kamchatka, Kurilskiye and Sakhalinsk (U.S.S.R.), Sapporo, Sendai, Tokyo, Osaka, Fukuoka and Naha (Japan).

3b. The Hawaii Regional Warning Center
The Hawaii regional system entered into service in 1975 providing warnings for locally generated tsunamis for the people of Hawaii. When an earthquake of magnitude 7.5 or greater occurs in the Hawaiian region, the Pacific Tsunami Warning Center issues warnings to the threatened coastal areas of Hawaii through the Hawaiian Civil Defense and other designated agencies.

Telemetered data from a quadripartite seismograph and tide gauge system located on Oahu, Maui and Hawaii provides the essential data needed to make decisions on the issuance of warnings utilizing computer technologies.



THE HAWAII REGIONAL TSUNAMI WARNING CENTER

3c. The Alaska Regional Warning Center

This regional system has been operational since 1967 and represents a collection of sophisticated equipment and techniques available to seismologists and oceanographers. The Center at Palmer Observatory, north of Anchorage, is highly automated and linked to telemetering tide and seismograph stations from Sitka to Shemya. There are good communication links to Civil Defense units and emergency measures organizations within the area of jurisdiction.

Whenever a major earthquake of magnitude seven or greater occurs along the Pacific coast of Alaska, a tsunami watch is issued to the Alaskan, Canadian and Mainland U. S. Pacific coastal population through the appropriate Civil Defense authorities.

The Alaska Regional Warning Center

3d. The Japanese Tsunami Warning Centers

The Tsunami Warning Service for Japan was established in 1952. Many seismic recorders and water level gauges are being used in the determination of tsunamigenic events. The Service employs up-to-date telemetry systems in order to obtain the information in almost real time. The Japan Meteorological Agency (J.M.A.) maintains six regional tsunami centers and designated Tokyo as the national center for Japan.

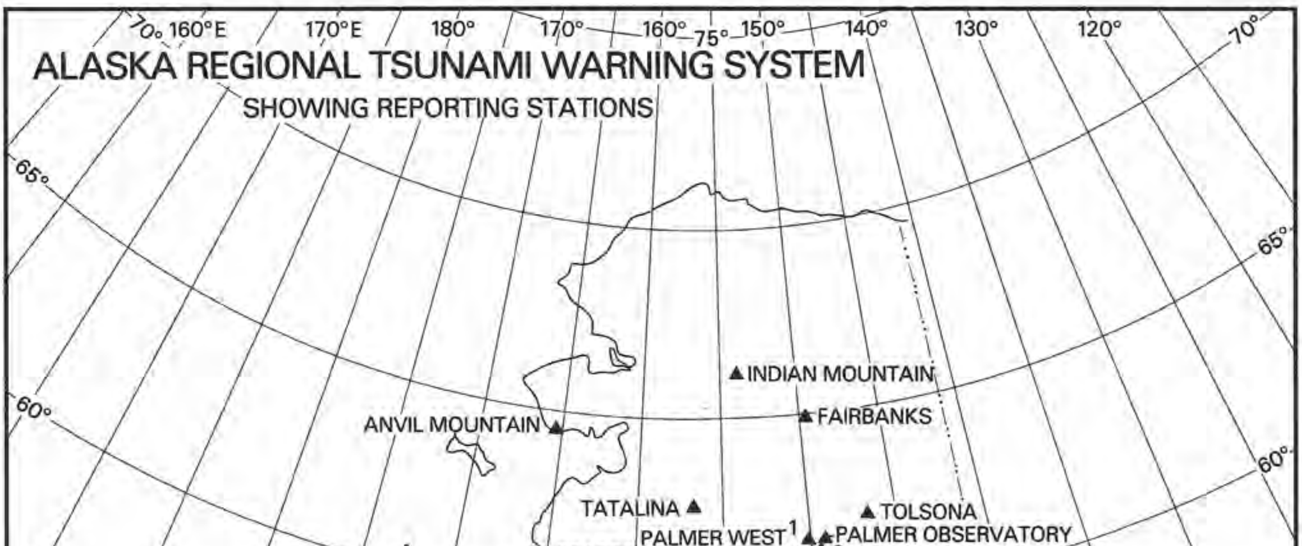
If a tsunami is generated within a 600 km radius of the coast of Japan, all centers will issue warnings through designated channels. For tsunamigenic earthquakes outside this radius, the National Center will establish contact with the Pacific Tsunami Warning Center and will advise its Civil Defense agencies and others accordingly. In addition, tsunami-related information is exchanged with Khabarovsk, Palmer and Washington through an automated switching system.

3e. The U.S.S.R. Tsunami Warning Center

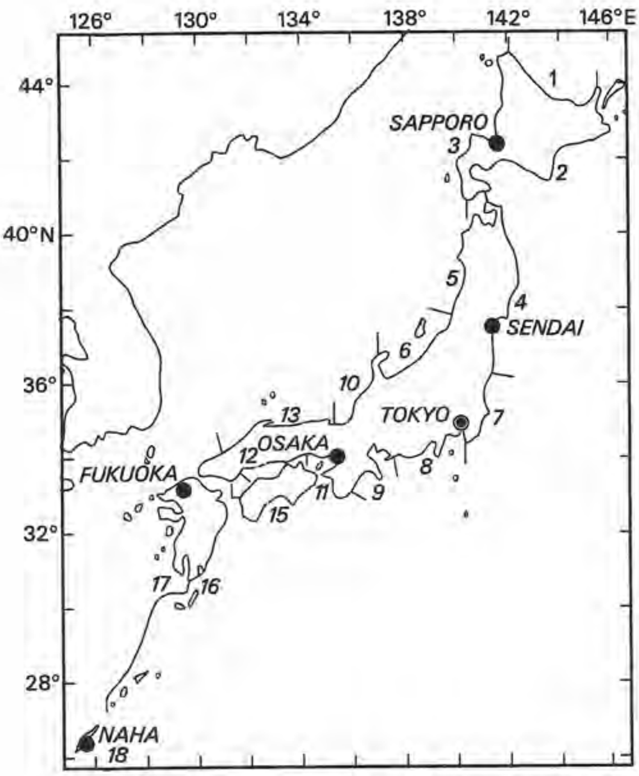
The U.S.S.R. started implementing a Tsunami Warning System after the 1952 Kamchatka earthquake. Three specialized seismic tsunami stations were established. The overall responsibility of these stations is exercised by the Hydrometeorological Service of the U.S.S.R. with the assistance of the Academy of Sciences and several other institutions. Each Center has full authority to issue a warning in case of a tsunami threat and appropriate quarters are advised to evacuate affected population centers.

Special instruments are in operation to detect earthquake magnitudes of seven and larger as well as resulting tsunamis at distances between 150 and 2000 km off-shore.

Tsunami wave travel time charts and historical data are used in the warning process. Communication is maintained with the Pacific community through the Khabarovsk-Tokyo cable link.



THE ALASKA REGIONAL WARNING CENTER

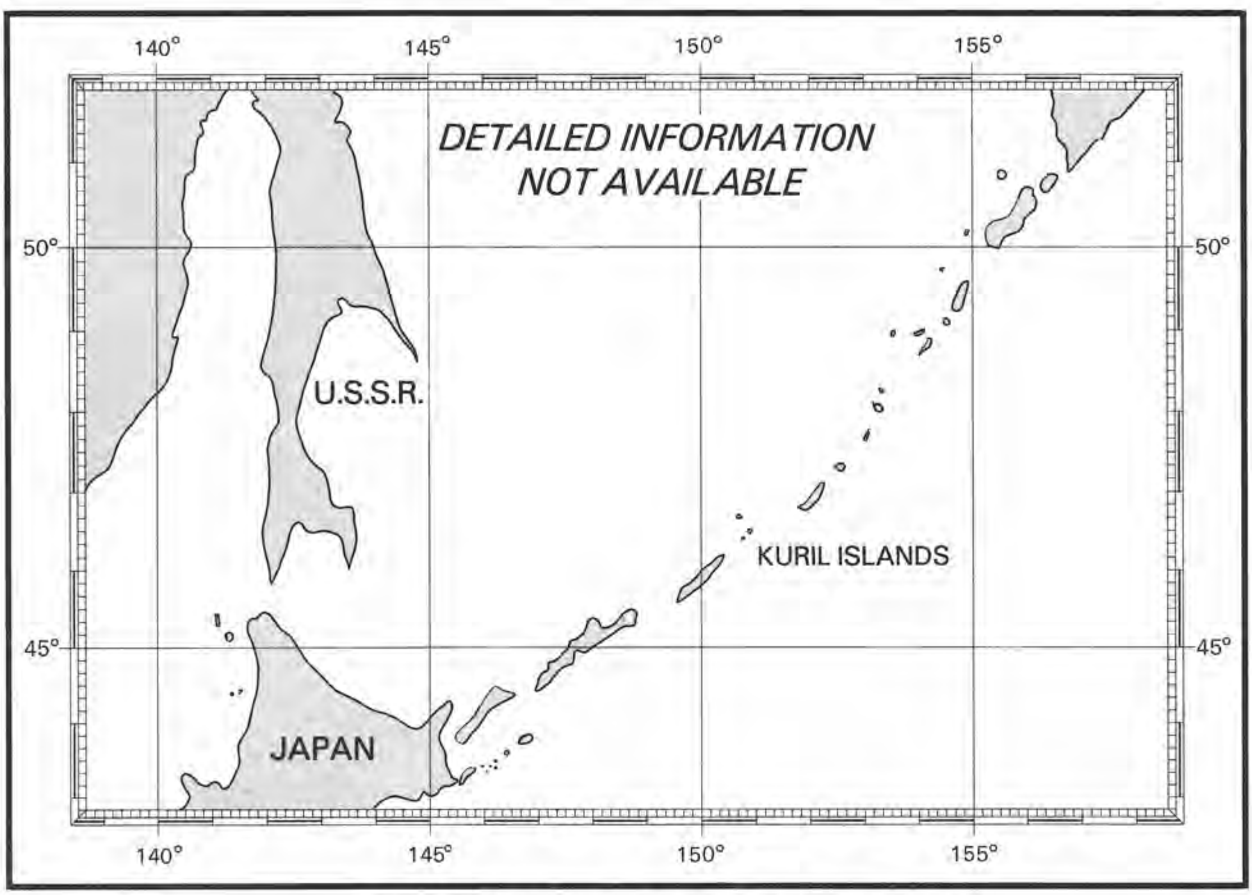


Showing the assigned areas of the respective Tsunami Centers.

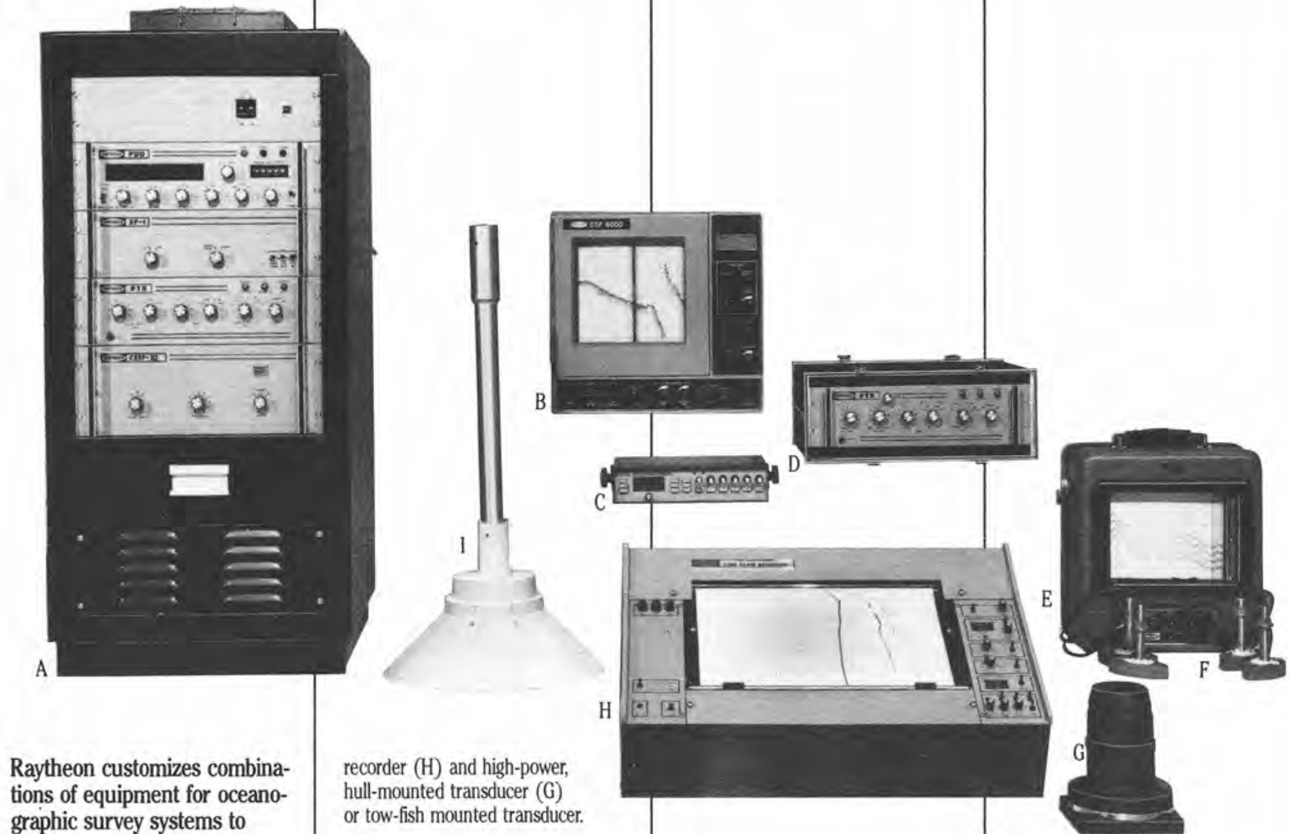
Centre	Coast
SAPPORO	*1, 2, 3*
SENDAI	*4, 5*
TOKYO	*6, 7, 8, 9, 10*
OSAKA	*11, 12, 13, 14, 15*
FUKUOKA	*16, 17*
NAHA	*18*

Closed circles show the Regional Tsunami Centers and a double circle shows the National Tsunami Center.

TSUNAMI WARNING SYSTEM OF JAPAN



TSUNAMI WARNING CENTERS OF THE U.S.S.R.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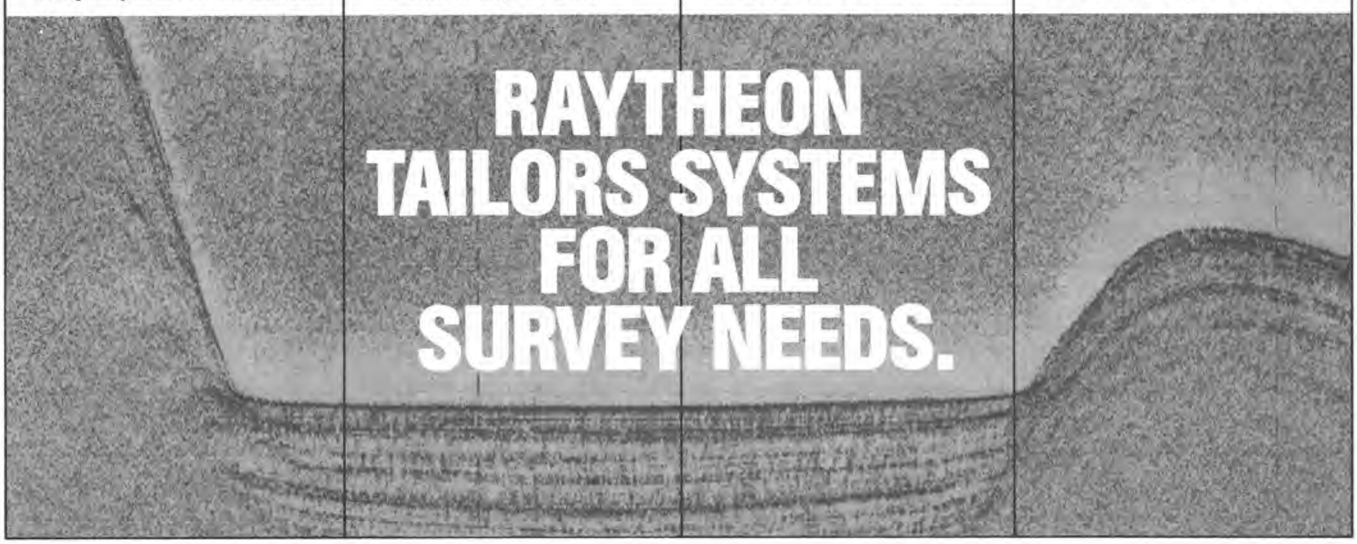
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EDITORIAL

In Canada there is a change of government and hydrographers may feel that "the devil you know is better than the devil you don't!" By all reports the new government is faced with a large deficit and if it wishes to introduce new programs it must do so at the expense of the old programs. This inevitably means cut backs on government programs which will affect both the public and the private sector because today much of government's work, particularly in the survey field, is done by private contractors using government funds. During the last two decades there has been a steady increase in social benefits provided by the government's purse and the social envelope at present amounts to between forty and fifty percent of all government spending. There is no doubt that government action to cut social spending is like walking through a minefield and spending cuts in that area will be very difficult to make. Another big area of government spending is defence and here the new government has made it clear that it has major plans of its own — to press on with naval ship construction and to turn the personnel into blue uniforms again. So here again, spending restraint will not be easy. So this brings us to some of the government programs that can be cut without offending the populace and these include those long term tasks such as surveying and research on which a nation must build its future.

The above political prologue serves to introduce the matter with which anyone who believes in the future of Canada must be concerned. This country's financial strength lies in its wealth of raw materials and much as we wish to cease becoming "hewers of wood and drawers of water", the fact remains that this is where our wealth resides. Surveying is intimately involved in the extraction of these resources and this country's surveying history is directly associated with the need to bring the resources to market economically. The laying out of the prairie farmlands, the development of northern mines and the opening of the St. Lawrence Seaway, all needed the surveyor. More recently, Canada has faced northwards and has opened lead-zinc and iron ore mines in the most remote northern localities. Once again it has been the surveyor who has shown that it can be possible, by laying out railway right of ways and by sounding out the channels to allow the ships to pass in safety. In the Beaufort Sea oil has been discovered and plans are being made to ship it south by ship or pipeline, and at every phase there is the surveyor and the hydrographer with their theodolites, levels, echo sounders and sidescan sonars.

Since natural resources are the lifeblood of our country and since they cannot be developed or transported without the land surveyor and the hydrographic surveyor, surely, oh surely, our political masters will soon realize that to cut costs here may be a political compromise but one that will have devastating effects on the future of this great land.

Adam J. Kerr
EDITOR

International Cartographic Association — Marine Cartography Commission "Methods of Display of Ocean Survey Data" Report of Second Seminar (Brest, France) and Future Proposals

1. Introduction

This Seminar was the second in a series associated with the investigation "Methods of Display of Ocean Survey Data", being carried out on behalf of the Marine Cartography Commission of the International Cartographic Association. Whilst the first Seminar (Swindon, UK, 1982) reviewed that, at that time, current methods, the Second Seminar was intended not only to continue that review, but also to examine areas of research that will be undertaken.

The Seminar was held at the Brittany Centre of Oceanography (COB) in Brest, France by kind permission of Monsieur J Vicariot, Director COB. It was attended by 25 participants from 8 countries who attended full-time as well as others mainly from COB, who attended particular sessions.

The Seminar commenced with a dinner attended by 12 participants on the evening of Tuesday, 21 August and ended at lunchtime on Friday, 24 August.

2. Seminar Programme

The first three papers of the Wednesday morning session were presented by members of staff of both COB and SHOM and gave an interesting insight to the cartographic and image display systems of both organizations. The fourth paper, by Juha Korhonen of Finland discussed the problems associated with correcting and displaying data collected by the Finnish Hydrographic Service's Sweep Sounding System.

The first session in the afternoon was devoted to Universities and others.

George Benwell, of the University of Melbourne, described a real time shipboard display system which is being developed for dredging purposes by the University under contract. This system depends on survey data transmitted from a survey vessel to a shore station where it is processed and added to the database. Extracts from the database are then transmitted to the dredger in the form of display images.

Alistair Wright of the Marine Transport Centre of the University of Liverpool suggested, in his presentation, that a microform output could provide a range of graphics more cheaply than can be obtained by normal map printing, or from computing systems.

The last paper of this session was by Ron Linton who reported on the work he had been carrying out in registering digital sidescan sonar with digital bathymetry.

The final session of the day was concerned with methods used by commercial companies. Two companies were represented. In his paper, Rod Powell of Wimpol Ltd discussed the problems of portraying wave, tide and current data and showed that the type of graphics required by the engineer were very different from those used by the mariner.

In the second paper of the session Bill Russell-Cargill demonstrated the methods of display of sidescan sonar data which were used within his Company, and he discussed the use of computer-aided drafting systems in displaying sidescan sonar images to complement a bathymetric survey.

The final paper of the day was a presentation by Christian Edy of COB who discussed the automated techniques in mosaicing and registering Seabeam data and demonstrated the methods of solving registration problems between swathes caused by navigational positioning errors.

The Discussion Groups which were convened on Thursday morning, were concerned with two aspects of the display of marine data.

A. User Requirements and Developments in the Display of Sea Floor Topography. Group Coordinator: Gilles Bessero, SHOM.

B. User Requirements and Developments in the Display of Time Varying Data. Group Coordinator: Rod Powell-Wimpol Ltd.

These groups reported to the Closing Session of the Seminar on Friday morning.

Visits to both COB and EPSHOM took place on Thursday afternoon. During the tour of COB, the Seminar participants were given demonstrations of the two image analysis systems which are used in SPOT simulation studies of the coastal zone (COMITEL system) and for the display and analysis of SAR and other satellite data (TIGRE system). The mosaicing and editing of SEABEAM data was demonstrated on a Tektronix 4115 colour VDU which was connected to the same VAX processor that "drives" their TIGRE image processing system.

During the visit, a slide presentation was given by Mme Melguen, Head of BNDO and the visitors were also shown the work of the section dealing with the processing of shallow water sidescan data as collected by their EG&G system.

The visit to EPSHOM commenced with a description of the work of the Service Hydrographique et Oceanographique de la Marine (SHOM) by General Francois Milard, Deputy Director and Head of Research Studies. The visitors were then taken round each of the sections in the Research Study Group where they were shown some of the more recent developments in automated data acquisition and digital cartographic processing.

The Closing Session on Friday morning comprised the reports of the Discussion Groups and a general discussion session. As in the case of the first Seminar, this Session was recorded and will be included in the published Report as a verbatim account of the discussions.

3. Future Proposals
At the 12th International Conference of the International Cartographic Association, a meeting of the existing Commission was held to discuss the future of the Commission and to make proposals to the General Assembly of ICA about the future work, if any, for the Commission to undertake.

After some discussion it was resolved to propose to the General Assembly that the Commission should continue for the next 3 years (to the next Conference and General Assembly in Mexico City in 1987). A number of proposals for future work were discussed and it was resolved that the following 2 tasks would be put forward to the General Assembly for approval.

A. "Methods of Display of Ocean Survey Data" — a continuation of the present Investigation with the intention of producing a final report covering all aspects of the Subject with any conclusions and recommendations in time for the 13th International Conference of ICA in 1987.

B. "A Review of Yachting and Small Craft Charts" — this will be undertaken in parallel with the above, and a report also produced for 1987.

The General Assembly agreed that the Commission should continue and also approved the 2 proposals described above. The General Assembly also agreed with the proposal from Adam Kerr, the then current chairman of the Commission, and supported by the existing Commission members, that I should be appointed as the Commission Chairman for the period to the next General Assembly. This proposal was also supported by the Chief Delegate from the UK. I am now in the process of establishing the membership of the Commission.

As to the organization of the Commission's work, I will continue to lead the investigation into the Methods of Display. The second task will be headed by Mr Bryce Beikoff of Queensland, Australia who is very much involved in the production of Yachting Charts. He will also assume the deputy Chairmanship of the Commission.

R. H. W. Linton
October 8, 1984

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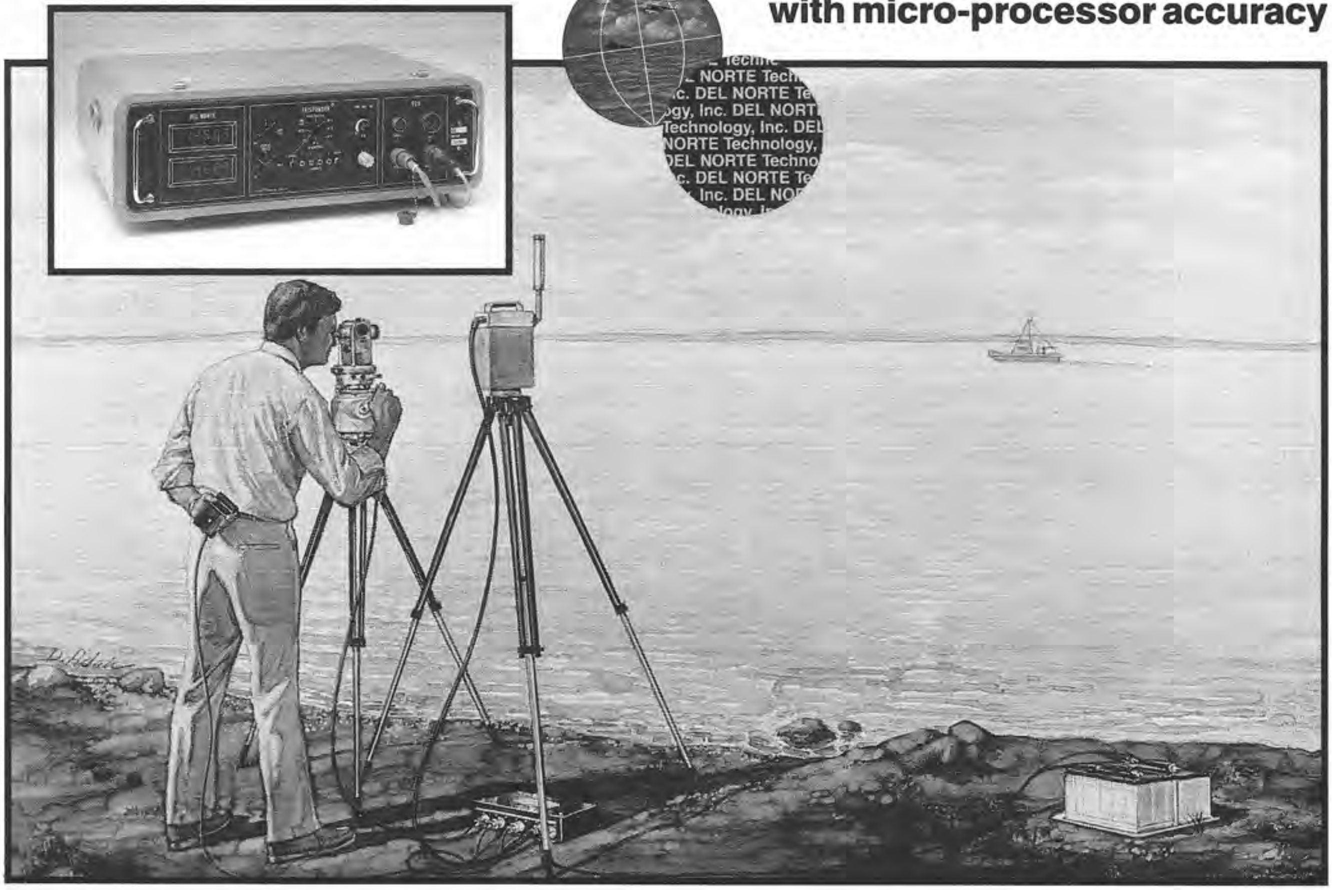
Rho/Theta System

Range/Azimuth marine positioning with micro-processor accuracy



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JOHN P. TULLY

by

R. W. Sandilands

The name for the new Fisheries and Oceans survey vessel to replace the WILLIAM J. STEWART was approved and on 27th October 1984, hull 302, built by Bel-Aire Shipyard Ltd. of Vancouver was launched as C.S.S. JOHN P. TULLY.

John Patrick Tully (Jack) was born in Brandon, Manitoba in 1906 and graduated with a bachelors degree from the University of Manitoba in 1931 joining the Pacific Biological Station at Nanaimo (Departure Bay) that year. In 1946 he became the Oceanographer-in-Charge of the Pacific Oceanographic Group (POG).

In 1948 he obtained his Ph.D. in chemical oceanography from the University of Washington and in 1966 moved to Ottawa as oceanographic consultant with the headquarters staff of Fisheries and Secretary of the Canadian Committee on Oceanography (CCOO). He was later to be elected a Fellow of the Royal Society of Canada and also awarded the Medaille Commemorative Albert Premiere de Manaco et la Mer for his work in oceanography. His other awards include the Coronation medal, the Queen's Silver Jubilee medal and for his work in WW II he was made a Member of the Order of the British Empire. Most recently he was the first recipient of the Tully Medal, an award instigated in his name and awarded by the Canadian Meteorological and Oceanographic Society (CMOS) for significant contributions to Canadian oceanography.

Dr. Neal Carter the chief oceanographer at Departure Bay when Tully joined tells the story of Jack Tully's first encounter with the ocean:

> "I had a lot of correspondence with Tully as one of the applicants for the position of my assistant in the oceanographic work. He lived in Winnipeg at the time and had never seen salt-water, but he assured me that he was interested, and in the course of the correspondence it turned out that he had a wooden leg. I felt a little reticent about the idea of employing him because in oceanographic work you have to be on a boat in rough weather when the decks are wet and slippery, and I wondered how his wooden leg would behave. He assured me that it wouldn't be any trouble, so I asked him to come to the station.
>
> He arrived when I happened to be away on the boat on a week's oceanographic cruise. When he came chugging up to the dock at the station on Friday afternoon, here was this individual whom I had never seen before walking down to meet the boat in a resplendent yachtman's uniform, complete with brass buttons. He figured he had to have a uniform if he was going to work on a boat, not knowing that we didn't go for uniforms. When the boat docked, I had on a dirty old sweater and was carrying some of the bottles of seawater ashore. He asked where Dr. Carter was. The skipper of the boat pointed to me and said: 'That's Dr. Carter.' Tully's face fell. I never saw the uniform again." (Johnstone)

Tully joined the Station and brought with him "a burst of boisterous enthusiasm which seemed a combined product of the prairie environment and Irish ancestry, which added a sparkle to the Station group" (Johnstone). This enthusiasm led to his initial involvement with hydrographers as at the Fifth Pacific Science Congress in 1933 where he entered into an arrangement with H. D. Parizeau, the west coast Regional Hydrographer of the day, whereby Tully went out with the hydrographer party aboard C.S.S. WILLIAM J. STEWART. The hydrographers used the ship by day and Tully carried out his field work when they had finished. These surveys were in effect the first multidiscipline surveys on the west coast. During the 1933/34 seasons the work was off the west coast of Vancouver Island and in 1935 off the west coast of the Queen Charlotte Islands.

During the 1935 season Tully met Lieutenant Commander Soulsby RCN who was doing reconnaissance surveys for potential destroyer bases, and realizing the greater mobility of HMCS ARMENTIERES on such a program he transferred his activities from the WILLIAM J. STEWART and for the first time the RCN on the Pacific Coast became a partner in oceanographic studies. ARMENTIERES also did winter duties as a rescue ship in the approaches to Juan de Fuca Strait and Tully seized the opportunity for winter oceanographic surveys in the area. (Sandilands)

In 1932 Tully was also successful in making arrangements with the Department of Transport where by a number of lighthouse keepers along the B.C. coast took daily seawater temperatures and samples. (Campbell)

Two of B.C.'s major industries are fishing and the production of pulp and the two are not always compatible hence the coastal mills consult with the Fisheries Department on their effluent discharge systems. The pilot project for these studies was Port Alberni in 1939-41 when extensive field studies were carried out. The project was assigned to Tully and a new large trolling boat was chartered for the project. The fish hold was fitted out as a laboratory.

Dr. Clemens, (Director of the Nanaimo Station 1924-40) reminisced thus in the Aquatic Explorers:

> "After accumulating and analyzing a mass of data, Mr. Tully decided he needed a model of the upper end of the Canal in order to interpret and confirm his conclusions as to the water movements. With the assistance of three young lads, R. L. I. Fjarlie, H. J. Holister, and W. Anderson, and with plaster of Paris, buckets, pulleys, hoses, an electrical fan, and parts of alarm clocks, there appeared a model approximately 6 by 4 feet complete with tides, river flow and winds, all recorded by well devised gauges. I was intrigued by all this activity and eventually found myself perched on a stool on a table, looking down on the model and recording on a diagram the flow of dye introduced to represent the pulp mill effluent. Needless to say, I was replaced by a camera. So the model idea was introduced to the Station. Later a larger and more effective model was built on the hill above the Station but the little model in the Chemistry building will always remain as a symbol of vision and ingenuity."

As a result of this study, the dispersion pattern of the pulp mill effluents in the inlet was predicted, and measures to reduce damage to the fisheries were recommended and carried out. (Johnstone)

During the war years the major activities in oceanography were in the acoustic field, directed towards submarine detection. The Atlantic coast was in the front line, but suitable water conditions for the development and trials of A/S equipment were available in the safe inner channel of B.C. (Sandilands)

Tully with his usual enthusiasm and energy was seconded to the RCN in 1942 to undertake research in underwater acoustics and sound-ranging. In this he was assisted by Dr. W. M. Cameron (later to be Director, Marine Sciences Branch) and Fred Barber as Mate and had HMCS EHKOLI, later used as a survey vessel by the Canadian Hydrographic Service (CHS). The research work was highly classified and curious requisitions emanated from EHKOLI for equipment which sorely tested the procurement skills of shore-based Naval Supply Officers, such as an urgent midnight signal for 4000 glass balls and several thousand feet of chicken wire (to simulate a submarine target). (Campbell)

Around that time Tully also carried out some launch hydrographic surveys, such as for submarine telephone links between Yorke Island/Kelsey Bay; Quathiaski Cove/Campbell River. (Barber — personal communication)

In 1946 the Canadian Joint Committee came into being and Tully was appointed Oceanographer of the Pacific Oceanographic Group (POG) where he steered the various agencies into co-operative research programs by pooling manpower, ships and equipment.

A significant program of that time was the oceanographic observations which were tied in with the meteorological observations undertaken by the weather ships on passage to and at Station "P" (Papa) some 1250 kilometres west of Vancouver Island.

Also with the formation of the North Pacific Fisheries Commission in 1953, Canada, Japan and the United States of America joined together in one of the world's greatest co-operative fisheries investigation and the Pacific Biological Station under Tully led Canada's contribution of a synoptic survey of the North Pacific.

These two programs led to the emergence of POG as a truly ocean-oriented establishment backed up with a significant coastal program in the Strait of Georgia and Hecate Strait and the combination of these studies served as a basis for the development of a mathematical models on ocean transport, a description of North Pacific waters and the construction of the Hecate Strait hydraulic model at Nanaimo in 1958. (Campbell)

Data from Larsen's transits of the NW Passage in the RCMP schooner SAINT ROCH sparked Tully's interest in the Arctic and in 1949 he became a partner in joint Canada/US investigations of the oceanography of the north mainly directed towards submarine passages of the Arctic.

In today's parlance, Jack would be classified as handicapped as he lost a leg in a car accident in 1928, a severe blow to an athletic man. Throughout his working life it never slowed him down and he led his team from the front and stood on heaving decks with the best of them. An inveterate pipe smoker he used his pipe as a management tool lighting, puffing, pointing and gesticulating with it. In conversation with some of Tully's old associates they always remember some of his mottoes. "The difficult — we do immediately; the impossible may take a little longer"; "Produce or perish" and referring to research, "Everything is pure gold". It is typical of Jack that in accepting his award of the Tully medal he said that he considered the medal to be a tribute to the Pacific Oceanographic Group — "that gallant band of pioneers who made oceanography practical in Canada."

Tully retired in 1969 but he had recruited his "gallant band" to continue his impetus. Though far from being a comprehensive list Johnstone cites F. G. Barber, A. J. Dodimead, L. A. E. Doe, R. L. Fjarlie, N. P. Fofonoff, G. R. Harris, B. S. Mackay, R. A. Pollard, J. A. Shand, Susumu Tabata, Michael Waldichuck and R. J. Waldie. Omissions from this list that come to mind are Dick Herlinveaux and Larry Giovando presently at IOS and Tully also supported W. M. Cameron and G. L. Pickard from the Institute of Oceanography, University of British Columbia.

Those and many other oceanographers were touched and inspired by Dr. Tully and the recognition of his activities in the choice of JOHN P. TULLY as the name for this new vessel is a fitting recognition for a dedicated marine scientist and public servant.

Principal Particulars

Dimensions:	Length, overall	69 m
	Length, waterline	62 m
	Breadth, moulded	14 m
	Displacement	1800 tonnes (approx.)
Speed:	Full service speed	14 knots
	Economical cruising speed	12 knots
Endurance:	Endurance	120 days provisions
	Range	12,000 nautical miles
Complement:	Officers	8
	Crew	17
	Scientiific Staff	15

CSS JOHN P. TULLY has an all welded steel hull with aluminum superstructure and is driven by two diesel engines coupled to a single, controllable pitch, propeller working in a nozzle. The vessel is also equipped with bow and stern thrusters.

Oceanographers will have at their disposal ten winches, four A-frames and two cranes, while hydrographers have four, 29 foot, aluminum survey launches. These launches are also classified as lifeboats. Scientific staff have two laboratories and a large chartroom available. These spaces, the after working deck and wheelhouse are joined by intercom and can be equipped with remote readouts from the various navigation systems.

The vessel's navigation system is fully integrated and includes SatNav, Loran-C, Omega and a doppler log besides radars, gyros and their associated repeaters. Communications are enhanced by a facsimile receiver and a teleprinter in addition to the normal marine and aircraft radio systems.

CSS JOHN P. TULLY will be based at the Institute of Ocean Sciences facility at Pat Bay, near Sidney, B.C. and her main area of deployment will be the Pacific seaboard and associated Arctic regions including the Beaufort Sea. The 1985 season is scheduled to include an extensive hydrographic survey in the Western Arctic.

The vessel is scheduled to come into service in March 1985.

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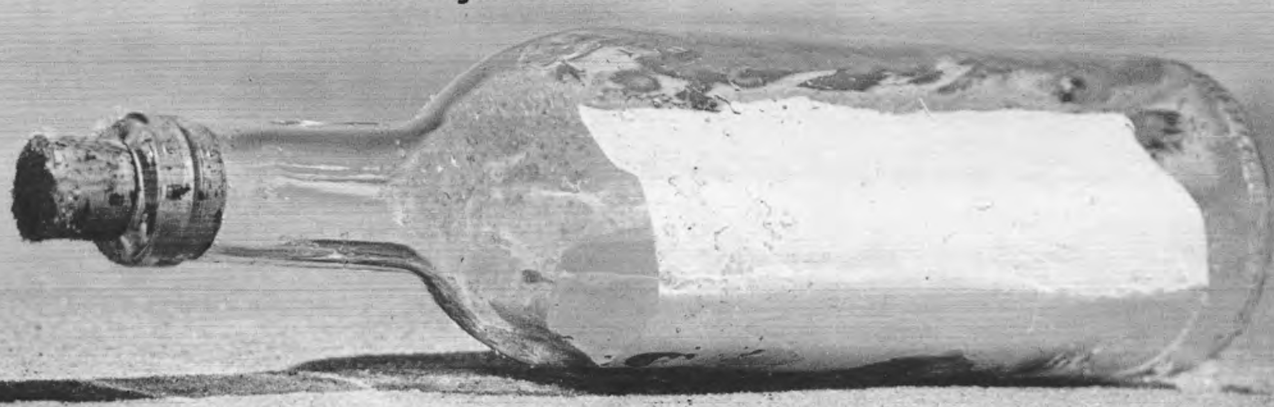

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How Often Should Charts Be Reissued?

S. B. MacPhee
Director General (CHS)

Introduction

During the summer of 1984, an "A" Base Review was carried out on the activities of the Department of Fisheries and Oceans. When the program for the Canadian Hydrographic Service was reviewed, one of the contentious issues discussed was "What is the required interval between reissuing charts, either as New Charts, New Editions or Reprints?" In this short paper, I would like to present some of the arguments used in developing our response to this question and would like to seek comments on what others believe to be required cycle times to ensure that charts are in an acceptable state for the marine user.

Discussion

In order to clarify the navigation chart production system, it is necessary first to define New Chart, New Edition, Reprint and Notice to Mariners as it is through these mechanisms that charts are recycled and kept up-to-date. As per our publication status of Canadian charts, the following definitions apply:

NEW CHART The first publication of a Canadian chart embracing an area not previously charted to the scale shown, or embracing an area different from any existing Canadian chart.

NEW EDITION A new issue of an existing chart containing amendments essential to navigation in addition to those issued in Notices to Mariners and making existing editions obsolete.

REPRINT A new printing of the current edition of a chart incorporating no amendments of navigational significance other than those previously promulgated in Notices to Mariners. It may also contain amendments from other sources provided they are not essential to navigation. Previous printings of the current edition remain in force.

NOTICE TO MARINERS A periodic notification issued by a national hydrographic office or other competent authority regarding changes in Aids to Navigation, dangers to navigation, important new soundings and in general all such information as affects Nautical Charts, Sailing Directions, Lightlists and other nautical publications.

From these definitions, it is obvious that Reprints are produced only to keep charts on the shelves and to reduce the chart correction workload which is derived mainly from Notices to Mariners. From experience, it is well known that when the correction workload exceeds a certain number, it is more economical to reprint the chart than to carry on with corrections which are highly labour intensive. This number of course is dependent upon distribution and complexity of the correction. It is not necessary that the mariner purchase a new reprint provided that the copy being used is maintained through Notices to Mariners.

New Editions are produced to incorporate large changes such as new surveys, to convert charts to metric units and in recent times to convert to the new Canadian Buoyage System (IALA System — Region B). It is not CHS practise to produce New Editions and force the mariner to purchase a new chart unless a New Edition is warranted because of a major change.

Due to the rescheming that has gone on over the past seven years, the change to A0 paper size for standard navigation chart, new surveys of areas not previously surveyed, changing traffic patterns, etc., there has been considerable emphasis on producing New Charts. There has however been a scarcity of resources to meet this requirement in an optimum manner.

Considerations

In addition to dredging, aid changes, siltation and other apparent changes, some of the other factors that render existing charts obsolete and that must be considered in chart recycling are:

(i) increasing ship drafts and patterns of shipping;
(ii) an increase in the number of recreational boaters;
(iii) changing fishing areas for commercial fishermen;
(iv) new requirements such as the need to better delineate continental margins;
(v) changing technology such as more accurate positioning, side scan sonar, electronic sweeping and ocean mapping that provide a better opportunity to obtain more detailed depth and bottom information.

Analysis

In an attempt to explain and justify an optimum recycle time for charts on a national basis, hence a required level of effort, charting areas in Canadian waters were divided into the following four categories:

(i) **Areas of minimal cultural change such as the Arctic** — Even in these areas, in a fifty-year time frame, reprographic materials begin to deteriorate, survey methods change and there are enough changes in shipping lanes and traffic patterns to require the recompilation of charts. For example, on charts produced in the 1930's, the shoreline and terrestial features were derived from obsolete photographic methods and soundings were obtained for the most part by leadline. In addition, in this period the survey danger line changed, the symbology changed, the units of measurement changed from feet/fathoms to metres and the policy on bilingual text was promulgated. The Canadian Hydrographic Service has approximately 400 charts fitting into this category. In addition to the fifty-year New Chart (NC) cycle, a 25 year New Edition (NE) cycle and a ten year Reprint (R) cycle are required to correct charts from resurveys and revisory surveys and to keep charts on the shelves. Charting activity from these areas translate to 8 NC, 8 NE, and 24 R / annum. (see Figure 1.)

(ii) **Settled areas with no rapid change in cultural features and no rapid change in the sea floor due to siltation, etc.** These charts are in areas where there are changes in navigation aids and quite frequent Notices to Mariners. There are approximately 320 charts fitting into this category with a 25 year New Chart, 10 year New Edition and 5 year Reprint cycle required. The charting activity is detailed in Figure 1.

(iii) **Charts named in the Charts and Publications Regulations to the Canada Shipping Act.** These are charts of the main shipping routes and major harbours. There are frequent revisory surveys, frequent aid changes, and considerable cultural activity, i.e. new facilities, etc. in these areas. There are 139 charts in this category and the charting activity is outlined in Figure 1.

(iv) **Charts in areas of high siltation.** There are approximately 180 charts in areas of high siltation where resurveys in some instances must be carried out as frequently as once/annum. These areas include the Miramichi River, St. John Harbour, St. Lawrence River, Gulf of St. Lawrence, Fraser River, McKenzie River, etc. The charting activity is outlined in Figure 1.

Figure 1
SUMMARY OF REQUIRED CHART PRODUCTION ACTIVITY

Category	Number of Charts	Cycle NC	Cycle NE	Cycle R	Quantity/Annum NC	Quantity/Annum NE	Quantity/Annum R
(i)	400	50	25	10	08	08	24
(ii)	320	25	10	05	13	19	32
(iii)	139	12	05	02	12	16	42
(iv)	180	10	04	02	18	35	45
TOTAL	1,039				51	78	143

NOTE
In computing the required output/annum, it is assumed that New Charts, New Editions and Reprints are all interdependent i.e. if a "stock situation" is satisfied by a New Chart or a New Edition then a Reprint is not required for that particular stock situation.

For the Canadian Hydrographic Service, if one compares the information derived in Figure 1, and our chart production output, the following facts become apparent:

(i) Our New Chart (navigation charts only) output per annum over a 17 year period (1967-83) has been 23 charts. This is clearly well below the optimum output and this is borne out by the fact that many charts in our folio are old and need replacing.

(ii) Our New Edition output for the same period has averaged 86 charts/year. This is close to the required output but does show that in some instances for the sake of expediency we are producing New Editions rather than New Charts.

(iii) Our Reprint has averaged 115 charts/year. This is below the computed level but not considered significant.

In analyzing the information, it is apparent that we should produce more New Charts. This is borne out by the enumerated points above and by the fact that although we have been attempting to convert charts to a metric and bilingual format since 15 and 12 years respectively, at this time only 20 per cent of our charts are in metric units and only 35 per cent bilingual.

In conclusion, it is felt that the main problem is in our inadequate production of New Charts. This problem will be somewhat alleviated through advances in technology and more rapid production but the fact remains that to satisfy our New Chart output, we require at least 25 additional cartographers or continuing funds to have this short-coming alleviated through contract activities.

Message from the President

As I mentioned in the previous edition of Lighthouse, I intend to keep the membership abreast on the progress being made by the various committees on a number of proposed changes:

A permanent address has now been established in Ottawa for all Canadian Hydrographers' Association correspondence.

I have asked the Editor of Lighthouse to negotiate with Erindale College in Toronto to see if it would be feasible to have our Journal prepared and printed by the College.

The Committee assigned to re-write the Constitution now has a first draft completed and this is being circulated to Branch Vice-Presidents for comment.

Further affiliation between the Canadian Institute of Surveying and the Canadian Hydrographers' Association may be beneficial to both our Organizations. The surveying and charting community would be better served if there was a higher level of co-operation between the various disciplinary organizations. This view was expressed at a recent Canadian Institute of Surveying Workshop.

No National Budget can be completed at this time in order to justify dues. Once the Editor of Lighthouse has determined the cost involved in the production of our Journal at Erindale College, this will be finalized. It is my opinion that dues should be standard in all Branches and be collected by the National Office if we are ever to achieve professionalism within our Association.

I would hope that your Branch Representative will come to Halifax in April 1985 prepared to discuss and resolve some of the above issues.

J. Bruce
National President

An Interactive Graphics *Editor* for Hydrography

By
Herman Varma

ABSTRACT
An extensive software package has been developed in the Atlantic Region that permits fast, user-controlled, efficient processing of bathymetric data. It is designed so that the data file contains all survey parameters collected at sea. The file permits all sounding data from any portion of the survey to be conveniently displayed and interactively edited. Changes are not only registered on the field sheet file but also on the preliminary day files collected in the field each day.

Hydrographic shipboard data must be processed to be useful, and this is usually best done using interactive computer software. The data processing consists of converting navigation data for plotting on a given projection, correcting depth data for tides, velocity, etc., plotting, editing, and sorting, and removing overplots. Frequently, data from previous surveys have to be merged and verified in conjunction with the present work and then replotted. The data must be reduced in a reasonable amount of time to plan ongoing survey activities, to ensure that the data is error free, and to verify that adequate bottom coverage has been obtained.

A problem that CHS Atlantic had to wrestle with was the feeling by some of its personnel that they had no control over the digital data. The situation came to a head with M.V. *Maxwell* was doing a channel survey of the Miramichi River in July 1982. It appeared that the channel soundings were being suppressed during the removal of the overplots at the scale of the survey. As a result of this experience, the Development Group at CHS Atlantic introduced an interactive editor.

The editor developed gives fingertip control to the user, who interacts with the system by typing on the keyboard, pointing a cursor at commands or expressions on the screen, or using an asynchronous mixture of the two. In particular, any material displayed on the screen can be selected and then treated as though it were input (i.e., typed or written). In this manner, the field sheet file and day files are consequently updated.

The ability to select or point at material currently displayed and cause it to be treated as input is frequently useful. Bathymetric data can be changed, moved, suppressed, or unsuppressed by utilizing the graphic cursor and menu displayed on the screen. One function allows the user to point to an area of soundings and have the software flag the shallowest depth within a given tolerance. If the hydrographer is not satisfied with the selected value, an alternate can be selected. The most significant feature of the program is its capability to identify where soundings came from and when they were collected (Figure 8).

THE DATA BASE
In order to implement the features of the editor, it was necessary to design a data base successfully. A Data Base Management System by definition is "the data processing system providing the means to access, organize and control all information stored in the data base." Beginning with this definition from the April 1971 report of the CODASYL DATA BASE task group, CHS Atlantic analysed its data requirements and set about designing a data base.

Data base designs implemented in the past few years have often seemed to bog down in the syntax and technology of the chosen D.B.M.S. Lost in the shuffle were the user and the application — the reason for being of the whole exercise. The goal of our data analysis was to examine the data currently residing in our dayfiles and, step-by-step, convert them into a detailed model of how the features of the planned system should interact. The process was mechanical, but the results had major implications upon the file design.

Modifications to existing programs (ODTDU, HYSOR, and FDATA) were both straightforward such as expanding the length of the field and more complex such as adding new fields with increased functional complexity. The hardware utilised in the design of this system was the H.P. 1000 series computer with H.P. 7900 and H.P. 7906 disk drives, and the H.P. tape drives and a TEKTRONIX 4015 scope. The time required to run the three programs incorporating 35,000 soundings on the H.P. 1000 system was about 2 hours. However, in benchmark tests, the H.P. A900 (the latest generation H.P. computer) ran the same number of soundings in under 3 minutes. These programs and the file structures are described below.

The ODTDU program scans a set of Day files as indicated by the user. The program then windows soundings according to the geographic constraints specified by the user and transfers the selected sounding, time, Northing, Easting, Tide, Type of sounding (shoal, line, checkline), launch I.D., Julian day, year, ship identifier, and record number of the day file to magnetic tape. After the scan, the user is asked by the program if another set of Dayfiles for a different year or vehicle is to be scanned; if so, these records are appended to the magnetic tape.

Upon termination of the scan program, HYSOR is run. This program creates a number of slot files (1 decimeter each in northing — no limit in easting) and sorts the data in each file in ascending order using the Universal Transverse Mercator Northing as the key value. The maximum number of soundings for a particular slot is presently 32767. A full disc (the H.P. 7900) is used for the slot files and, if over 50,000 data points are to be sorted, a second disc is presently required. The data is read from magnetic tape and written to the appropriate slot file. Each slot file is then sorted and written to another magnetic tape.

The final program, FDATA, reads from the magnetic tape the sorted data generated by program HYSOR. It then eliminates overplots that range within the percentage of the character size, biasing the selection to the least depth. Soundings not selected are flagged and kept within the file.

All three of these programs are scheduled and run in turn by a controller program called SUPPR. This program creates an answer file for the user. It also passes information from one program to the next (i.e., number of soundings read from ODTDU to HYSOR). A section file is then created by a program called FSECT. The section file (2 × 3 decimeter U.T.M. grid pattern) is for a particular survey area, one that encompasses all field sheets to be used in the project). The U.T.M. limits for each grid are represented by one record in the file. This file is utilized later when the various data are linked and also when they are accessed. The first two records of the section file of 80 characters each contain the limits for each 2 × 3 square decimeter section. The number of sections is determined by the overall limits and scale of the survey area (maximum of 700 per 2 × 3 square decimeter sections). This file is archived along with the data files.

The program that performs the links between soundings that use the section file is called PUILD. It opens up a final plot file and links each set of file records common to a particular part of the section file. The program will do the initial link or relink the records if the original section file is lost. The last six header records of the data file are allotted for saving the section numbers and the first record number of the data within that section.

FILE STRUCTURE

The final plot file is a random access file, which enhances file access and speed. Its records presently consist of Northing, Easting, sounding, time in seconds, Julian day, year, launch identifier, type of sounding, tide, record number of day file, ship identifier, and position links. This record length will be extended in 1985 to incorporate error ellipse parameters, velocity corrections, time stamp, time links, and memory tombstones. The memory tombstones are necessary to maintain the initial position and the value of a sounding moved or changed via the interactive editor. The time stamp gives the time when this transaction took place. The time links facilitate track plotting, such that a data processor would be able to obtain a set of track plots without going back to the Day files. The error ellipse parameters give an additional facet to the many ways to view data from this type of file. The processor was previously unable to distinguish between different types of positioning systems, and had to be careful that overlaps between field sheets plotted at different scales did not incorporate soundings from a less accurate system. With the present file structure, the processor can dictate the level of accuracy required to portray soundings on a field sheet at any scale. All soundings outside the positional criteria are not to be plotted.

These extensive records were added to increase the flexibility of data processing. Should an error be detected in, for example tides, the user can rectify it in his final plot, and his correction will be echoed back to the Day files simultaneously. This capability eliminates the costly reprocessing of data from source files.

THE INTERACTIVE EDITOR

The interactive editor (PROGRAM TAEDT) accesses this final plot file and displays all the soundings within a user-defined area (maximum size 20 cm in Northing and 30 cm in Easting), and allows the user to edit the sounding data by changing, deleting, moving, or identifying particular depths. The user can control the information by defining the minimum and maximum areas using the cursor and displaying the information at a larger scale. This is useful when cluttered plots are the norm. In addition, the user can update the screen by redrawing the information after editing or by specifying new limits by choosing areas adjacent to the displayed area with the "auto limits option" or by entering the new limits in Northing-Easting via the terminal. The "continue option" allows the user to specify the maximum number of depths to be displayed and then display another block (e.g., if 100 depths are displayed initially, the next 100 depths can be displayed by specifying

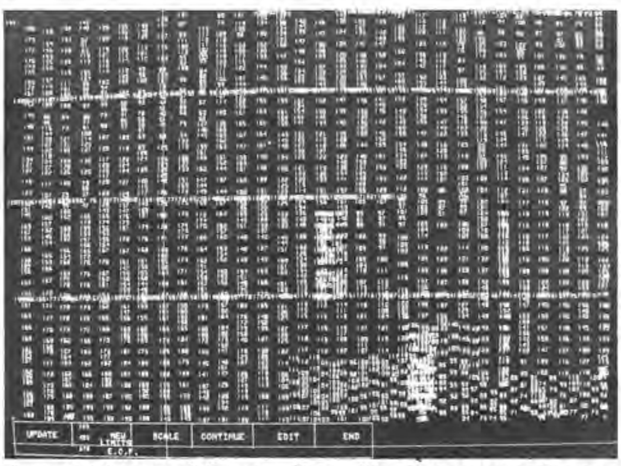

Figure 1: Displays all the soundings without any suppression on a Tektronix 4015 scope.

"continue"). These options — UPDATE, NEW LIMITS, SCALE, CONTINUE, EDIT, and ENDPROGRAM are chosen using the CRT cursor and the menu.

Since as much of the utility of the system described in this paper rests on visual effects, it is difficult to transmit the feel and smoothness of the system through words. Therefore the form chosen for presenting the system in this paper is to take the reader through a sample session with the system, using frequent "snapshots" of the display as a substitute for the actual display itself.

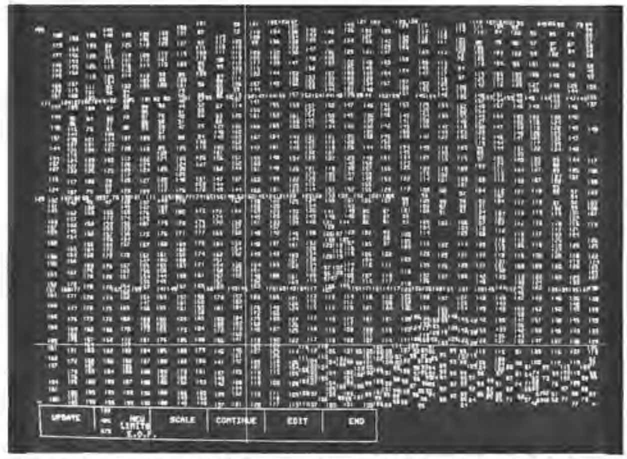

Figure 2: Displays all the soundings with the overplots removed with a least depth bias.

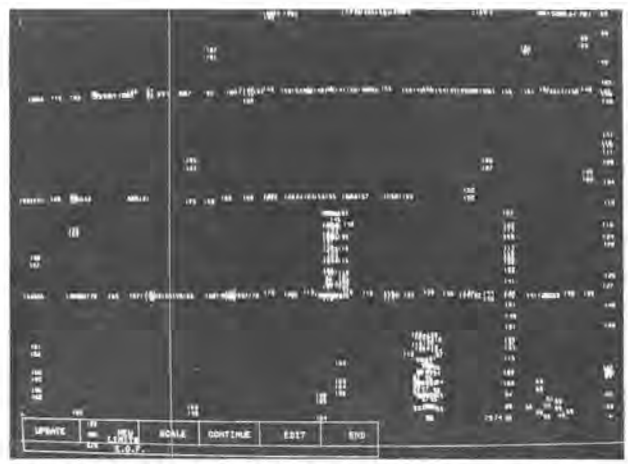

Figure 3: Displays all the soundings that were flagged as deeper overplots.

The next 3 (figures 4, 5, 6) display the power of the editor in blowing up sections of the screen. The cursor was first placed in the menu at the 'scale' box, a key was depressed. The cursor was then moved to the bottom left of a cluster of soundings. The cursor was then moved to the top right of the cluster of soundings and another key was depressed. The immediate result is then displayed in the third snapshot.

The next sequence of photos show the editing capabilities of the editor. All edits update the Field Sheet file, and the same edits are reflected in the day files, collected during the field season. This feature maintains data integrity at the source as well as at the field sheet level.

The cursor is moved into the 'edit' box in the menu, a key is depressed. The program now goes into edit mode. The graphic

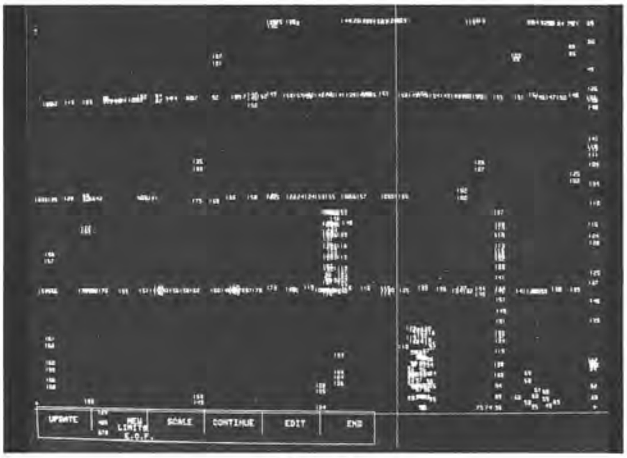

Figure 4

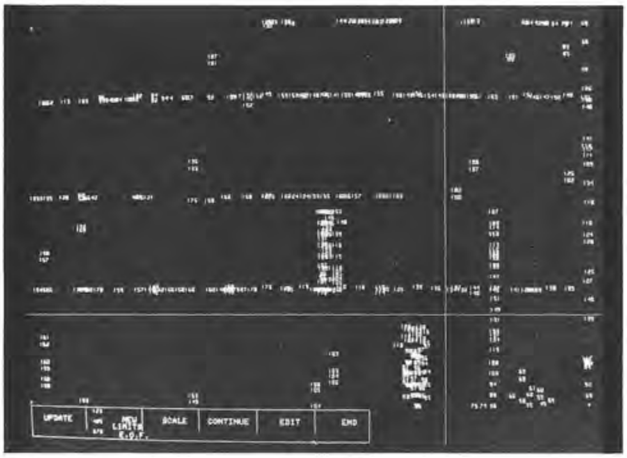

Figure 5

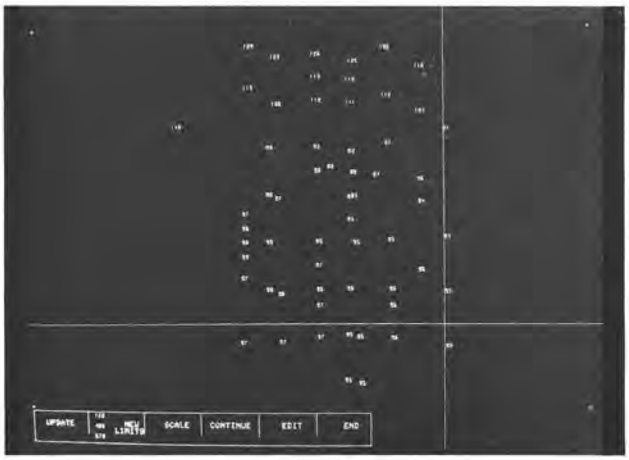

Figure 6

cursor was then moved onto sounding 141 (Figure 7) at the bottom left of the screen. The sounding is identified by pressing key L. The output on the line printer or decwriter is listed in Figure 8.

Several other sounding ID's were obtained in order to show the reader the different types of information that can be had.

With the cursor remaining on sounding 141, the user can press the 'C' key in order to change the value of the sounding to 778 as is seen in the next snapshot (Figure 9). The edits are constantly being reflected on a list device as seen in Figure 10.

Figure 7

HERON TIME 12 47 10	BAFFIN SABLE I BRUCE MACGOWAN N E POSITION 5499110 652987	HYDROGRAPHER DEPTH 1410	TIDE	YEAR84 5
DATA TYPE LINES	F S FILE P0000 DAYFILE D33192			
HERON TIME 15 06 50	BAFFIN SABLE I BRUCE MACGOWAN N E POSITION 5499116 653736	HYDROGRAPHER DEPTH 1132	TIDE	YEAR84 8
DATA TYPE LINES	F S FILE P0000 DAYFILE D33192			
HERON TIME 10 11 26	BAFFIN SABLE I BRUCE MACGOWAN N E POSITION 5499264 654091	HYDROGRAPHER DEPTH 1071	TIDE	YEAR84 11
DATA TYPE SHOAL	F S FILE P0000 DAYFILE D33195			
FRIGATE TIME 14 27 45	BAFFIN SABLE I RICHARD PALMER N E POSITION 5498524 655373	HYDROGRAPHER DEPTH 1330	TIDE	YEAR84 6
DATA TYPE LINES	F S FILE P0000 DAYFILE D36195			

Figure 8: A List of Identified Soundings

Figure 9

SDNG	5499110	652987	1410	CHANGED	TO	7780	FILESP0000	D33192
SDNG	5498217	652241	1971	CHANGED	TO	1458	FILESP0000	D33192
SDNG	5498356	652238	1884	CHANGED	TO	1670	FILESP0000	D33192

Figure 10: A List of Changed Soundings

In the next photograph (Figure 11 & 12) a series of soundings are deleted using the 'D' command. The list device reflects the edits made in Figure 13.

The user can then exit the edit mode by hitting the "F" key (finished), and can proceed in display mode. The display overplot removed mode is enabled, and the soundings that were deleted in the previous section are portrayed (Figure 14) along with the rest of the overplots.

The cursor is then moved onto sounding 778 (Figure 15) in edit mode, and key "C" is depressed. This action unsuppresses the sounding. If the screen is refreshed as is seen the next snapshot (Figure 16), the sounding disappears from the suppressed

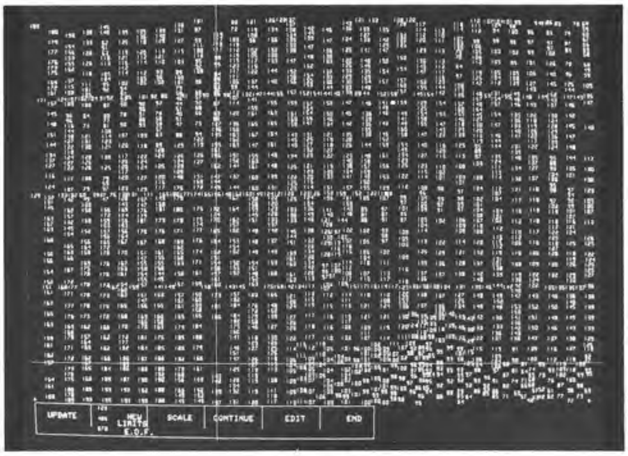

Figure 11

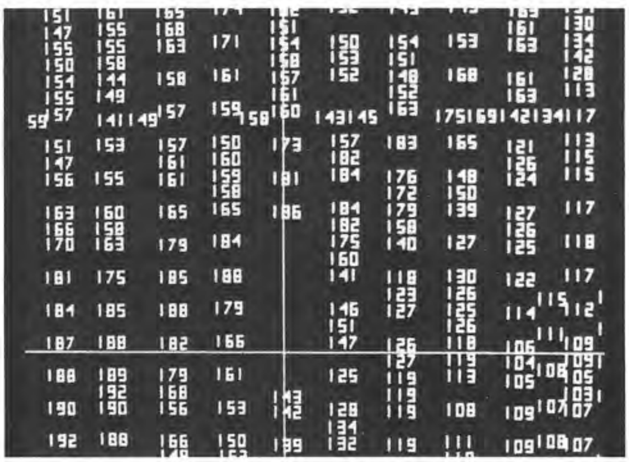

Figure 12

SNDG. DELETED	5499626	652987	1880 FILESP0000	D33192
SNDG. DELETED	5499557	652987	1720 FILESP0000	D33192
SNDG. DELETED	5499488	652987	1560 FILESP0000	D33192
SNDG. DELETED	5499250	652987	1450 FILESP0000	D33192
SNDG. DELETED	5499110	652987	7780 FILESP0000	D33192
SNDG. DELETED	5499095	652985	1370 FILESP0000	D33192

Figure 13: A List of Deleted Soundings

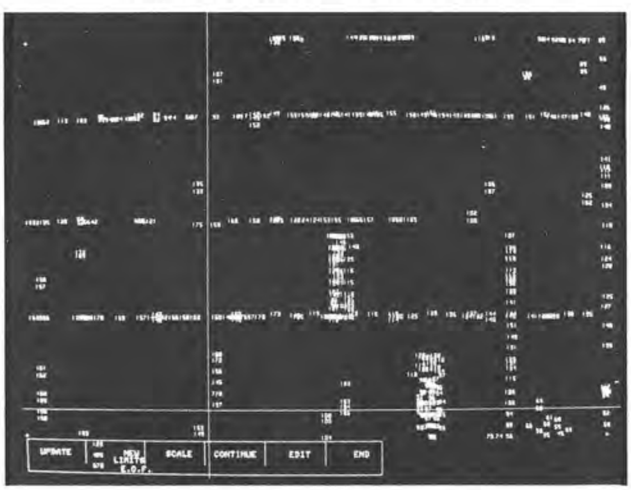

Figure 14

sounding. When the screen is put in clear file mode sounding, 778 appears on the screen with the rest of the no overplot file (Figure 17).

Figure 15

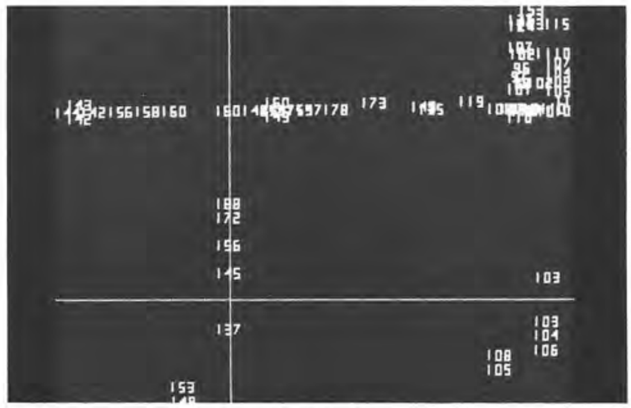

Figure 16

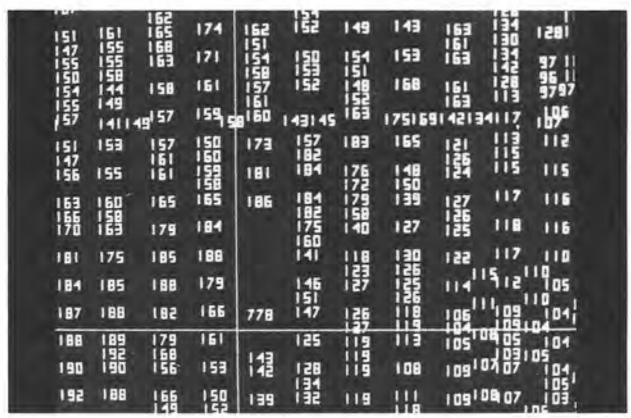

Figure 17

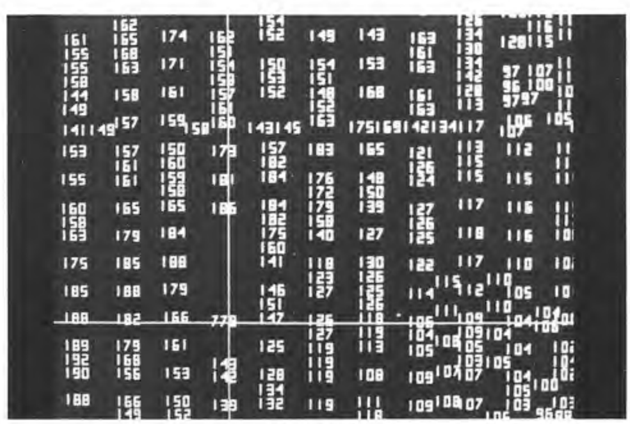

Figure 18


If weather data is important, you want
ACCURACY and RELIABILITY
AANDERAA AUTOMATIC WEATHER STATION
A dependable, high quality weather station designed for remote locations. It can be set up to operate as a recording and/or VHF telemetering station, or interfaced to a satellite. Easily assembled and installed, it can be land-based or buoy-mounted. It uses very little power; both battery and solar operated versions are available.
In the Aanderaa tradition, this station is built of fine quality hardware, produced with expert workmanship. It provides for up to eleven sensors for air, ground and water data. Hardware, service, and calibration is conveniently provided by Aanderaa in Canada.
Let's get technical
Tell us your specific requirements. You'll find our system is adaptable to all kinds of applications.
See for yourself
We'll be pleased to show you how our weather stations work on location. Call or write to arrange a demonstration.
STANDARD SENSORS AVAILABLE ARE AS FOLLOWS:
Wind Speed
Wind Direction
Air Temperature
Air, Soil and Water Temperature
Three new, high quality sensors manufactured by Aanderaa Instruments
RADIATION SENSOR 2770
Highly sensitive measurement of incoming solar and sky radiation under all weather conditions.
RESOLUTION: 0.4 mW/cm²
ACCURACY: Better than ±2 mW/cm²
RANGE: 0-200 mW/cm²
AIR PRESSURE SENSOR 2810
A barometric pressure sensor with practically no hysteresis, no temperature effect and no ageing.
ACCURACY: ±0.3mb
RESOLUTION: 0.2mb
RANGE: 850-1050 mb
RELATIVE HUMIDITY SENSOR 2820
Accurate measurement of relative humidity, even at very low temperatures.
ACCURACY: ± 4.0% RH
RESOLUTION: 0.3% RH
RANGE: 0-100% RH
OPERATING TEMPERATURE: −35°C to + 65°C
AANDERAA INSTRUMENTS LTD.
560 Alpha St., Victoria, B.C. V8Z 1B2
Telephone (604) 386-7783 Telex: 049-7390
Data collecting instruments for land, sea and air
2770
2810
2820

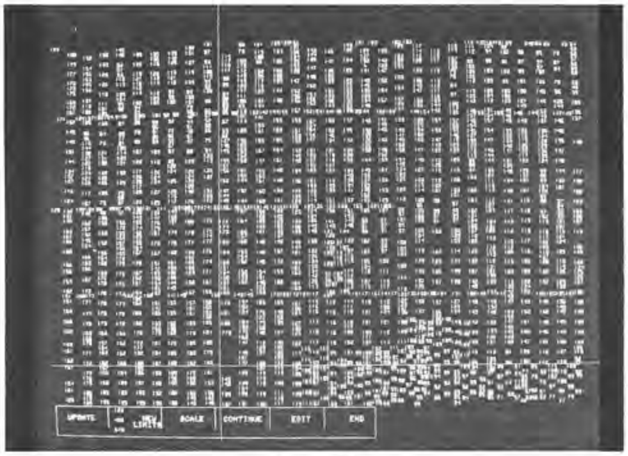

Figure 19

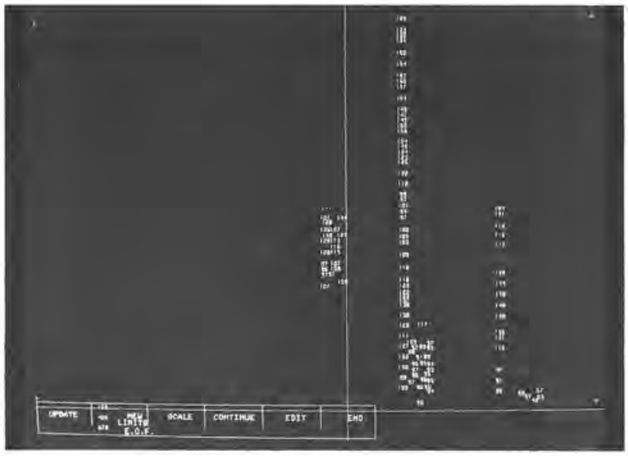

Figure 20

The program is then put into edit mode and the cursor is moved onto sounding 778 (Figure 18). The Move Key (M) is then depressed. The cursor is then moved to the desired location and Key M is depressed again. When the screen is refreshed, sounding 778 will appear at the desired location (Figure 19).

The final picture (Figure 20) displays soundings that are only shoal examinations. The editor has the capability to portray all soundings or selected soundings, i.e. shoals, lines, checklines.

In conclusion, the interactive editor has been found to be a true man machine interface which has put the user back in control of his data. Such an interface will prove to be a true companion to most hydrographers and cartographers. With this final word this paper can be terminated with a quote from Aldous Huxley "Welcome to a Brave New World".

The Second International Hydrographic Conference

The tremendous success of the first International Hydrographic Technical Conference (IHTC) held in Canada in 1979 led to a resolution at the FIG Congress in Switzerland recommending a second IHTC be organized by the United Kingdom. The U.K. met the challenge by holding an equally successful conference in Plymouth, England from September 3 to 7, 1984. The four and one-half day conference, organized by The Hydrographic Society in collaboration with The Royal Institution of Chartered Surveyors, was a well balanced mix of carefully selected papers, numerous exhibits of the latest in technology and services, and a most entertaining social program.

There were approximately 45 papers presented ranging from the very philosophical to the very technical. Five of the papers were presented by Canadian authors.

The discussion that followed each and every paper was a distinct highlight of the conference. The positions and opinions that were expounded from the conference floor were often lively and entertaining. R.Adm. G. S. Ritchie (Rtd) could always be counted on to provide the right comment at the right moment to stimulate the discussion.

The technical exhibits provided an excellent opportunity to observe and discuss the latest developments. It was particularly beneficial to delegates from North America to see the equipment being developed and used on the other side of the Atlantic. About 35 exhibitors were on site and were only too willing to discuss their products and services.

Put 400 hydrographers together and the social program is bound to be a success. And a success it was with numerous dinners, cocktail hours, etc., etc.

All in all it was a conference well worth attending and Mike Wright and his merry crew are to be commended.

CHA/CIS WORKSHOP ON HYDROGRAPHIC DATA PROCESSING

A jointly sponsored workshop was held in Ottawa on November 5th and 6th, 1984. The seventy-five individuals that attended were from several government departments and included a large contingent from private industry. The presentation covered a broad range of topics including existing techniques and some of the new technologies currently being developed for data acquisition, processing, and data presentation. The workshop ended with an interesting session on the electronic chart. Speakers were equally divided between those from federal agencies and those from private industry and universities. Certificates were awarded to all participants on behalf of CHA/CIS and it is hoped to organize another workshop on computer-assisted cartography.

NEW HYDROGRAPHIC SURVEY CATALOG

A definitive international catalog of currently available hydrographic survey equipment has been published by The Hydrographic Society in association with the UK Royal Institution of Chartered Surveyors.

The 350-page publication covers integrated survey and positioning configurations, echo sounders, swathe sounding systems, sonars, tide gauges, swell compensation units and current meters. Full technical details and operating characteristics of systems within each of the eight categories are given, with equipment listed on each section by manufacturer in alphabetical order.

Copies of the catalog are available post-free at $20 each from the US Branch of The Hydrographic Society, PO Box 732, Rockville, Maryland 20851 (Tel: 301-443 8232).

Editor's Note — While Memory Serves

Due to a misunderstanding the name of the author of the article "While Memory Serves" was omitted when it was published in Edition No. 29, April 1984. The author of the article was Bruce Wright of the Central Region, Canadian Hydrographic Service and the Editor apologizes for this oversight.

The Advantages of Using a Ship as a Dynamic M.R.S. Station

By

G. W. Henderson, C.L.S. and H. P. Varma

Canadian Hydrographic Service
Atlantic Region
Dartmouth, N.S.

ABSTRACT
In the 1981 field season a relatively new system was tested. It involved the mounting of an M.R.S. transponder on a ship. The ship would be positioned by M.R.S. or R.P.S. from shore stations, and in turn would provide a dynamic station which would position launches using it and a shore station. This paper will discuss the advantages of this system in relation to control, and improved accuracy with respect to geometry. There is also the possibility of using the ship and two shore stations to provide better accuracy, and also eliminate baseline crossing problems. With full data logging capabilities this system will be completely user oriented. At the time, we had only one data logger aboard the ship, the launch positions being entered manually.

INTRODUCTION
As part of Atlantic Region's 1981 field program, C.S.S. BAFFIN was required to survey an area around Ballard Bank, off the southeast coast of Newfoundland, and to run a number of sounding profiles at each end of Sable Island. The Cape Race area posed the problem of sparse existing control on a heavily wooded, convex coastline, whereas the Sable Island project presented difficulties in achieving acceptable two range fix geometry due simply to the configuration of the land feature itself.

These problems led to the development of a method for using the ship as a dynamic station, which was directly incorporated into the Region's semi-automated data processing system. It was also recognized that, to meet future needs, the system had to be flexible enough to be adaptable to fully automated, multi-ranging survey operations.

SYSTEM DESCRIPTION
The first function of the system was to log two observed ranges against time to establish the ship's position. The logging interval was user specified anywhere from once per second to once per hour.

The second function of the system was to establish the position of a launch using two measured ranges, one from the ship and one from a shore station. To assist the launches in their sounding operations, and to aid in housekeeping during data processing, an initial approximation of the ship's position was established using the first few logged ranges. This position (PA) was then used as an arbitrary reference point, stored in the stations file, along with all the shore control, and was used as the reference station for subsequent processing.

The third and final function of the system was to adjust all the ship based ranges to ranges referenced to the arbitrary postion, P.A. This merely entailed working the inverse between the computed launch position and the P.A.

HARDWARE
The following hardware requirements were designed to take the fullest advantage of equipment already on hand:

(i) An R.P.S. ranging system for positioning the ship;
(ii) An M.R.S. ranging system for positioning the launches;
(iii) An HP 21MX-E computer system;
(iv) An HP 9815 programmable calculator, with BCD and HP IEEE 488 interfaces;
(v) An in-house built interface to couple the R.P.S. to the HP 9815 via the BCD interface; and an H.P.I.B. to interface the HP 9815 to the 21MX computer.

SOFTWARE
Since the software package for using the ship as a dynamic station required the use of an HP 9815 programmable calculator to interface the ship positioning system (R.P.S. or M.R.S.) to the HP 21MX-E computer for logging time and ranges, parallel programs were developed for both machines.

The R.T.E. clock of the H.P. 21 MX-Ecomputer acted as a trigger to the HP 9815 calculator via the HP interface bus. The calculator, in turn, would interrogate the R.P.S. interface box and send the two ranges to the HP 21 MX-E via the H.P.I.B. The computer would log these ranges and the time on the HP 7900 disc platter, after which the program would go dormant until the R.T.E. clock reached the next logging interval, at which time it would re-activate and trigger the calculator, thus repeating the process.

A default option was included so that instead of logging on a disc platter, it was possible to record on magnetic tape cassettes on the HP 9815. However, the calculator had to be triggered by the RTE clock, since it has no real time clock, and it took approximately 2 seconds to record on cassette tape due to the mechanics of the tape device. Consequently, data was logged exclusively on the 7900 disc platter.

Obviously, this hardware arrangement was very cumbersome due to the limitation of using equipment already on hand, but many microcomptuers and calculators on the market today have real time clocks and faster recording rates, which would enable them to operate this system on a stand alone basis.

SYSTEM OPERATION
Once the R.P.S. and MRS transponders were installed ashore and the ship was in the desired position (either at anchor or on station) for the best geometric configuration, the HYNAV clocks in the launches were synchronized to the R.T.E. clock. The logging interval used for the ship's position was 10 seconds, due to the unknown drift and swing rates for the ship. As will be seen later, this logging interval worked out very well due to a filtering routine that was employed in the post processing.

The launches, then, would enter the approximate position of the ship into the HYNAV units and conduct their sounding operations in the normal fashion, using the pertinent features of the HYNAV software. If HYNAV, or its equivalent, is not available, then sounding lines may be run along the arcs radiated from the shore station so that control of the lines will not be affected by any motion of the ship around the P.A. When the launch returned to the ship at the end of the day, its MRS fixes were manually key-punched into a temporary disc file.

The logged data was then run through a filter program (FILTR). The number of samples to be averaged was user selectable, and a range gate was applied to flag and reject erroneous readings. This filtered data was stored in a new disc file and was used to compute the final launch positions. This was accomplished by running the temporary file of launch fixes through another routine (RERHO), which adjusted the ranges from the ship to the P.A.

Program RERHO could handle a combination of positioning configurations, i.e. changing from one shore station to another or reverting to shore stations only, and this was controlled by simply typing in the station names at the appropriate locations when keypunching the launch fixes.

The system also used for positioning shoreline by helicopter between Cape Race and Fermeuse on the Ballard Bank survey, and it worked extremely well. The only operational difference was that we had to log the ship's position at a rate of once per second rather than at a logging interval of ten seconds.

ERROR PROPAGATION

Using a simple, approximate, geometric approach for the two-range accuracy lobe and referring to Figure 1, we have:

$$d_1 = \frac{\sqrt{\sigma_{r_1}^2 + \sigma_{r_2}^2}}{\sin \beta_1} = \frac{\sqrt{2}\;\sigma_r}{\sin \beta_1}$$

Then, $$\sigma'_{r_4} = \sqrt{d_1^2 + \sigma_r^2}$$

so that $$d_2 = \frac{\sqrt{\sigma_r^2 + \sigma'^2_{r_4}}}{\sin \beta_2}$$

and, by substitution:

$$d_2 = \frac{\sqrt{\sigma_r^2 + \dfrac{2\sigma_r^2}{\sin^2 \beta_1} + \sigma_r^2}}{\sin \beta_2}$$

Thus: $$d_2 = \frac{2'\sigma_r}{\sin \beta_1} \quad 1 + \mathrm{Cosec}^2\, \beta_2 \qquad \text{(I)}$$

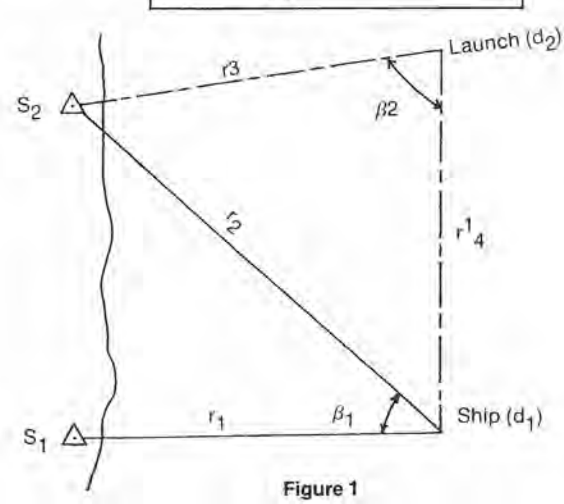

Figure 1

and in graphical form:

Plot of d_2 for given values of β_1 and β_2

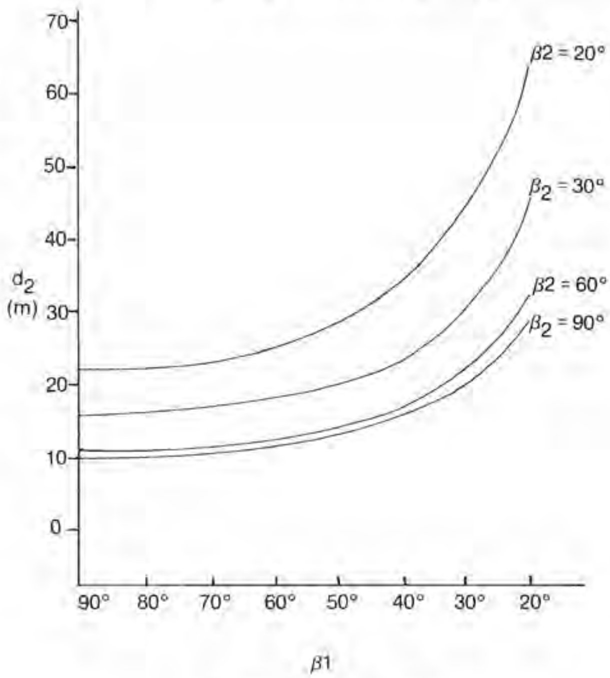

Figure 4 (see also Figure 1).

Thus, one is capable of designing the survey geometry to satisfy accuracy requirements at survey scale, or quickly visualizing the limitations of the method for any given survey area.

FUTURE APPLICATIONS

This system will permit surveying of areas using combinations of positioning systems, multi-ranging techniques and additional survey vessels with a greater flexibility, increased accuracy over larger areas and a great reduction in shore control requirements.

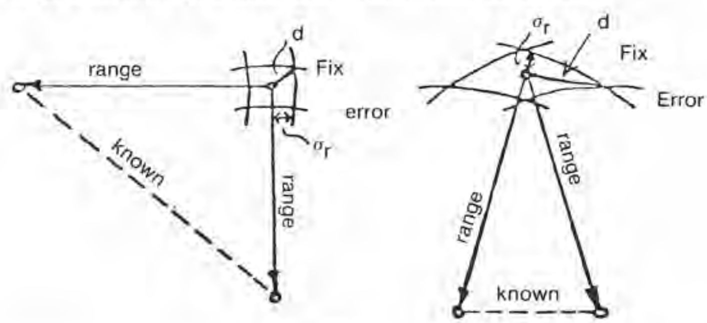

Figure 2

where:

d_1 = semi-major axis of the standard error ellipse for the ship.

d_2 = semi-major axis of the standard error ellipse for the launch.

σ_r = σ_{r_1} = σ_{r_2} = σ_{r_3} = σ_{r_4} is assumed to be ± 5 metres

$\sigma^1_{r_4}$ = is the assumed error in r_4 increased by incorporating d_1.

A more rigorous approach is the combined case of a least squares network analysis, and is the subject of a Technical Report presently being prepared by a Surveying Engineering Student at the University of New Brunswick. This approach is, however, beyond the scope and intent of this paper.

Equation 26, page 52.
* "Surveying Offshore Canada Lands for Mineral Resources Development", Second Edition, Surveys and Mapping Branch, Energy, Mines and Resources Canada, October, 1975.

To give some representative values, rounded to the nearest meter:

Table of d_2 (metres) for given values of β_1 and β_2

		β_1							
		90°	80°	70°	60°	50°	40°	30°	20°
	90°	±10	±10	±10	±11	±12	±13	±16	±22
	80°	±10	±10	±10	±11	±12	±13	±16	±22
	70°	±11	±11	±11	±11	±12	±14	±17	±23
β_2	60°	±12	±12	±12	±13	±13	±15	±18	±25
	50°	±13	±13	±13	±14	±15	±17	±21	±28
	40°	±16	±16	±16	±17	±18	±20	±24	±34
	30°	±20	±20	±21	±22	±23	±26	±32	±44
	20°	±29	±29	±30	±32	±34	±38	±46	±64

Figure 3

Properly applied, it can be used for establishing additional secondary control (e.g. "sounding marks"), providing photo control, and positioning shoreline, cultural features and navigational aids around difficult coastline configurations.

However, as with any new developments, there will have to be expenditures of time and money. Multi-ranging applications will require the acquisition of new ranging systems and more sophisticated loggers. Using combinations of positioning systems and additional survey vessels will necessitate the availability of extra positioning and logging systems. In addition, data processing will require new software to be developed, incorporating least squares techniques, to handle multiple ranges or system combinations.

However, with the success enjoyed by using this system during the 1981 field season, it is felt that any expenditures towards the implementation of this technique will be rewarded many times over by increased efficiency and reduced survey time per project area.

CONCLUSIONS

Although not a new concept, the technique of using the ship as a dynamic station to assist in the positioning of survey vessels permitted the completion of surveys in the area around Ballard Bank, Newfoundland and on each end of Sable Island within a time frame that would have been impossible by conventional methods.

In addition, it has considerable potential for increasing the efficiency, flexibility and accuracy of future hydrographic surveys.

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1. "Surveying Offshore Canada Lands for Mineral Resources Development", Second Edition, Surveys and Mapping Branch, Energy, Mines and Resources Canada, October, 1975.
2. "Comdev Trisponder versus Motorola MiniRanger", Comdev Marine Ltd., November 10, 1973.

Contours and Contouring in Hydrography Part II — Interpolation

By

M. J. Casey & D. Monahan

INTRODUCTION

Mathematical Interpolation is the heart of machine contouring — the rest is purely cosmetic. This is the thesis we follow in this paper. Cosmetics are an important issue — but they are secondary in importance. The interpolation algorithm will determine the shape and course of the plotted contours and THIS is what we care about.

Before becoming immersed in the details of interpolation, let's examine the situation at a HIGHER level. Figure 1 illustrates the main ideas behind interpolation. Figure 1a shows a sequence of measured sounding profiles. This is the data from which we wish to draw our contour map. One can imagine the contours as a sequence of shoreline snapshots — each one taken with the water level at progressively lower elevations. Figure 1b shows the situation at a particular water level — say 10m below datum. The LOWER level problem is this — HOW do we connect-up the protuberances above each water level in a meaningful way?

In order to draw contours we need to predict the behavior of the contours BETWEEN the survey lines. To do so we want depth estimates at regular intervals between the observations. The closer together the depth estimates, the smoother the contours. Figure 1c illustrates one popular approach called GRIDDING. In this method, one drops a UNIFORM GRID over the survey area and, at the grid intersections (called "NODES"), estimates depths by using the observed depths. HOW these estimates are made is the crux of the matter.

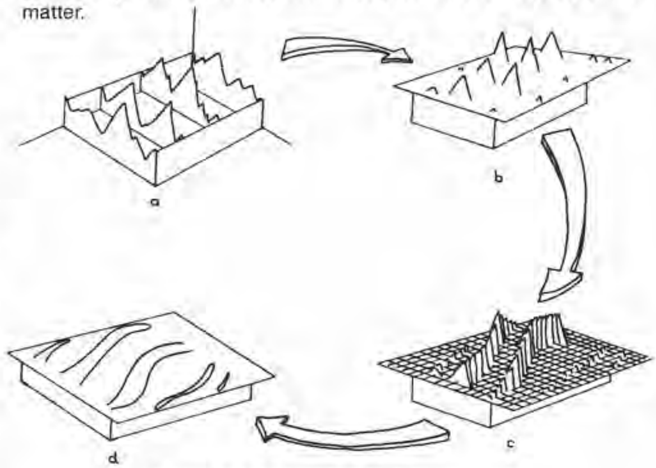


Figure 1: Interpolation and Contouring

WHY GRID THE DATA?

The threading of the individual contour lines through the survey area can be a straightforward procedure if the data is established on a uniform and tightly spaced sampling plan. Contouring a typical field sheet for instance, where the soundings are spaced every 5mm at scale, is relatively straightforward and a set of rules can be established to define the contouring procedure. When the data is sparse however, the rules become less meaningful and, as a consequence, more and more judgement is called for. This becomes a case of INTERPRETATION, not interpolation. Such procedures cannot, in general, be mechanized. To overcome the problem of sparse or non-uniform sampling, researchers have found it expeditious to re-cast the survey so that it would appear to have been sampled in a more convenient manner. DENSITY and UNIFORMITY are the two characteristics of the data which make machine contouring more viable. The uniform grid is an obvious choice but others, including triangulation schemes, are used in practise. We concentrate on gridding because that is the technique with the widest useage and because, in the end, the differences between gridding and its alternatives is often academic.

The actual contouring itself is done by threading the individual contours through the grid. Once depth values have been established for each grid node, these grid nodes can be used as gate posts, allowing or denying access to the INTERIOR of the grid box. If access is allowed, then progressively finer grids can be established inside the main box in order to guide the course of the contour. In this way the contour's apparent smoothness is governed by the fineness of the gridding. Finer gridding can improve the SMOOTHNESS of the contours and make them appear more "realistic". Appearances can be deceiving however. The ACCURACY of the contour position is governed by the survey sampling resolution — not by the resolution of the grid.

There are essentially two main methods for making these estimates, POINT MODELS and AREA MODELS. Point models estimate depths at FIXED points in the area — such as at the grid nodes. Area models, on the other hand, estimate surfaces CONTINUOUSLY over an area. That is, a smooth mathematical function (often a polynomial in 2-Dimensions) is fitted to the data points within an area. This estimated surface then defines depth estimates at EVERY point within the region over which the surface is fitted. Thus the knowledge of the contours' location is continuous — resulting in very smooth contours. Of course, if the surface model is wrong (i.e. if the fit is not very good) then the contours are ALSO wrong.

We now examine these two methods in some detail.

POINT MODELS

Point models estimate depths by linearly combining the surrounding observed data points. That is, the depth at any unobserved point can be "guessed" by a weighted average of the observed depths which fall geographically CLOSE to the unobserved point. Consider Figure 2. In this illustration we see the essence of point

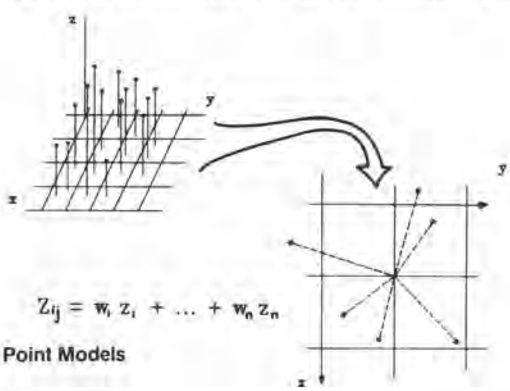


Figure 2: Point Models

modelling. On the x-y plane we have a number of observations. The observations are more-or-less, RANDOMLY located on the plane with no connecting information uniting them. To contour, we want to have values on the uniform grid. This can be accomplished by sequentially marching through the grid nodes and making weighted averages at each grid intersection. In Figure 2b we examine one intersection in detail. The area around the point to be estimated is searched for observations and then these values are used in the weighted average formula. The two issues we should concentrate on are the concepts of NEIGHBOURHOODS and WEIGHTING.

NEIGHBOURHOODS

A typical field sheet contains about 20,000 soundings. How should we use this vast volume of data? In general, the soundings in the lower-left corner of the field sheet can not be used to predict the behaviour of the bottom portrayed in the upper-right corner. In hand contouring, hydrographers examine only those soundings which sit close to the spot where his pen lies. We need some similar mechanism to limit the blind inclusion of excessive and unconnected data.

Neighbourhoods are required to limit the number of data points included in the linear combination. In its simplest form the neighbourhood is defined to be a circular area of user-set radius, centred upon the point to be estimated. Any observations found within this area are included in the computation. Figure 2b shows that 6 observations were found in the neighbourhood of the central grid node. The observations are found by doing a search of the data record and checking each point to see if it falls within the neighbourhood.

Unfortunately, defining the neighbourhood as some simple circular area surrounding the grid node won't always work. Figure 3 shows some of the drawbacks of using a simple, pre-defined, static neighbourhood.

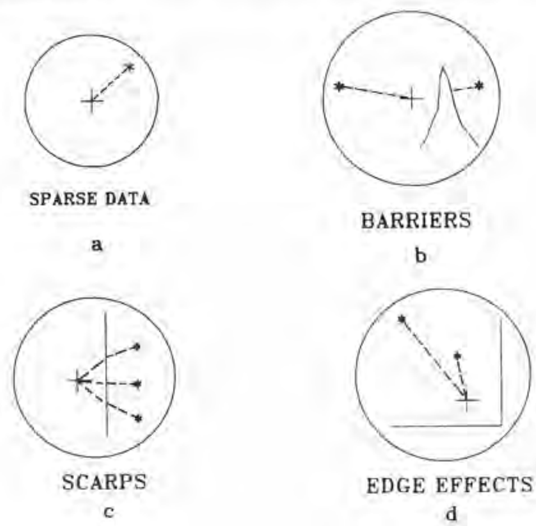


Figure 3: Neighbourhood Problems

In Figure 3a we have the problem of sparse data. In order to include a minimum number of observations in the calculation, some programs expand the search circle in increments until either the required minimum number of points is included or some maximum radius is achieved. Alternatively, if there are too many points in the standard neighbourhood, the radius is reduced incrementally until the maximum number of desired observations is achieved or, until some pre-set minimum radius is reached. Note that the neighbourhood in these cases is independent of the VALUE of the data and is dependent only on its SPATIAL STRUCTURE.

Figure 3b illustrates another common problem — how to include some UNMEASURED information in the interpolation scheme. Here we have a situation where an observation is geometrically close to a grid point — but on the other side of a BARRIER (in this case a point of land). Clearly, the observation indicated should NOT be used in estimating the value at the grid point — even though it falls in the neighbourhood. To overcome this one could sample, digitize and include the shoreline information as observations. But this method is not foolproof since the shoreline points are considered in the same way as all of the other observations — as elements in the weighted average. The real solution is to have some mathematically impermeable barrier through which inerpolation cannot take place. The inclusion of barriers is a feature of many of the more sophisticated contouring packages available on the market.

A similar problem is shown in Figure 3c. Here we have an underwater scarp or cliff. The problem here, again, is that observations made on ONE side of this feature should NOT be included in the estimation of grid point values on the OTHER side. In this particular case, only data points on the LOWER level of the scarp should be included in the estimation of grid nodes there.

The problem illustrated in Figure 3d is one of EXTRAPOLATION, not interpolation. This problem is particularly apparent with polynomial surface fitting procedures and is diagnosed as a very "wavy" appearance of the contours along the edge of the sheet. One solution is to ensure that only INTERPOLATION takes place. This can be done by having the program ONLY contour within a window which is bounded externally by observed depths.

WEIGHTING SCHEMES

In the depth estimation process, weights are applied to the observed data to allow observations of higher "quality" to have a greater influence than points of lesser "quality". This quality feature can refer to the RELATIVE quality of the various depth measurements, but is usually used as a means of ensuring that "closer" observations have a higher weight than observations farther away. In this restrictive sense, quality is a function of the distance between the observations and the grid node to be estimated. The fact that closer observations should have a higher weight than ones farther away is initially appealing, but is NOT universally applicable. This can be seen in Figure 3b where the geometrically closest observation is hidden behind a barrier. Hence, a more sophisticated distance-weighting scheme is required.

The distance weight can be simply the inverse-distance between the observations and the grid node to be estimated but, usually, the INVERSE-SQUARE of the distance is used. This ensures a faster drop-off of the influence with distance. This inverse-square weighting is commonly referred to as the "Gravity Model" — the relevance being the inverse-square relationship between two bodies in Newton's Universal Law Of Gravitation. Note again, that the weighting is independent of the VALUE of the observations but is based on the SPATIAL relationship alone.

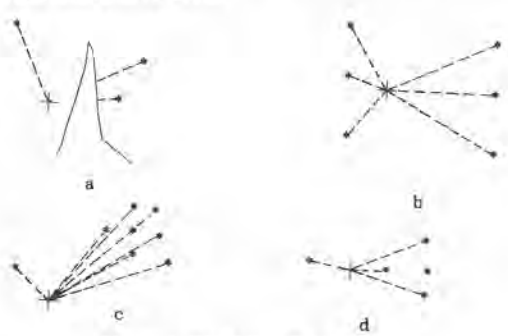


Figure 4: Weighting Problems

Figure 4b illustrates another problem associated with simple distance weighting — TRENDS in the data. The data points on the left hand track will clearly have a greater influence on the estimate than those on the right hand track. Suppose that there is a left-right linear trend to the data with the soundings on the left considerably deeper than those on the right. Then the estimated depth at the point indicated will be DEEPER than it should be. Weighted averaging systems have no EXPLICIT way of handling data which has clear trends in it. Such data sets are better handled by contouring algorithms which model these trends.

CLUSTERING of data points can also place emphasis on the WRONG data. This situation is shown in Figure 4c. The data points to the upper right will have a greater effect on the estimate than the lone point to the left — yet this point SHOULD be included in any estimate. Why? Because firstly, it is CLOSER than the other points and secondly, it acts as a means of DETERMINING trend.

Data SHEILDING is also an important consideration. If one were to hand contour the data shown in Figure 4d, one would NOT consider the values of the data points in the line to the right of the right-hand sounding. This would be inappropriate since the right-hand data point SHEILDS the line data. For instance, if the track data was considerably deeper than the other two soundings then the interpolated depth would be influenced by the nearness of these deep soundings. This would result in a depth estimate which is TOO DEEP — thus showing a depression where one probably does not exist. To get around this problem, one can apply a second level of weighting — DIRECTIONAL weighting. In this case the algorithm must seek out observations within the neighbourhood which are sheilded by other observations. This can be accomplished by examining the spatial relationships of the observations vis-a-vis the grid node, determining the associated angles and de-weighting any observations which fall within the shadow cast by closer observations. Many modern contouring programs feature such directional weighting automatically.

Another of the consequences of simple weighted averages is the fact that each observation is considered as a LOCAL EXTREMUM. That is, each observation is considered to lie on either the peak of a local hummock or the pit of a local depression. This is a direct fall-out from the use of the weighted average. The grid estimates will ALWAYS be bounded by the observations. You can't estimate a value deeper than the deepest observation within the neighbourhood and neither can you estimate one shallower than the shallowest. The effect of this is most apparent when a rugged area is contoured at a close contour spacing. The observations are all ringed by contours. This might make sense for topographic surveying where observations are taken upon the local extrema but it would NEVER make sense in hydrography where we NEVER see the surface we are mapping and consequently the chances of occupying a local peak or pit are slight.

Including some slope information is the way to get around this particular problem. But slopes are not observable in hydrography so they have to be INFERRED. Geomorphogists use EXTERNAL information on the surrounding geology and geomorphology to help them create models for the unseen surface. If this information is not available, then the observations alone must be used to estimate the slopes. Essentially this involves calculating the slopes from the differences in depth of the observations. Several of the contouring packages available commercially offer slope estimation as a program option. Once slope information is available, it can be used to predict extrema other than at the observation points.

AREA MODELS

To overcome some of the above limitations — particularly those which deal with TRENDS in the data — methods have been derived which specifically EXPLOIT these trends to make estimates. Such methods assume that the surface can be expressed as a analytical function — usually a polynomial. Deviations from these surfaces would be classified as noise. Figures 5, 6, and 7 show some examples of analytical surfaces used by surface-fitting programs.

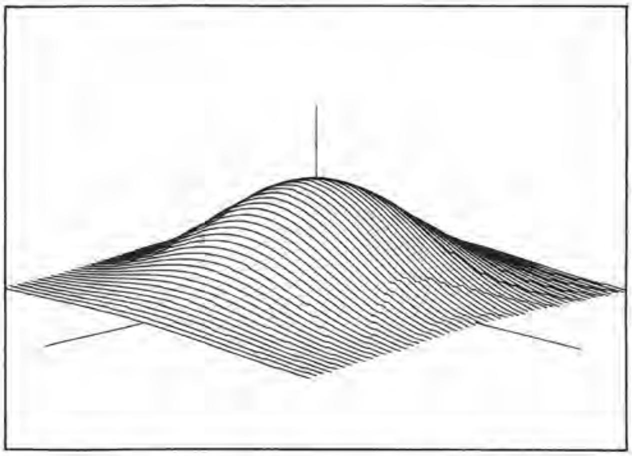


Figure 5: An Exponential Surface

Having the surface expressed as a mathmatical function has certain advantages. Depth estimates can be calculated at ANY position. Once the surface has been fitted, grid estimates at any density can be calculated quickly and easily. The SHAPE of the surface is also, to some degree, predictable. A polynomial surface of the first order would exhibit a constant slope. A quadratic surface (Figure 7) would show concavity — either upwards or downwards, depending on the data. A Fourier surface (Figure 6) would appear periodic.

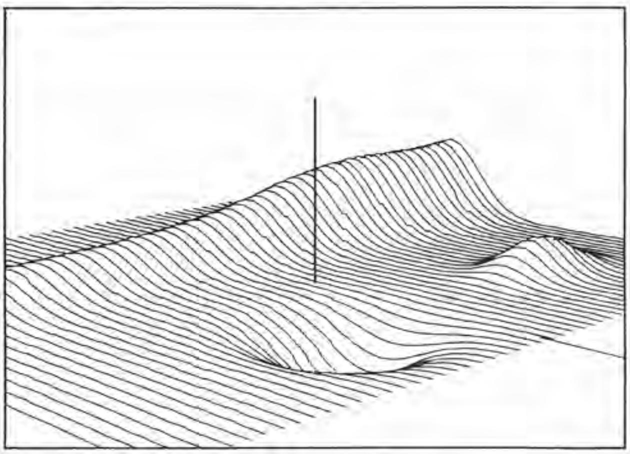


Figure 6: A Fourier Surface

This ability to predict the shape of the surface has some attraction because we are often faced with data which has clear trends which could be exploited by such surface-fitting techniques. On the other hand, if we FORCE a surface onto data which does NOT exhibit such a trend we could introduce artificial features into the surface — for instance, more hollows than actually exist.

In order to gain an appreciation of this problem let's consider the surface shown in Figure 7. This is a bivariate (i.e. a 2 variable), second-order polynomial — a common function used in surface fitting. Fitting functions to data is usually accomplished by using a numerical technique called REGRESSION or, more commonly, LEAST SQUARES. The details of the method can be found in any text on regression, such as APPLIED REGRESSION ANALYSIS (Draper and Smith, 1981).

To fully see the effects that the fitting of such a surface has, it is far easier to examine the graph in TWO dimensions. Let's see what happens in the quadratic case. In other words, we will take a slice (or section) out of a surface like that of Figure 7.

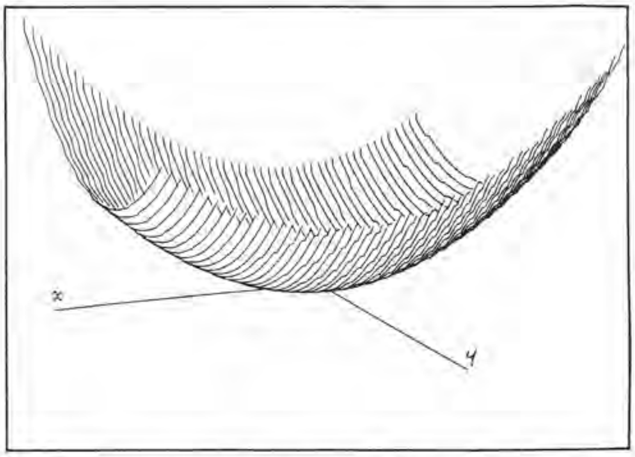


Figure 7: A Quadratic Surface

In Figure 8a we have some data taken from a depth profile to which we have fitted a quadratic curve. We can see that the choice is not a good one. The data does NOT exhibit a significant trend — yet a quadratic one has been imposed. This is important, since the contours will be determined by this ARTIFICIAL surface — NOT the one defined by the observations. Figure 8b illustrates another problem. In this case the data DOES exhibit a trend — a LINEAR one, whereas, again, a QUADRATIC one has been imposed. Depths substantially DEEPER than measured have been estimated. Alternatively, Figure 8c shows a case where the quadratic does fit well.

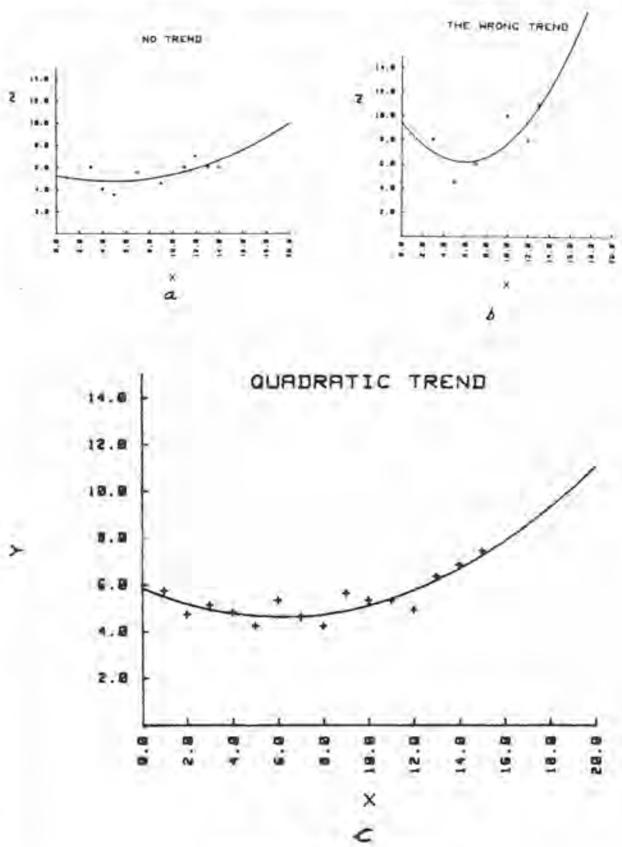


Figure 8: Trend Fitting

Figure 9 illustrates the problem of sensitivity in extrapolation when fitting a polynomial. In this case only the LAST point has been changed. Note the drastic change in the value extrapolated at X=20. Extrapolation is SAFER with distance-weighted averaging since the extrapolated values are bounded by the extreme values in the neighbourhood.

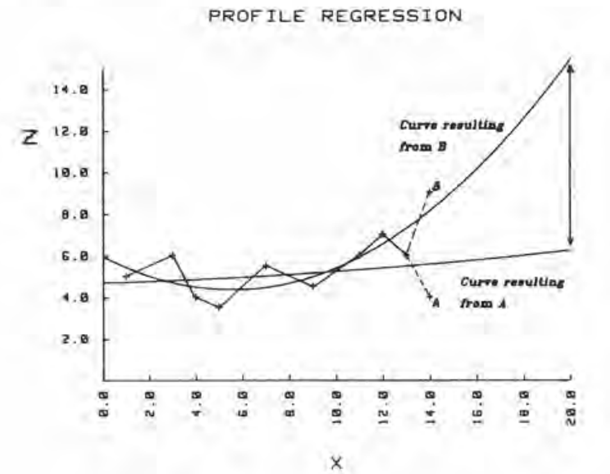


Figure 9: Problems in Extrapolation

Clearly, area-modelling methods ALSO suffer drawbacks. All too often the surface is far too RANDOM to be approximated, even locally, by an analytical function.

AREA vs. POINT MODELS

It will come as no surprise that one method is not clearly superior to another. Point models offer safer interpolation in areas where the bottom undulates randomly about some near-constant level whereas area models are safer where the bottom has a clear trend. Area models are cosmetically cleaner and more efficient in storage space and in execution — but these are, by and large, irrelevant issues for hydrographers who have the time and equipment to do the job right. One can't help but feel uneasy about fitting smooth functions to surfaces which are by nature rugged and unpredictable. Point models can handle the ruggedness but are defeated by trends. Clearly some combination of the two techniques might be the ticket; an area model to detect and model the trends and a point model to work on the residual surface which rides on top of the trend. This is the essence behind UNIVERSAL KRIGING — a topic beyond the scope of this particular paper. There are two other techniques, however, which do, to some degree, incorporate features from both area and point models, namely TRIANGULATION and PARALLEL LINE techniques. We investigate those now.

TRIANGULATED NETWORKS

Many, many techniques have been developed to generate the grid estimates upon which the contour placement will be based. Literally dozens are available — each one considered optimal in one way or another by its author. Some are designed to expolit features inherent in the data itself or in the geometric structure of the sampling program. For instance, some surfaces are very smooth and slowly changing — such as our perception of a gravity surface. Others, including bathymetry, can be very RUGGED. Some surveys are very DENSE and REGULAR — like that of Gestalt Orthophotography while others, like borehole surveys, are often SPARSE and IRREGULAR. A technique developed particularly for one type of data will not necessarily perform as well on another, radically different, type of data. A technique developed for a large main-frame computer will not perform well — or at all — on a medium size mini-computer. STORAGE and processing SPEED are two of the chief considerations which many designers hold supreme.

With such a variety of programs and techniques available it is not surprising that a certain amount of controversy is apparent in the literature on which technique is REALLY the best. One of the most frequently debated items is the GRID VS. TRIANGULATED IRREGULAR NETWORK (TIN). The grid, as we have already discussed, is a square MESH applied over the measured surface with the non-regularly-spaced observations being used in some interpolation procedure to derive estimates at the mesh nodes. A TIN, on the other hand, JOINS TOGETHER the observations into a triangulated network (see Figure 10) and THEN interpolates. New estimates inside the network are interpolated by sub-dividing the network triangles into a series of smaller CLONE triangles. Depth estimates are then made at each of the new vertices. TINs are particularly appealing to hydrographers because they HONOUR the data.

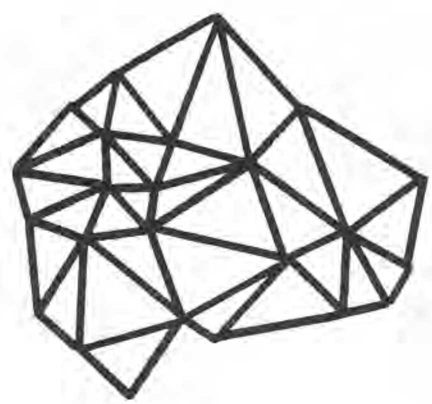


Figure 10: A Triangular Irregular Network

We have previously argued (Monahan and Casey, 1983) that honouring is an important issue. We included it in our Musts and Wants list as a MUST. We can now differentiate between TWO kinds of honouring: STRICT honouring and WEAK honouring. By strict we mean that the observed data points are honoured in the strict MATHEMATICAL sense. The observations lie ON the interpolated surface. Weak honouring implies that the observations do NOT lie on the surface but lie SO CLOSE as to appear, for all intents, to be ON the surface. This might seem like a minor academic point but, in fact, is quite important. The most important card Triangulation proponents have to play is that their technique strictly honours the observations and most other systems do not. We do NOT differentiate between strict and weak honouring since to do so would be to unfairly catagorize systems on what we feel is a minor technicality. Most gridding systems do NOT honour the observations in either sense and so, for hydrographic purposes, are suspect.

Interpolation in triangulation can be relatively straightforward. In its simplest guise, the three data points at the vertices define a planar surface. Contour location on this planar surface is then linearly interpolated. See Figure 11. The survey area can be imagined as being built-up with a network of triangular facets, like, say, a geodesic dome. The contours drawn on such a surface have a very characteristic "angular" look. This is a consequence of the discontinuity of slopes which occures at each triangular boundary. Much more elaborate and sophisticated techniques are also available to overcome some of these limitations.

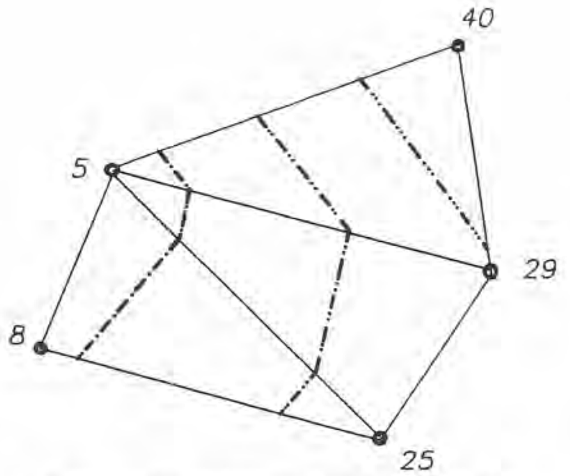


Figure 11: Planar Interpolation Within the Triangles

One of the most sophisticated of the triangulation algorithms is due to Akima (Akima, 1978). This algorithm applies a 5th order bivariate polynomial to the SURFACE of each of the observation triangles. First and second partial derivatives are computed at each of the vertices and directional derivatives computed along each side to ensure the smoothness within the triangles and along the triangle's borders. These measures ensure that the strong contour angularity, which is so characteristic of triangulation schemes, is minimized. Akima's algorithm is also designed to supress the unsubstantiated undulations or RINGING effect which the fitting of polynomials usually involves.

Triangulation systems are not without their problems. A re-examination of Figure 10 will show that many OTHER networks could be established from the SAME data points. Early generation triangulation schemes did not address this problem to any great extent, so the impression has grown that these schemes do not have unique ways of defing the network. If different networks are used the resulting surfaces can look VERY different. Primitive triangulators used the ORDER that the data was ENTERED as a guide to establishing the network. If the data was re-ordered, then a DIFFERENT set of contours would be derived. This is clearly distressing. Such incongruities have not helped the proponents of machine contouring in promoting the use of computers in, what is for many, the final and most visible outcome of their work. Fortunately, many researchers have been working on this problem. The result is that there now are standards for the definition of triangulation networks. The de-facto standard is known as Delaunay Triangulation (Sibson, 1978).

One popular method for achieving Delaunay triangles is to first form a set of polygons (called Thiessen Polygons) from which the triangles can be formed. This is known as Dirichlet Tesselation (Green and Sibson, 1978). See Figure 12.

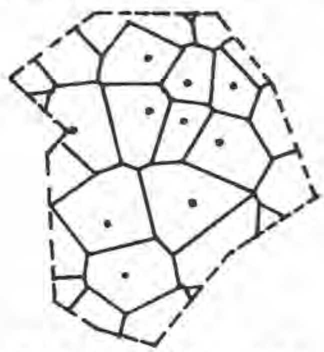


Figure 12: Dirichlet Tesselation

TINs and Thiessen networks have attracted much attention in the recent literature and are the subjects of continued study but are relatively rare in commercial usage (Sallaway, 1981).

Can Triangulation schemes do the job in hydrography? Yes, in some specific cases. The vast amounts of data produced by area-mapping systems such as the NAVITRONIX or the LARSEN could be successfully contoured using a triangulation scheme IF (and ONLY if) sufficient controls were added to ensure a bias for safety. This should be feasible.

If the object was to contour an existing digital field sheet using ONLY the data presented there, then a triangulation scheme would be superior to a gridding scheme. But there is a far better way to contour digital hydrographic data and that is by using ALL of the observed depths — not just the ones portrayed on the field sheet. We investigate one method now which does just that.

PARALLEL-LINE DATA

All of the contouring techniques we have discussed above assume that the data is IRREGULARLY and RANDOMLY distributed throughout the survey area. Indeed, most users of machine contouring packages have data which is in this form. HYDROGRAPHIC data, on the other hand, is blessed with a very important characteristic — CONTINUITY of information along the sounding lines. This feature can, and should be, exploited.

Most users of contouring packages have to be satisfied with interpolated contours. In our case, however, the position is KNOWN along the sounding lines because we MEASURED it there. This measured position can then be used to ANCHOR the contour's position as it intersects each sounding line. These points, commonly known as CONTOUR INTERCEPTS, are as well known as any of the soundings we normally plot on our field sheets. Thus only the contour's path across the inter-line zone has to be interpolated. The use of contour intercepts is the modus operendi of geomorphologists who create bathymetric charts such as Edition V of GEBCO. Its use in conventional hydrography can be traced to (Quirk, 1966).

We can also exploit the parallel line nature of our sounding lines in determining the contour. To control the contour's position BETWEEN the lines requires an interpolated grid of one kind or another. The sounding lines can be used to establish this grid. Consider the situation shown in Figure 13. In this case we have a

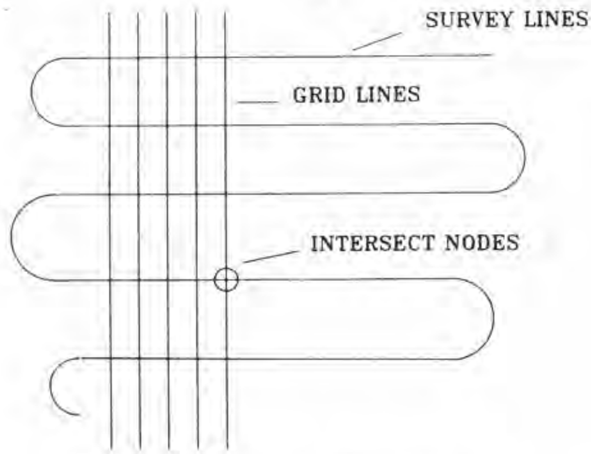


Figure 13: Gridding From Parallel Survey Lines

series of sounding lines crossed by a set of uniformly spaced parallel lines. These lines will form the COLUMN lines in the regular grid we are about to construct. At each point where the column lines intersect the sounding lines, the digital data record is searched for the appropriate depth associated with that position. These cross-over points are called the INTERSECTION NODES. These nodal soundings are then used in the generation of the grid estimates.

Both contour intercept honouring and parallel-line gridding are incorporated in a new contouring package developed by the Pacific Region of the CHS in cooperation with Barrodale Computing Services of Victoria, B.C. The package is known as the HYDROGRAPHIC CONTOURING SYSTEM (HCS). An overview of its interpolation procedure is shown in Figure 14.

In Figure 14a a grid has been placed over the sounding lines and the soundings extracted at the intersection nodes. For simplicity, we are showing one grid line between each sounding line. In practise this is a variable. Typical values would range from one to four.

We now examine a one-column SECTION in the next diagram (14b). Here the actual sounding values are plotted as continuous straight lines. We now fit a special type of polynomial to these values. This function, known as a CUBIC SPLINE fits the observed data EXACTLY and yet retains smoothness, throughout the curve. Estimates are then made, using the spline, at the uniform interval corresponding to the intersection of the ROW lines crossing the COLUMN lines in the grid. These estimates are indicated as dashed lines in the section. This spline fitting and interpolation is then carried out for each of the column lines of the grid. In this way the grid estimates are established.

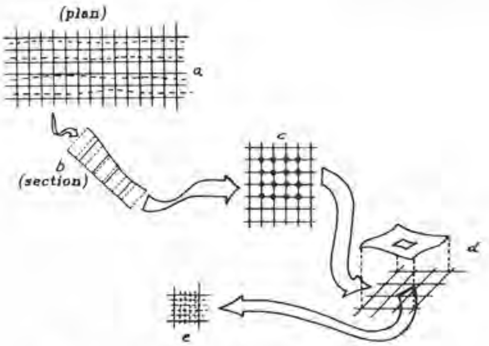


Figure 14: The HCS Interpolation Scheme

The next diagram (14c,d) illustrates how the course of the contour is controlled WITHIN each grid cell. Recall that on the sounding lines, the contour's position is fixed. It is only in the inter-line zone where position estimates are required. Here we show a block of 16 depth estimates corresponding to 9 grid cells. We use the 16 values to fit a SURFACE from which we will guide the contour in the CENTRAL cell. Again we fit a spline — this time a bi-cubic spline since we are now working in TWO dimensions. A much finer grid (14e) is then established on the bicubic surface within the central cell and depth estimates made for this fine grid. This procedure is continued throughout the entire grid. The contour is then strung through each of the grid cells by allowing or denying access to the cell's interior.

The contour is constrained to pass through the contour intercepts. The data is honoured in the WEAK sense. In fact, the honouring is to the nearest fine-grid intersection. Since the fineness of this grid is a variable, the degree of the honouring is also variable. In practise, the grid fineness is about 1mm. More information on the HCS is given in (Casey et al, 1984).

SUMMARY

We have given here an overview of how most of the available contour packages work. There will be detail differences that we have left out for simplicity, but we have tried to capture the ESSENCE of each technique.

Hydrographers and Cartographers are usually reluctant to work with what they perceive as COMPUTED depths (see footnote). The feeling is that these computed depths are very much second class compared to measured depths. This is true — they are. Nevertheless, the charts we produce show a continuity of information despite the fact that we seldom make continuous measurements throughout the survey area. So, whether we like it or not, some form of depth computing is built-in to our procedures. The fact that such interpolation is done in the head of some experienced professional does not sanctify the result — a guess is still a guess. To mechanize this guessing — that is the objective of machine contouring. If care is taken in the selection of the interpolation algorithm and in the principles laid out for its implementation, then perhaps contouring of hydrographic data can be mechanized. We will find the answer to this question only after an extensive period of experimentation.

One point cannot be over-emphasized. The most sophisticated and elaborate contouring system ever devised cannot improve a poor survey. The ground rules of hydrography will not change — a poor survey will produce a poor chart every time. No amount of post-survey data manipulation will ever change that.

ACKNOWLEDGEMENT

The authors would like to acknowledge Jim Vosburgh (CHS, Pacific Region) and Dr. Pam Salloway (XXXX, Victoria, B.C.) for their assistance in explaining the workings of the HCS.

*This same reluctance apparently does not hold for positions, which are smoothed; tides, which are modelled; speed of sound, which is averaged; or heave, which is filtered.

Dolphin: A Proven Hydrographic Vehicle

By

A. K. Malone, R. G. Burke and R. Vine

On a late Friday afternoon in September of 1983 a moving van rolled onto the deserted wharf of Bedford Institute of Oceanography. From within its depths came various sundry packing cases and a long, cigar-shaped, bright orange bulk. The van was unloaded, the crates opened and over the next few days a strange creature was assembled.

This was the DOLPHIN (Deep Ocean Logging Platform with Hydrographic Instrumentation and Navigation). A semi-submersible intended for bathymetric surveying in offshore waters, it is unmanned, and remote controlled, designed to operate in up to 4 metre swells at speeds up to 15 knots. With six of these vehicles abreast a mother ship, seven lines of bathymetry could be collected more cost effectively than using the ship alone. As well, the perils and hazards of men working from small boats could be avoided.

This vehicle, designed and built by International Submarine Engineering Ltd. of Port Moody, B.C., is the prototype or proof of concept. Its first weeks at B.I.O. were spent undergoing trials on Bedford Basin and the approaches to Halifax Harbour. Part of these acceptance trials included one week of sea trials which were conducted from the C.S.S. Baffin from December 3 & 10, 1983.

During the December 83 cruise the DOLPHIN demonstrated itself to be a very stable platform, well suited for the harsh environment intended. Confident that this vehicle could become a valuable hydrographic tool, the next logical progression was to outfit the vehicle with instrumentation and put it to the test in actual survey conditions.

The DOLPHIN was outfitted, during the winter of 84, with an EDO 444 echo-sounder and an Internav 403 Loran-C reciever. Once again the DOLPHIN took to sea, this time operating in conjunction with a survey of the Sable Bank. The cruise on the C.S.S. Baffin was from June 3 to June 15. Figure 1.

Figure 1

This paper presents a brief description of the DOLPHIN, its operation and handling as well as overviews and results of the two sea trials.

VEHICLE DESCRIPTION

The hull of the DOLPHIN is constructed of 6 mm marine grade aluminum with four longitudinal strength members. Two water-tight bulkheads of 10 mm aluminum separate the engine compartment from the ballast compartments. A 636 kg lead keel is attached to the hull via a faired aluminum frame.

The 4.6 metre mast mounted at the forward end of the engine compartment draws air for the engine. This mast is closed by a float and drag operated butterfly valve at the top and by an air operated butterfly valve at the bottom. A rudimentary water separator is also fitted.

Ballast compartments are provided fore and aft of the engine room. A normal and an emergency blowing system is provided from two — 80 SCF air bottles charged to 3000 psi. For dive operations the ballast tanks are flooded bringing the hull of the vehicle awash. Normal dive depth of 3 metres is attained with the vessel under power by use of the planes. In an emergency situation with the engine room flooded and the ballast tanks blown, there is a buoyancy reserve of 182 kg. As well there is sufficient air to blow both tanks twice at 53 metres depth.

The propulsion system consists of a 120 HP Ford Lehman marine diesel engine with a Borg Warner 2.5:1 reduction gear. The shaft is connected to the engine by a flexible coupling, and a left-hand propellor with a diameter and pitch of 25 × 20 inches. The engine exhaust is water cooled and passes through a spring loaded valve in a water trap then through a second spring loaded valve in the stabilizer.

Control is implemented through the use of active planes. Two independently actuated forward planes, placed approximately at the center of pressure, control depth and roll. Two after planes operate in unison for pitch control. A rudder provides steering and heading control. An engine driven hydraulic pump is the heart of the 1000 psi hydraulic system providing power to the planes. Associated with each plane is a feedback potentiometer to position the planes' actuator.

The control of the planes is via a single board microprocessor which monitors various sensors, performs data processing and provides active planes control. The sensors include; a gyrocompass for heading; a pressure transducer for depth; a 3 axis rate sensor outputting signals for yaw, roll and pitch motions; an inclinometer relating pitch position; two inclinometers outputting position on pitch and roll; and a linear accelerometer with integrating filter outputting both velocity and acceleration in the heave axis. The microprocessor, analogue to digital converter and sensors are housed in water tight cannisters in the forward ballast compartment. Electric power for the electronics and starting the engine is provided by two 105 ampere hour 12 V DC lead acid batteries. These are charged by an engine mounted alternator.

The heart of the DOLPHIN telemetry/control system is an RMS telemetry system with analog, on/off, serial and parallel interfaces and a full duplex 400 Khz radio. Linked to the telemetry system of the vehicle are the active control electronics. At the surface is an IBM personal computer, video screen, operator's console and LED display panel.

The operator's console has control for active control set-points, engine speed, engine transmission, engine start/stop and enable, venting and blowing aft and forward ballast tanks, air system disable, console/computer and auto/manual modes, and gyro power, cage and uncage commands.

The LED display panel indicates critical operational functions returned from the vehicle. These include telemetry traffic errors, status of vents (open/close), engine on/off, air enabled/disabled, bilge pump on/on longer than 2 minutes, engine room flood.

The IBM personal computer is not necessary for the operation of the vehicle. The DOLPHIN can be operated solely by the operator's console and LED display panel. Presently, the primary function of the computer is to interpret all telemetered information from the vehicle and draw this information in real-time on the video screen. Approximately 35 pieces of information are telemetered to the surface and are displayed on four different operator selectable pages. The information includes: vehicle pitch/roll attitude, deflection of planes and rudder, gyro heading, gyro setting, engine R.P.M., engine oil pressure, cooling water temperature, hydraulic pressure, and air system pressure. The computer can also be employed to set the heading of the vehicle. In the future it will be used to control line-running and depth.

VEHICLE OPERATION

The DOLPHIN was intended to be able to be operated in up to 4 metre seas while providing a stable platform for conducting hydrographic data collection. Seas of that state have not been encountered during either cruise so the vehicle has not been tested to its design limit. The DOLPHIN did, however, operate effortlessly in seas of 2 metres, during the December 83 cruise, manoeuvring very steadily at speeds of up to 14 knots. The mast sliced through short waves and the vehicle appeared steady while in long swells the DOLPHIN tended to follow the swell though with less amplitude. The only detectable motion has been a tendancy to surf in a following sea. To test for possible problems in larger seas with waves breaking around the snorkel and antennae, the DOLPHIN was run such that the snorkel was less than one metre above the water surface. Spray and the snorkel head being briefly submerged had no adverse affect on telemetry or vehicle operation. Every indication has been that the DOLPHIN can perform to desired specifications.

Maneuvering the DOLPHIN alongside the ship for recovery has proven quite difficult. Slowest forward speed is approximately four knots, steering is either slow in responding or quickly sheers and reverse is totaly undirectable. One attempt was made (June 84) to maneuver DOLPHIN alongside with the ship proceeding at four knots. This proved quite nerve-racking and only pointed out the need for better slow speed control. The adopted procedure for maneuvering into recovery position is to keep the hull submerged by about one metre, thus taking advantage of better control in submerged rather than surface running. Approaching the ship at a 45° or greater angle the vehicle is brought to a stop just off (sometimes against) the ship. The bow conveniently rises, exposing the bow and allowing the bowline to be attached. With the ship making a slight amount of way the DOLPHIN streams into the recovery position.

HANDLING

During both cruises the DOLPHIN was launched and recovered from the Baffin using the launch davits. Though not necessarily the most suitable they were available. Figure 2.

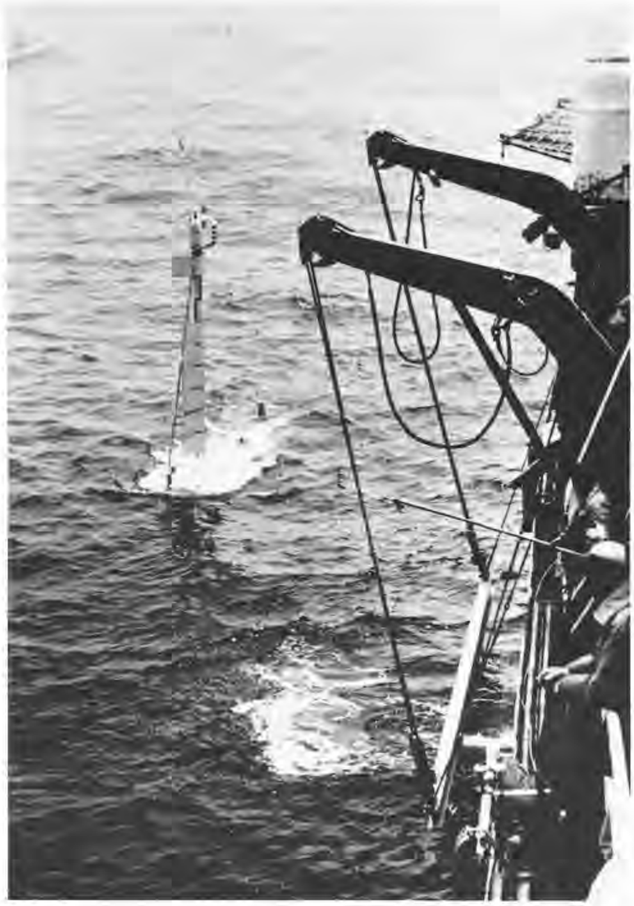


Figure 2

In December 83, the vehicle was handled from the starboard luffing davits. Blocks from the davits were shackled to rings on the DOLPHIN. A spring tension was used to prevent shock loading on the hull. With this system it was necessary to have a rubber boat in the water to connect or disconnect the shackles. This proved hazardous with the blocks swinging about the heads of those in the boat.

For the June 84 cruise, it was intended to launch and recover the vehicle without the use of the rubber boat. The starboard aft gravity davits were employed rather than the luffing davits. Because the davit arms are separated by a greater distance than the hull of the DOLPHIN, an I-beam spreader bar was used. Attached to the beam were two nylon straps which could slip over two hooks on the hull of the vehicle. To connect or disconnect straps to hooks, poles were used from the deck of the ship. Launching with this system was simple, quick and safe. The DOLPHIN was lowered over the side, upon reaching the water the straps loosened and were easily slipped off of the hooks using the poles. On recovery, it proved difficult and frustrating to catch and hold the hooks in the straps. Several variations were attempted, none worked entirely satisfactorily. When the vehicle was initially maneuvered into position, a bow-line was attached by means of a snap hook slipped onto a pole. This worked very well with the connection most often being made in one attempt. For future trials, snap hooks to close on lifting rings will replace the nylon straps and hooks.

INSTRUMENTATION

The primary mission of the June 84 cruise was to test the capability of the DOLPHIN to handle hydrographic instrumentation. Time and fiscal constraints limited the available options. An

EDO 444 transciever was available at B.I.O. for the echo-sounding system. A digit echo sounder, which could have been incorporated in the existing control Telemetry Link, was ruled out because a great deal of bottom detail would be lost if only the digital value of the depth was transmitted for each measurement cycle. After reviewing positioning system options, LORAN-C was decided upon. ISE was awarded a contract to retro-fit the DOLPHIN vehicle with the echo-sounding and positioning systems.

The LORAN-C receiver selected was an Internav 403 which is specifically designed for remote operation. A receiver is given its own unique ID code and only responds when interrogated. Some functions supported by the receiver are:

Messages: Test Pattern
System Status
Send Time Difference (Any pair of A, B, C and D)

Commands: Reaquire
Move up 10 μ sec
Move down 10 μ sec
Enable cyle selector status
Send message

ISE modified the DOLPHIN electronics and the onboard vehicle control software to accommodate the Intervav LORAN-C receiver. Changes incorporated in the shipboard control console allow an operator or an externally interfaced computer to poll and receive messages from the receiver via the DOLPHIN/Console telemetry link. An HP 9836 Desktop Computer, line printer and Tandberg TDC 3000 tape drive were utilized to log LORAN-C data. A simple software package was written prior to the cruise to log LORAN-C data and time on the basis of user selectable time intervals.

The EDO 444 echo-sounder transceiver was modified by the Hydrographic Development Division to fit into a standard size DOLPHIN instrument cannister (25 cm diameter × 51 cm long). The interfaces to the sounder and Raytheon 1811 Line Scan Recorder were provided as part of the ISE Ltd. retro-fit package. A block diagram of the system is shown in Figure 3. A separate full

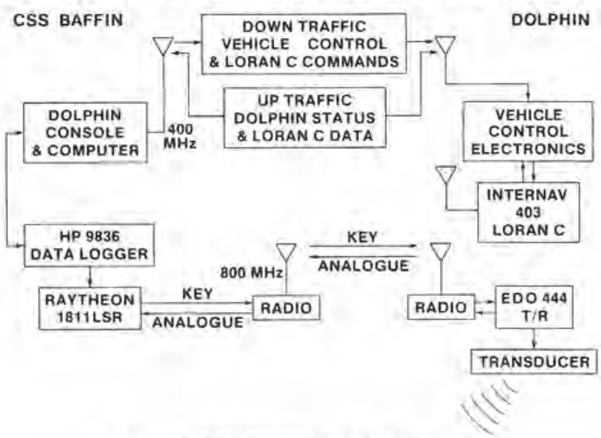


Figure 3: DOLPHIN System Electronics

duplex 800 MHz radio link was installed to operate the echo sounder. The Raytheon 1811 Line Scan Recorder provided the key pulses and recorded the incoming analogue signals. A fix mark was generated via the HP 9836 Computer.

Two instrument cannisters were utilized to house the vehicle echo-sounder, LORAN-C, and radio electronics. The echo-sounder and its associated power supply were contained in one and the LORAN-C receiver and echo-sounder radio unit in the other. Figure 4 shows the location of the cannisters and echo-sounder transducer. No adjustments had to be made to the ballasting of the vehicle after the installation.

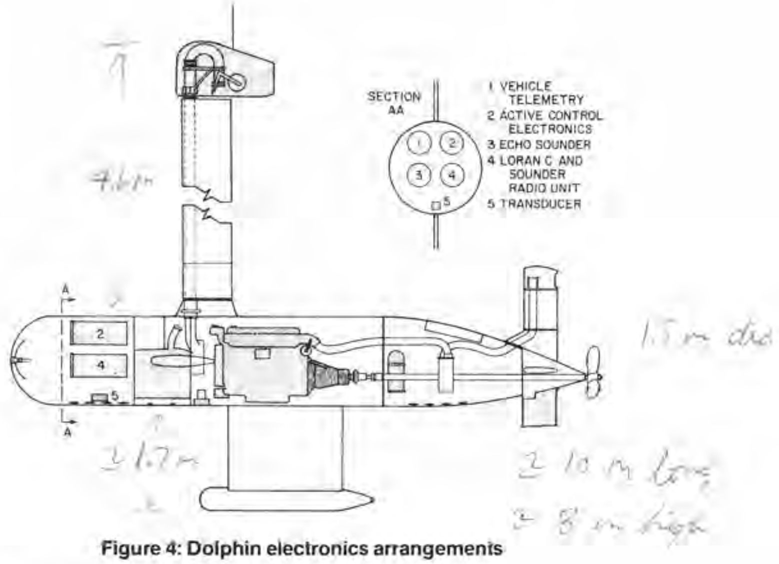


Figure 4: Dolphin electronics arrangements

INSTRUMENTATION TEST RESULTS

Numerous problems were encountered in installing and getting the echo sounding and positioning system up and running. This was further compounded by the requirement to operationally demonstrate the vehicle during the BIO Open House Display immediately preceeding the test cruise. When the echo sounding system was made operational it gave excellent results. Figure 5

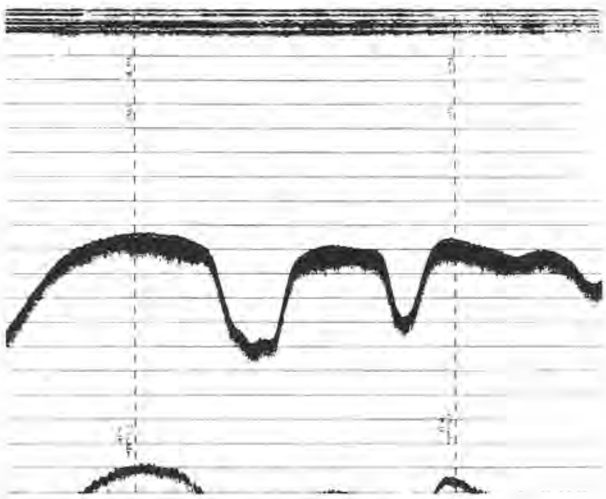


Figure 5: Sample analogue echo-sounder record

shows a typical record. DOLPHIN is a acoustically superior platform for echo sounding in rough weather in comparison with a standard survey launch or large vessel because one does not encounter the typical aeriation problems. The vehicle was bar checked using one of the Baffin's survey launches. An alternative technique would be to carry out a velocimeter cast and calibrate the Raytheon 1811 (or other) recorder. For the purpose of this test the vehicle depth was manually annotated on the record by observing the depth that the vehicle was riding in the water. The logging computer has access to vehicle depth data from an onboard pressure transducer, however, this had not been calibrated prior to the cruise. One limitation of the existing system is that the settings of the echo sounder can not be altered without removing the unit from its cannister. Any production vehicle will require a sounding system that allows the user to alter the echo sounder controls (gain, pulse length, power output, etc.) via the telemetry link. As a wide variety of bottom conditions and water depths were not encountered during the trials, this restriction did not present a serious problem. Range tests were conducted and the link worked well up to a range of 4.8 kilometers from the mother ship. These results were inconclusive as ideal weather conditions existed at the time and the DOLPHIN 800 MHz radio antenna had been damaged in a recovery accident prior to the test.

The Internav 403 Loran-C antenna coupler had been damaged prior to sailing and considerable time was spent tracking down the problem. A strobe light was installed on the mast head adjacent to the Loran-C antenna and created noise problems. Once these were cleared up the unit still would not automatically lock on to the Loran-C signal and operator intervention was required to acquire the chain. The Internav 403 tracked well once it had been locked on. An HP9836 computer was used to log Loran-C time differences and times at user selectable intervals. For these trials data were logged at both 5 and 10 second intervals. In addition the program allowed the user to select the fix mark interval for the LSR1811. Data were logged on a Tandberg TDC 3000 Cartridge Tape Drive.

Data were transferred to the BAFFIN's HP1000 Computer system. DOLPHIN's position was computed and plotted using the logged time differences that were adjusted using corrections computed by the C.S.S. BAFFIN's onboard integrated Navigation System (BIONAV). Figure 6 shows a track plot of the C.S.S. BAFFIN and the DOLPHIN. No checks of the DOLPHIN's absolute positioning accuracy were carried out, however, the results obtained indicated that accuracy appears to be consistant with what would be expected from using Loran-C in a differental mode.

CONCLUSIONS

The DOLPHIN has demonstrated itself to be a very good platform for hydrographic surveying in the offshore environment. The utilization of instrumentation can also be considered a success, though the full extent of useful instrumentation has yet to be explored.

Plans are now underway to build up to three more vehicles under the government sponsored Source Development Fund. To aid in the refinement of systems and the design of a production vehicle, trials on the existing prototype are currently being conducted by I.S.E. Ltd. These trials include propulsion, hull drag, vehicle stability, generation of acoustic noise, telemetry range and hull strength.

Sea trials are once again scheduled for November 1984. The intent is to more formally analyze the accuracy of both position and depth measurement and perhaps to utilize the DOLPHIN on a production role.

Side-scan sonar is to be fitted to the DOLPHIN and trialed in the immediate vicinity of B.I.O., late in 1984 or early in 1985.

The single major hurdle left to clear is an adequate handling system for rough-sea launch and recovery. It is hoped that this complex problem may be seriously reviewed in the near future.

This orange hulled, yellow snorkled emmulation of the Loch-Ness monster is proving its worth as a hydrographic vehicle and is gaining interest and respect in a variety of other quarters.

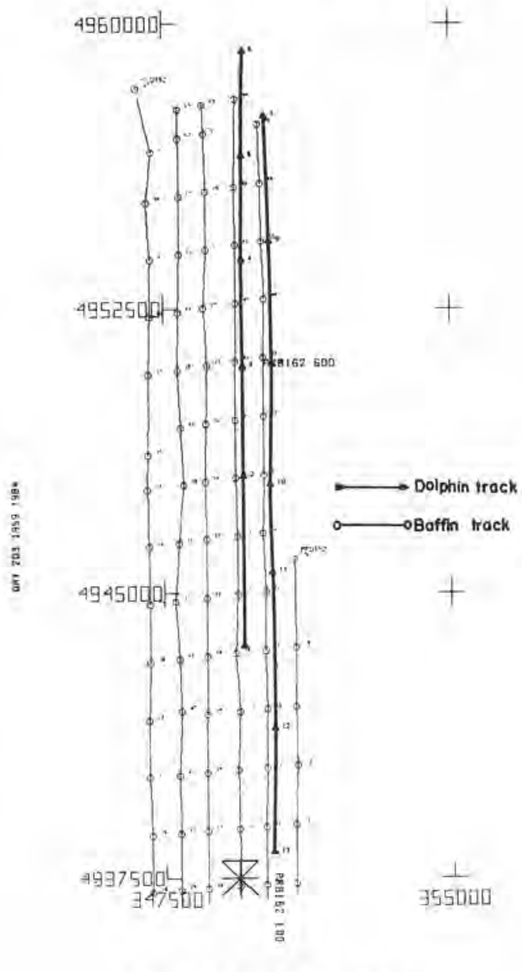
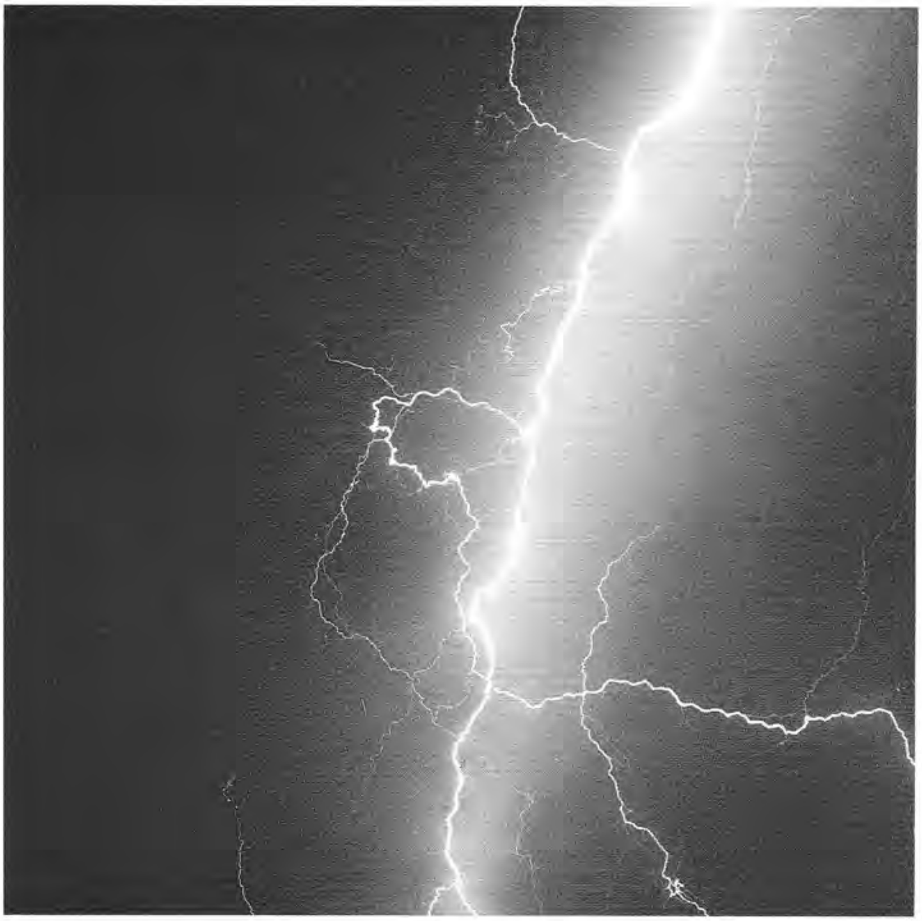
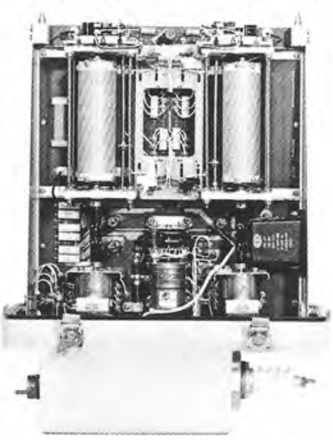


Figure 6: Sample track plot

We build ARGO® systems to take a 110,000 volt lightning bolt and keep on sending accurate positioning data.



A lightning bolt flashes from the sky above the Mississippi Delta. An ARGO antenna takes



a direct hit — 110,000 volts surging down the antenna, across the spark gap system, through the surge coil and arrestor, to the blocking capacitor and transorbs.

Thanks to Cubic's "overbuild" philosophy, the killing surge of power is reduced to 100 volts by the time it reaches ARGO's Range Processing Unit. Without interruption, ARGO continues transmitting to the survey ships offshore.

EVERY UNIT IS "TEST DRIVEN"

Lightning, extreme heat and cold, storms and accidents are facts of life in the offshore surveying environment. So we make sure every ARGO system is ready for the roughest duty before it leaves our labs. By

building each ARGO system, testing every component, and testing the entire system, again and again. Then subjecting each unit to extremes of temperature to test for thermal shock. Finally, we "burn-in" each piece of equipment by operating it continuously for 30 days. Every single unit.

So, when you get your ARGO system, it's already proved that it can take the toughest use. And, just in case that's still not enough, redundancy is built in for critical input power connections. Nothing is left to chance.

Social Activities from Year's Gone By (50's & 60's)

Picnic 1961

L to R: Arnie Stanzel, Rolly Gervais, Marg Malloy, Marty Fredericks.

Art Read.

L to R: Rolly Gervais, Bill Covey.

Diana Pantalone.

Hallowe'en Bowling Tournament 1961/62

Jim Bruce, John Gaskin.

Ed Lischenski.

Doug Green.

L to R: Jim Bruce, John Gaskin, Jay MacDonald, Art Read, and ?

Private Photos, 1957

Rolly Hamilton, Dick Cashen, Bernie Wilson.

Arnie Stanzel.

Rolly Hamilton.

Rose MacDonald, Bernie Wilson. Ron Lamirande.

CHA/CHS Social News

Atlantic Branch

Congratulations to Ann Ryan and Dale Nicholson on successfully completing their Hydrography I Course.

Congratulations also to Hank Boudreau who completed his BSc in computer science and is now working with the Navigation Group. Good luck to Walter Burke, Gerard Costello and Jim Ross who have returned to university.

Linda MacMillan has transferred into the Tidal section as Tidal Data Processor. Charlie O'Reilly, also in the Tidal Section, recently broke his arm and leg after falling from a ladder while painting his house.

Hearty congratulations to Mike and Sheila Lamplugh on the birth of their daughter Samantha.

Malcolm Joy won first prize for his pumpkin pie and second prize for his raisin pie at the Atlantic Winter Fair in Halifax. Unfortunately Joy will not give out the ingredients for his pie crust, but anyone interested in obtaining Dorothy Joy's prize winning recipe for CHOW are advised to watch the program LIVE IT UP.

Marcel Chimer and Doug Frizzle returned from Canto 2 in October.

Congratulations to Dave and Josephine Roop on the birth of their daughter Mary.

Central Branch

Proud parents from a long cold winter are:
- Brad and Joanne Tinney — a girl
- Bob and Danielle Langford — a boy
- George and Leanne Fenn — a girl

So much for additions, now deleting:
- Dan Chase left the CHS on his return from the Hudson Bay Survey to go east and south — east to the trading vessel Stella Maris (he is the captain) and south to Haiti to import art objects, etc., to Canada. An informal meeting was held for Dan at one of the local establishments to wish him the best in his new venture/adventure.

Dick MacDougall holds a new position in the CHS, working on the digital data base for control information, and he appears to be heading for Ottawa for 2 years in conjunction with this assignment.

Reports from our industry membership are sparse, undoubtedly because they are all busy in the great FIELD of hydrography.

OTTAWA BRANCH

Gerry Dohler retired on September 19 as Director of Marine Cartography. A farewell party in his honour was held at Dows Lake CFRB and many individuals as well as CHS regional representatives presented him with some beautiful gifts.

Harold Comeau, Chief of Quality Control and Services, announced that he will be retiring on February 27, 1985. Harold plans to go into business for himself making wooden toys and here's hoping he gives Fisher-Price a run for his share of the market.

Ron Logan, Assistant Hydrographic Planning Officer, announced he will be retiring early in the new year. Best wishes from all of us.

Gil Lance, Programmer, accepted a promotion to the Conference Board of Canada. We wish him well.

A third Carto 2 course was presented this fall with a total of 10 regional and H.Q. staff in attendance. Claude Chantigay, from Québec region, was admitted to the hospital under the pretext of not feeling well but we know better. Anything to get out of exams eh Claude!

A bus tour with all seats filled was organized by Clay Fulford. Our first stop was to visit a Central Region survey party in Marrisburg, then on to visit the Tall Ships in Kingston — an excellent day all around. Special thanks to Ross Douglas, Regional Director of Central Region and John Menendorp, HIC, for their kind assistance.

A Chinese luncheon with Mike Casey as guest speaker (topic — the Larsen project) was presented in June — an excellent presentation organized by Rolly Gervais.

The Hydrographer Data Processing Seminar is slated for November 5 and 6 at the Skyline Hotel. It is being organized by Roger Landriault and Tim Evangelatos who is also serving as Chairman.

The annual Christmas Dinner will be held on December 14. Anyone who may be in Ottawa and interested in renewing old acquaintances please notify Ken Peskett, who is organizing this year's bash.

L to R: Ken Peskett, Rolly Hamilton, Dan Peskett, Jim Bruce, Gil Lance, Colin Bromfield, Ron Haas, Jeep Seguin, Arnie Stanzel, George Madynski, Terry Tremblay and Mike Blondin (kneeling).

Hydrographers stand back! Here comes the cartographic staff. This past summer the motley crew you see above set out to run the rapids of the mighty Ottawa. Riding the crest of 10 foot waves with an expertise that can only be attained by HQ personnel (this comes from years of trying to keep our heads above water) the river was sounded. This was achieved by dropping Ron Haas overboard and carefully documenting the time it took him to bob back up (similar to an echo sounder.) This field sheet will soon be submitted — are you ready Boyd?

PACIFIC BRANCH

Mike Woods has returned to Hydrography after graduating from the University of Calgary. Pete Milner commenced his UTP at the University of Victoria.

Living on a boat? Mike Hohl purchased a 26-foot sailboat and is going for it. Mike also won "Cartographer of the Week" for dropping a weight on his thumb. The trophy was previously held by Art Lyon for breaking the glass on his light table twice.

Jim Vosburgh left the CHS after 15 years to join Terra Surveys. Also Chart Corrections lost Marg Patton and Dave Harrison to retirement.

Sue Michaux is engaged and George Eaton got married. How about that?

Old Pete Browning finished his farm work and is back on term for awhile.

The good life in Ottawa attracted Heather Pite, or was it something else?

Carto 2 is on again with Ray Chapeskie, Dave Jackson and Eric Earl attending.

Seen in passing, Mike Bolton after six months on the 'A Base' Review Team en route to the 2nd IHTC where he presented a paper.

Hydrographer Hustler of the Month:

August: Barry Lusk — for convincing P.W.A. to pay half a helicopter trip from Sandspit to Rose Spit! P.W.A. typically had delivered 3 people to Sandspit but their luggage was left in Vancouver. Two days after the men had joined the ship the suitcases finally arrived.

September: Doug Popejoy — who rescued two silent 700 terminals (with acoustic couplers) from Crown Assets! Thanks to Doug's quick action these terminals are now on hydrography inventory.

PRAIRIE SCHOONER BRANCH

Richard Good has accepted a position with Offshore Surveys and Positioning Services Ltd. of Vancouver.

Ian Tilmouth has accepted a position with Hardy and Associates of Calgary.

Bruce Calderbank worked as a survey consultant in the North Sea this past summer and has now returned to Calgary.

For the first time a CHA workshop will be held in Calgary in the spring of 1986. More information will be published in the next issue of Lighthouse.

Région du Québec

Alain McDonald et Sylvie Labrie se sont mariés le 13 juillet dernier avant de passer deux semines de rêve à Puerto Rico sur les plages de sable brûlant.

Félicitations à Richard et Suzanne Lambert pour la nuissance d'une jolie petite fille du nom de Arianne. Félicitations également à Claude et Denise Perron pour la naissance d'un joli petit garçon du nom de Maxime.

Claude Chantigny s'est rendu à Ottawa afin de suivre le cours de Cartographie 2. Nous lui souhaitons la meilleure des chances de cussès.

Le Comité Éxécutif Régional se rencontrait en septembre afin de discuter des plans futurs de l'ACH dans la région.

Québec Region

Alain McDonald and Sylvie Labrie were married on July 13 and left for two weeks to enjoy the hot beaches of Puerto Rico.

Congratulations to Richard and Suzanne Lambert on the birth of their daughter Arianne. Congratulations to Claude and Denise Perron on the birth of their son Maxime.

Claude Chantigny attended the Cartography 2 course in Ottawa. We wish him the best of luck.

The Branch Executive Committee met in September to discuss the future plans of the CHA in the region.

News from Industry

MAGNAVOX

Magnavox Advanced Products and Systems Co. announced the installation of the Series 5000 aboard Shell Offshore Inc.'s new 300 foot seismic research vessel SHELL AMERICA. The system includes up to 10 radio navigation aids as well as Global Positioning System (GPS) capability, Deep Water Correlation Sonar and Dynamic Translocation.

Magnavox has also introduced a new 3-D, Binning and Display System for seismic surveys. In addition, they have introduced the Magnavox MX211T Transportable INMARSAT Earth Station which is designed to bring telephone and telex capabilities to remote locations quickly and easily.

The Newsletter "Points and Positions" informs us that the US Navy has decided to recommend to the USA Department of Defense that the overlap between Transit and GPS be extended two years until 1984. Their source is a report from the Radio Technical Commission for Maritime Services.

DEL NORTE

Del Norte Technology Inc. announces that James Stegall, Vice President and Product Manager is presently responsible for all field service and worldwide sales for the Trisponder systems. In addition Mr. Stegall will now be responsible for all engineering and production activities of the Trisponder.

James Lavender, Product Manager for TRACS and Sentrie Security Products has been given the responsibility for the engineering and production functions of these product lines.

KLEIN

Klein Associates Inc. are pleased to announce the winners of their annual representative awards:

Outstanding Representative for Domestic Sales	— C. A. Richards & Associates Houston, Texas
Outstanding Representative for International Sales	— Racal-Decca Svenska AB Stockholm, Sweden
Distinguished Service Award	— Stewart Engineering Duxbury, Mass., USA
	— Hakuto Company Ltd. Tokyo, Japan

Mr. Kevin McCarthy has joined the marketing staff and will assume direct responsibility for sales and continuing contact with Klein customers in Asia, Australia and Southeast and Middle Atlantic areas of the United States.

Mr. McCarthy has over 10 years of experience in the oceanographic community and has most recently served as Ocean Advisor to Senator Lowell Weicker, drafting federal legislation and overseeing federally funded oceans programs.

Klein also announces the availability of a towing accessories brochure as well as a new extended range 500 kHz towfish.

NBA (Controls) Ltd.
NBA (Controls) Ltd. announces the availability of a freely rotating real time and/or surface recording current meter, model DNC 4 for periods of extensive deployment.

TELEFIX CANADA
Telefix Canada announces the availability of their Microwave MICRO-FIX positioning system by Racal.

SONATECH INC.
Sonatech announces the introduction of the SSV — On board Navigation System — Model NS-016. This acoustic system is designed specifically for navigation of submersibles and is to be used in conjunction with an array of bottom-mounted transponders and an on-board computer.

EG & G
EG & G announces the introduction of the Model 260 Image Correcting Side Scan Sonar system. This unit is used with the Model 272 Tow Fish and provides sonar images that are fully corrected for slant range ship speed and amplitude.

MESOTECH Systems Ltd.
Mesotech's Model 971 Color Imaging Sonar has won a "Special Meritorious Award for Engineering Innovation" in 1984. These awards are presented annually by "Petroleum Engineer, International" and "Pipeline and Gas Journal".

TARGA ELECTRONICS SYSTEM INC.
Targa is introducing a removable bubble memory cartridge containing one-half megabyte of memory.

QUBIT
QUBIT wishes to announce the introduction of the CHART IV interactive editor. This system allows the surveyor to preview and edit bathymetric and trackplot data shortly after it is acquired.

GEOMARINE ASSOCIATES LTD.
Geomarine reports that M/V Brandal has returned to Halifax after conducting wellsite surveys and sidescan work in Hudson's Bay.

FIG '86 — PRELIMINARY ANNOUNCEMENT

The Canadian Institute of Surveying is honoured to host the XVIII Congress of the International Federation of Surveyors in Toronto, Canada from June 1-11, 1986. The Congress will feature an informative technical program, excellent exhibits, interesting tours and excursions and an exciting social program. To have your name added to the mailing list for the preliminary announcement, write to:

REGISTERATION COMMITTEE
FIG CONGRESS '86
P.O. Box 186, Station Q
Toronto, Ontario, Canada
M4T 1M2

The Canadian Hydrographic Service and Canadian Hydrographers Association

1st Biennial Conference
April 16, 17, 18, 1985
Halifax, Nova Scotia

Hydrography and Technology in the Mid-80s

(How well are they working together?)

Areas of interest — **Hydrographic Data Collection**
— **Data Manipulation/Management**
— **Presentation of Information** — Field (Work) Sheets and/or Charts

This conference will touch on future developments, but the main thrust is to examine what is presently available and working today!

Towards this end there will be practical demonstrations of C.H.S. developments aboard hydrographic launches in the harbour, as well as the post-processing systems at the conference site. Those with competing or complementary systems are encouraged to participate.*

The organizing committee welcomes papers and/or demonstrations in any of the above areas especially with regard to state of the art working systems. Any organizations in related disciplines that are interested in demonstrating accomplishments that may have some application to the hydrographic community are encouraged to do so.

Looking forward to seeing you in '85

For further information contact:
Mike Lamplugh Conference Chairman
Linda MacMillan Conference Secretary
C.H.S. Atlantic Region
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth N.S.
Canada B2Y 4A2
(902) 426-3846

*If required, arrangements can be made for a launch as well as other backup to demonstrate your system.

N.B.
To be followed by a one day Workshop on the Electronic Chart sponsored by the Canadian Hydrographic Association and the Hydrographic Society, to be held at the Bedford Institute of Oceanography on Friday, April 19th, 1985.