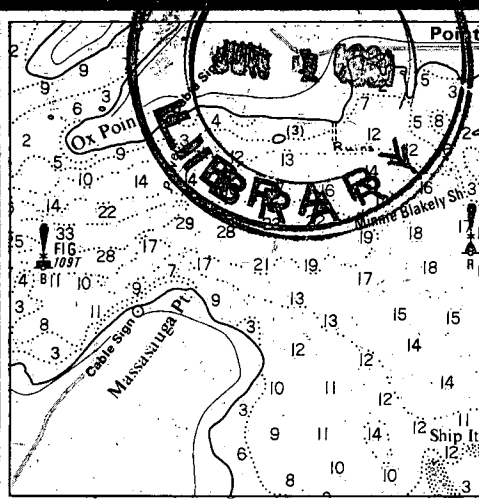
1976
ANNUAL REPORT



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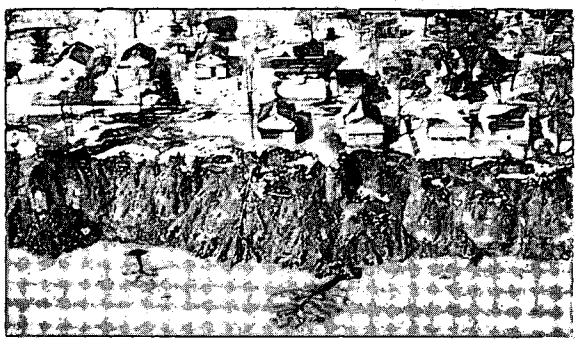

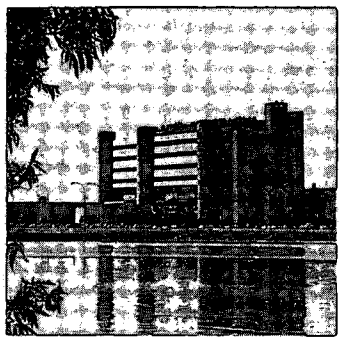

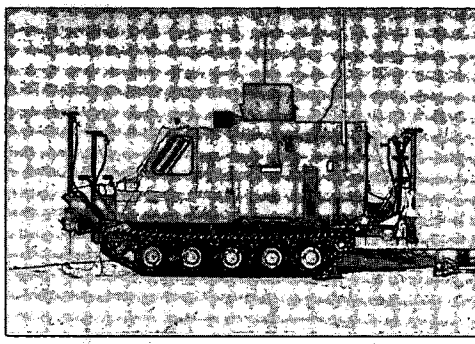

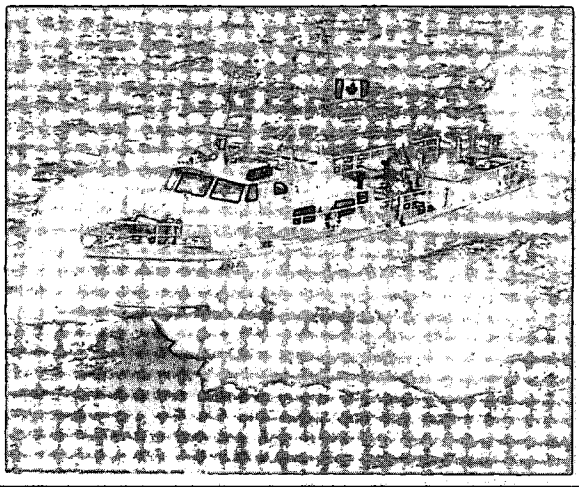

Ocean and Aquatic Sciences
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Environment Canada
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1976 ANNUAL REPORT

CENTRAL REGION

OCEAN AND AQUATIC SCIENCES

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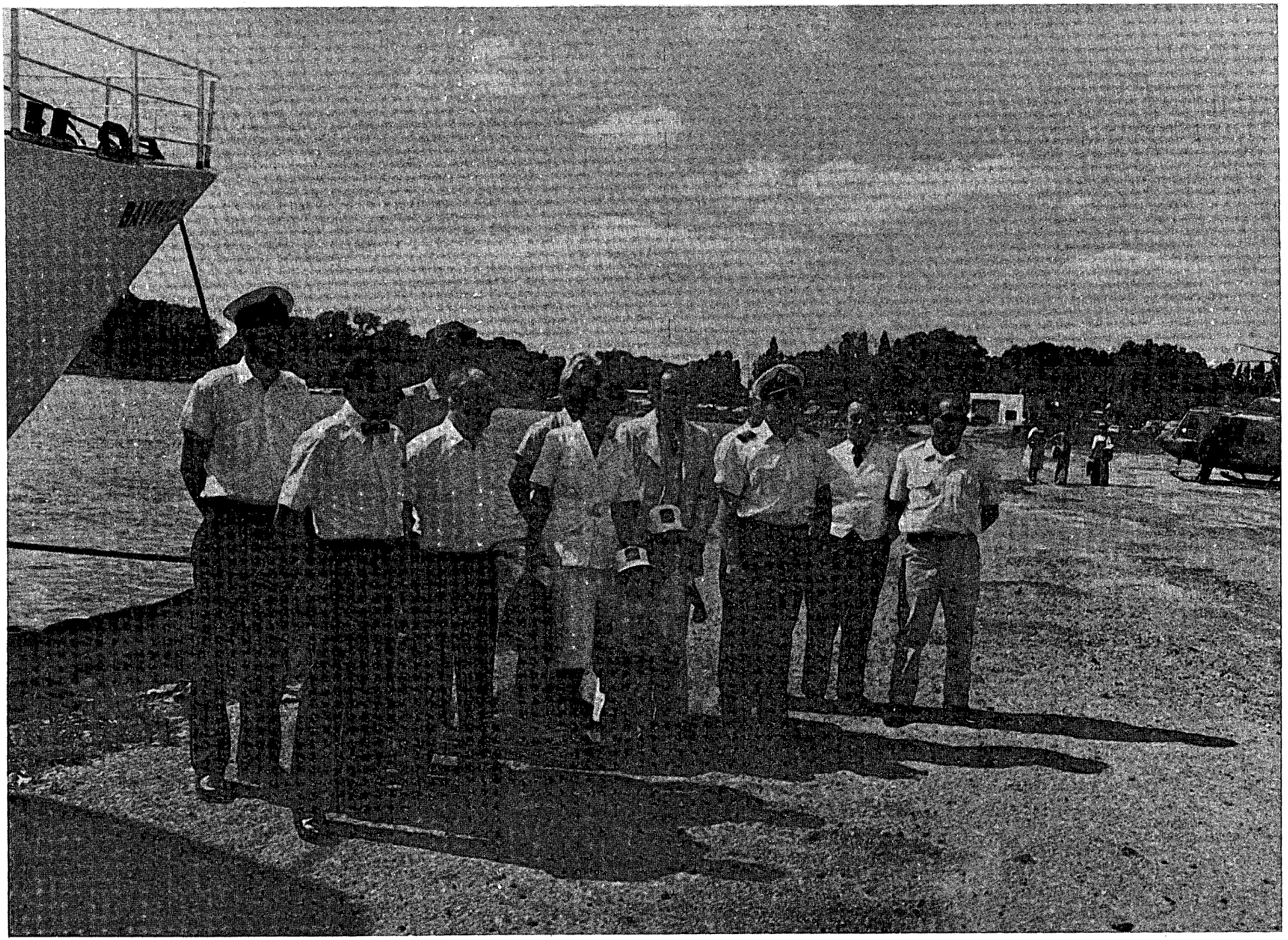


The Prime Minister, Mrs. Trudeau and Family with Captain M. Birchall and crew of C.S.S. BAYFIELD following an enjoyable afternoon viewing the yachting events at the Olympic Games, Kingston, Ontario.

OVERVIEW

The Central Region of Ocean & Aquatic Sciences has its headquarters at the Canada Centre for Inland Waters, Burlington, Ontario. The operating area of the Region stretches beyond the Great Lakes to the Saskatchewan-Manitoba border in the west, the Gulf of St. Lawrence in the east, and James Bay/Hudson Bay and the Queen Elizabeth Islands in the north.

The Region reports operationally through the Director to the Director-General, Fisheries and Marine Service for Ontario and functionally for the development of national policy to the Assistant Deputy Minister, O&AS. The Region is subdivided operationally into four divisions: Hydrographic, Research & Development (Oceanographic), Ships, and Administration, with an allocated man-year total of around 155 and a budget in excess of $6.5M. The Hydrographic Division is the largest group and provides the central core of strength around which the Region is constructed. The R&D Division is largely oceanographic in content, with additional expertize in matters affecting the coastal zone. The Ships Division provides both ships and launches required by O&AS, other elements of F&MS and last but certainly not least, meets the varied and sometimes complex requirements of the Inland Waters Directorate, the major occupant of CCIW.

During 1976 the Region was engaged in a multitude of activities, and completed all its commitments while painfully adjusting to meet a man-year cut of 12 man-years ordered by Department and Service heads over the two fiscal years of 75/76 and 76/77. If we had any fat in our organization prior to the cuts, all that is left now are the sinew, the bone and most importantly the guts.

The appointment of a DG for Ontario, and the regrouping of O&AS within the new F&MS region have so far made few changes necessary in our modus operandi. However, it is another additional filter in the bureaucracy that requires effort from us in O&AS to fine-tune the filter so that our responses and our input into the development of national policy are as noticeable and as notable as they have been in the past.

There are additionally other organizational changes which will have some significance for the Region, particularly in hydrography. One is the decision to establish a Quebec based hydrographic region - obviously, eventually our boundaries will change to exclude much of the St. Lawrence River; however, it is hoped that the flexibility between oceanographic regions will be maintained and both Regions will feel free to investigate and survey as expertize is available and need exists. The second decision - to decentralize the cartographic function into the Regions - is now entering its build up stage and promises to be most interesting and hopefully most challenging. A full regional marriage between hydrographic surveying and cartography, will bring a whole new dimension to hydrographic and charting techniques.

Highlights in hydrography during the year were the management of a combined bathymetric and geophysical survey off Senegal and Gambia, the development of the tracked vehicle for sounding in ice-covered waters and the development of a Tidal Acquisition and Telemetry System for the systematic collection of water level data.

Highlights in physical oceanography, shore properties studies and environmental assessment were the completion of comprehensive analysis of the freshwater budget of Hudson/James Bay, and in-depth study of Point Pelee erosion and a one-dimensional model of tidal propagation in Chesterfield Inlet. However, probably the most significant event of all was

the official release in July, by both Canada and Ontario, of the Canada/Ontario Great Lakes Shore Damage Technical Report and the first Coastal Zone Atlas of the Canadian erodible shoreline of the Great Lakes, based on the findings of the technical report. A memorandum of understanding signed by the Ministers of the Department of Environment and the Ontario Ministry of Natural Resources authorized a number of follow up programmes which include shoreline erosion monitoring, hazard land definition, a site specific study, the development of a coastal zone management modelling system and a public awareness series of workshops, seminars and other thrusts. A Co-ordinating Task Force, consisting of the Director, O&AS, Director, IWD and the Director, OMNR, Engineering Services, was formed with clear instructions to implement these programmes while taking into consideration the present climate of financial constraint. Action is underway in all these programmes.

The Ship Division acquired a new chartered vessel, MV "PETREL", and CSS "BAYFIELD" played host to the Prime Minister and his family at the Yachting Olympic Games in Kingston. This Division suffered most severely under the man-year cuts imposed and deserves great credit for meeting every demand made of them.

Administration very seldom get any credit when things go well, but they always get it in the neck when things go wrong. This Division may not be perfect, but when compared to those of other organizations, it shows up as the shining star of F&MS and probably of the entire Department. In 1976, with organizational change, factual or implied, making things just that much more difficult, it continued to perform superlatively.

Enough of looking inward - it is time to consider the Region's relations within O&AS, within F&MS, within DFE and with other Departments, and finally with other governments, nationally and internationally, and the government and non-government organizations that are the focal point of our various professional aspirations.

The O&AS situation is not quite as clear as it might be. Nationally there is reasonably good communication on matters of national or international interest, but the informal relationship between Regions and Ottawa which worked extremely well in the days when Marine Sciences organizationally were virtually autonomous no longer works well in a situation where administrative and financial power is at the Service level. In these circumstances we desperately need a more formal linkage between responsibility centres to ensure that everyone on the management team knows what is going on. We need to develop clearly articulated national policies in dealing with oceanographic matters as we have done for many years in dealing with hydrographic matters. Most of all we need to knit the two together in a manner that enhances both and demonstrates our oceanic and aquatic competence.

The Ontario Region of F&MS is still too recent an evolvement for useful comment.

There are several Services of the Department at CCIW and although each has its own mandate there should by now have evolved a CCIW position on a number of concerns particularly in the sciences. Instead, we each go our own way, meeting occasionally on working groups or as members of the Executive Committee. Initiatives started to improve this situation have all perished, because of suspicion and inertia.

The ORB and WNRB are useful as sources of information, but certainly play no real role in bringing the separate parts of the Department closer together. There is much philosophizing about the great scientific issues, but all the great decisions are being made elsewhere. Nowhere is the dichotomy between

the doers and the thinkers more evident than at a Board meeting, and nowhere can the preoccupation with structure and control be observed with greater clarity. Certainly these Boards appear to be unduly influenced by these concepts and thereby waste a great deal of the time of members.

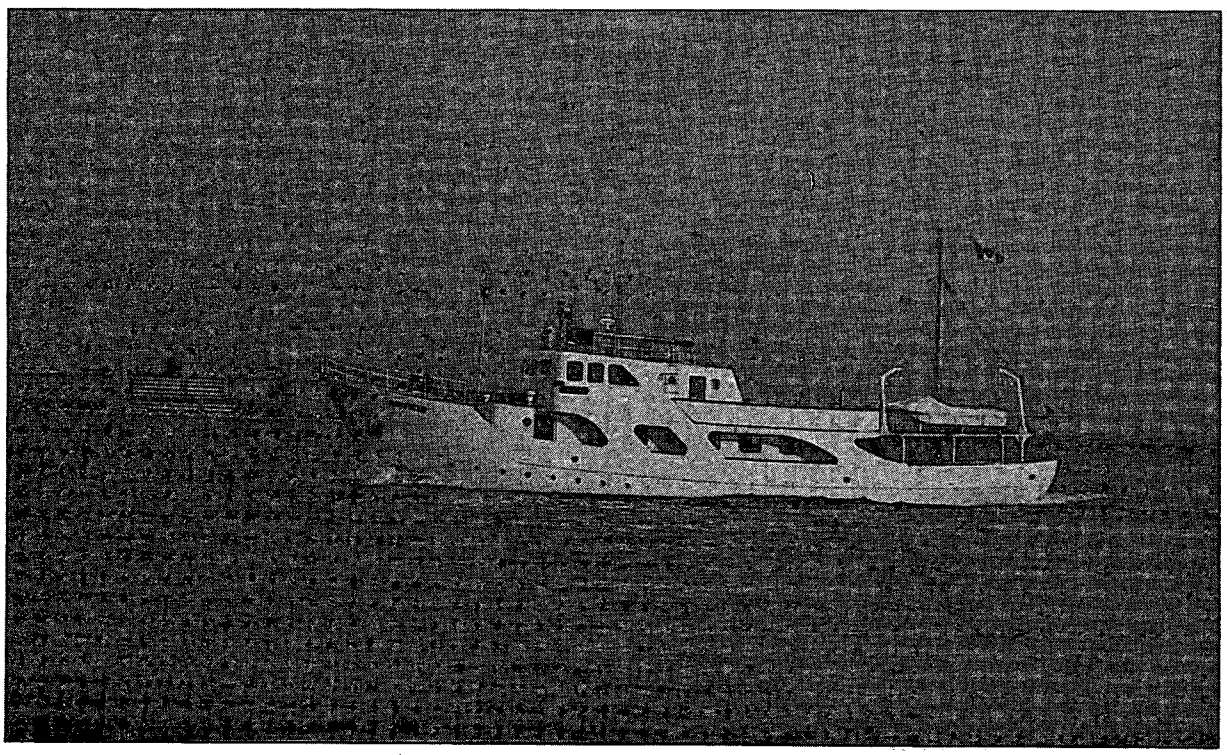
The formal and informal committee structure between Services at all levels works well in cases like the Assignment of Vessels Committee but in matters concerning the Coastal Zone works imperfectly and in fits and starts.

Generally, interdepartmental committees are effective and the committee structures we have evolved with other levels of government have all proven excellent. Examples one could quote would be the Charting Advisors for the Great Lakes and the Canada/Ontario Great Lakes Shore Damage Steering Committee. Additionally regional officials are members of national delegations to such international bodies as the International Hydrographic Organization.

Finally non-governmentally, the Region's links are strong with the professional associations such as the Canadian Institute of Surveying, the International Federation of Surveying and others through the prominent roles played in these important non-government organizations by both the Director and the Regional Hydrographer.

In reviewing the health of the Region in 1976 it is conceivable to say that we are very much alive and well. To stay that way we must strengthen our tried and true national network of hydro-oceanography, while continuing to build another regional network of communication and planning with other organizations who share at least in part our goals and our aspirations.

The scope of the following report reflects that health.



C.S.S. BAYFIELD at C.C.I.W. Burlington, Ontario.

HYDROGRAPHIC DIVISION

Introduction and Highlights

The Canadian Hydrographic Service has, until this year, had three regional offices located at Victoria, Burlington and Dartmouth. A further regional office is being established. Known as the Laurentian region, it will have its office in Quebec City. The Headquarters, under the Dominion Hydrographer, is located in Ottawa.

The Central Region of the Hydrographic Service forms part of the Ocean and Aquatic Sciences organization located at the Canada Centre for Inland Waters. The regional office is responsible for hydrographic work in the area stretching from the Saskatchewan border to the St. Lawrence estuary and from the U.S. border to the Arctic Islands. With the formation of the Laurentian region the eastern boundary has moved from Pte. des Monts to the Beauharnois Locks west of Montreal.

The Canadian Hydrographic Service must be responsive to the present and foreseen future needs for navigational information. Since the process of planning, collecting and processing the data from field surveys to the published chart is lengthy it is necessary to speculate on the economic developments that will affect shipping. The regional offices work with headquarters in developing a system of priorities, since the need for surveys and improved charts and navigational publications far outweighs the resources available to provide these services. In the Central Region there is a demand for improved charts throughout the Arctic. In the south there is the need to continuously update the existing charts and also to provide new charts for the recreational traffic.

A significant development during the year was the decision to accelerate the pace of decentralizing staff and certain operations from Ottawa to the regions. The largest group which will be moved during the next three years will be chart production. In the case of Central Region, the existing cartographic staff will be increased from two to at least twelve during the decentralization period.

An unusual and important field operation during 1976 was the management of a combined bathymetric and geophysical survey off the coast of Senegal and Gambia, West Africa. Funding for this operation was provided by the Canadian International Development Agency (CIDA). CSS BAFFIN was provided by the Atlantic Oceanographic Laboratory and the work was conducted jointly with other scientific groups at the Bedford Institute, in particular, the Atlantic Geoscience Centre. The results of the surveys are being used to provide Senegal and Gambia with a set of bathymetric, gravity and magnetic maps and a comprehensive report. The field operation was notable in completing its objectives given a very short advance notice.

In the realm of technical development two projects were outstanding. Both were partially supported through the Unsolicited Proposal Fund of the Department of Supply and Services which is directed towards the development of innovative ideas by industry. The major project was the development of a system, utilizing a tracked vehicle for sounding in ice covered waters. That contract was awarded to Banister Technical Services, Edmonton. The second development was a Tidal Acquisition and Telemetry System (TATS). The system, which incorporates a micro-processor, promises to revolutionize the systematic collection of water level data.

FIELD SURVEYS

The areas of Central Region that were surveyed during the 1976 field season are illustrated on the following two pages. In addition, details of the survey vessels, positioning systems and data processing techniques are given in Table 1.

Belcher Channel

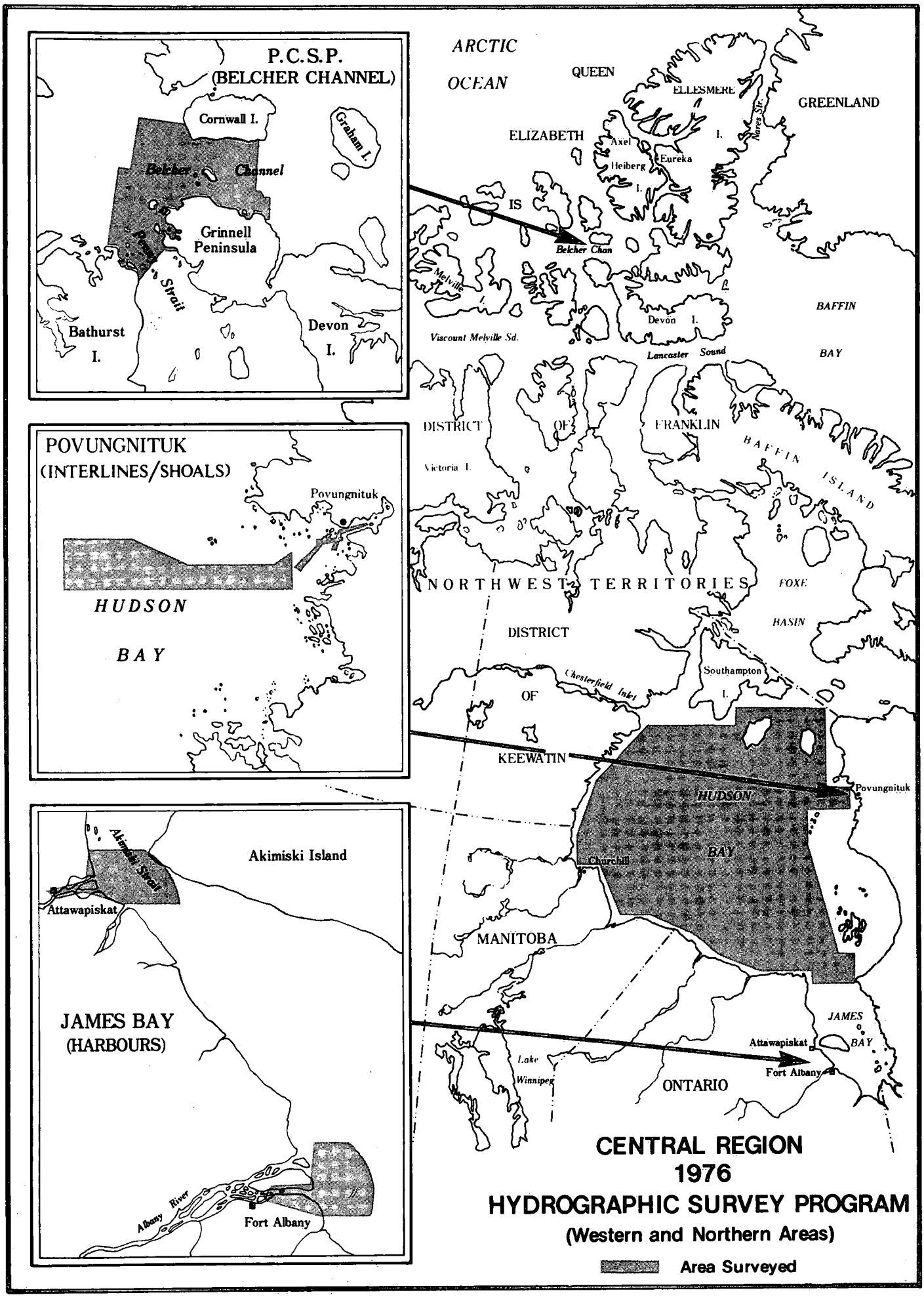
A survey was made of the Belcher Channel situated in the Arctic Islands between Cornwall and Devon Islands. The channel is named after Sir Edward Belcher, who led the last and greatest search expedition sent out by the British government to search for Sir John Franklin. The channel is critical to navigation as it lies on the route that ships must take from Jones Sound to King Christian Island. The latter is the site of a major natural gas field and there has been considerable discussion on the use of liquified natural gas (LNG) tankers for exporting the resource from that point. There has also been a proposal that a pipeline may cross the Belcher Channel as one means of exporting the gas from King Christian Island to the south.

The survey utilized three chartered helicopters provided by the Polar Continental Shelf Project under a commercial contract. These worked out of a base camp situated on the channel ice. During the period of the survey, from March to May, the area was ice covered with ice of approximately two metres thickness. Through-ice sounding methods were employed and a record 8,705 spot depths were measured. In addition to the helicopters an experimental sounding system using a BOMBI tracked vehicle was used.

Belcher Channel Base Camp

Initially the entire channel was sounded with spot depths on a 2 kilometre square grid. This provided a general picture of the bathymetry, revealing that the southeast corner of the channel was very shallow with numerous shoals that were examined with closer spaced soundings. The northern side of the channel had rough bottom topography but was generally deep with depths from 50 metres to 180 metres. A shipping corridor 10 kilometres wide was delineated and sounded with measurements on a square grid of 500 metres to ensure that there were no obstructions.

BOMBI Tracked Vehicle


P.C.S.P.
(BELCHER CHANNEL)
Cornwall I.
Graham I.
Belcher Channel
Grinnell Peninsula
Penny Strait
Bathurst I.
Devon I.
POVUNGNITUK
(INTERLINES/SHOALS)
Povungnituk
HUDSON BAY
JAMES BAY
(HARBOURS)
Akimiski Island
Akimiski Strait
Attawapiskat
Albany River
Fort Albany
ARCTIC OCEAN
QUEEN ELIZABETH IS
ELLESMERE I.
GREENLAND
Axel Heiberg I.
Eureka
Nares Str.
Belcher Chan
Melville I.
Devon I.
Viscount Melville Sd.
Lancaster Sound
BAFFIN BAY
DISTRICT OF FRANKLIN
Victoria I.
BAFFIN ISLAND
NORTHWEST TERRITORIES
FOXE BASIN
DISTRICT OF KEEWATIN
Chesterfield Inlet
Southampton I.
HUDSON BAY
Churchill
MANITOBA
Lake Winnipeg
ONTARIO
JAMES BAY
CENTRAL REGION
1976
HYDROGRAPHIC SURVEY PROGRAM
(Western and Northern Areas)
Area Surveyed

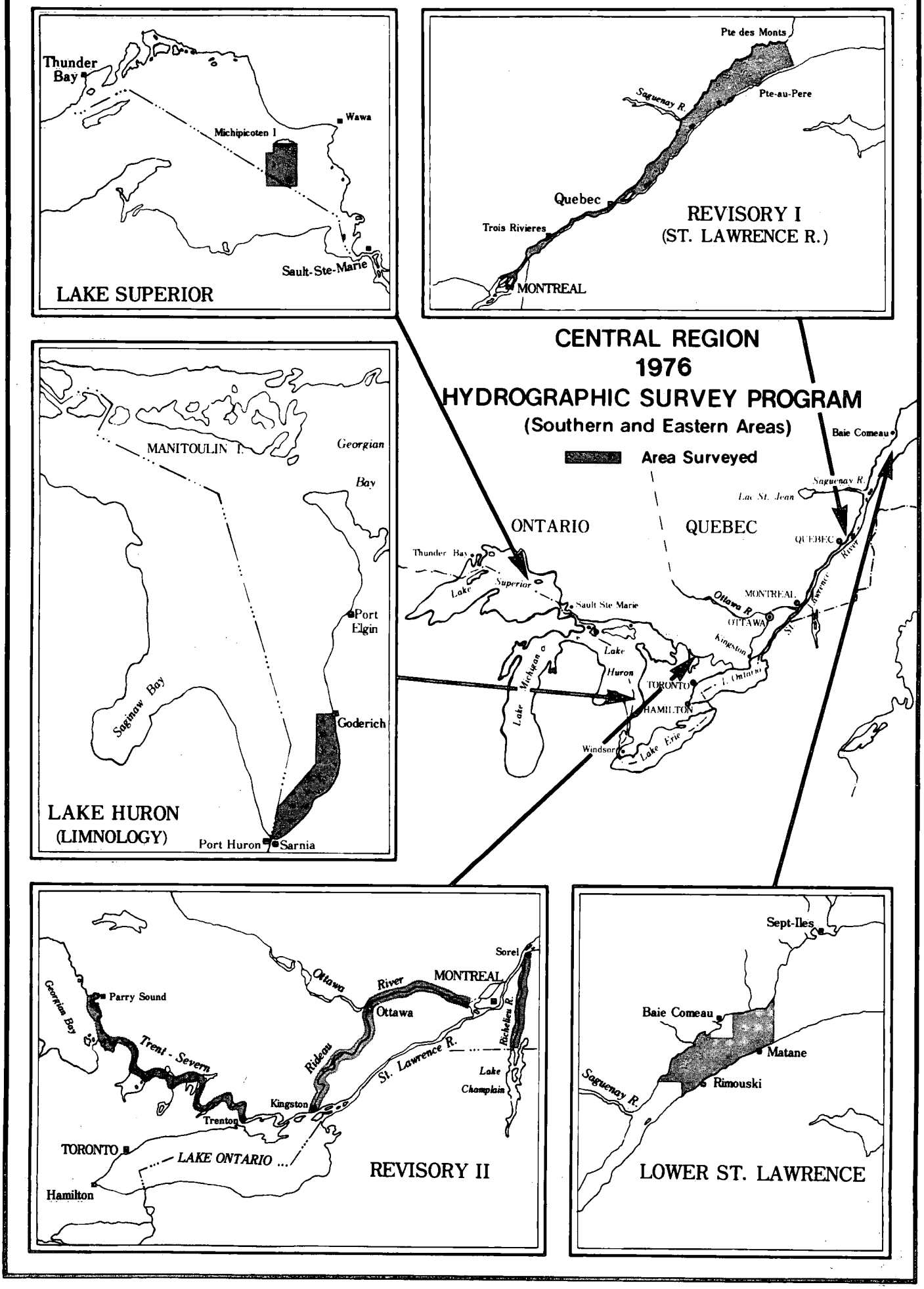

Thunder Bay
Michipicoten I
Wawa
Sault-Ste-Marie
LAKE SUPERIOR
Pte des Monts
Saguenay R.
Pte-au-Pere
Quebec
Trois Rivieres
MONTREAL
REVISORY I
(ST. LAWRENCE R.)
CENTRAL REGION
1976
HYDROGRAPHIC SURVEY PROGRAM
(Southern and Eastern Areas)
Area Surveyed
ONTARIO
QUEBEC
MANITOULIN I.
Georgian Bay
Port Elgin
Saginaw Bay
Goderich
LAKE HURON
(LIMNOLOGY)
Port Huron
Sarnia
Baie Comeau
Lac St. Jean
Thunder Bay
Lake Superior
Sault Ste Marie
Ottawa R.
OTTAWA
Kingston
Lake Huron
Lake Michigan
TORONTO
HAMILTON
Windsor
Lake Erie
St. Lawrence River
Parry Sound
Georgian Bay
Trent - Severn
Ottawa River
MONTREAL
Ottawa
Rideau
St. Lawrence R.
Richelieu R.
Sorel
Lake Champlain
Kingston
Trenton
TORONTO
LAKE ONTARIO
Hamilton
REVISORY II
Sept-Iles
Baie Comeau
Matane
Rimouski
Saguenay R.
LOWER ST. LAWRENCE

TABLE 1, SUMMARY OF THE 1976 SURVEY PROGRAM, CENTRAL REGION

SURVEY AREA	VESSELS	POSITIONING SYSTEM	FIELD DATA PROCESSING
Lower St. Lawrence	NUCLEUS (34 ft.) ADVENT (77 ft.) 2 HYDROS (25 ft.)	Mini-Fix Mini-Ranger	INDAPS
Lake Huron	AGILE (44 ft.) HUSTLE (22 ft.)	R.P.S. Mini-Ranger	Manual
Lake Superior (East End)	BAYFIELD (103 ft.)	Mini-Fix	INDAPS
Polar Shelf (Belcher Channel)	3 x 206 Helicopters	R.P.S., Mini-Ranger	Manual
Polar Shelf (Rea Point)	Canadair Flextrac CF23	Mini-Ranger	INDAPS
James Bay (winter)	4 x 206 Helicopters	1 Decca Lambda 6f	Manual
James Bay (Summer)	2 Monarks (20 ft.)	Mini-Ranger	Manual
Hudson Bay (Offshore)	NARWHAL (252 ft.)	* see note	
Hudson Bay (Coastal)	SURGE (35 ft.)	Mini-Ranger	Manual
Revisory I/Navigational Ranges (Lower St. Lawrence)	VEDETTE (48 ft.)	Hydrodist	Manual
Revisory II (Richelieu River, Ottawa River, Rideau Canal Trent-Severn Waterway, Small Boat Route - Port Severn to Parry Sound)	VERITY (37 ft.)	Hydrodist	Manual
Senegal	BAFFIN	Integrated SatNat/Loran-C	Interdata Model 70

* - integrated SatNav-Doppler Sonar Navigation and Data Acquisition System (Magnavox) and Geophysical Data Processing System

A further refinement of the survey was to measure seven depth profiles along potential pipeline crossings of Belcher Channel and Penny Strait to the west. The profiles proved to be very rough in places.

An oceanographic team shared the field camp while making observations in nearby Penny Strait.

James Bay - Winter

A similar type of survey to that of Belcher Channel was conducted during February to April in James Bay. The program is a joint program of the Hydrographic Service and the Gravity Division of the Department of Energy, Mines and Resources with some participation of the Research and Development Division of O.A.S Central Region.

The program provides regional gravity coverage and reconnaissance bathymetry in the shallow coastal zone of James Bay and Hudson Bay. This area would be difficult to systematically survey by ship. During 1976 a total of 1,479 gravity measurements and 1,169 soundings were taken on a 6 kilometre square grid. This completes the systematic mapping of James Bay.

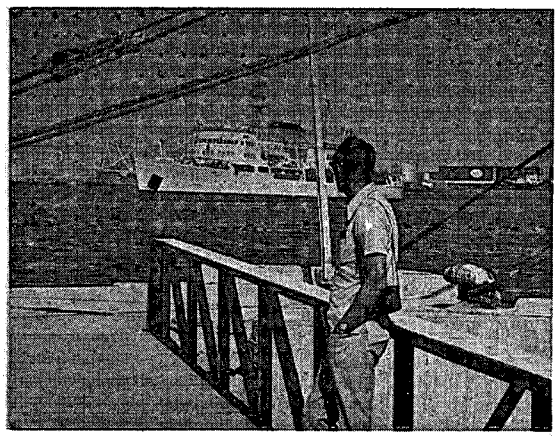
The Hydrographic Service provides a Decca 6F electronic positioning system which is

operated under a commercial contract. Three Fisheries and Marine Service helicopters, manned by Ministry of Transport crews provide the logistic support. The actual observations are taken by a small contract crew arranged by the Gravity Division.

Oceanographers again took advantage of logistics provided for this operation to obtain winter observations.

Senegal and Gambia

A new departure for Central Region hydrographers was to participate in a multi-parameter survey of the continental margin of Senegal and Gambia, West Africa from January to April. The survey was funded by the Canadian International Development Agency (CIDA). The survey program, which was managed by Central Region included participation of the Atlantic Geoscience Centre (DEMR) and physical and chemical oceanographers from the Atlantic Oceonographic Centre (AOL). CSS BAFFIN was provided by A.O.L.



CSS BAFFIN in Dakar Harbour

A major feature of the survey was the establishment of an Accufix electronic positioning system (miniature Loran-C). The system was integrated with a Satellite navigation receiver to provide precise positioning over the survey area which extended 300 miles off the African coast. The Accufix system was provided under a commercial contract.

The main program consisted of measuring depth, gravity and magnetism along east west lines. A total of 29,454 kilometres of depth measurements, 28,568 kilometres of gravity and 28,568 kilometres of magnetics were observed.

One part of the program involved the use of a Huntec Seismic System in the area between the 2,000 metre depth contour and the coast.

The results of the surveys were plotted on seven field sheets at 1:300,000 and later compressed and merged with other data into a set of geophysical and bathymetric maps at 1:1 million.

Thirty-nine oceonographic stations were occupied. Sampling was arranged to examine the distribution of temperature, salinity, oxygen, dissolved and particulate oil, dissolved and particulate organic matter and oxygen isotope ratios. Tidal and current measurements were taken in the survey area. An additional program was the wildlife observations for birds and marine species.

Bathymetric data for the General Bathymetric Charts of the Oceans (GEBCO) program were taken on passage across the Atlantic.

A comprehensive report of the entire survey and results is being prepared at Headquarters for presentation to Senegal and Gambia.

Senegalese Participating in Training Programme.

Lower St. Lawrence

Although the St. Lawrence River is the most important thoroughfare in Canada the charts are made from surveys dating back to the earlier part of this century. To overcome this shortcoming a major re-survey was initiated in 1969. The survey this year completed the program to provide new data from Quebec City to Pointe des Monts on the St. Lawrence Estuary. New metric charts can now be produced.

The 1976 survey covered the area from Ile du Bic, close to Rimouski, down river to a line drawn approximately from Pte. des Monts to Matane. The offshore was surveyed at scales of 1:50,000 and 1:100,000. A number of the harbours, including Rimouski, Matane and Baie Verte were surveyed at the larger scale of 1:10,000. Although the depths in the critical shallows proved to vary little from the existing chart, a difference of 30 metres was found in the deep water. This is perhaps not surprising since the existing chart includes data gathered as long ago as 1885. An interesting note of the survey was measurements over the wreck of the EMPRESS OF IRELAND which sank in 1914 off Pointe au Père. The wreck lies in 40 metres of water with 21.6 metres depth over it. The total survey program was highly productive with 19,188 kilometres of soundings run and 59 shoals examined. The high productivity was partly due to exceptionally fine weather.

Survey equipment included a Minifix chain and the INDAPS automated system was installed aboard the survey vessels. These included ADVENT, a fast 77 foot crew type vessel, NUCLEUS a 34 foot Nelson launch and a 25 foot HYDRO class launch.

Lake Superior

The systematic offshore surveys of the Great Lakes were interrupted this year to respond to a request by the Ministy of Transport on behalf of a U.S. Board of Enquiry. The request was to survey in detail an area between Michipicoten and Caribou Islands in Lake Superior where it was thought that the lake carrier EDMUND FITZGERALD might have touched bottom prior to foundering in November 1975 with the loss of all hands.

The existing chart is comprised of surveys dating back to 1919 and 1920. A number of shoals exist to the north of Caribou Island and in the channel between it and Michipicoten Island. The survey, which included lines run as close as 25 metres apart in critical areas, revealed no significant changes. CSS BAYFIELD was used for the work and was positioned by a Minifix chain. Data were recorded and processed by the INDAPS automated system. A Bell 206 helicopter supported the operations.

Lake Huron

A continuing co-operative program with the Environmental Management Service has been the limnogeological surveys of the coastal zone around the Great Lakes. The program which started in Lake Ontario has moved through Lake Erie and in 1976 started in Lake Huron with the coastal strip between Sarnia and Goderich. The data which includes depth profiles and bottom samples from the

water's edge to the 20 metre depth contour provide the geologists with information on littoral drift and the hydrographers with a systematic reconnaissance and review of the existing charts. The profiles for the geologists are 1000 metres apart and are subsequently interlined to 500 metres for hydrographic use. During 1976, 1,100 square kilometres were surveyed.

The 44 foot launch AGILE was used for the survey with Motorola RPS and Miniranger systems providing the positioning. Support for the geological coring was provided by CSS LIMNOS and the chartered tug LAC ERIE.

Revisory Surveys

The high rate of urban growth and the active development of recreational areas within Central Region makes it necessary to carry out an active program of chart revision. Information is provided by a cyclic program of revisory surveys. Two crews are deployed each year to examine the charts along a particular strip of coastline. During this year one crew aboard the large survey launch VERITY was active in the Richelieu, Rideau and Trent canal systems and extended operations into Georgian Bay north to Parry Sound. The second crew using the launch VEDETTE, examined the charts in the Lower St. Lawrence This included a large scale survey to examine some reported changes at Sorel.

Hudson Bay Offshore

This was the second year of multiparameter surveys in Hudson Bay. Once again this survey is a co-operative effort of the Hydrographic Service with the Gravity Division of DEMR. Depth, gravity and magnetics are measured simultaneously. The 250 foot CCGS NARWHAL was provided for the fifth year in succession by the Canadian Coastguard, MOT. The ship has been fitted with an integrated satellite navigation and doppler sonar system to provide positioning accuracy to better than 250 metres over the entire area. The survey is arranged with primarily east west lines. The operation will extend over a number of years with each year's data contributing to the density of the survey. The ship entered Hudson Bay on the early date of July 21st. The offshore program had to be terminated earlier than usual as the ship had to be used to recover some current meters that could not be picked up by the chartered vessel PETREL which had broken down.

During September NARWHAL was dispatched to Povungnituk where, assisted by the launch SURGE, it completed surveys of the channel leading into the port.

James Bay Coastal

Very few of the harbours in Hudson and James Bay are adequately charted. Paralleling the offshore program is a program to carry out detailed surveys of the ports. This will be followed by surveying coastal corridors to connect the ports. There are a number of outstanding requests to survey the ports on the west side of Hudson Bay. Unfortunately the lack of a ship this year eliminated plans to survey Eskimo Point and Whale Cove. Instead the Hydrographic Service responded to a request from the Moosonee Transport Company for surveys of Attawapiskat and Fort Albany on the west side of James Bay. These are two small Indian settlements that are partly supplied by tug barge units. The ports themselves are poor being very shallow river estuaries. The coastline is muskeg and the riverbed is reported to be continually changing. Due to the very shallow water it was necessary to work only during the higher stages of the tide. Monark launches, powered by twin outboard motors were used. A particular problem was caused by the squatting of these crafts as they increased speed.

1977 Survey Plans

During the winter season, surveys will be carried out in Viscount Melville Sound and in the Belcher Islands area of Hudson Bay. The CF-23 and Bombardier tracked vehicles, modified to incorporate system improvements based on last year's tests, will be employed during the Viscount Melville Sound survey. The entire western half of the area will be sounded and gravity measurements taken on a 6 km. grid. A detailed corridor will be surveyed with the tracked vehicles close to the Melville Island shore.

Summer surveys in Hudson Bay will include a continuation of the offshore program, using the NARWHAL as the survey vessel, and a coastal survey in the Whale Cove - Eskimo Point area.

The Winnipeg River will be surveyed during the summer season, with coverage from the Lake of the Woods outlet at Kenora to the Ontario-Manitoba border anticipated.

Two revisory survey parties will operate this summer, one on Lake Ontario and the St. Lawrence River downstream to Montreal, and the second on Lake Huron from Sarnia to Goderich, with possibly some work on Rainy Lake and Lake of the Woods.

Activities on Lake Huron will include a survey in the north end of the lake covering both offshore areas and the south coast of Manitoulin Island. This survey will be coordinated with work of the National Ocean Survey on the west side of the lake. The limnogeological work will continue on Lake Huron this summer, stretching from Goderich to Tobermory.

Elsewhere on the Great Lakes, a survey in Lake Erie will concentrate on the ends of the lake, east of Long Point and west of Pelee Point, to provide data for Canada/U.S. cooperative charts. U.S. survey teams will also be working on the south east shore of this lake.

Finally, a control survey of Lake Nipissing is planned in preparation for a bathymetric survey during the 1977-78 fiscal year.

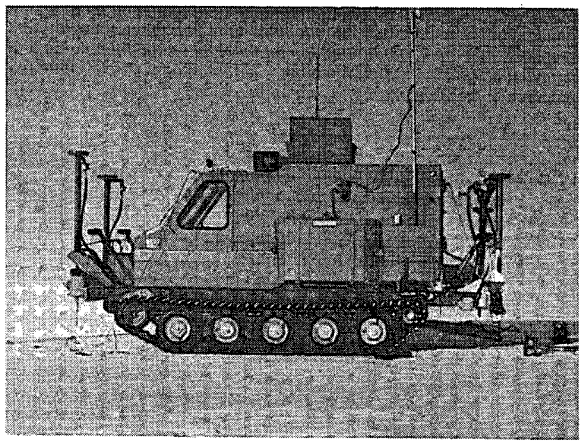
TECHNICAL DEVELOPMENT

The hydrographic development group is involved in the design, development, implementation and evaluation of systems and techniques to improve the quality of hydrographic surveys and chart compilation through the application of engineering and computer science. In 1976 established projects such as INDAPS and the support of multi-parameter surveys saw continued activity while new ventures were undertaken with emphasis on the Arctic and the application of micro-processors.

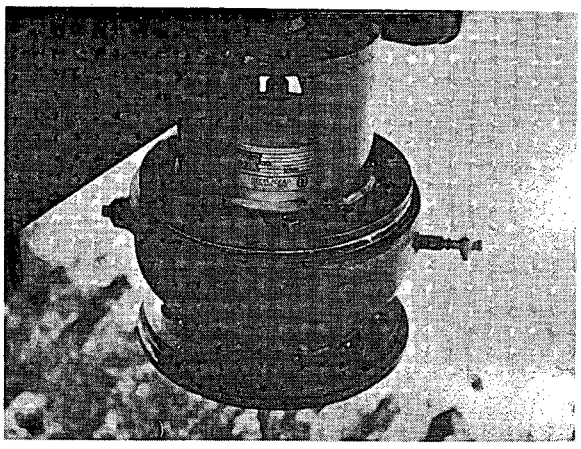
The group was involved with the BAFFIN's survey of Senegal in projects relating to the positioning and navigation of the ship, data aquisition and data processing. A two station Accufix Loran-C system was established ashore in Senegal under a contract with Comdev Marine (now Marinav) of Ottawa. Operating in the Rho, Rho mode the system provided velocity information to the Magnavox Integrated Navigation System (INS) which was used to position the ship and provide line following navigation. This particular implementation of the Loran-C signals eliminated the need for detailed calibration of the system and obviated the necessity of accurately fixing the position of the transmitter sites. As a result the survey began on schedule despite tight time constraints and the problems of establishing the system on remote foreign soil. Following a first week of erratic performance the system worked almost flawlessly providing better than 200 metre accuracy (95%) over the entire survey area on a 24-hour per day basis. Improved programs were developed to edit and select depth data which was recorded on the INS and routines were implemented to improve

the accuracy of the fixes derived from the integration of SATNAV and Loran-C through post-mission processing.

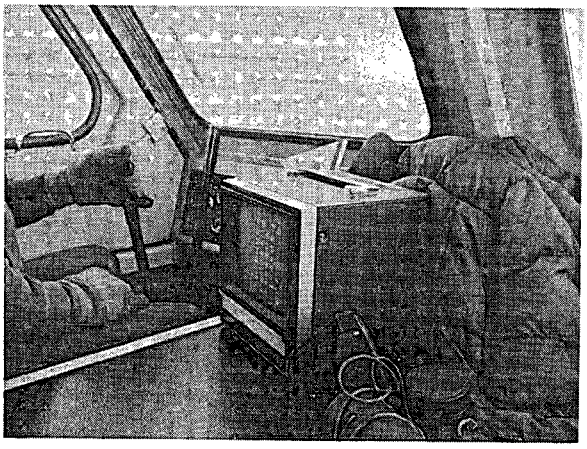
Banister Technical Services of Edmonton was awarded a contract as a result of an unsolicited proposal to develop and test a tracked vehicle sounding system for ice covered Arctic waters. The development group participated in this program by reviewing the contractor's work and providing INDAPS for use in the vehicle. A Canadair Flextrack CF-23 was modified to provide the vehicle for the system. It was fitted with a hydraulic system for raising and lowering the transducers which were coupled to the ice with metal spikes. This technique for echo sounding eliminated the requirement for cleaning and wetting the ice surface prior to sounding greatly speeding up the process and eliminating the requirement for the surveyor to leave the vehicle as is the case with conventional helicopter sounding. Closely spaced spot soundings could be economically obtained using this method. A program was developed for INDAPS that employed range data from Mini-ranger to provide navigation to the next sample point on the sounding line. The system is illustrated, the visual display being located immediately to the right of the operators hands. While on station the system analyzed the echo sounder signals to select the bottom return which it then recorded along with the station co-ordinates. The capabilities of INDAPS, which was introduced in 1974, were further enhanced with the addition of new software in 1976. Conversion and navigation routines for two range systems were developed and implemented on the St. Lawrence River survey with Motorola Mini-ranger III as the input. The system was successful and several large scale sheets of harbour approached were completed. An improved depth tracking program was added to the data aquisition software to improve the reliability of the online depth editing process. The new program permits selection of gate length to increase the differentiation between fast rising slopes and spurious responses.



Canadair Flextrack CF-23



12 khz Transducer Mounted on CF-23



Navigation Display in Use on CF-23

The next generation of hydrographic data aquisition systems will employ micro-processors in place of the mini-computer as used in INDAPS. A typical system will require a number of these processors, however, to match the capabilities of the previous equipment. As part of an inter-region development program, Central region is engaged in the solution of position finding and navigation problems using micro-computers. Interest in easily portable systems for Arctic use in heli-copters and small tracked vehicles has been the largest motivating factor for this development. Work began in the fall of 1976 on the "NAVBOX" that will be employed in the BOMBI during the 1977 PCSP survey south of Melville Island. This system using Mini-ranger III for range data, provides navigation instruction to the driver in the form of distance to sample point and cross course error via a small CRT display. Depth, which is entered on a keyboard, and position of each spot sounding are retained in memory during daily operation and then transferred to the INDAPS computer on the CF-23 at the end of the day over a standard communications link.

TIDAL INSTRUMENTATION

An important responsibility of the Tidal Instrument Development Group is the network of water level telemetry systems which provide real time and near real time water level information for shipping in the St. Lawrence Seaway, for storm surge warning, and for regulation of Great Lakes water levels. The increased draft of vessels navigating the St. Lawrence River to Quebec City and above in recent years has severely strained the capabilities of the existing telemetry equipment and has been the impetus to the Tidal Instrument Group's major development project of 1976, the Tidal Aquisition and Telemetry System, or TATS.

A micro-computer based system designed to communicate over telephone lines or radio, TATS can provide instantaneous digital water level information to shipping, or alternatively transmit several days' record from memory to a central computer. Implementation of TATS in the telemetry network will begin in 1977 and will eventually include most of the permanent gauging stations.

Preliminary work has begun on the next major project, the development of a field portable, computer compatible water level instrument to be used in support of automated hydrographic survey operations.

TIDES AND WATER LEVELS SECTION

The basic function of the Tides and Water Levels Section in Central Region is to conduct studies of tides, currents and water levels in support of regional hydrographic activities. This involves the provision of technical information and advice on all aspects of vertical control to hydrographic survey parties and to other government and outside agencies. The section supplies tidal, current and water level data required for various Canadian Hydrographic Service publications, and also publishes, itself, a monthly Great Lakes water level bulletin. Over 80 permanent water level gauging stations on the Great Lakes-St. Lawrence River system are the responsibility of the section, many of these gauges providing information that is vital to commercial and recreational navigation.

During 1976 the section contributed to the processing of survey data in the field with the development of automated sounding reduction techniques based on schematized co-tidal charts. These were integrated into data logging systems employed during surveys of the Lower St. Lawrence River and of Hudson Bay. The co-tidal charts were schematized by dividing them into blocks based on lines of latitude and longitude. The sizes of the blocks were chosen to give

fair representation of the co-amplitude and co-phase lines on the co-tidal chart (5' latitude x 10' longitude in the case of Hudson Bay). The resulting array of blocks, indexed to the phase lags and range ratios of the co-tidal zones, was the basis for the computerized reduction process. The program used the position of each sounding to locate it within a specific block, retrieve the reduction parameters for that block, and compute the sounding reduction using the time of the sounding and the relevant tidal height from the reference port. Reference port data were obtained on a real-time basis from Pointe-au-Père for the St. Lawrence survey and in the form of predicted levels at Churchill for the Hudson Bay survey. Using this method one day of soundings from three launches in the St. Lawrence were reduced in 30 minutes and one day of soundings from the survey ship in Hudson Bay in 10 minutes. A comparision of temporary tide gauge data collected during the St. Lawrence survey and the prediction from the schematized co-tidal chart indicated that the predicted levels were within accuracy requirements.

An increased number of deployments of submersible Aanderaa pressure gauges took place this year in support of both hydrographic and oceonographic surveys. During the PCSP survey of Belcher Channel three gauges were installed; one gauge was deployed in La Grande Estuary in James Bay during the winter oceonographic survey; one gauge was loaned to Laval University for installation in Rupert Bay during the summer; and one gauge was loaned to Research and Development division for a study of the tidal characteristics at the mouth of Hudson Bay. During the Senegal offshore survey one gauge was moored along with two current meters near the edge of the continental shelf, south of Dakar. At the same time a conventional onshore tide gauge was installed permanently at Dakar.

Many of the computer programs required to translate and analyze data from Aanderaa pressure gauges were developed during 1976 and successfully applied to available data.

The section continues to contribute to the work of the U.S.-Canadian Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data, Vertical Control and Water Levels Sub-Committee. Of major concern at present is the re-evaluation of the International Great Lakes Datum. The elevations of all bench marks around the Great Lakes and down the St. Lawrence River to Pointe-au-Pere will be updated on the basis of land based levelling and water level transfers carried out within the next few years. The central year of the evaluation will be 1980.

The Monthly Water Level Bulletin of the Great Lakes and Montreal Harbour produced by the Tides and Water Levels section was changed during 1976 to a dual dimension format. Water level information for Lake St. Clair was added to the bulletin to satisfy the needs of various government agencies and outside users. A major upgrading of instrumentation at the Belle River gauging station was required in order to obtain the required data for Lake St. Clair. The water level information given for Montreal Harbour was modified during 1976 to reflect the change in river characteristics brought about by the building of an ice structure at Montreal during 1966. It was felt that a minimum of 10 years of data were required to reasonably reflect these changes.

Eighty-eight permanent water level gauging stations on the Great Lakes, the St. Lawrence River, the Ottawa River, Lake Simcoe and on Hudson Bay are the responsibility of the Tides and Water Levels section. The maintenance of these gauges is, however, carried out for Ocean and Aquatic Sciences by the Water Survey of

Canada, Inland Waters Directorate. The process of metricating the instrumentation in all of the stations was initiated during 1976 and a large percentage of the equipment was converted, the remainder to be completed in 1977. Due to severe ice conditions on the St. Lawrence River during the spring of 1976 four gauging stations were badly damaged. Reconstruction of these stations was the major item in the 1976 permanent gauging program.

During 1977 it is expected that the section will be more active in the installation of temporary water level gauges in support of both hydrographic and oceanographic surveys, and in the annual inspection of permanent gauging stations. A permanent gauging station, using an Aanderaa gauge, will be established at Ft. George in James Bay in cooperation with the Montreal office of Water Survey of Canada. Additional computer programming required for the analysis of tidal data will be carried out during 1977. In conjunction with this work a review will be made of all historical tidal stations in Central Region for submission to the IHB Tidal constituents databank.

CARTOGRAPHY

Until this year a small section consisting of two persons provided a support service in the preparation of technical illustrations. The decision earlier in the year to accelerate the decentralization of the chart production functions from Headquarters has had a major impact. By the year's end the staff had grown to five with several new editions of charts well on their way to completion.

The first task in taking on regional chart production has been the setting up of a Hydrographic Data Centre. Previously data from the field surveys only was kept at Central Region. This year it has been necessary to bring duplicate files of all chart production material from Headquarters. The establishment of a new data centre has permitted the purging of old material and the setting up of a sound new system.

Supporting material for all Great Lakes charts was passed to the Region during the year. Material for Hudson Bay, the Trent and Rideau canals and various other major lakes, including Lake Winnipeg, will be transferred at a later date. Work was carried out on the preparation of four new editions in the upper St. Lawrence River. Specifications were prepared for a new chart of Toronto Habour.

The Regional Hydrographer and other regional staff have worked with Headquarters personnel in the U.S./Canada Charting Advisers organization. Results of this co-operative effort has been the production of co-operative general charts of Lake Erie and Lake Ontario and agreement on a chart scheme for future co-operative charting of the confluence areas of the Great Lakes. The co-operative charts are produced by one or the other of the two agencies (CHS and National Ocean Survey). The reproductive materials can then be readily used by the other agency with a few changes to provide a virtually identical chart. The end result should be a considerable reduction in the work for both agencies and uniformity of charts for the mariner.

The Cartographic Section has continued to produce the Great Lakes Monthly Water Level Bulletin and provide graphics support to other groups in Ocean and Aquatic Sciences. In particular, it has provided considerable support in providing graphics for the Shore Properties Section. In addition, it has prepared a new edition of the Small Craft Harbours reference map.

RESEARCH AND DEVELOPMENT DIVISION

INTRODUCTION

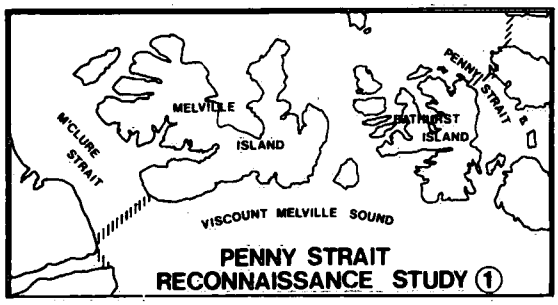
The three scientific programs of the Division are physical oceanography, shore properties studies and environmental assessment. During 1976 these were increasingly directed to answering environmental concerns raised by the growing demophoric (technology x population) pressures around the Great Lakes shoreline and energy-related developments in the mid and high-Arctic. Project development within these areas generally consisted of three phases: 1) the collection, analysis and interpretation of physical oceanographic and coastal morphological baseline data; 2) the carrying out of research or site-specific studies to fill in gaps in understanding and to develop a predictive capability; and 3) the compilation of the scientific results in the form of readily-understandable environmental impact statements. The program support function, consisting of ocean operations, ocean instrumentation, data processing, remote sensing and survey electronics, increased its overall capability by the hiring of additional full-time staff.

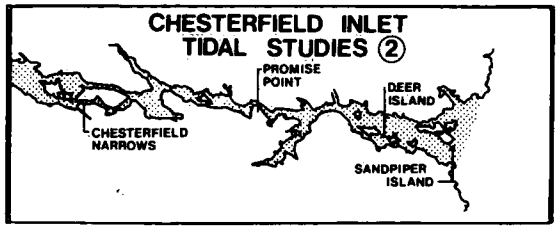
This year saw the successful completion of a number of projects initiated in previous years. These included: a comprehensive analysis of the freshwater budget of Hudson-James Bay, an in-depth study of Point Pelee erosion, a one-dimensional model of tidal propagation in Chesterfield Inlet, an impact assessment of the effect on littoral drift of a barge placed off Long Point, the development of a new portable deep-water sounder, and the contracting out to Canadian industry for the assembly of a computer-controlled oceanographic data acquisition system. New projects initiated by Divisional staff ranged all the way from erosion monitoring on Lake Erie in the south to a physical oceanographic reconnaissance survey in Penny Strait in the high Arctic, and varied from a one-day marina site evaluation to a three-month shipborne physical oceanographic study of Hudson and James Bay. Again, considerable integration of our field programs took place with Hydrography, including a particularly noteworthy operational rescue effort by CCGS NARWHAL when PETREL incurred an engine failure.

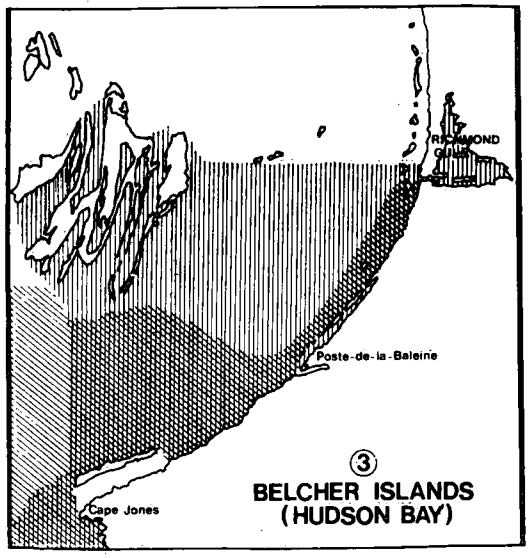
For an indication of the direction of future programs we first look to the Minister's Policy/Program Workshop, where thirty senior members of the Department, and world-renowned environmentalists Kenneth Hare and Maurice Strong, debated the emerging issues in the environment. These included energy and the environment, environment and development, and land use practices. In this vein, R&D personnel will play an increasingly greater role in the upcoming years in such energy-related baseline study programs as Excellence in Ice-Covered Waters, Arctic Islands Environmental Studies, and the Eastern Arctic Marine Environmental Studies. Insofar as development is concerned, the emphasis will be on the environmental impact assessment of the incremental effects of uncontrolled development along the Great Lakes shoreline. We will also play a major role in determining land use practices for riparian properties on the Great Lakes within the context of the emerging Coastal Zone Management Program. Lastly, we anticipate our budding cooperation with the Great Lakes Biolimnology Laboratory in Hudson Bay and the Bay of Quinte will grow into a continuing integrated physical-biological oceanographic program.

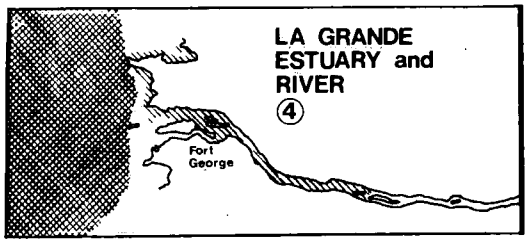
PHYSICAL OCEANOGRAPHIC SECTION

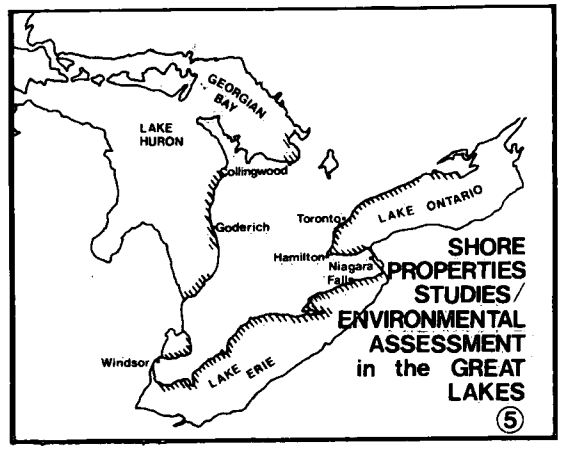
General physical oceanographic studies are conducted in the regions of Hudson Bay, James Bay, St. Lawrence River Estuary, Chesterfield Inlet and the Arctic. The aim of the studies is to increase our knowledge of the general circulation in these regions, and to determine the relative importance of the contributing factors controlling the circulation. Future changes in the circulation caused by man-made developments in the environment can then be monitored and possibly be predicted when enough data is available for modelling. In a number of these studies we have collected extensive time series and station data, and are presently at the analytical and model building stage.

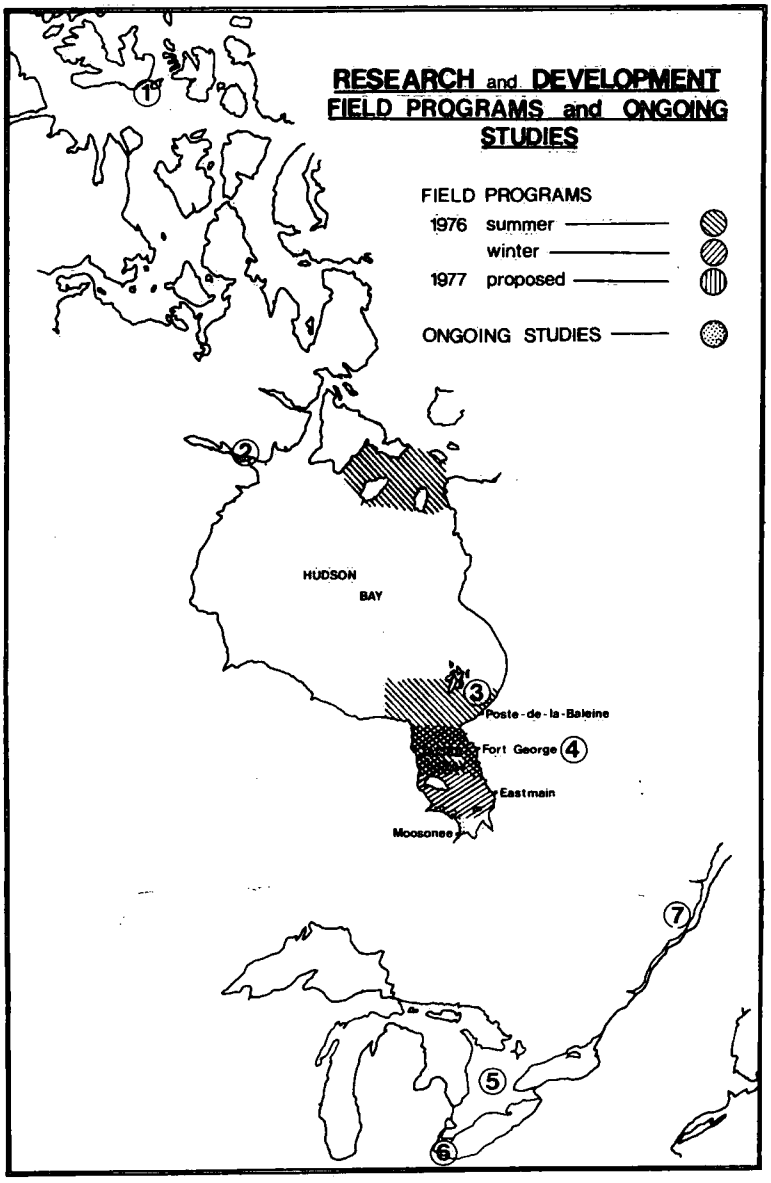

MELVILLE
ISLAND
M'CLURE STRAIT
VISCOUNT MELVILLE SOUND
BATHURST ISLAND
PENNY STRAIT
PENNY STRAIT RECONNAISSANCE STUDY (1)

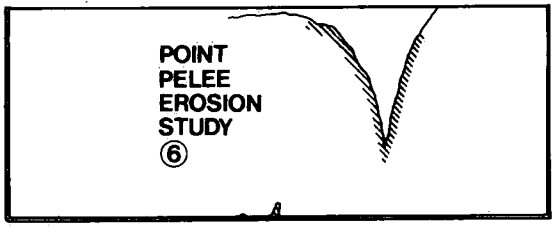

CHESTERFIELD INLET TIDAL STUDIES (2)
PROMISE POINT
DEER ISLAND
CHESTERFIELD NARROWS
SANDPIPER ISLAND

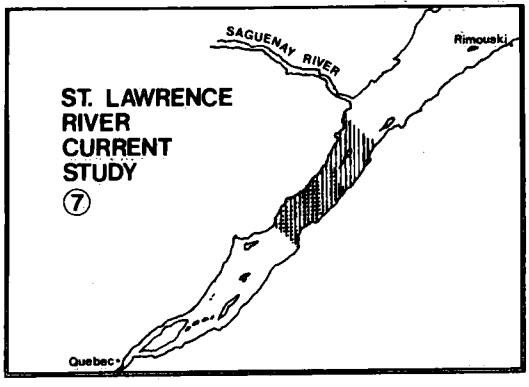

RICHMOND GULF
Poste-de-la-Baleine
Cape Jones
(3)
BELCHER ISLANDS (HUDSON BAY)


LA GRANDE ESTUARY and RIVER
(4)
Fort George


GEORGIAN BAY
LAKE HURON
Collingwood
Goderich
Toronto
LAKE ONTARIO
Hamilton
Niagara Falls
Windsor
LAKE ERIE
SHORE PROPERTIES STUDIES/ ENVIRONMENTAL ASSESSMENT in the GREAT LAKES
(5)


RESEARCH and DEVELOPMENT FIELD PROGRAMS and ONGOING STUDIES
FIELD PROGRAMS
1976 summer
winter
1977 proposed
ONGOING STUDIES
(1)
(2)
HUDSON BAY
(3)
Poste-de-la-Baleine
Fort George (4)
Eastmain
Moosonee
(7)
(5)
(6)


POINT PELEE EROSION STUDY
(6)


SAGUENAY RIVER
Rimouski
ST. LAWRENCE RIVER CURRENT STUDY
(7)
Quebec

1) Water Mass Budgets for Hudson-James Bay

The freshwater input of the Hudson-James Bay region determines the vertical and horizontal density gradients. The large vertical gradients found at the depth of the pycnocline inhibit the vertical transfer of nutrients, while the small horizontal gradients cause the anticlockwise circulation in both the Hudson and James Bays. The freshwater input on a monthly basis is required in order to understand the circulation and possible changes that may occur when hydro-electric developments change the freshwater input cycle. The total freshwater input includes the runoff from the surrounding land, as well as the excess precipitation minus evaporation over the water surface itself. Estimates were made from 10 years of available surface water and climatological data.

The total annual discharge entering James Bay is of the same order of magnitude as the annual discharge for the St. Lawrence River or the Mackenzie River. Over one year, the total runoff is equivalent to an addition of a 1.26 metre layer of fresh water over the total Hudson-James Bay region, or a 4.7-metre layer when the James Bay region is considered on its own.

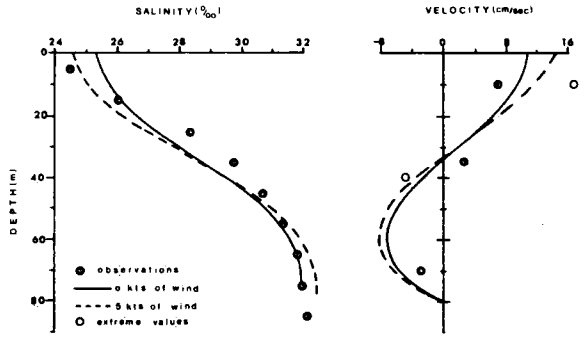
	Drainage Area ($10^5 km^2$)	Discharge Rate $10^3 m^3/sec$	Rate/Area $10m^3/sec/10^2 km^2$
James Bay rivers	6.8	10.0	1.47
Hudson Bay rivers	24.2	22.6	.93
Hudson-James Bay rivers	31.0	32.6	1.05
Nelson and Hayes rivers	11.9	3.6	.30
St. Lawrence River	10.3	9.9	.96
Mackenzie River	9.9	10.8	1.09

Average monthly evaporation and precipitation estimates were made by splitting up the total area of Hudson-James Bay into six regions. The five regions in Hudson Bay all showed a yearly net loss of water to the atmosphere, while in James Bay a small net gain was found. A larger loss was obtained in the northeastern corner of Hudson Bay than in the southwestern corner, since the dry Arctic air moving in a southwesterly direction slowly picks up water vapour and becomes saturated along its passage over Hudson Bay. On a yearly basis, the Hudson-James Bay water surface loses a .31-metre layer of water to the atmosphere, thus reducing the yearly runoff addition of 1.26 metres to a net freshwater gain of .95 metres over the total water surface.

2) Water Transport in James Bay

The large Hydro-Electric Development of the La Grande River will change the total freshwater budget and, in turn, the density gradient circulation mode of James Bay. The contributions to the water exchange between Hudson and James Bays caused directly or indirectly by the freshwater input have to be understood first before changes in transport between the Bays, due to the development, can be predicted.

The magnitude of the freshwater current mode is compared to: 1) the gravitational mode which is caused by the density difference of the Hudson-James Bay waters, and 2) the wind-driven mode. Although it is necessary to approximate James Bay as a rectangular bay of constant depth, the two-dimensional analytical model of Hansen and Rattray is very helpful in determining the relative amplitudes of the three modes. The model was applied to the northern part of James Bay, since for this area two years of cross-sectionally averaged salinity profiles were obtainable from two transects. Also an averaged current profile was derived for the northernmost transect.



Current and Salinity Results James Bay

The observed and analytical water velocity and salinity results for a small northerly-directed wind stress as well as a zero wind stress are shown in the diagram. The general distribution of the observational data agrees with the analytical results, showing an outflow of less saline water

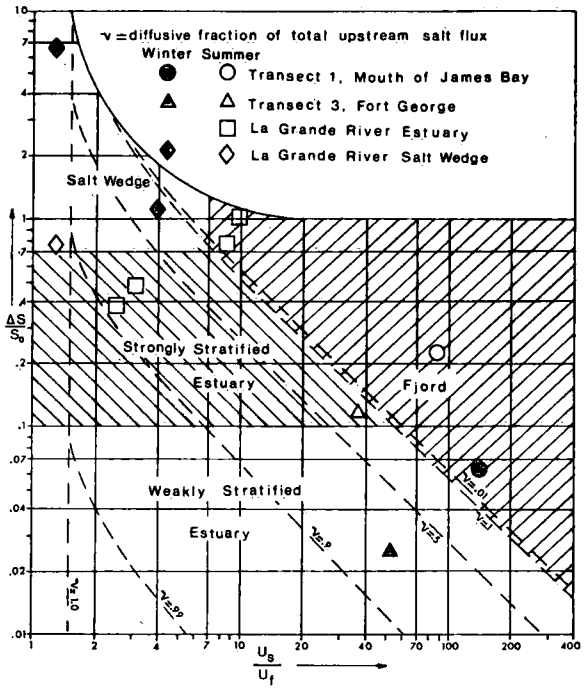
in the surface layer and an inflow of saline water in the bottom layer. The meteorological data from a surface buoy at the entrance of the bay revealed a general northerly-directed wind stress during the observation period of the current meters. The extreme current values plotted on the diagram are single current meter values rather than cross-sectional values. The extreme surface outflow value of 16.4 cm/sec was found on the eastern side of the bay, while the extreme inflow value of 5.0 cm/sec was found in the centre of the bay at a depth of 40 metres.

James Bay may be considered a highly-stratified fjordal-type estuary in which the salt flux into the bay is primarily accomplished by advection, while diffusion is negligible. The analytical model results for the bay show that the advective salt circulation is mainly dependent on the gravitational and wind-driven modes. Although the freshwater mode contribution is small, the rivers do play a major role in the circulation since they cause the density difference between the Hudson and James Bay waters necessary for the gravitational mode. The mean surface outflow of James Bay can be reversed by a northerly wind of 15 knots, at which time a three-layered velocity profile develops. During the summer months, however, a generally weak southwesterly wind is present with the occasional storm from the northwest.

3) La Grande River Estuarine Studies

The largest changes in the aquatic environment, due to the Hydro-Electric Development on the La Grande River, can be expected in the La Grande River estuary and the La Grande River itself.

The region between the La Grande River mouth and James Bay is considered the La Grande River estuary. It is rectangular, bordered by shoals and islands with average dimensions of 6.0 kilometres long, 2.7 kilometres wide, and 22 metres deep. The outflow of the La Grande River makes it a highly-stratified estuary in the summer, the upstream salt flux being accomplished by both diffusion and advection. In the winter, the ice cover decreases the vertical eddy diffusion to such an extent that the fresh water continues to flow above the salt water out of the estuary into James Bay proper. The estuary during this time is a highly-stratified fjord where the upstream salt flux is achieved mainly by advection.



Estuary Classification Following Hansen-Rattray

Modifications to the river discharge will cause major changes in the circulation, since both the river mode and the gravitational mode will be altered. An oscillating tidal salt wedge between Fort George and the river mouth can be expected during periods of low discharge and onshore winds.

Analytical and numerical two-dimensional models are being applied to the lower La Grande River and the La Grande estuary to predict any major mean salinity changes that would occur during the filling period of the reservoirs, as well as during the expected high outflow following the completion of the power dams.

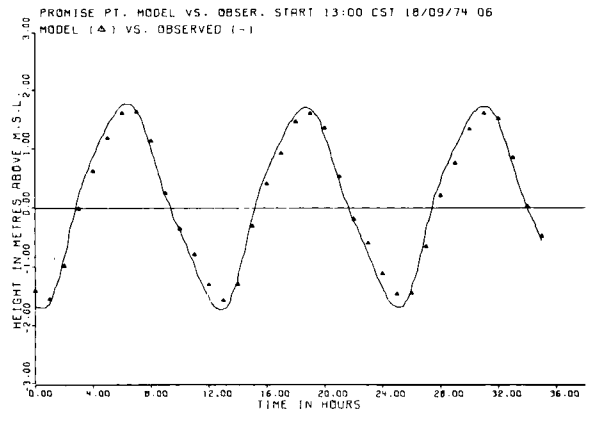
4) Chesterfield Inlet Tidal Studies

Chesterfield Inlet drains an area of 290,000 km^2 of predominantly continuous permafrost terrain between Great Slave Lake and northern Hudson Bay. Polar Gas plan to use the 220 kilometre-long inlet

as a major supply route for moving materials required in the construction of the eastern Arctic pipeline. The inlet forms a complex network and is characterized by strong tidal forcing.

A study of the tidal propagation in Chesterfield Inlet was carried out using a one-dimensional numerical model with a weighted implicit finite difference scheme, modified for application to the network. Sparse matrix techniques were incorporated into the model to speed Gaussian Elimination in the solution of the equations. Tidal constituents derived from admittance calculations were used to predict water levels at eight tide gauge locations. Tidal predictions at Sandpiper Island were employed as the downstream boundary condition for the numerical model, while tidal predictions at the other gauge locations were used in the model calibration.

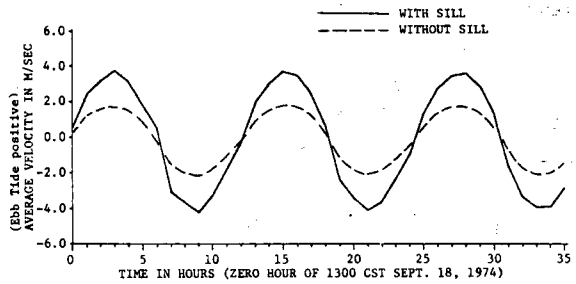
Only in the upper reaches of the channel does the steady current due to freshwater discharge have any appreciable effect on the tidal propagation. At major constrictions of the inlet, considerable tidal energy is lost in producing rip tides and other large-scale turbulence. The continual loss of tidal energy and negligible energy reflection causes the tide to remain progressive in nature throughout its propagation up the inlet. The tide reaches its maximum spring amplitude of 2.5 metres near Deer Island, which is located about a third of the way into the inlet. Energy losses at the first major channel constriction above Deer Island (Ekatuvik Point) reduce the spring currents, and



Computed and Observed Water Levels at Promise Point - Spring Tide

shallow bottom topography causes noticeable distortion in the sinusoidal tidal curve as shallow-water constituents are being generated.

The observed and computed heights for Promise Point shown in the diagram reveal the shallow water effect of the tidal wave (steepening of th tidal curve during flood). Power spectra of the observed and model-predicted water levels reveal that nonlinear interactions of the major tidal constituents take place in the upper portion of the inlet. The numerical model results show a large current value of 4 m/sec at the Chesterfield Narrows, the last constriction before entering Baker Lake. If this maximum current is too severe for shipping, a 50% reduction of the current, as predicted by the model, can be obtained when the shallow sill of the Narrows is deepened by ten metres.



Model Predicted Currents at Chesterfield Narrows

The model pointed out some shortcomings in the tidal data and a major field survey is planned for 1978 to investigate these and to obtain current meter and salinity profile data for a vertical two-dimensional model now being developed for Chesterfield Inlet

5) St. Lawrence River Current Surveys

Although the St. Lawrence River and estuary support a large volume of shipping, very little coherent scientific data on tidal heights, tidal currents and water properties is available. The 1974 and 1975 oceanographic surveys of the St. Lawrence estuary were planned to investigate the current regime and update the existing tidal current charts of the middle estuary. During 1976

no field survey was carried out, in order to provide time to thoroughly analyze the data from the previous three years of observation.

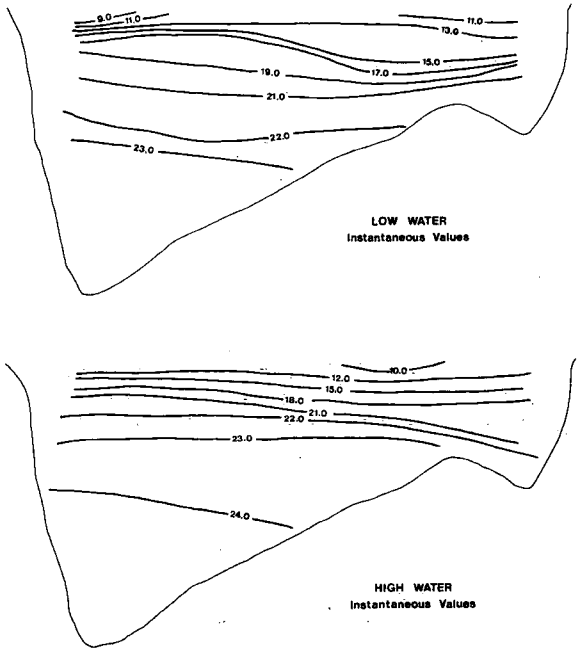
The very irregular and shallow topography between Ile aux Coudres and the Saguenay River and large tidal amplitudes cause extensive variations in the constituents from one record to the next. The mean current varies from a minimum of 3.3 cm/sec to a maximum of 47.2 cm/sec, and the amplitude of the major axis of the M_2 ranges from a minimum of 31.8 cm/sec to a maximum of 140.3 cm/sec.

In almost all cases, the shallow-water constituents are well developed down to the 12th diurnal. These are locally-generated constituents in the current regime which do not appear in the water level elevation records. Further interactions between the tidal currents and the topography produce local eddies causing large variation in mean currents as well as turbulence. The turbulence is an important source of tidal energy dissipation, resulting in the tide being a mixture of standing and progressive wave components. The large vertical density variation introduces a baroclinic component to the vertical structure of the tidal currents which can't be approximated by a simple two-layered current model.

The current meter data were analyzed both by the Response Method and the traditional harmonic analysis method, with the better results, in terms of smaller residuals, being obtained by the harmonic analysis. In the analysis of the surface tide, better results are obtained by the Response Method, since the shallow-water constituents generated by the bottom topography do not show up as readily in the tidal elevations as they do in the tidal currents. Both tidal currents and tidal elevations at any required time interval can now be predicted for a desired location with only the knowledge of the local tidal constituents. Also the Response Method points out nonlinearities and non-tidal frequencies in the tidal signals.

The most noticeable feature of the oceanographic observations is the large differences in the non-tidal, cross-sectional distributions of salt, heat, and density from spring to neap tides. As a starting point, the estuary characteristics have been plotted on a Hansen-Rattray classification diagram. Although the estuary is not laterally homogeneous, as required in the analytical model, it does provide the relative importance of the advective and diffusive terms. In the 10-mile section of river examined, there is a significant difference in the estuary type. At the downstream end, the primary mechanism for upstream salt flux is advection, while at the upstream end diffusion becomes more important. Although the effects of the large diurnal inequality in the vertical tides have not been examined, it can be safely assumed that these also are very important in the mixing processes in the middle estuary.

A survey is planned for 1977 to complete the current meter studies and investigate the effect of the high frequency turbulence on the mean observed currents.

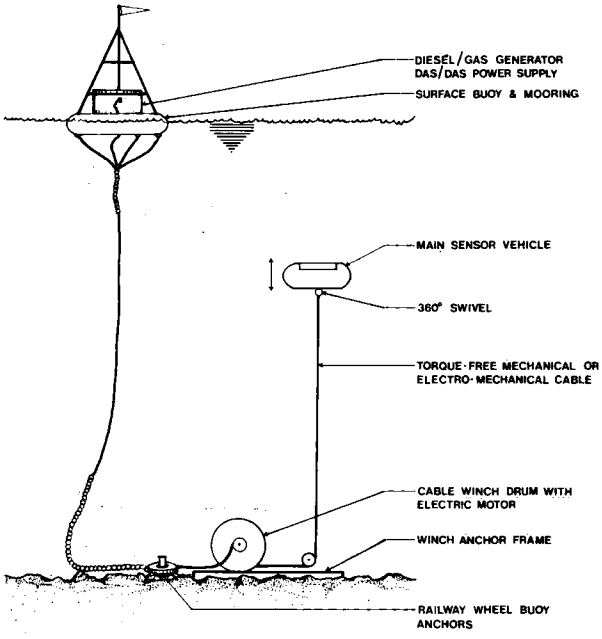


Sigma-T at Neap Tide - St. Lawrence River Near Pte au Pic

6) VAPS - Vertical Automatic Profiling System

In early 1976 a committee was formed with members from IWD and OAS to design a profiling instrument package that could be placed in water up to 150 metres deep and measure current speed, current direction, temperature, and salinity over a vertical profile at 10 cm intervals.

An operating life of at least 600 cycles was required. All existing instruments were examined and none were found that could be used for the application envisaged. The final design consisted of a submersible winch package, a modular power package, and floatation cell which incorporated the sensors and the data logger. A prototype was built and deployed in Lake Ontario for testing in October, 1976, and an exhaustive analysis of the collected data was carried out. The results showed that the VAPS should not be used for profiling at depths where surface waves contaminate the low frequency currents. Further tests are planned for this spring in deeper waters, after re-designing the vehicle body.

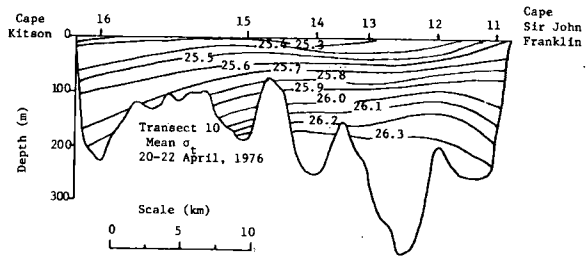


Proposed VAPS Configuration

7) Penny Strait Reconnaissance Study

The three-week reconnaissance survey of Penny Strait came about in response to DIAND's request to examine surface currents and related physical oceanographic parameters which could determine the spread of oil in the event of a spill or oil well blow-out in the Sverdrup Basin. Results of the data collected across one transect (30km long and an average depth of 200m) from Cape Sir John Franklin (Grinnell Peninsula, Devon Island) to Cape Kitson (Bathurst Island) have provided an insight into the scales of motion and general physical oceanography of Penny Strait.

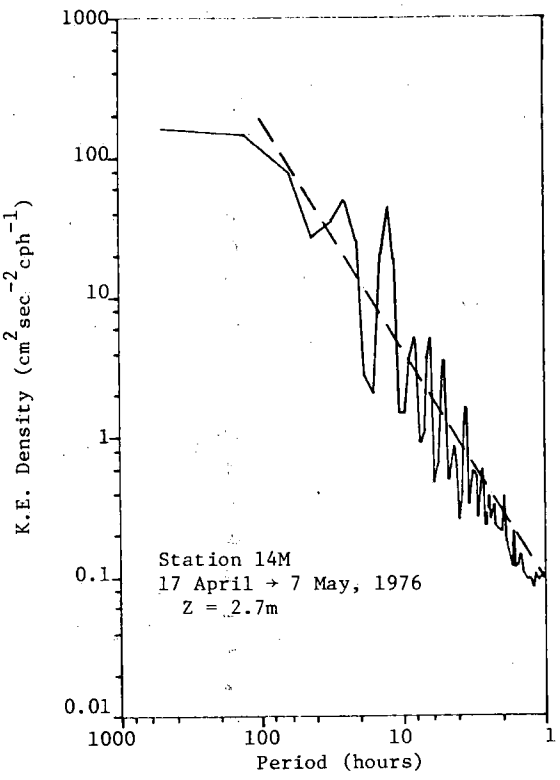
Temperature increased from typical surface (2m) values around -1.8°C to -0.7°C at 200m, while salinity ranged from a low of 31.25‰ at 2m to almost 33‰ (200m). The average of four sets of T, S, σ_t data collected at the six CTD stations across the Strait and over a two day period was taken to remove tidal effects. The mean internal pressure field, characterized by a downward slope of the isopycnals towards Cape Kitson indicates a net flow towards the southeast, which is in agreement with the net drift obtained from the current meters (5cm sec^{-1}).



Mean Sigma-T Distribution Across Penny Strait

Total current speeds reached 60cm sec^{-1}, of which tidal contributions were 30 - 35cm sec^{-1}. The rectilinear current ellipses of the major constituents align with the NW-SE axis of the channel. The records were run through a low-pass filter (25 hours) and the residual currents exhibit long period oscillations from four to eight days, reaching amplitudes of 25cm sec^{-1}. Similar oscillations have been observed in the Arctic Ocean, apparently caused by atmospheric events (Coachman, 1969: Arctic, vol. 22, #3). Atmospheric pressure corrections were applied to the tidal record obtained in Pelham Bay, and while the length of common record is short, the pressure corrections seem to match the oscillations in the residual currents.

Ice thickness varied across the Strait, with thin ice (15cm) and open water encountered west of John Barrow Island. Thick ice (2m) was found near the middle of the transect and elsewhere the average thickness was 1.3m. There was more ridging in Penny Strait than Belcher Channel, and one area, several hundred metres across, was uplifted, probably more in response to ice stress



Power Spectrum of Current Meter 14M Penny Strait

than to other forces.

In 1977, a similar reconnaissance study will be conducted across M'Clure and Prince of Wales Straits, again in cooperation with the Hydrographic Division in conjunction with Polar Continental Shelf Project.

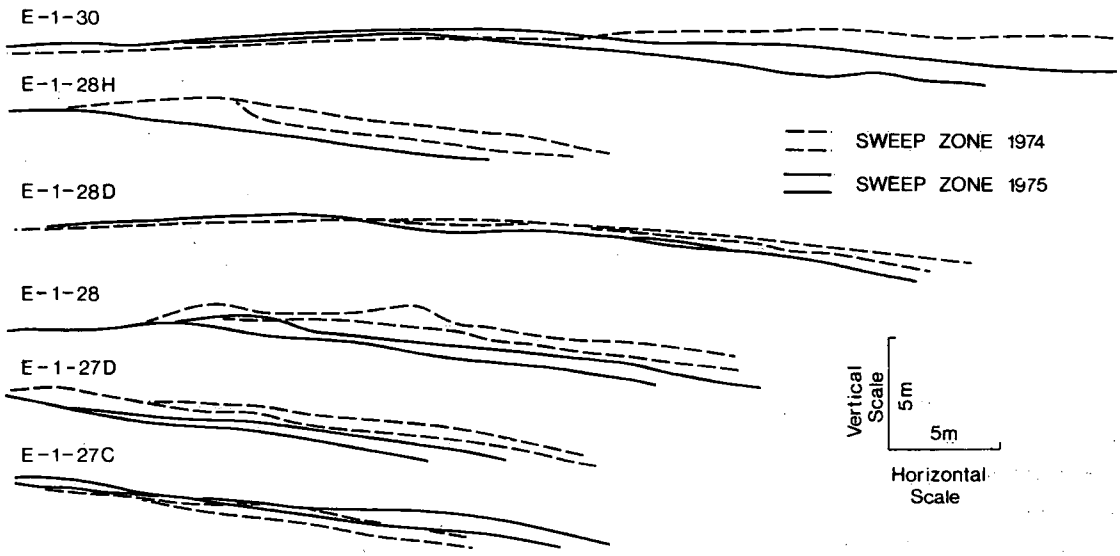
SHORE PROPERTIES STUDIES

Ongoing research projects undertaken by Shore Properties Studies include: the Canada/Ontario Great Lakes Shore Damage Survey; site-specific studies at Point Pelee, the La Grande and Eastmain estuaries in James Bay, the Hudson Bay Lowlands, Goderich Harbour, Scarborough Bluffs, and Port Dover; studies of significant storm-related incidents; applications of ERTS-1 digital data to sediment transport; definition of hazard lands for the Great Lakes; and studies of vegetation and its role in controlling shore erosion.

1) Canada/Ontario Great Lakes Shore Damage Survey

Studies of the erodible portions of the Great Lakes' shorelines continue to be of vital importance. The scientific value of this research provides the information required to establish an understanding of erosion rates and related phenomena necessary to support both the overall and site-specific aspects of coastal zone management.

To fulfill this requirement, monitoring of established erosion stations (162) was continued this year, and will continue for the next 4 years, updating erosion rate data as well as providing a base for the comparison of the effects of water level variations. The monitoring is carried out by onshore and offshore measurement of profile



Sweep Zones of Beach Profiles for the East Shore of Point Pelee

change, stratigraphic analyses, and successive photography. In addition, sequential low altitude oblique photography is periodically updated to maintain a record of change for the entire shoreline (Lakes Huron, St. Clair, Erie, and Ontario).

2) Point Pelee Erosion Study

The concern about the preservation of a valuable natural resource such as Point Pelee is readily apparent, yet along with this concern is the need for raw materials such as aggregates dredged from submarine sand and gravel deposits. This could involve a conflict in resource management, therefore the question of how significant commercial dredging is as a process element in the local coastal dynamics needs to be resolved. To provide a basis for this assessment, offshore and onshore surveys, bottom sediment analyses, wind-wave analyses, and current measurements have been taken over the last two years to derive a sediment budget for the Point Pelee spit and shoal system.

The magnitude of response was measured by the morphologic and volumetric variation between successive profiles at 18 sites throughout Point Pelee. The beach zone of the east shore evidenced the most dramatic morphologic and volumetric changes to its profile, with an average loss of 17.5 m^3/m from fall of 1974 to spring of 1975. Maximum material restored to the east beach in 1975 did not exceed 4.5 m^3/m. Although changes to profile sweep zones for the spoke network at the tip of Point Pelee were of similar magnitude, the relevance of such volumetric displacements is much less, as they merely represent reorientation of the submerged spit extension.

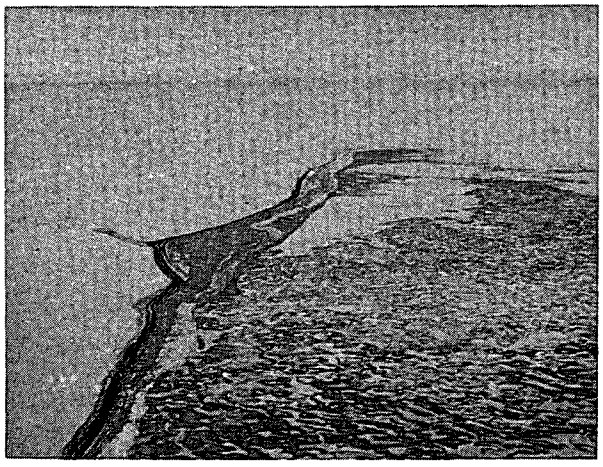
3) James Bay Hydro Development

This project attempts to define rates of erosion in the estuaries of the La Grande and Eastmain Rivers in order to predict the magnitude of response to discharge modifications resulting from the James Bay hydroelectric power development. This year, onshore and offshore profiles, current measurements, soil samples, and sequential low-altitude oblique photography for both estuaries were continued and updated.

The banks of both rivers are composed of coarse alluvial deposits ranging from medium to coarse sand, which is highly susceptible to retrogressive flow slides and wave erosion. Shoreline processes are complex in these estuarine environments and must be fully understood to ensure effective protection of these environmentally-sensitive areas.

4) Hudson Bay Lowlands

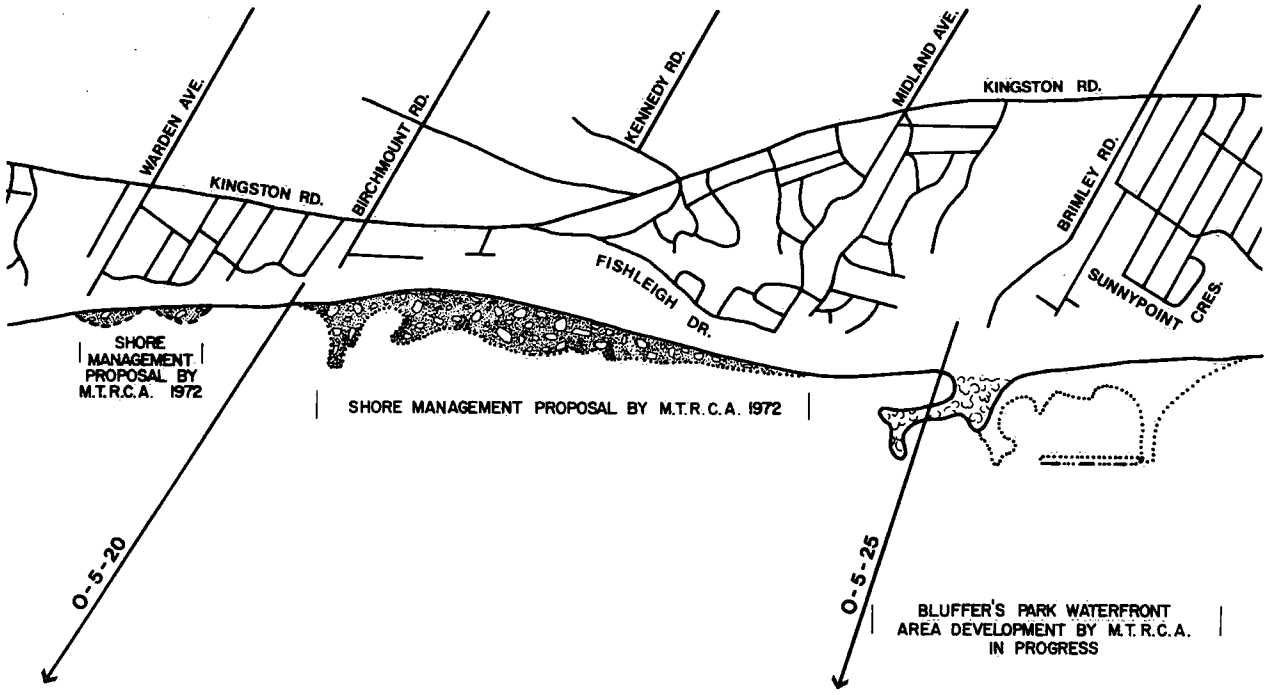
In support of the need for environmental baseline data in the Hudson Bay Lowlands, oblique low-level photography of the Albany River estuary and the shoreline between Fort Albany and Moosonee was undertaken this year. Also, shore profile stations were established at key locations to enable the measurement of shoreline dynamics. Future work will involve nearshore current measurements and possibly locating additional shore profile stations in the Attawapiskat River estuary.



Coastal Features in Hudson Bay Lowlands

5) Maitland River - Goderich Harbour

Major siltation problems at the Maitland River outlet at Goderich have led to a study of the process and response elements affecting the natural and man-made regime in this area. Erosion of the adjacent bluffs, littoral drift, and



Bluffers Park Erosion Station

seasonal discharges of the Maitland Watershed interact with the offshore breakwater system. This year attempts were made to delineate the parameters involved, using a tight grid of offshore soundings, current measurements, stream flow data, and nearshore sediment sampling. Not only does this study support scientific research, but it could also be used in an applied sense to assist in the development of local management practices.

6) Scarborough Bluffs

In conjunction with the Physical Sedimentology Section of the Hydraulics Research Division, two shore erosion profile stations were established this year to measure both onshore and offshore physical changes of the Scarborough Bluffs. One station is located where the toe of the bluff is protected by the nearshore landfill, while a second is located downdrift or to the west of the landfill. Thus, in the former case it is possible to measure bluff recession in the absence of toe erosion, while the latter station serves to measure the effect of the nearshore landfill on the unprotected shoreline to the west.

7) Port Dover

The recent arc slump of an 80-foot high bluff near Port Dover on Lake Erie has since been protected at the toe and dewatered at the top, providing an ideal opportunity to study the temporal effects of the protection and the overall stabilization of the bluff. Groundwater seepage acts as a lubricant between the base clay deposits and sandy overburden. Monitoring of this area was started this year and will continue annually in conjunction with the Hydraulics Research Division, providing useful data in a determination of slope stabilities.

8) Significant Storm-Related Incidents

The problems of shore erosion and flooding must certainly be viewed on a long-term basis, yet it is equally important to grasp the implications of short-term, significant incidents. Information of this nature is a key in the analysis of the temporal and spatial scales of erosion and shore damage.

Previous studies include the Lake Huron Storm

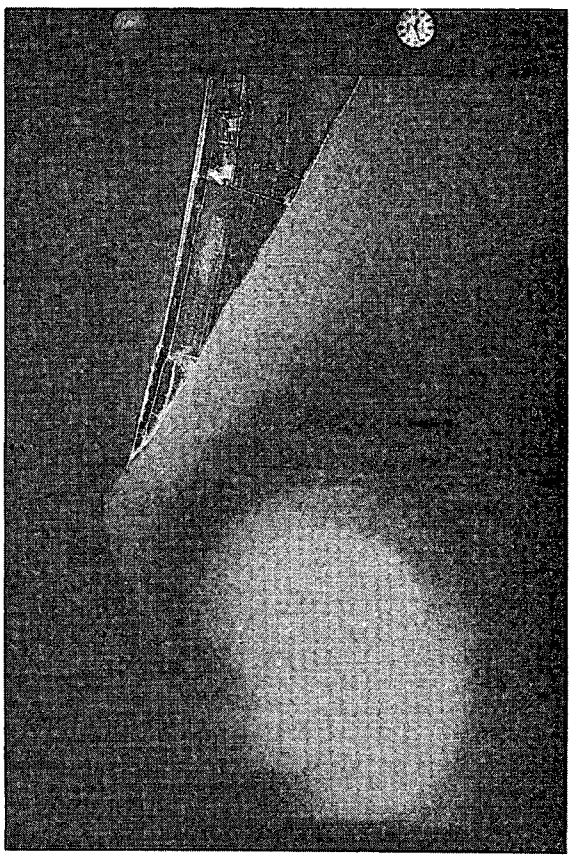
Surge (1971), Lake Ontario "Agnes" Storm Surge (1972), Western Lake Erie high water damage (April, 1973), and most recently, the storm on eastern Lake Erie (November 10, 1975). If a major storm surge occurs again in the future a site-specific study will be carried out, with the erosion monitoring data and the Canada/Ontario Great Lakes Shore Damage Survey Atlas and Technical Report serving as benchmarks.

9) ERTS-1 Satellite Data Applications to Sediment Transport

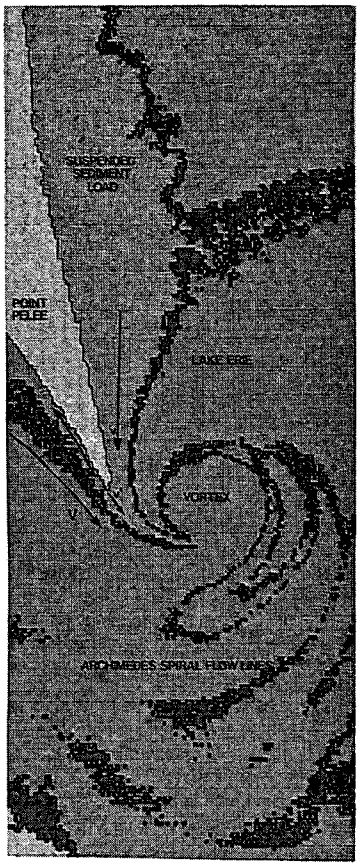
In conjunction with the Remote Sensing Section, this study is directed to an investigation of a bifurcated sediment transport system for the north shore of the Central Basin of Lake Erie. This transport system, identified by digital ERTS-1 satellite data, suggests bifurcation of the near-shore current, midway between Romney and Port Crewe, which gives rise to a "mirror image" model for the temporal evolution of the Point Pelee-Rondeau landforms. Bifurcating sediment transport to the east of Port Crewe is opposed by the lake return current flow most of the time, but reinforced by the surface flow. The sediment transport to the west of Romney is almost always reinforced by the lake return current. This would suggest that the sediment transport avenue involved in the evolution of Point Pelee is more effective as a generation mechanism than the sediment transport avenue involved in the evolution of Rondeau. Hence, Pelee has assumed the classical "knife-edge" configuration. Further study of this phenomenon is anticipated, including the deployment of current meters as ground truth for ERTS-1 satellite data.

10) Hazard Land Mapping

One of the recommendations of the Canada/Ontario Great Lakes Shore Damage Survey was the delineation of erosion and flooding hazard lands. Long-term recession rates and definition of bluff



Colour-infrared Aerial Photography



Computer Classification of ERTS

Point Pelee

profiles and stratigraphy enables the establishment of erosion setback guidelines for coastal zone management. Along with this, contour elevations, wind set-up, and wave uprush calculations enable delineation of hazard flood-prone areas. These hazard lands are being defined in conjunction with Ontario's Ministries of Housing and Natural Resources for eventual implementation by local municipalities.

11) Shoreline Vegetation Study

The objective of this study was to examine, in a relatively short period, a broad range of shoreline vegetation communities in terms of both their geographical distribution and their effect on shoreline stability. The function of vegetation in stabilizing backshore slopes was evaluated for the studied shorelines and several approaches to improve the stability of these slopes have been suggested. The study was completed this year by a consulting firm under contract jointly to Process Research Division and the Shore Properties Studies Section.

ENVIRONMENTAL ASSESSMENT

Environmental impact assessment is an activity designed to identify, predict, interpret and communicate information about the impact of an action on man's health and well-being (including the well-being of ecosystems on which man's survival depends). These "actions" may include legislative proposals, policies, programs, projects or any operational procedures. With heavy developmental pressures in our region, both existing and anticipated, the significance and increasing priority of environmental assessment is becoming apparent.

1) Environmental Assessment and Review Process

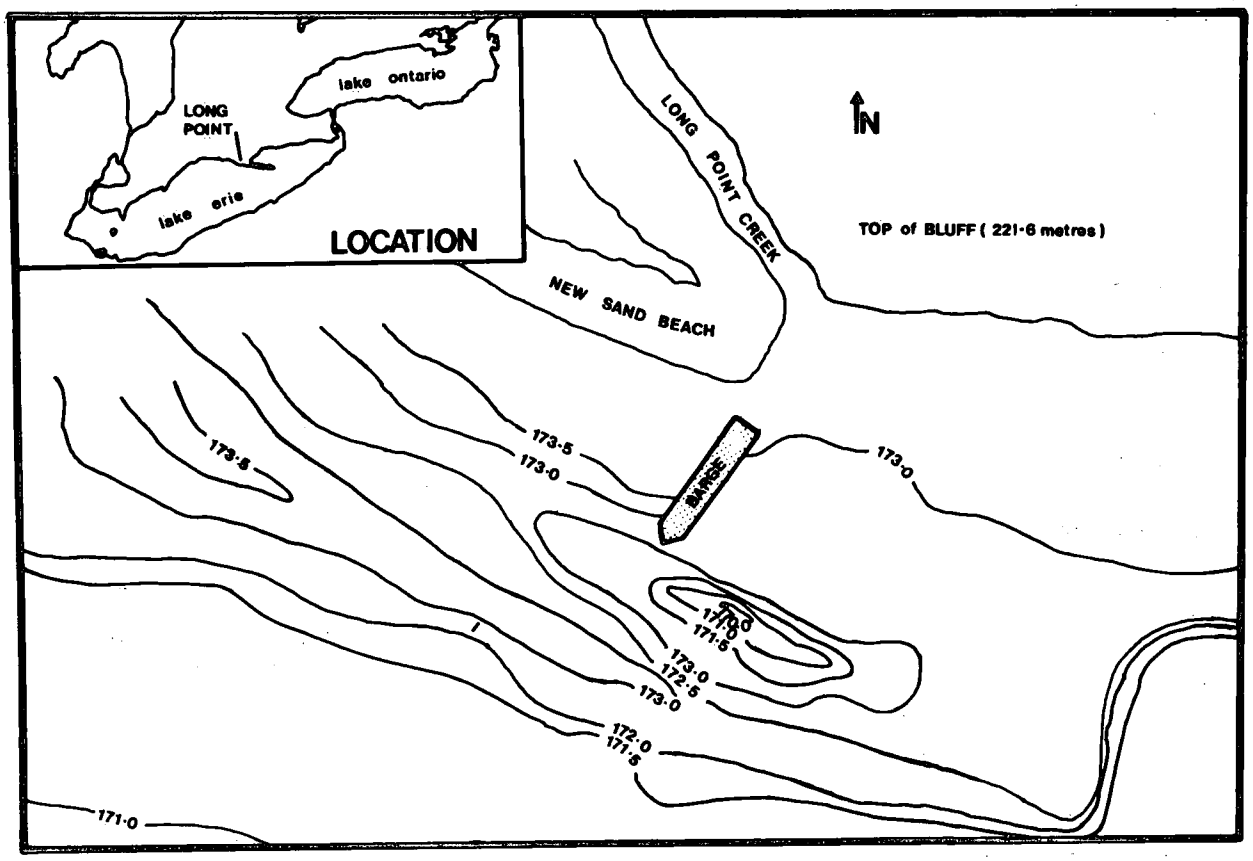
Our involvement in the Environmental Assessment and Review Process (EARP) was stepped up during the year as we undertook the review of a number of projects and proposals. Coastal zone management, and in particular a problem analysis of Lake Ontario, became one of the major undertakings. Efforts were made to ensure the compatibility of this coastal zone management exercise, with the follow-up projects emanating from the Canada/Ontario Great Lakes Shore Damage Survey. The objective was to identify existing and anticipated problems related to coastal zone management on Lake Ontario, including environmental, socio-economic and institutional considerations. Work will be undertaken on the other Great Lakes in 1977, and the resulting problem analysis will be used to help delineate federal responsibilities and priorities in the Great Lakes coastal zone.

The review of policy items related to EARP and the assessment of particular development projects were the other concentrated work areas in environmental assessment. The review of generic guidelines for initial environmental evaluations was completed during the year. These guidelines are now available in subject areas such as hydroelectric development, nuclear power, transmission corridors, industrial development, highways and railways, and dredging. Another policy item dealt with during the year was the review of a guide for environmental evaluation for use by other federal government departments. This guide is quite important, considering the fact that the federal EARP is a voluntary process whereby the particular federal department involved in a project is responsible for any judgments on environmental suitability.

Our participation in the environmental assessments of particular projects ranged from brief environmental reviews of proposals to the major undertaking of a field survey and data analysis related to a problem in the Long Point area of Lake Erie.

2) Long Point Impact Assessment

In August, 1974, the hull of the barge "Ivey" was sunk on the Lake Erie shoreline at the mouth of Long Point Creek. It was placed at right angles to the shoreline by a developer who intended to locate a marina at the mouth of this creek. Since the barge now acts as a groyne and intercepts littoral material as it moves from west to east, accelerated erosion downdrift has resulted. Some



Long Point Survey - Contour Map

of this erosion involves the barrier beaches protecting Big Creek National Wildlife Area at Long Point. The breaching of these beaches and subsequent intrusion of the lake is threatening the trees and marsh vegetation of this valuable reserve. The survey has shown that the littoral material is not getting to the downdrift shores, but rather building up on the updrift (west) side of the barge. Possible courses of action regarding removal of the barge are now being investigated.

3) Review of Marina Policy Assistance Program Applications

There was also a considerable involvement in the review of applications for federal assistance under the Marina Policy Assistance Program administered by Small Craft Harbours Branch. No commitment of funds was made until this environmental evaluation was completed for each marina proposal. Among the harbours or proposed harbours reviewed during the year were Smith Falls, Trenton, Cobourg, Humber Bay West, Lake Couchiching, Burlington, Matchedash Bay, and Bluffers Park in Toronto. More thorough field investigations and reviews proved to be necessary at Cobourg, Trenton, Lake Couchiching and Bluffers Park.

Plans for the future in environment assessment will include an increased level of effort, including lead agency status, in the review of proposals and an input to the development of an environmental baseline information program. The collection and organization of baseline data in areas where development is anticipated will help to ensure that environmental considerations are taken into account as early as possible in the planning process.

PROGRAM SUPPORT SECTION

The consolidated Program Support group, consisting of survey electronics, oceanographic operations, data processing, remote sensing, and ocean instrumentation, saw its first full year of operation in 1976. During the year, areas of re-

sponsibility and operating procedures were established and potential areas of conflict resolved. The reorganization has resulted in an ability to better and more completely support our programs while improving utilization of available resources. Additionally, several key positions were staffed or were in the final stages of staffing action at year's end. Technical training courses held this year included Sat Nav Maintenance, Indaps System Design, and Advanced Digital Logic.

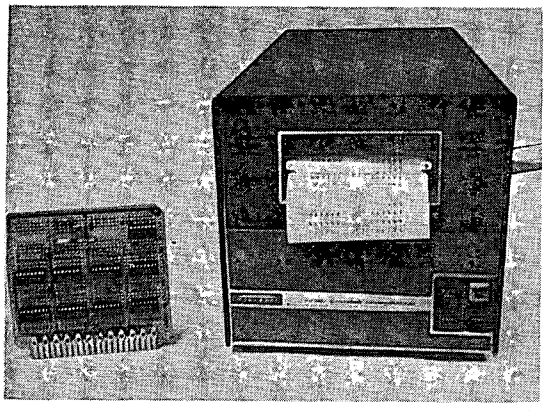
1) Survey Electronics

During 1976, the Survey Electronics Section provided technical support to several hydrographic field parties, other programs at the Canada Centre for Inland Waters, and programs of several other Departments. Development projects in the Sonar and Positioning Systems groups were also undertaken.

Technicians were provided to support Hydrographic field parties on Hudson Bay, Lake Superior, Lower St. Lawrence River, and the Polar Continental Shelf Project. Local support was provided for the 1976 Hydrographic Training Course by supplying a Mini-Fix chain setup on Lake Ontario. An experimental Mini-Fix beacon was installed on Bear Island in James Bay and was used by helicopter pilots to locate fuel caches under winter survey conditions. In addition to ongoing service responsibilities, maintenance services were provided this year for two Sat Nav systems and several Indaps logger and processor systems.

A new solid-state, low-voltage power amplifier was developed for the Mini-Fix transmitters and was successfully field-tested on the Lake Superior Mini-Fix chain. This amplifier provides power equal to older tube amplifiers while eliminating the forced-air cooling problems and the line voltage requirement. The new amplifier is approximately one-quarter the size and weight of the older model. In addition, a new 70-foot Mini-Fix transmitting tower utilizing Kevlar guy lines was field-tested at two sites and was found quite successful. The use of Kevlar guy lines, which are almost totally transparent to radio frequency radiation, resulted in an estimated power gain in excess of 6 db. A self-clocking digital monitor recorder was also developed for use at remote Mini-Fix monitor receiver sites. Several design changes were made to the MRA-3 and MRB-201 tellurometers to improve the noise rejection and the automatic gain control action.

A new portable digital deep-water sounder was developed. The self-contained sounder, slightly larger than a shoe box, is capable of measuring depths to 1000 metres and can run off an internal power pack for up to 4 hours of continuous sounding.

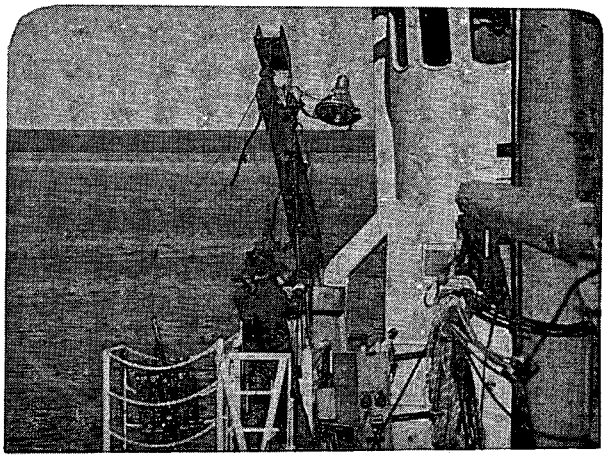


Mini-Fix Monitor Printer

2) Oceanographic Operations

Support in 1976 was divided between two major oceanographic programs. The first was part of a multi-disciplinary project coordinated by the Hydrographic Division at Fort George, P.Q., between January 30 and April 15, 1976. The program consisted of a large grid of CTD measurements obtained at specified locations and depths throughout James Bay and concentrating specifically in the La Grande and Eastmain estuaries. These CTD observations were taken utilizing a Bell 206B Jet Ranger, an Aanderaa CTD system, and an in-house winch. The aluminum winch, which was designed and constructed in late 1975, utilizes the engine from an ice auger. As a result of extensive use in 1976, a new lighter-weight winch, capable of deeper operation and with internal sliprings, has

been designed and constructed. In addition to the CTD program, four current meter moorings were deployed in the La Grande estuary.



On Board MV PETREL

The second program was a major oceanographic project undertaken in Hudson-James Bay during the summer months using the charter vessel MV PETREL. This project, which was designed to investigate boundary conditions of Hudson Bay and delineate the outflow of James Bay, commenced with the installation of eight current meter moorings in northern Hudson Bay, as well as CTD sampling along transect lines encompassing these moorings. All moorings were accurately positioned with a Satellite-Navigation system. The second part of the program consisted of CTD measurements in James Bay, southern Hudson Bay, and the La Grande estuary, to further supplement data collected during previous years.

Prior to proceeding north from Churchill to complete CTD sampling and mooring retrieval in northern Hudson Bay, PETREL experienced major engine failure, terminating her use on the program. Subsequently, the moorings were retrieved by the CCGS NARWHAL and CTD sampling was discontinued, reducing the data return in the northern Hudson Bay portion of the program.

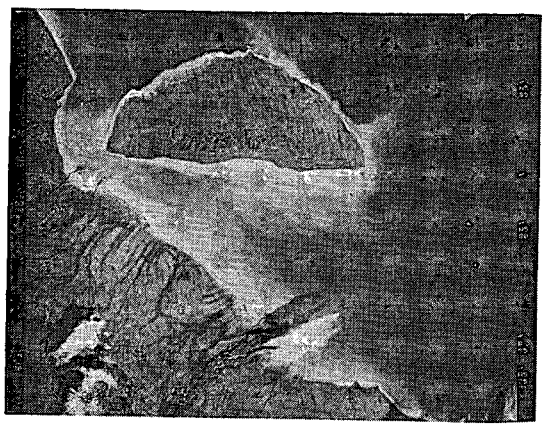
3) Data Processing

Large quantities of oceanographic and coastal erosion data were obtained during 1976. To facilitate handling of this data, programmers in the group and in Data Management (IWD) developed improvements to the Aanderaa time series processing system and major changes to the CTD profile processing system. The group spent extensive time processing profile data and creating data bases for the 1975 Hudson Bay Survey, the 1976 James Bay Survey, and the 1976 Penny Strait Survey. Considerable effort was expended on processing the Aanderaa time series data from the 1975 Hudson Bay Summer Program and the 1976 James Bay Winter Program.

In addition to processing oceanographic data, one man-year was expended on processing coastal erosion data. This included digitizing sounding rolls, coding onshore data, compiling card decks and submitting programs, and numerous other tasks. The group also developed several new programs to meet specific requirements.

4) Remote Sensing

During the second half of 1976, a project in support of GLBL entitled "Lennox Heat Budget Analysis" was undertaken. The project seeks to quantify the advective effect the Lennox Station has on the heat budget of an arbitrarily chosen adjacent control volume of approximately seven (7) square miles of air-water surface. The analysis is based on data collected by Ontario Hydro, AES, and IFYG, covering the period from June 1 to October 31 for 1972 and 1973. A computer program will be developed to generate the heat budget for the study area for a typical pre-project period. Based on projected intake and outlet parameters,



ERTS Imagery - Akimiski Island

the change and extent of change caused by the station can be modelled.

Landsat I digital data was examined to assess the applicability of turbidity as a passive sensor of surface flow in the Hudson-James Bay system. Band 5 gives a strong indication of counter-clockwise flow around Akimiski Island. Field studies are planned to ground truth this area.

5) Ocean Instrumentation

Support was provided to the James Bay Winter Survey, the Penny Strait Survey, and the Hudson-James Bay Summer Oceanographic Survey.

The James Bay Winter Survey consisted of a CTD instrument evaluation project, support to a small oceanographic project in conjunction with the Société d'Énergie de la Baie James, and the James Bay Estuarine and Offshore Program. The instrument evaluation project tested the Guildline Mark IV CTD system for helicopter use in Arctic operations. Although the basic CTD system worked well, problems were encountered with its peripheral gear and with interference with the Decca navigating system. These problems have largely been resolved; however, further tests are necessary with the Decca equipment. In support of the Société d'Énergie de la Baie James and the regular James Bay Survey, two modified Aanderaa CTD systems, eight Aanderaa in-situ current meters, an Endeco EM current meter, and two Beckman RS-5 CTD systems were prepared and field-supported.

Ocean Instrumentation also prepared instrumentation for and took part in a one-month oceanographic program in Penny Strait. The program utilized two Marsh-McBirney 501 and two Endeco 720 electromagnetic current meters and an Aanderaa modified CTD system. Two current meters were surface-referenced at each of two locations, and approximately sixty CTD casts were made.

Of the three projects undertaken by Ocean Instrumentation during 1976, the third, the Hudson-James Bay Summer Survey, was the most complex and utilized the largest amount of sophisticated oceanographic instrumentation. In preparation for the survey, a computer-controlled oceanographic data acquisition system was designed and contracted out to Canadian industry. The system utilized a Guildline MK III CTD probe, a multiplexer, analog to digital (A/D) converter, Interdata model 70 computer, a Silent 70 data terminal, and cartridge drives for data recording. The system was capable of automatically controlling the winch deploying the CTD package. An A/D linearity problem prevented full utilization of the system, but the system concept was confirmed. Redesign of the A/D converter is ongoing and will be completed prior to the 1977 summer survey. In addition to the computerized logging system, an automatic bottle sampling system was purchased and employed on the survey; twenty-three Aanderaa current meters were deployed, and two Guildline 8400 salinometers were utilized. As well as using the Guildline MK III CTD system from the ship, the Guildline MK IV CTD was used from a small launch.

6) Future Surveys in the Division

The major summer oceanographic survey in 1977 will be carried out from May to mid-July in the middle estuary of the St. Lawrence River in order to complete the current measurement program in the area. The winter survey will be split between the Belcher Islands in Hudson Bay and M'Clure Strait in the high Arctic. It is anticipated that a major estuarine survey in Chesterfield Inlet and a full-scale winter survey in the high Arctic will be carried out in 1978.

LAKE SUPERIOR G.L.B.L. PROGRAM

After major modifications and conversion to a miniature fishing stern dragger, CSL AQUA proceeded to Lake Superior to work in the Bachawana Bay area. Adverse weather conditions and the breaking in of new engines made this transit slow and difficult.

The lack of docking facilities in Bachawana Bay caused many problems, including bent shafts and propellers, not to say the least, one successful attempt at vandalism due to the lack of security at the few docking facilities available. Following this break in, it was then decided to place a mooring at the mouth of the Harmony River, near the work site and anchor off the launch, which has proven very successful.

Reports from G.L.B.L. personnel are that AQUA has been a very versatile fishing craft and requests have been made for the use of this launch for the duration of the program which will continue for the next four years.

CSL AQUA after completing the season's work at Bachawana Bay proceeded to Sault Ste. Marie where it was removed from the water and stored for the winter months.

LAKE HURON GEOLIMNOLOGY AND HYDROGRAPHIC SURVEY

Again assigned to a combined program consisting of hydrographic and geolimnology survey, CSL AGILE was outfitted at Burlington and proceeded to Sarnia.

The survey area, located in the southern end of Lake Huron, has very few ports of refuge and AGILE had to steam many miles to and from the work areas.

This survey, also supported by CSL HUSTLE, operated in Lake Huron from May to September when all launches and equipment were returned to Burlington.

GEORGIAN BAY, SENSOR NETWORK PROGRAM

CSL SHARK which has been used extensively in the past by the Dive Unit has been retired from that program as it was too small to comply with the demands required for a dive tender.

The vessel underwent major modifications during the winter and after fit-out at Burlington, SHARK sailed to Georgian Bay. Heavy winds were encountered in transit resulting in a slow passage, and, at one point, the loss of the pilot house windows.

After nine days in transit, the launch finally arrived at Pointe au Baril and started what has been considered a highly successful season for the Sensor Network Unit. A Boston Whaler was also used extensively on this program.

During the season SHARK steamed a total of 4,588 nautical miles in Georgian Bay and the North Channel with very few delays due to mechanical problems. She returned to Burlington late in November and will remain there for the winter.

QUINTE PROJECT

Once again CSL SANDPIPER was outfitted at Burlington for a G.L.B.L. Program on Quinte Bay. This program also supported by an additional Boston Whaler and Dell Quay Dory started early in May. However, delays in transit were encountered due to the Murray Canal being inoperative at that time of year.

This is the second year for this program and again the launch was based at Picton. SANDPIPER covered an area from Picton to Trenton during each week of service. Upon returning to Burlington in October, the launch was leaking very badly in the bottom plating and had to undergo major repairs.

REVISORY I

CSL VEDETTE which had wintered at Hamilton was brought to Burlington and made ready for revisory surveys in the Lower St. Lawrence River. This program was also supported with a Boston Whaler which was trailered to the survey area.

SHIP DIVISION

OPERATIONS

CSS LIMNOS

The major role in vessel support was once again provided by CSS LIMNOS.

Following engine overhaul and repairs, the vessel was fitted out and departed Burlington on April 5 to begin limnological surveys resulting in successful completion of 24 cruises on the Great Lakes and one mooring cruise in the Lower St. Lawrence River.

Throughout the season LIMNOS spent 136 days at sea, steaming a total of 19,158 miles. During this period no time was lost due to mechanical breakdown which has set some kind of record. There was a problem with one of the "Harbormaster" units, however this was repaired while the vessel was not participating in survey operations.

During the summer, LIMNOS has been visited by many Government officials including the Hon. Mitchell Sharp and the Hon. Russell Train (Administrator U.S. EPA) who toured the vessel on July 22 while it was moored at Burlington.

Student Science Fair Award winners and their chaperones spent two weeks on board the vessel while on a mooring cruise in Georgian Bay. This cruise was greatly enjoyed by both visitors and crew.

Adverse weather conditions late in the fall caused some difficulty in completing programs and for this reason one Lake Erie cruise was cancelled. On December 8, LIMNOS returned to Burlington with the final cruise completed and was laid up for the winter months.

CSS BAYFIELD

Once again CSS BAYFIELD was outfitted for Hydrographic survey operations, this year for Lake Superior.

The vessel departed Burlington in the wee hours of the morning of May 14 and proceeded to the work area in the southern end of Lake Superior around the Caribou and Michipicoten Islands.

With very few ports of refuge in that area except for Quebec Harbour (situated on the southern shore of Michipitocen Island), it was decided that as this harbour was "no that wee" the vessel would shelter there in bad weather conditions. Every second weekend BAYFIELD proceeded to Sault St. Marie to replenish her stock of fuel and supplies.

During the season BAYFIELD broke away from normal survey work and proceeded to Lake Ontario to participate in the Kingston Sailing Olympics. During this period senior officials from Central Region and Ottawa visited the vessel.

The highlight for BAYFIELD during this visit to the Olympics was on July 7, when the Captain welcomed on board Prime Minister Trudeau, Mrs. Trudeau, their son Justin and other members from the Prime Minister's Office.

After a buffet luncheon, the vessel proceeded to the racing area escorted by the R.C.M.P. patrol vessel "BRULE" and remained there for the afternoon, after which it then proceeded back to Richardson Wharf at Kingston so that the dignitaries could disembark.

Following five days at the Olympics, BAYFIELD proceeded to Kingston dry dock where both propellers were changed, tail shaft drawn and new bearings fitted. The vessel then returned to Lake Superior to once again take up her role in Hydrographic Surveys.

After steaming a total of 12,216 nautical miles, of which 5,115 were running sounding lines, BAYFIELD returned to Burlington for winter lay-up with another successful season completed.

On May 8, VEDETTE left Burlington to join the survey party at Sorel, Quebec. Revisory surveys continued in this area throughout the summer months and the launch and equipment returned to Burlington on September 24 with another successful season completed. Late in November VEDETTE was again taken to Hamilton and stored for the winter.

REVISORY II

CSL VERITY was outfitted at Burlington for this program and after a week's delay due to high winds, sailed to the Richelieu River to participate in revisory surveys.

From Chambly, Quebec, the launch proceeded up river working the Ottawa and Rideau Rivers until July 9, when it was reassigned to the Kingston Olympics. At Kingston, VERITY was used as a meteorological support craft for the Olympic races.

After completing this program, the launch proceeded to Lake Simcoe rejoining the Revisory II survey there. On October 8, VERITY returned to Burlington with the season completed for another year.

LOWER ST. LAWRENCE RIVER SURVEY

Support for this survey was provided by CSS ADVENT, CSL NUCLEUS, HYDRO IV and a Boston Whaler.

Playing the major role, CSS ADVENT was used for Hydrographic equipment trials at Burlington from April 14 to May 8 when the vessel, along with NUCLEUS and VEDETTE in convoy, sailed for the Lower St. Lawrence, arriving at Rimouski on May 16. HYDRO IV and the Boston Whaler were transported to the same area via road transport.

Surveys continued in the Rimouski area until August 3. At that time the base camp, all vessels and equipment were moved 45 miles down river to Matane.

On August 26, after completing 6,480 miles of sounding, ADVENT was released from the Lower St. Lawrence survey and set out on the homeward journey to Burlington arriving at CCIW on September 1.

While in transit ADVENT spent a day at Quebec to demonstrate survey systems and equipment to the local branch of the Canadian Institute of Surveying.

Meanwhile, the Lower St. Lawrence survey continued with the use of NUCLEUS, HYDRO IV and the Boston Whaler until October when the survey was terminated and all launches and equipment were returned to Burlington.

M.V. PETREL

The charter ship M.V. PETREL owned by Techno Maritime Ltee. of Quebec, arrived on site April 18, Easter Sunday.

After an extensive fit-out at Burlington, PETREL completed four limnological cruises on the Great Lakes and immediately returned to Burlington to prepare for oceanographic surveys in the Lower St. Lawrence River, Hudson and James Bay areas.

On July 6, PETREL departed Burlington and proceeded to the Rimouski area in the Lower St. Lawrence. After work was completed, the vessel then proceeded northward into Hudson and James Bay. Surveys went extremely well and reports are that PETREL is a very versatile ship for these types of surveys. However, on September 5, the vessel suffered engine problems resulting in a return to Quebec under tow.

A new engine has been installed and PETREL returned to Burlington in December where it will winter and prepare for the 1977 Season.

HUDSON BAY OFF-SHORE SURVEY

For the fifth consecutive year, CCGS NARWHAL was made available for Northern Surveys.

The vessel was dry docked on July 5 for the installation of new transducers. Following three days on dry dock and the loading of equipment, NARWHAL departed Dartmouth, N.S. on July 15 and

proceeded to Hudson Bay where the launch SURGE, a Boston Whaler and survey equipment were off-loaded for the Povungnituk Survey Party.

During the season, NARWHAL ran a total of 14,817 miles of sounding lines in Hudson Bay and after recovery of the Povungnituk equipment returned to Dartmouth where all launches and equipment were unloaded and returned to Burlington.

POVUNGNITUK SURVEY

For two reasons the launch STURDY was offered as a support craft for this survey. First, it was already at Fort George and had successfully been used in this area during the 1975 Season and secondly, it was a means of returning the launch to Burlington at the end of the 1976 Season. However, this offer was rejected and request for the sister ship SURGE began the outfitting of this launch at Burlington.

After trials at Burlington, the launch was then transported to Dartmouth where further trial runs proved SURGE to be in good operational condition. The launch along with a Boston Whaler was loaded on board CCGS NARWHAL and taken to Povungnituk.

Mechanical problems from the outset of this survey plagued SURGE. A Cummins mechanic and parts were flown in to the site to effect repairs which were finally completed. However, very little survey work was done as a barcheck chain fouled the propeller crippling the launch once again. With no lifting facilities available, SURGE and equipment once more were loaded on board NARWHAL and returned to Dartmouth. This launch and Boston Whaler were road transported back to Burlington.

JAMES BAY SURVEY

A request for two 21 ft. Monark launches for James Bay involved the task of transporting the launches from Churchill where they were stored after the 1975 Season, back to Burlington.

After the launches were equipped with new engines, they were loaded, along with one Boston Whaler on railroad cars and shipped to Moosonee. From Moosonee they were transported to Attawapiskat, arriving at the survey site on July 14.

The survey areas, a rock strewn, turbid, nightmare were undeniably some of the most difficult areas to operate survey launches. At the end of the season eight of the ten new motors were damaged to the point where they were unserviceable.

On September 16, following the completion of surveys at Attawapiskat and Fort Albany, the boats were stored for shipment to Burlington in January, 1977, via tractor-train and railroad.

M.V. LAC ERIE

The charter tug LAC ERIE departed Burlington and proceeded to Whitby on January 5 to partake in a survey near Pickering. This survey continued until March 31 when the vessel was again outfitted at Burlington for the Dive Unit.

Throughout the season, LAC ERIE participated in projects ranging from Lake Huron to Kingston. At the termination of the field season LAC ERIE returned to Burlington and was used by various divisions for instrument trials and to ferry personnel and equipment to the scientific tower located off Confederation Park.

LOCAL LAUNCHES

During the season CSL LEMOYNE was used extensively on Lake Erie and western Lake Ontario. This has been a very popular launch with scientific staff and was operated on various projects from April through to December with no delays due to mechanical problems.

Various small craft operated throughout Ontario. On occasion a motor or boat was returned to Burlington for repair. However the never ending efforts of the boat repair shop performed an excellent job of maintaining our operational fleet.

C.S.L. NUCLEUS - running lines during Lower St. Lawrence River Survey.

ENGINEERING

What eventually amounted to major modifications were carried out on two vessels prior to the start of the operating season, CSL SHARK and CSL AQUA.

It had been decided to remove CSL SHARK from service as a dive boat at the close of the 1975 Season and to keep her as a base work-vessel. Following this decision, the after part of the superstructure was removed over seven feet and closed in, using the original aft bulkhead to close off the shortened section and closing in the opening in the after deck, thus greatly enlarging the useable deck space aft.

The overall improvement was such that the vessel was assigned to the Georgian Bay Sensor Network program. However, the additional freeboard and aft deck space allowed for the installation of a scientific winch after her release to the field, which somewhat overloaded the 3.5 KW capacity generator installed primarily for the purpose of supplying power in her projected role as a base workboat. Despite these changes, the vessel operated in a satisfactory manner throughout the season.

CSL AQUA

Modifications to this vessel involved removing main engines, outdrives, generator and wiring completely and gutting the vessel, removing existing bulkheads and wood flooring and deck. This required complete renovation using aluminum floors, stringer bulkheads and deck plating, carrying existing bulkheads down to bottom plating and installing two additional bulkheads in way of the new engine compartment.

The original construction of the vessel negated the possibility of installing completely watertight bulkheads, however, construction was such as to allow a minimum of water to flow from one compartment to another, which flow could be controlled by automatic bilge pumps installed in each compartment.

The main engines were moved to a position immediately aft of the wheelhouse bulkhead, the drive being converted to pure inboard drive with a minimum of shaft angle and the old engine space vitalized as a machinery space for a hydrographic winch and hydraulic power unit.

Topside the vessel was equipped as a stern trawler

complete with gallows and trawl winches powered by a self-contained diesel driven hydraulic system located as previously stated in the aft machinery compartment.

HYDRO LAUNCHES

Following the successful season of last year, which had been marred only by an overheating problem experienced when the vessels were operated at low tide and around mud bottoms, the installation of specially designed closed cooling systems on all units proved an unqualified success. This had eliminated the source of overheating, resulting in a trouble free 1976 season, so much so, that CSL BROCK and BRONTE were similarly repowered this year. As a matter of interest and possibly due to our recognizing this overheating problem and its cause, closed cooling systems are now standard on all volvo 140 h.p. inboard/outboard units.

CSL AGILE

Both main engines were removed and completely rebuilt by shop mechanics when estimates received from the engine manufacturers were considered unreasonable.

Trouble was experienced early in the season in one engine, primarily diagnosed by phone as fuel contamination of the lub oil. This was later found to be the result of two injector tips being fractured when the fuel lead back to the tank was restricted after being apparently stepped on.

CSL VERITY

Both main engines were removed at the close of the 1976 season, completely rebuilt and reinstalled by Boatshop staff.

A new 3.5 KW diesel generator was installed, a more efficient engine compartment ventilating system was provided and the exhaust system modified and relocated to prevent fumes being drawn back aboard the vessel.

CSL NUCLEUS

Modifications to the vessel were finally completed prior to the start of the season. These were proven to the extent that it was possible to prepare a comprehensive list of requirements to be incorporated into the specifications for future vessels of this type. This will include transducer installation below the keel, a modification which should vastly improve sounder operation particularly when data is fed directly into an integrated data acquisition system.

The installation of a splash rail, omitted by the builder when delivered, proved beneficial in deflecting the bow spray away from the cockpit. Both the shaft and propeller were replaced by more efficient units and the corrosion-prone exhaust system replaced by a stainless steel arrangement.

CSL SANDPIPER

This vessel returned from the field in a poor and leaking condition due mainly to a cracking condition on the bottom plating adjacent to the starboard transom. Inexpert welding repairs carried out in the field had caused rapid deterioration of the plate to the extent that it was possible to see right through the bottom.

Bottom plating at both sides of the keelson was cropped and renewed and additional floors installed in way, with modifications being carried out to the strut and skeg allowing the installation of a more diversified selection of propellers.

The engine was removed, completely rebuilt and reinstalled by shop personnel.

All outboard engines were again rebuilt during the winter lay-up period and maintained during the operating season.

The new 75 h.p. proved to be a mixed blessing, heavy damage being sustained to lower units on the Monark launches serving up north. Subsequent design deficiencies were revealed during repairs,

one of these being the original installation of a standard bearing in the upper part of the vertical shaft instead of a thrust type bearing, and a further weakness in the lower horizontal shaft thrust-bearing retention arrangement.

As a result of discussions with the manufacturers, recommendations made by our department were acted upon and modifications made to later models.

With requirement for vessels reduced this season, a large number of boats were left at the base and completely overhauled, water tested and laid up following winterization.

CSS BAYFIELD

Major modifications were carried out prior to the commencement of the survey season involving the entire removal of the existing sewage and grey water systems and replacement of same.

The sewage system was replaced by a Mansfield low volume flush vacuum system with holding tank for total retention, the grey water system was replaced by a Clearwater chlorine treatment system.

Minor shaft troubles had manifested themselves in the form of heating and leakage immediately prior to her departure for Kingston. It was therefore decided to dry dock the vessel before her return to survey duty.

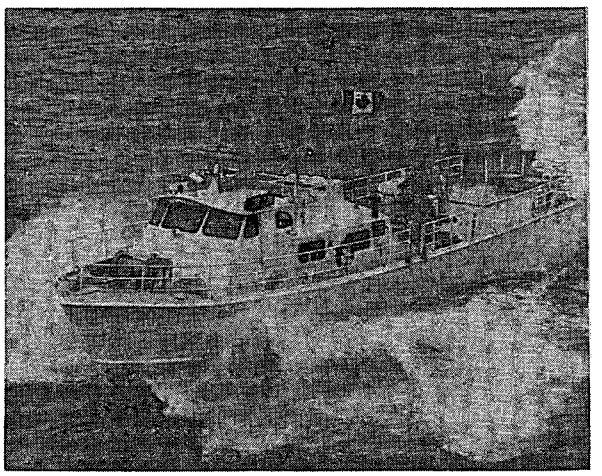
The vessel returned to Burlington and following a brief respite, departed for Lake Superior to complete a highly successful season, returning to Burlington early in October to complete part 2 of her major modifications previously postponed from the start of the season.

CSS LIMNOS

Following an extensive investigation during the winter lay-up period which involved almost complete disassembly of both main engines, the cause of the piston failures which had plagued the vessel over the past two years was determined to be the result of incorrect size circlips supplied by the engine manufacturer.

This condition was corrected by the installation of the correctly sized circlips resulting in a whole season of operation free of problems from this source.

Two "Harbormaster" coupling bolt failures were experienced during the operational season, only one of which resulted in lost survey time. The probable cause of these failures has been determined and steps taken to correct it.



"ADVENT" at speed during Lower St. Lawrence River survey.

CSS ADVENT

This vessel performed very well during the season. Fuel consumption was reduced and speed increased following major tune-ups to both main engines and generators.

While at Rimouski the vessel also sustained considerable ranging damage which was repaired during the fine weather on her arrival back at Burlington. During transit from the Lower St. Lawrence, it was necessary to carry out repairs to the stainless steel flexible exhaust overboard discharge pipe due to leakage from corrosion. The repair carried

out was the same as that made as an experiment to one exhaust following the vessel's first operational season which proved to be trouble free ever since.

CCGS NARWHAL

Again this year the department had use of NARWHAL for service in Hudson Bay. Prior to her departure, the vessel was dry docked at the department's expense for the installation of new equipment and the overhaul and service of that equipment already installed.

All the necessary equipment was designed at the region and fabricated locally for shipment to the dry dock, leaving only doublers and fairing pieces to be fabricated on site.

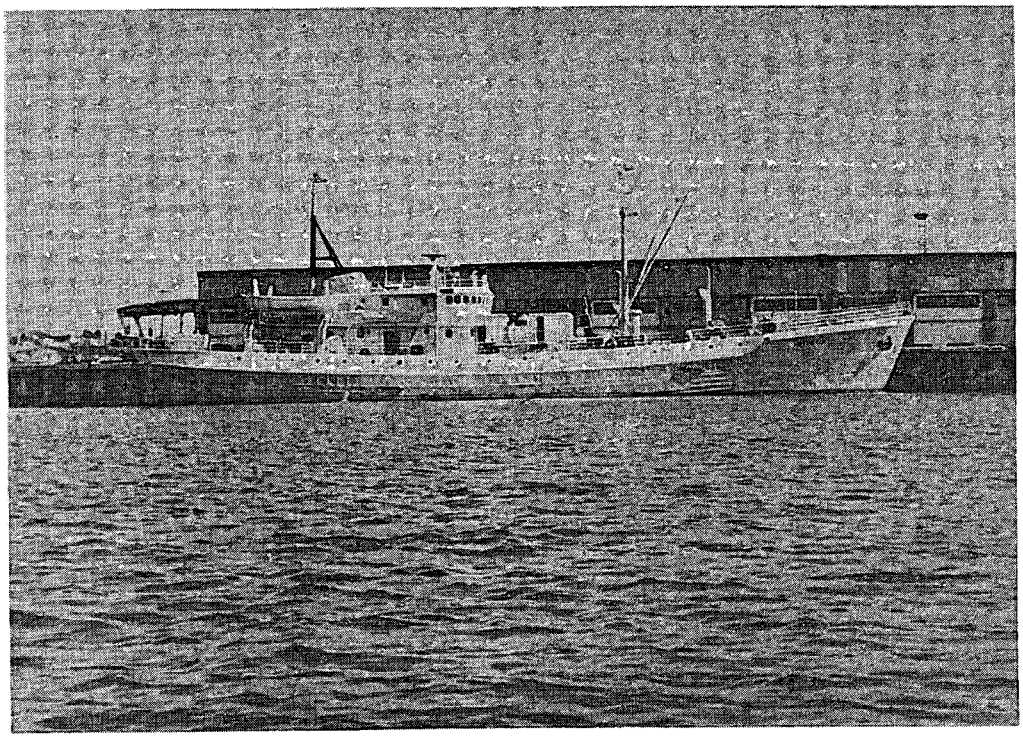
Work was completed early in July and following sea trials, the vessel departed for a most productive season.

CHARTER VESSELS

M.V. PETREL was acquired as a charter vessel for scientific survey work both in the Great Lakes and Hudson Bay with short stints in the Lower St. Lawrence River. Originally a steam powered North Sea Trawler, the vessel had been converted to motor power and as an Oceanographic Survey vessel spent many years in the Pacific based in Australia prior to returning to Norway where she was purchased by Techno Maritime Ltee. of Quebec and offered to the Department.

Changes were necessary following her arrival at Burlington. The major items were the installation of self-contained "no overboard" discharge sewage and grey water systems and a 200 KW generator to be used solely for scientific purposes. A deck lab, wet and dry labs below deck and a rec room for operations personnel plus all the department owned equipment necessary to carry out surveillance and oceanographic surveys were installed.

Prior to her departure, the vessel was dry docked at the department's expense for the installation of new equipment and the overhaul and service of that equipment already installed.



M.V. PETREL V at Quebec City before departure for Hudson and James Bay.

ADMINISTRATION AND FINANCE DIVISION

GENERAL SERVICES

Increased restrictions were imposed on employment of new staff during the early part of September, the result of which was a reduction in the number of Staffing Actions in the latter part of the year.

A total allocation of 154.8 man-years accounted for 81 Staffing Actions as follows:

Employee Type	Number
FTC	33
Term	17
Seasonal	23
COSEP/Co-op	8

The staff strength peaked at 178 during the summer of 1976, and 90 positions were submitted to Classification.

During the year there were 29 employees promoted, 7 acting appointments and 12 employees were granted acting pay.

Safe working practices and the availability of protective equipment continued to be emphasized by all supervisory staff, but reportable accidents increased from 14 to 17 with four of these resulting in substantial lost time and WCB claims.

MATERIAL MANAGEMENT

The supply staff continued to provide logistic support to the wide spread summer and winter field operations mentioned elsewhere in this report. Increased activity in the Arctic and in James/Hudson Bay during the winter months with attendant long supply lines and communication difficulties added to an already heavy workload during a period of time normally devoted to equipment refurbishment, inventory adjustments and disposal of unrepairable and obsolete equipment. It had been hoped to carry out a complete stocktaking of O &AS holdings during 1976; however, it was only possible to complete approximately 20% of the job. In December a revised policy on "Equipment In Use" was received from Departmental HQ. This involves extensive changes to equipment accounting procedures (inventory control) and implementation will be phased throughout 1977.

MOBILE EQUIPMENT

The regional fleet, consisting of thirty-one vehicles and several short-term rentals, travelled a total of 319,000 miles. It was encouraging to note that only two minor accidents occurred during the year reducing the accident frequency rate to 0.65 per 100,000 miles operated. The cost of accidents was also reduced from $10,400 in 1975 to $275 in 1976. Since most of the miles are driven by user operators this is a creditable performance and all concerned are encouraged to keep up the good work in 1977. Nineteen operators attended a Defensive Driving course in November which we would like to think contributed in part to the safe driving achievement.

FINANCIAL SERVICES

A total of $5,300,000 was spent from Departmental appropriation during 1976. Of this amount, $4,700,000 covered personnel costs, $2,600,000 general operation and maintenance costs, and $500,000 was spent on the acquisition of capital equipment. An additional allotment of $500,000 was provided through the Canada/U.S. Great Lakes Water Quality Agreement in support of the Great Lakes Surveillance Program. This funding covered vessel support and charter costs incurred during the 1976 field season.

Funding in the amount of $1,233,400 was also provided to O & AS from the Canadian International Development Agency in the latter part of 1975, in support of a survey of the continental margin off Senegal and Gambia (Senegal Project). Of this total O & AS Central Region expended $438,000 - the remaining $796,000 being transferred to other Fisheries & Marine establishments and the Department of Energy, Mines & Resources.

Supplementary funding was also received from other external sources, namely EM & R which provided $140,000 for the James Bay Project. Environmental Management Service which provided $50,000 for erosion monitoring on the Great Lakes and the Province of Ontario which also provided $50,000 for erosion monitoring.

Conversion to an automated financial accounting system commenced in the fall. Manual systems are still being maintained in parallel and will continue until the system is running smoothly. There are still some minor programming problems affecting the operation of the system but it is hopeful that complete conversion will be possible by the summer of 1977.

Finance Clerk, B. J. Pinkerton, operating the Datapoint 1100- automated accounting equipment.

PRESENTATIONS AND PUBLICATIONS

HYDROGRAPHIC DIVISION

Bryant, R.S., C. Doekes, R.L.K. Tripe, 1976. INDAPS: Integrated Navigation, Data Acquisition and Processing System. *International Hydrographic Review, Vol 53, #2,* July, 1976.

Bryant, R.S., M.J. Casey, C. Doekes. "Integrated Navigation in an Offshore Survey of Hudson Bay". *Presented at the Institute of Navigation, National Marine meeting in San Diego, California,* November, 1976.

Casey, M.J., G.D. Macdonald, 1976. Integrated Navigation Systems - Using the Positions on Offshore Surveys. *Lighthouse, Journal of the Canadian Hydrographers Association, Edition Number 14* November, 1976.

Chapeskie, R.E., 1976. "Designing Charts in the Seventies to Reflect Change and Changing Traffic Patterns into the Eighties". *Presented at the 15th Annual Canadian Hydrographic Conference, Ottawa,* April, 1976.

Crutchlow, M.R., 1976. Tracked Vehicle Sounding over the Ice. *Lighthouse, Journal of the Canadian Hydrographers Association, Edition Number 14,* November, 1976.

Doekes, C., R.S. Bryant, G.D. Macdonald. "Automated Selection of Bathymetric Data to Accurately Represent Bottom Topography". *Presented at the 15th Annual Canadian Hydrographers Conference, Ottawa,* April, 1976.

Doekes, C., 1976. Use of Indaps in Arctic Surveying. *Lighthouse, Journal of the Canadian Hydrographers Association, Edition Number 14,* November, 1976.

Kerr, A.J. "Hydrographic Surveys and Charting in the Arctic - A Match of Economics and Technology". *Presented at the Third International Conference on Port and Ocean Engineering Under Arctic Conditions, University of Alaska,* August, 1975.

Kerr. A.J., 1976. Chart Design Considerations for the Navigators of Today and Tomorrow. *International Hydrographic Review, Vol. 53, No. 1,* January, 1976.

Kerr, A.J. "The Work of the Canadian Hydrographic Service". *Presented to the Honourable Company of Master Mariners, London, England,* April, 1976.

Kerr, A.J. "Planning New Navigational Chart Design in Response to the Changing Patterns of Shipping in the Great Lakes". *Presented to the Map Use Interest Group, Canadian Cartographic Association, University of Waterloo,* November, 1976.

Marshall, R., G.D. Macdonald, R. Bryant. "Coastal Survey in Africa Using Loran-C". *Presented at the Fifth Annual Technical Symposium of the Wild Goose Association, Arlington, Virginia, U.S.A.* October, 1976.

RESEARCH AND DEVELOPMENT DIVISION

Muir, L.R., 1976. Unsteady Flow in Networks of Open Channels, *Manuscript Report Series #1,* Ocean and Aquatic Sciences, Central Region.

Budgell, W.P., L.R. Muir, 1976. St. Lawrence Current Survey Data Report - 1974. *Data Report Series,* Ocean and Aquatic Sciences, Central Region.

Muir, L.R. "Transient Flows in the St. Clair/Detroit River System". *19th Annual Conference on Great Lakes Research,* 4 - 6 May, 1976, Guelph, Ontario.

Freeman, N.G., T.S. Murty, 1976. Numerical Modelling of Tides in Hudson Bay. *Journal Fisheries Research Board of Canada, Vol. 33, No 10, presented at the 15th International Conference on Coastal Engineering.*

Peck, G.S., 1976. A Summary of Ice Conditions in Hudson Strait, Hudson Bay and James Bay 1964 - 1971. *Internal Report.*

Haras, W.S. "Survey Analysis and Compilation of the Great Lakes Shoreland Resources as an Integral Part of Coastal Zone Management". *Presented at the C.I.S. Conference,* Winnipeg, Manitoba May 19 - 21, 1976.

Boyd, G.L., 1976. A Study of the Lake Erie Storm Surge of November 10, 1976. *An unpublished report.*

Chandrashekhar, M., L.R. Muir and T.D. Unny. Two-Dimensional River Simulator. *Proceedings of the International Symposium on Large Engineering Systems.* University of Manitoba, August 9 - 12, 1976. In press.

Prinsenberg, S.J., 1976. Offshore Oceanography of James Bay. *Published in the Proceedings of the James Bay-Environmental Syposium.* In press.

Peck, G.S. 1976. Winter and Nearshore Oceanography of James Bay. *Published in the Proceedings of the James Bay-Environmental Symposium.* In press.

Haras, W.S., 1976. Shore Properties Studies Research Programs. *Proceedings of the Workshop on Great Lakes Coastal Sedimentation and Erosion.* C.C.I.W.

Peck, G.S., 1976. James Bay Data Report 1973. *Data Report Series,* Ocean and Aquatic Sciences, Central Region.

Haras, W.S. "The Role of Vegetation in Retarding Shore Erosion on the Canadian Great Lakes Shoreline". *Proceedings of the Workshop on the Role of Vegetation in Stabilization of Great Lakes Shoreline, co-sponsored by Soil Conservation Service and Great Lakes Basin Commission,* December, 1976, Chicago, Illinois.

Brooks, D.J., 1976. James Bay 1976 Winter Field Report. *Internal Report*

Brooks, D.J., 1976. Hudson/James Bay Oceanographic Survey 1976 Field Report. *Internal Report.*

Baird, S.D., 1976. "Computerized Oceanographic Data Acquisition System" (CODAS). *Presented at the 4th Plessey STD Symposium in San Diego, California,* January, 1977.

Haras, W.S., R.P. Bukata, K.K. Tsui, 1976. Methods for Recording Great Lakes Shoreline Change. *Geoscience Canada, Vol. 3, No. 3.*, August 1976.

Shaw, J.S. A Study of the Process-Response Elements in Beach Dynamics at Point Pelee on Lake Erie. *Manuscript Report Series #3,* Ocean and Aquatic Sciences, Central Region. In Press.

Haras, W.S., et al, 1976. Canada/Ontario Great Lakes Shore Damage Survey. *Coastal Zone Atlas,* a joint Environment Canada/Ontario Ministry of Natural Resources publication. Cat #Fs99-10/1975

Peck, G.S., 1976. Oceanographic Observations, Penny Strait, NWT. *Preliminary Report,* April, 1976.

Baird, S.D. "Calibration of the Guildline Digital CTD". *Presented at the Ocean Technologists Conference in San Francisco, California,* November, 1976.

Baird, S.D., 1976. CTD Cost and Availability O.I. Project August 1976. *Internal Report.*

Kopec, J.A., 1976. "A Study to Determine Magnetic Tape Selection and Methods of Handling to Prevent Data Dropouts in Aanderaa RCM4 Meter Recordings". *Internal Report.*

Budgell, W.P., 1976. Tidal Propagation in Chesterfield Inlet. *Engineering Lecture Series, Department of Civil Engineering, University of Waterloo,* November, 1976, and *Manuscript Report Series #2,* Ocean and Aquatic Sciences, Central Region. In press.

Baird, S.D., 1976. RCM Cost & Availability O.I. Project October 1976. *Internal Report.*

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