Canada Centre for Inland Waters

ANNUAL REPORT 1968

Canada Centre for Inland Waters
Annual Report
1968

DEPARTMENT OF ENERGY, MINES AND RESOURCES

FISHERIES RESEARCH BOARD

DEPARTMENT OF NATIONAL HEALTH AND WELFARE

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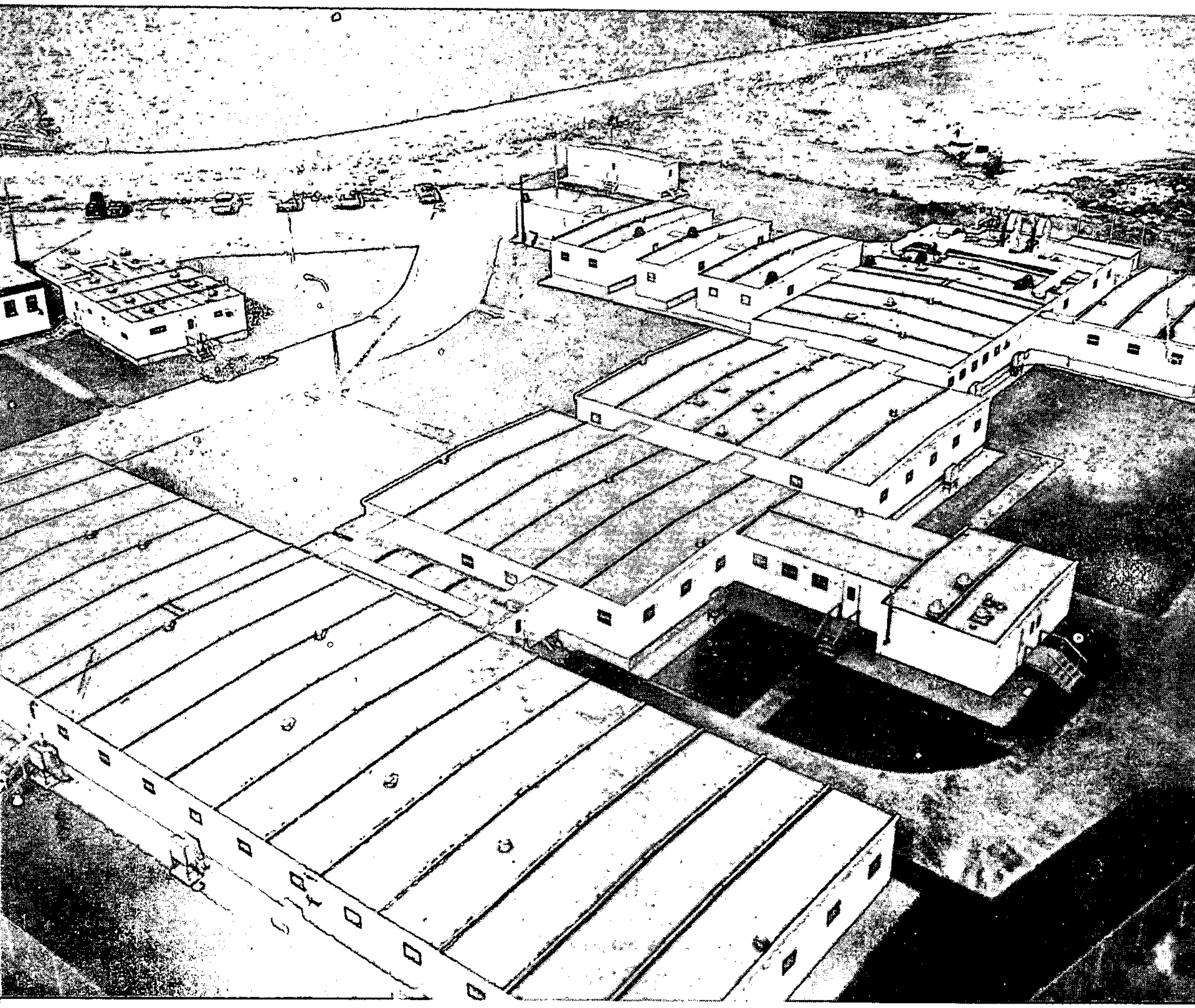


The temporary trailer complex of the Centre as it appears today (1968). Upper right, and out of the photo, is the site for the new buildings of the Centre.

INTRODUCTION

Organization and Purposes

The year 1968 saw the firm establishment of the Canada Centre for Inland Waters as a major research Centre concerned with Canada's vital fresh water resources. CCIW is one of Canada's most significant responses to the challenge posed by need for knowledge to ensure optimum management of water resources for both economic and social purposes.

Three federal government agencies are developing the Centre - the Department of Energy, Mines and Resources, the Fisheries Research Board and the Department of National Health and Welfare. The Department of Energy, Mines and Resources co-ordinates the program and provides support facilities to the participating agencies and to University scientists undertaking projects in collaboration with the Centre's agencies.

The following components of the three Departments were involved in 1968 in the interdisciplinary water studies.

Department of Energy, Mines and Resources

Inland Waters Branch

1. Great Lakes Division undertakes physical, chemical, geochemical and sediment studies on major Canadian lakes, with special emphasis on the Great Lakes;

2. A detachment of Water Quality Division is responsible for analyses of samples of water from the Great Lakes for chemical composition and pollution load, and for research and development of analytical methods.

3. A detachment of Marine Sciences Branch operates a small fleet of research vessels in support of the Great Lakes program.

The Fisheries Research Board

A detachment of the FRB studies the biological aspects of Great Lakes pollution.

The Department of National Health and Welfare

Staff of the Kingston laboratory of the Public Health Engineering Division undertook sampling from CCIW vessels and analysis of bacterial distributions in the Great Lakes.

The initial major effort in 1968 of the Centre's three Departments was in preparing major sections of the International Joint Commission report in connection with the pollution reference on Lakes Erie and Ontario. This three-volume report, prepared in collaboration with the Ontario Water Resources Commission and United States federal and state agencies will be completed early in 1969. It will summarize available knowledge of pollution of the two lakes and make recommendations for remedial measures based on present information and understanding. However, in the course of preparing portions of the report, significant gaps in our knowledge of the lakes became evident and the scientific programs of CCIW are being designed to answer the more important unsolved problems.

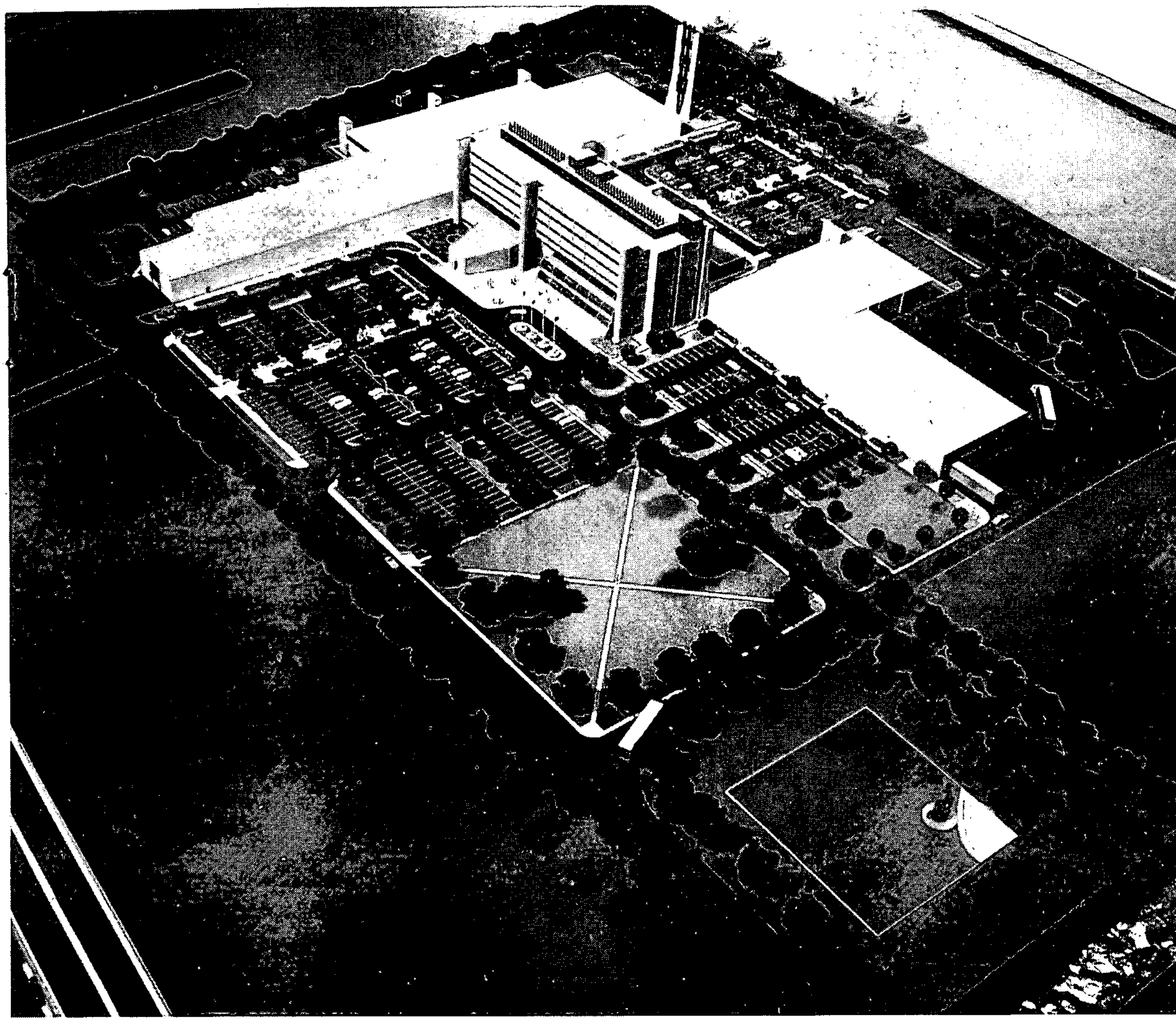
Most of the effort of the Centre in 1968 was directed towards Canada's prime water resource, the Great Lakes. However, a preliminary study of sedimentation in Lake Diefenbaker, Saskatchewan, is an early indication of the national scope that the Centre will assume. Full implementation awaits completion of buildings in 1970, '71 and '72 and the arrival of other component Divisions and Detachments of the Centre.

Between April and December, 1968, an extensive field program was conducted on the Great Lakes. Supported by two major ships, the C.S.S. Limnos and the charter vessel M/V Theron, the three participating Departments conducted a number of inter-disciplinary surveys. These surveys, along with the data collected from fixed moorings of instruments in the lakes, and other studies, are designed to develop a body of information from which it will be possible to: predict diffusion and movements of pollutants; determine temperature distributions and the availability of light for biological productivity; assist in assessing water budgets; determine the trends in chemical composition of lake waters under the impact of natural and man-made processes; assess extent and nature of water level fluctuations; assess the problems of erosion and sedimentation; quantify the role of sediments in the cycling of pollutants in lakes; determine the degree to which the aging process or "eutrophication" has progressed in the various parts of the Great Lakes; assess the impact of pollutants on the lake environment. Research on subjects such as these will provide the basis for determining means by which pollution abatement and other water management programs may be designed to take advantage of and work with, rather than against, natural lake processes. This will ensure efficient use of the large sums of money which are being, and must be, spent on pollution abatement, water level control, shore erosion prevention, and construction of lake structures.

The early vigour of the Centre's research program is amply attested to by the extensive list of papers published and/or presented by staff members in 1968 (p. 26).

Building Program

Since December 1967, the Centre's staff has been occupying a 25,000 sq-ft trailer complex comprising office and laboratory facilities. During 1968, planning for the permanent buildings was a time consuming activity for all staff members who met frequently with the EM&R Project Manager E. R. Long, with Dept. of Public Works officials, with engineering and planning consultants of Reid, Crowther and with architects Wall and Yamamoto. By the end of 1968, the development of the site plan



Architect's model of the Centre as it will appear when completed in 1972. Part of the Burlington overpass is seen in the left foreground.

neared completion and extensive work on site services and construction of a breakwater and wharf and launch basin facilities were well under way. Grading of roads and wharf areas had been completed and the general site area had been brought to an elevation of approximately 254 ft. In December a contract was awarded for the electrical substation; delivery of transformers, switchgear and cable is expected prior to April, 1969.

The first phase of building construction is scheduled for completion in 1970. This will consist of the warehouse and workshop facilities required to provide the necessary on-shore support for the scientific vessels presently in use. The other principal components in place are the central heating and cooling plant, facilities for instrument and equipment maintenance, research and development, physical limnology laboratories, and space for Technical Operations and Marine Sciences Branch staff.

A hydraulics laboratory and towing tanks for calibration of all current meters, used to measure stream flow and currents in rivers and lakes across Canada, is scheduled for completion in 1971. The main laboratories, and a water-quality pilot plant for full-scale evaluation of experimental waste-treatment methods, have scheduled completion dates of 1972 and 1973, respectively.

Public Relations

With the beginning of full-fledged operation of the Centre, the interest of the public, and of the professional and scientific community in the Centre's work and facilities has been very high. A number of special events were held during the year, a large number of visits were arranged, staff members gave numerous talks to service clubs, professional groups, school groups, etc., and many interviews and articles appeared in magazines, including Time, Reader's Digest and trade publications, and in the national and local press, TV and radio.

The christening of the C.S.S. Limnos, the Centre's major research vessel took place at Port Weller on April 6, and the event was given extensive TV and press coverage. On May 31 the Department's former Minister, Hon. Jean-Luc Pepin, the Hon. John Munro and 150 senior government officials and scientists from Canada and United States participated in official opening ceremonies for the Centre. On the following day more than 4,000 citizens visited the Centre and its research vessels at the first Open House.

The number of individuals and groups visiting the Centre increased rapidly as the year progressed reaching a rate of about 1,000 visitors a month by October. In fact, long before this time it had become essential to impose restrictions on the times of tours and visits to permit the scientific activities to continue. To ensure that visitors received a clear picture of the Centre's activities, without taking excessive amounts of scientists' time in repetitive explanations, a combined slide and recorded sound show "What About Water?" was prepared. One set is used permanently at the Centre for touring visitors and another is used to illustrate and describe the work of the Centre to service clubs, school groups, and public gatherings. The show, prepared by Hopkins, Hedlin Ltd., under contract to Dept. of Energy, Mines and

Resources describes the Centre's purposes, research program and outlines the federal government's role in research and management of Canada's fresh-water resources.

Research and Engineering Contracts

One of the purposes of the Centre is to encourage development of water resources research interests and capabilities in Canadian universities and industry. This is done in many ways. One of the most effective is through contractual arrangements for university or industrial specialists or groups to undertake portions of the Centre's over-all research program that cannot readily be handled with the staff and facilities available at CCIW.

During 1968 the following contracts were entered into:

Great Lakes Institute, University of Toronto

1. Participation in preparation of Great Lakes data atlas

2. Undertaking of monitor cruises and provision of data summaries

3. Studies of thermal bar phenomena and special instrumentation for such studies

Waterloo University

Investigation of coastal jet circulation phenomenon in Lake Huron

Geospace Engineering, Ottawa

A study of position fixing methods for use in Great Lakes surveys.

At year's end negotiations were underway for four other contracts with universities (Lakehead, McMaster, and Waterloo Lutheran) and with consulting engineering firms for studies of needs in ice research and on the long-term implications of thermal inputs from nuclear and conventional power plants on Great Lakes shores.

DEPARTMENT OF ENERGY, MINES AND RESOURCES

Great Lakes Division

(a) Physical Limnology

During 1968, the basic approach of physical limnologists to Great Lakes problems underwent a change. Prior to and during the first part of 1968, a large proportion of effort was devoted to examining circulation, thermal and turbidity features in Lake Ontario and Lake Erie, and reporting on these in sections of the report to the International Joint Commission on the pollution of these lakes. The emphasis was later shifted to studies of lake processes, such as diffusion, wind stress, internal waves, and others, in order to improve the state of knowledge about lakes for devising techniques for prediction of lake phenomena.

Also, during 1968, physical staff turned their attention to lakes other than the Great Lakes. Although proportionately small at present, this effort is expected to increase over the next few years.

Preparations for the 1969 programs have centred around combined studies of processes in western Lake Ontario. This Massive Effort on Lake Ontario (MELON) will involve two 7-week periods of concentrated measurements once during the unstratified spring period and once during stratified conditions in mid-summer. These studies are in the nature of feasibility investigations prior to the International Field Year on the Great Lakes in 1971-72.

Water Movement Studies:

Current meter and thermistor arrays were placed in Lake Ontario for the purpose of examining coastal "jet" and edge wave phenomena along the south shore. The role of these concentrations of relatively high speed flow may prove to be of great importance in several of the Great Lakes. Analyses of these data are expected to continue through the summer of 1969.

Other arrays, supplemented by an instrumented tower, were placed to study the circulation near the mouth of the Niagara River, its response to wind patterns, and how the river effluent interacts with Lake Ontario. These data are being examined in coordination with other programs in the same area (mentioned later).

Short-period measurements (1 minute and more) with current meters were undertaken in western Lake Ontario to study turbulent fluctuations. These data suggest that presently available meters are not fully suitable for such studies.

Current measurements were also made in Lake Erie, mainly between the eastern and central basins to examine the detailed current features there (such as a possible coastal jet, and a mid-lake gyre). During periods of strong density stratification, it was found that the first harmonic of the inertial motion associated with internal waves was detectable. Analyses are continuing.

Drift-card releases were made periodically in Lakes Ontario and Erie; and in Lakes Huron and Superior. Returns are still being received and collated, to determine surface water movements. By year's end 15% of the drift cards had been returned by Canadian and U.S. citizens.

Diffusion Studies:

During the 1968 summer season, general turbulent diffusion studies at the Great Lakes Institute, University of Toronto's Baie du Dore Research Station, Lake Huron, were undertaken in a joint program with Dr. G. T. Csanady, University of Waterloo. The main objective of the project was to examine the turbulent diffusion phenomena under various conditions of the lake, using a dye plume formed in the wake of a continuous source. The dye plume was continuously sampled at four depths extending to 4 m below the surface. Supporting information such as current profiles (speed and direction), temperature profiles and meteorological observations were also collected during each experiment. The analysis of the data is nearing completion and the results reveal interesting aspects of turbulent diffusion phenomena in the lake environment, particularly in regard to windrows, slicks, vertical thermal structure, and variability in the general circulation. Variable currents were found to act to promote horizontal diffusion, with effective eddy diffusivities in these conditions 2 to 5 times higher than in steady currents.

A limited amount of drogue tracking and infrared scanning of the Niagara River effluent in 1967 revealed certain interesting circulation features. The Niagara River is the major source of nutrient input to Lake Ontario. This prompted the Section to undertake an extensive field program during 1968 related to the dispersal of the Niagara River effluent in the main body of Lake Ontario. In addition to a concentration survey of diffusing dye plumes, other experimental techniques such as aerial photography of dye plumes and extensive drogue tracking were undertaken simultaneously at the river mouth. Analysis of the data is underway and it is hoped that the results of the diffusion studies and other related studies will contribute greatly to the understanding of the diffusion of Niagara River effluents into the main body of the lake.

Air-lake studies - (small scale):

Measurements of wind, temperature and humidity profiles were continued in Lake Ontario during 1968, but at a new tower location near the Niagara River. These data are being used to improve techniques for predicting profiles and the effect of winds on water movements, from more standard meteorological data.

This program will continue and will be supplemented by a program of atmospheric turbulence measurements. Particular emphasis is being placed on the improvement of parameterized techniques for estimating wind stress at the lake surface.

Air-lake studies - (large scale):

Techniques for improving empirical heat budget computations were tested in a program of radiation measurements at the Niagara River tower. Incoming, reflected, and diffuse solar, and net long-wave radiation measurements were made continuously, along with appropriate meteorological measurements. This program will continue during 1969, mainly through arrangements with staff at McMaster University. Similar studies are planned on small lakes near Kenora, Ontario in collaboration with Fisheries Research Board.

Overlake winds, water and air temperature measurements were made on a continuous basis at four mid-lake sites, in each of Lakes Ontario and Erie. These measurements will be compared with periods of concurrent meteorological data based on shipboard measurements in order to evaluate the performance of the buoy system on which the overlake measurements were made. Satisfactory measurements obtained from these sites will be used to study the problem of representation of large-scale overlake wind patterns from shore-based wind data.

Remote Sensing:

The use of an infrared scanner, an airborne radiation thermometer, airborne solarimeters and cameras, in periodic surveys of western Lake Ontario, has resulted in acquisition of lake-surface data of considerable value in assessing the movement of warm inflows from rivers, waste-treatment plants and thermal-power stations. The major component, a Singer scanner, which is undergoing further development at National Aeronautics Establishment in Ottawa, was used to obtain "thermal" mosaics of the lake. These are being interpreted in terms of surface thermal phenomena, with the assistance of surface data and the other "airborne" data, such as infrared thermometer temperatures. In addition to effluent plumes such features as the "thermal bar", areas of upwelling and surface manifestations of internal waves have been identified.

Water Level Studies:

Water level measurements at three locations in western Lake Ontario, including a tower in shallow water near Burlington, resulted in analysis of long period lake oscillations, specifically longitudinal seiches. The oscillations with a 35-hour period, first reported by Matheson, are seiche-like in character but are not predicted directly from computations based on wind stress over the lake.

A tower was placed in the western end of Lake Ontario during the field season of 1968. These data have been compared to adjacent nearshore water level stations in order to evaluate the usefulness in lake dynamic studies of nearshore water level measurements. Preliminary analyses have shown that free seiche amplitudes for all modes are twice as large at the open lake stations as observed at nearby shore stations.

Mathematical - Hydrodynamical Modeling:

Progress has been made in the mathematical representation of the physical processes important in lake circulation. These numerical representations have been applied to idealized lakes, specifically to the problem of the wind and hydraulically induced circulation of circular lakes of varying bottom topography. Work continues on application of the numerical representations to more realistically shaped lakes.

Work on other numerical and statistical models is being given high priority. To complement this work, emphasis in the experimental dynamics and thermodynamics programs is being placed on clarifying the relative magnitudes of physical processes and scales of motion in the Great Lakes.

Great Lakes Data Atlas:

Work has begun on the preparation of an atlas of Great Lakes data. Two formats are planned: one, a collection of contoured horizontal distributions of parameters, namely dissolved oxygen and temperature at various depths, cruise by cruise; the other, a collection of averaged distributions of parameters, month by month, from all available data. Other styles of data presentation are envisioned for inclusion in future years. Arrangements have been made for a major contribution to the atlas from the Great Lakes Institute, University of Toronto, making use of data collected by the Institute since about 1960.

Monitoring Programs and Descriptive Studies:

Descriptive studies of temperature distributions and regimes and of energy storage continue, using data from monitor surveys.

Shore station data collections continue to receive high priority. During 1968, surveys were made with Meteorological Branch, Dept. Transport, the Water Survey Division of Inland Waters Branch and Tides and Water Levels Section, Marine Sciences Branch, to update and expand the network of shore stations to record meteorological and lake data.

Instrument Assessment:

Technical evaluation of current meters of the type used in the field programs has been made in conjunction with the Engineering Systems Section. Improvements to existing instrumentation have been made in conjunction with the Engineering Systems Section; for instance, suggested sensors for low current speeds and a re-design of meteorological buoys needed for circulation studies. Several data collection systems appropriate for detailed thermal studies have been proposed by the Section, including both moored and towed thermistor chains for use in the Great Lakes.

(b) Limnogeology

The Limnogeology Section was transferred from temporary offices in the Geological Survey of Canada building, in Ottawa, to the CCIW trailer complex in January, 1968. The first two months of the year were spent in setting up laboratory equipment and organizing sampling and field equipment. In June, Dr. P.G. Sly was appointed as Head of the Section.

Results of the 1967 field work were available early in 1968 and were used as a basis for developing the '68 programs. The 1968 programs were designed as the first part of a series of long-term continuing studies. The co-ordinated programs fall into the following categories: sedimentology, stratigraphy, palaeoecology, inorganic geochemistry and organic geochemistry.

Sedimentology:

Under this heading there were five major projects:

(1) Study of Canadian nearshore areas of Lake Ontario: In this program bottom samples, short cores, photographic recordings, underwater television, echo soundings and diver reports have been used to cover the lake shore in water depths of 20 metres or less, traversing at 1-km intervals. The project was conducted from a specially constructed twin-hulled vessel (C.S.L. Gosling) which could work in water depths as

shallow as 0.5 m. The area between Niagara-on-the-Lake and Oshawa was studied. Navigation control was by Mini-Fix and Cubic Autotape. Although the program has been in progress only a relatively short while it has already shown that in the nearshore areas of Lake Ontario (which have been studied) the thickness of recent sediment deposits, particularly sands, is generally thin. In many areas the unconsolidated material lies, as a veneer (about 0.5 m thick), over glacial or preglacial deposits.

(2) A grid sampling program in the Niagara-on-the-Lake area of Lake Ontario: This study was based largely upon the results of a preliminary survey in 1967. The 1968 field work consisted mainly of very detailed echo-sounding traverses, side-scan-sonar recordings, and selected bottom samplings and corings. The data have enabled the production of a bathymetric chart with contouring at 1-m intervals at a scale of 1:10,000. Sub-bottom penetration and bed reflectivity have been plotted with similar accuracy. Using side-scan-sonar, a physiographic chart is also being constructed. By the use of side-scan it has been possible to interpret some of the otherwise inexplicable sediment distributions in the area east of the Welland Canal entrance in Lake Ontario. It has been possible, for example, to show not only the general area of dumping, but many of the individual dumps by scows, removing material from the canal excavations.

(3) A grid sampling project in Georgian Bay, in the area immediately northeast of Tobermory: Here, in addition to procedures used in Lake Ontario, underwater colour photography was used to record lake-bed characteristics at selected sample sites. The final sampling program in both the Georgian Bay and Niagara-on-the-Lake areas calls for about 280 samples in each. The samples form a large rectangular grid within which sampling areas of progressively lesser grids are located. The area of the grid covered by the most closely spaced samples is 10,000 square feet. By using this method of sampling, variance analyses based either on spot locations or enclosed areas, will be possible. It is intended that the final results will relate sedimentological, geochemical and biological data. Surveys were conducted from the charter vessel Lac Erie. The highly variable distribution of bottom deposits in the Niagara area is in marked contrast to those studied in Georgian Bay. This reflects not only the difference in natural conditions but also the environmental changes that have occurred in response to the activities of industrial and urban development.

(4) Western end of Lake Ontario: This project involved the use of bottom sampling and coring equipment, echo sounders and underwater diving techniques. The project was designed to provide preliminary data for a study of mineral provenance in the area and its relation to source, erosion, transportation and deposition of sediments. Preliminary studies of sand transport using fluorescent tracers were carried on. The heavy mineral assemblage, so far determined, strongly reflects its source in the glacial deposits of southeast Ontario.

(5) A preliminary assessment of sedimentation in Lake Diefenbaker, the newly formed reservoir behind the Gardiner Dam, Saskatchewan. This study, in collaboration with the Physical Limnology Section, resulted in a report submitted in December for publication in the Inland Waters Branch Technical Report series. The report makes recommendations concerning a continuing observation program to assess the rate and nature of reservoir sedimentation taking place over the next few years.

Stratigraphy:

This part of the Section's activities is under the direction of staff of the Geological Survey of Canada. The long-term projects of coring and bottom sampling in Lakes Erie and Ontario were continued. Much of this work was undertaken jointly with the geochemistry unit of the Limnogeology Section. A recent publication by Kemp and Lewis (10) has considered in detail the degradation products of chlorophyll found in Lake Erie and Lake Ontario sediments.

Based on 37 surface samples taken along the axis from Lakes Erie and Ontario, the following were determined: chlorophylls, pheophytins, organic carbon, carbonate carbon, Eh, pH and particle-size distributions. Sub-environments within each lake were recognized on the basis of bathymetry, particle-size distribution, clay mineral content and thickness. Total chlorophylls (a and b) ranged in concentration from 0-30 ppm (dry weight) in the two lakes, while total pheophytins (a and b) ranged from 0-192 ppm. Concentrations of pheophytins along the axis of Lake Erie were generally greater than along the axis of Lake Ontario. Calculations showed that phytoplankton chlorophylls are 93-100% decomposed before settling to the bottom. The pheophytins decomposed, on average, 70% with burial in the sediments at 5 cms, whereas the organic carbon decomposed about 33% under the same conditions. Per-cent organic carbon ranged from 0.23 to 3.60 in Lake Erie sediments and from 1.90 to 5.00 in Lake Ontario sediments. The pheophytin content paralleled that of organic carbon, and both varied with the clay content of the sediments. The generally lower values of organic carbon in Lake Erie were attributed to the dilution of the sediments with coarser non-clay particles. A detailed outline of other Great Lakes geological programs is available in the annual review of the activities of the Geological Survey of Canada.

Palaeoecology:

The work of this unit has been under the direction of W. Warwick and is closely related to studies conducted by the Fisheries Research Board. Mr. Warwick is studying the environmental relationships of the chironomidae in the Great Lakes. Because of the complex nature of the problems involved in identifying the fauna, it is necessary to catch and rear various species and identify them at various stages in their life-cycle. With the build-up of this information, it will become possible to interpret sample data from sediment cores, based on the identification of chironomids in various stages. Chironomids are extremely sensitive to eutrophication, thus fossil forms will provide delicate indicators of the palaeo-environment. Mr. Warwick is concentrating on the Lake Ontario fauna.

Geochemistry:

Although the geochemical work of the Section is divided into two units (organic and inorganic), the field projects of these units were run as one lakewide survey of Lake Ontario. This survey resulted in the complete sampling (Shipek bottom samples and selected cores, up to 50 ft in length, on an 8-km grid). The samples were freeze-dried aboard ship and later analyzed in the geochemical laboratories at CCIW. The study was undertaken using two ships (at different periods); the C.S.S. Limnos was used for work in the open lake and the C.S.L. Lemoyne was specially equipped for nearshore geochemical studies, and as well as having a sample processing laboratory, she was equipped with low frequency echo sounders and precision ranging radar. Shipek samples, gravity cores and piston core samples were collected in Lake Erie on a Limnos cruise for organic geochemical studies, the samples being treated as for the Lake Ontario program. Preliminary results of this program show that from both the sedimentological and geochemical aspects, Lake Ontario is composed of four major depositional basins. These have been tentatively designated: Niagara basin, Mississauga basin, Rochester basin, and Kingston basin. The basins are separated by various sills or divides: Whitby-Olcott, Scotch Bonnet, and Duck Galoo. Although these divides appear to be largely structural in origin, a similar fourfold (with minor variations) distribution occurs in the distribution of phytoplankton. Hence lake productivity would also seem to be affected by the presence of these same divides.

Additional Projects:

In addition to the major projects outlined, various other smaller research projects were undertaken by the Section. A diver-controlled program was conducted in the Duck Island area of Lake Ontario to investigate the occurrence of certain dark, manganese-coated deposits. A short side-scanning and echo-sounding program was undertaken in Georgian Bay, in the areas (i) south of Flowerpot Island and, (ii) east and south-east of Yeo Island, for Dr. W. Tovell of the Royal Ontario Museum. Diver-controlled equipment trials programs were carried out in the Dunks Bay area and Prince Edward Bay, and bottom sampler trials were conducted jointly with the Fisheries Research Board in the western part of Lake Ontario and Hamilton Harbour. These tests were designed to find the most suitable type of bottom sampler for co-ordinated geological and biological surveys (sediments and their related bottom fauna). (See additional information on these bottom sampler trials in the FRB portion of this report).

Laboratories:

The Section has continued to develop methods for the quantitative geochemical and sedimentological analysis of sample material. The sedimentology laboratory processed 748 short pipette analyses, 196 complete seive and pipette analyses, 73 half Ø analyses, 99 quarter Ø analyses and made up a total of 79 slides for clay X-ray analyses. By the introduction of X-radiographic techniques (with the assistance of the nondestructive testing section of the Mines Branch) it has been possible to log on a standard basis, all of the cores presently stored by the Section (total length in excess of 4,000 ft).

The use of sedimentation tubes for rapid particle size analysis has continued to be held back due to the problems of vibration in the trailers. The development of methods of overcoming this problem are still underway.

(c) Chemical Limnology

Lake Studies and Chemical Monitoring:

The Chemical Limnology Section is responsible for the planning and the evaluation of the results of chemical monitor cruises on the Great Lakes. The samples are collected by personnel of the Operations Section, G. L. D., and analyzed by Water Quality Division.

Study of the 1968 monitor cruise data for Lakes Erie and Ontario indicate that both more sampling stations and more frequent sampling and analyzing for total P and total N are needed in order to make more meaningful the analytical data for PO_4 and NO_3, and to improve our understanding of the nutrient budgets of the lakes. Accordingly, for 1969, an intensive year-round chemical monitoring of Lake Ontario with special emphasis on these nutrients, is planned.

Trace elements, Cd, Cr, Co, Mn, Ni, Fe, Zn, Cu, Pb, Li, and Sr, were determined (by Water Quality Division) in samples from eleven stations in Lake Erie and three in Lake Ontario in 1967. Cd, Co, Cr, were not detected in most of the stations and data for the others show a high degree of variability. Investigations to improve the sensitivities for the above mentioned elements will be made and more stations and more depths will be sampled during 1969 for trace element studies.

The data for major ions in Lake Erie from chemical monitor cruises in 1967 were evaluated in collaboration with Water Quality Division, and a description presented at the 11th Conference on Great Lakes Research at Milwaukee. Although the concentrations of major ions tend to increase somewhat with time, their rate of change is slow, and therefore they will be monitored less frequently than some other chemical species.

Extensive studies on trends from 1928-68 in dissolved oxygen depletion rates in the bottom water of Lake Erie were undertaken and the results will be presented and published early in 1969.

Section members prepared several sections for the IJC Report on major ions, nutrients and dissolved oxygen in Lake Erie. The Sixth Conference of the IJC Working Committee on Methodology was organized by the Section, and preparation of an appendix to the IJC Report on Methodology was started in collaboration with Water Quality Division.

Rain Monitoring:

One aspect of the nutrient budget of the Great Lakes for which data are scanty is the input from rainfall, and therefore plans were made to sample rainfall, starting probably in May or June, 1969. The rain samplers will be similar to those used in Europe and in the United States, and will consist of an inverted glass bottle whose bottom has been cut off. A glass wool filter will be used to minimize contamination by foreign materials (chiefly insects). The rain samples will drain into glass storage bottles in a styrofoam container equipped with a thermostated heater to keep the temperature about 40°F, so that in the winter snow will melt and be collected. During the first phase of the project, one collecting station will be at CCIW, Burlington, and about six more stations will be located around Lake Ontario. The accumulated samples will be shipped to Burlington each month for complete chemical analysis.

Laboratory Projects:

Isopiestic measurements - Isopiestic measurements on mixed salt solutions were made. Such measurements permit the calculation of deviation from ideal behaviour of salts in aqueous solution.

The fundamental physical and chemical properties of aqueous solutions must be known before we can completely understand the behaviour of natural waters. Freezing point depressions, osmotic pressures, vapour pressures and molecular diffusion all depend on the activities of the components in any system.

H_2O - $NaCl$ - Na_2SO_4
H_2O - $NaCl$ - $MgCl_2$
H_2O - $Na_2B_4O_7$
H_2O - $K_2B_4O_7$
H_2O - H_3BO_3
H_2O - $NaBO_2$
H_2O - $NaBF_4$

Other systems will be studied during 1969 by this method, and with specific ion electrodes.

Electrodes - A thermodynamic dissociation constant for MgF^+ was measured in dilute solutions, using the Orion fluoride and water-hardness electrodes. The water hardness electrode, used to measure Mg, in the absence of Ca or other divalent cations, and with 0.01 M $MgCl_2$ as the internal reference solution and as one of the standard solutions, behaved well, but the standard potential changed by several millivolts each day. When the liquid ion exchanger had completely equilibrated with the $MgCl_2$ solution, the standard potential had changed from about -30 mv to about -155 mv. This experience indicates that when using these liquid ion exchanger electrodes, it is advisable to pre-equilibrate the exchanger with one of the standard solutions and to have both the internal reference solution and the standard solutions as much like the test solutions as possible.

Specific ion electrodes make possible the direct, non-destructive, analysis of a number of chemical species, but intelligent use of such electrodes requires a thorough knowledge of the chemistry of the solutions to be measured. Such factors as the presence of interfering ions (with respect to the electrode) and the presence of complexing agents (with respect to the ion being measured) need to be considered.

Some specialized electrodes, a metal-sealed, flow-through, capillary glass electrode for pH, and a platinum disc sealed inside a syringe, were developed to permit the anaerobic measurement of pH and Eh of interstitial water of lake sediments.

Interstitial Water - Some sediment samples from western Lake Ontario were taken during August, and analysis of the interstitial water showed considerably higher levels of SiO_2 (16 to 52 mg/1.) and PO_4 (up to 1.16 mg/1.) than are found in the lake water. As much as 9.3 mg/1. K and 83 mg/1. Ca were found. One sample, from Hamilton Harbour, contained about 50 mg/1. of dissolved iron.

The sediment mineralogy was studied by X-ray diffractometry, and a rather simple suite of clay minerals - illite or muscovite, kaolinite, and chlorite - was found. One sample, surprisingly, contained tremolite (a Ca Mg amphibole) but this sample was taken in an area where much of the sediment consists of glacial debris, and the sediment has probably not been subjected to very much weathering. This project will be continued and expanded during 1969.

(d) Engineering Services

During 1968, Mr. G. A. Jones joined the staff as Section Head.

Data Translator:

A significant advance has been made in the preparation of current-meter data for computer analysis. A system has been developed which translates data from Plessey current meters directly onto computer magnetic tape. The system, called the CCIW data translator, was designed and constructed by staff personnel during 1968 and is now fully operational. A technical report about the system has been prepared.

One of the components of the system itself is a small computer, a PDP-8. The computer makes it possible for the system to perform functions such as error checking and data summarizing. In addition, it means that only minor changes will enable the system to accept many different types of data input for translation. Work on this aspect of the system is currently proceeding.

Wave Probe Array:

A fast response, non-wetting wave probe was developed to meet a requirement for detailed analysis of small-scale water waves in conjunction with the air-water interaction program. Building on the feasibility experiments of 1967, an experimental model of a single probe unit, using an electric field principle was built and tested. It confirmed the soundness of the approach and satisfied the requirements of linearity, accuracy, and suitability for clean or polluted waters. Plans to follow on with this work, making an operational unit for the field and further expanding to a six-probe array for spectral and directional studies, have been temporarily postponed to direct efforts to more urgent programs.

Meteorological Instrumented Buoys:

In response to the need for detailed meteorological data, coincident with current-meter observations, the Engineering Section undertook the construction of two additional meteorological recording buoys. Essentially improved versions of the 1967 model, the new systems employed a Plessey data recorder to monitor, every ten minutes, total wind run, wind direction relative to magnetic north, air temperature at 3 metres and 1.5 metres, and near-surface water temperature. The eight-foot diameter toroidal buoy made by Geodyne Corporation was the platform for the instrument system. Making the wind vane with oil damping, strengthening the construction of sensor supports and improving the water-tight case for the recorder units were the major modifications incorporated into this year's models.

The buoys were operated, unattended for about 50 days at a time on selected current meter stations. Data are being processed using the same translation system as for the Plessey current meter.

Electronic Bathythermograph:

A long expressed dissatisfaction with the accuracies, response and data formats associated with the conventional mechanical bathythermograph, has resulted in the continued, but low priority, development of an electronic probe to measure temperature as a function of depth. The unsuccessful model attempted last year was repaired and the complete shipboard electronic package was rebuilt. Laboratory calibrations indicate that accuracies of $\pm.01°C$ and ± 8 inches in 400 feet can now be achieved. Important features distinguishing this model from most oceangoing salinity temperature depth systems developed commercially, are its smaller size and lower cost. In one form it can be used from a small motor launch by hand, and in another form, it can be operated with a winch and interfaced to the shipboard computer.

Shipboard Sensor Systems:

The Engineering Systems Section has long been dedicated to the concept of a large-scale automatic system to monitor routinely measured variables for the major research vessels operated by the Centre. Apparatus used in previous years was integrated into one system of stripchart recorders, signal conditioning modules, various transducers and special power supplies. Systems were installed on the C.S.S. Limnos and the M.V. Theron. Parameters recorded were air temperature and relative humidity at mast height, incoming solar radiation and the near surface water temperature from a towed vehicle held just outside the ship's wake. As a further step towards automation, a Hewlett Packard 2110B data acquisition system on C.S.S. Limnos recorded these parameters onto punch paper tape for direct computer analysis ashore. An engineering student was placed on board C.S.S. Limnos to operate and maintain this system.

The PDP-9 computer, which is to be the shipboard computer for C.S.S. Limnos, was delivered and temporarily installed in the computing room onshore. Plans to install the computer on board ship were postponed until 1969. The computer was turned over to Computer and Data Services Section for development of special and utility programs.

Towers:

Two towers were designed and built. Both were set in about 40 feet of water, one being at the mouth of the Niagara River, and the other was situated in Lake Ontario near Burlington.

The Niagara tower had a total of 26 data channels which were recorded using four interconnected digital tape recorders, controlled by a central clock. Averaged profiles of wind speed and air temperature were recorded every ten minutes along with supporting measurements of surface-water temperature, water level, real time and wind direction. This system incorporated several improvements, including a better method for measuring the differential air temperature, which gave accuracy to ±.05°C in all but unfavourable conditions. A floating thermistor for measuring temperature in the upper inches of the water surface and a three-level, humidity profiling system were added.

A subsystem to measure the solar energy flux was developed to operate on this tower. It used a Plessey Hy-met recorder with a set of amplifier adapters which could accept the low level signals from the upward and downward facing solarimeters, the C.S.I.R.O. net radiometer and the Eppley pyrheliometer. Because of the variability of these parameters, this subsystem could operate in a ten-minute or a one-minute sampling mode.

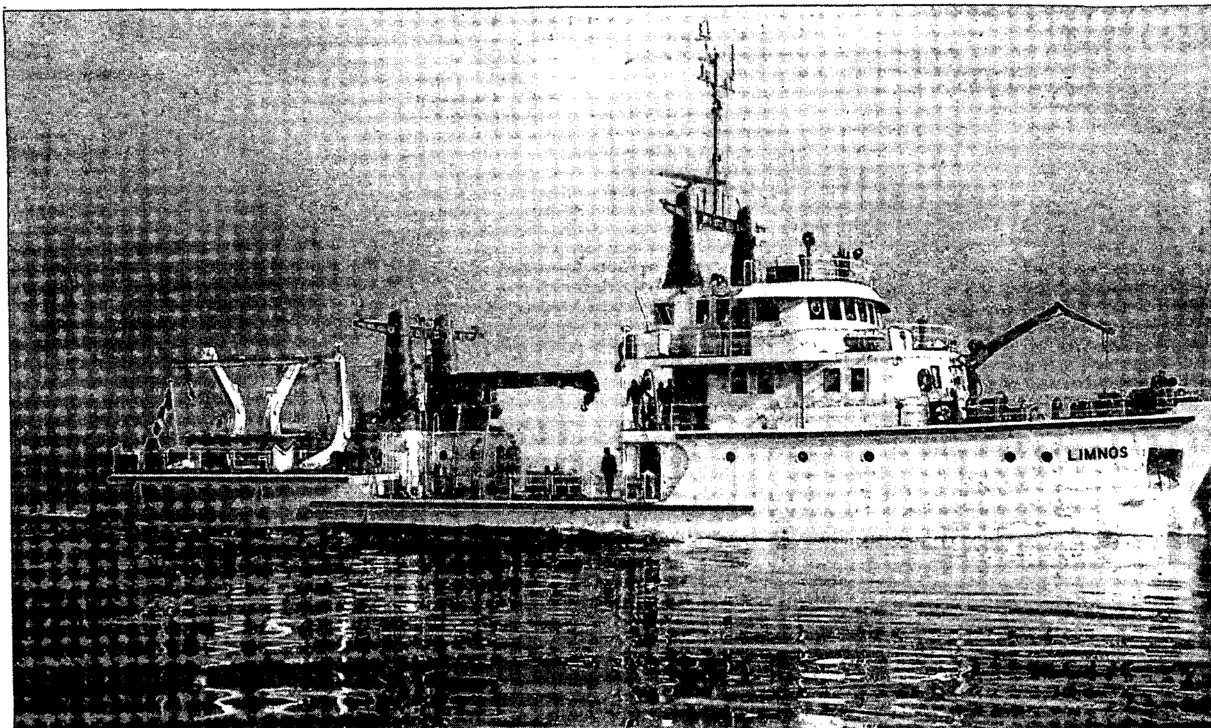
The Lake Ontario tower was equipped with a water level recording gauge and a Plessey current meter.

Dye Diffusion:

A prototype dye diffusion system was evolved for dispersal and diffusion studies. The system consisted of a raft, complete with apparatus for injection of rhodamine "B" dye into the water, and a sampling boat with a "Braincon" V-fin, towed unit for continuous water sampling by fluorometer. Fifteen shore stations were also supplied for sampling of shoreline water. A more refined dye diffusion system is being planned for use in the 1969 season.

Calibrations Laboratory:

When the temperature calibrations equipment was moved into the trailer complex, it was found that the high level of ambient vibrations made operation of the equipment impossible. Consequently, this equipment was housed in a nearby building where calibration of all electronic temperature sensing and recording equipment for the field program was performed. In the meantime, the nature and extent of the vibration problem was investigated in consultation with N.R.C. and the consulting engineers for the new building. This resulted in procurement of two special vibration isolation tables which are now installed and proving themselves.


LIMNOS

General:

About 50% of total Section man hours was expended for the repair, maintenance and operation of equipment in the field. For the electronics unit, this effort was primarily channeled into the Plessey current meter program, the Niagara and Burlington towers and ships continuous monitoring program. For the mechanical unit, the major effort was on repair of ships' equipment, launches and winches.

(e) Technical Operations

Major Ships:

Two major ships, the C.S.S. Limnos and the charter vessel M.V. Theron, were used for the Great Lakes Studies in 1968. The C.S.S. Limnos is owned by the Department of Energy, Mines and Resources and operated by the Marine Sciences Branch. She arrived at CCIW on May 3rd, and after completing the installation of scientific equipment she commenced operations on May 13. The original charter period for the M.V. Theron was from April to October, however, this was later extended until November 29. Before leaving Halifax the vessel was fitted out with oceanographic winch and platform, davits, temporary deck housing, and laboratory facilities. She arrived at CCIW on April 21st, and after completing the installation of scientific equipment she commenced regular operations on April 29th.

The schedules for both vessels had been planned prior to the beginning of the season. However, owing to mechanical problems in the break-in period, C.S.S. Limnos and the St. Lawrence Seaway strike from June 21 to July 15 schedules were changed considerably.

Operational Table*

Ship	Arr. CCIW	Dep. CCIW	Total Days	Away on Operations	%
C.S.S. Limnos	May 3	Oct. 15	166	86	51.8
M.V. Theron	Apr. 21	Nov. 29	223	170	76.2

*Complete 1968 schedules for M.V. Theron and C.S.S. Limnos are shown at the back of this report.

The pattern of operations was changed from the previous year when one ship was assigned to Lake Ontario and the other to Lake Erie. During 1968 the Limnos was assigned to both Lake Ontario and Lake Erie. Theron, in addition to operating in Lake Ontario and Lake Erie, also carried out a monitor cruise on Lake Huron, and a monitor cruise on Lake Superior. Personnel from the Operations Section at CCIW were assigned to both ships on a continuing basis, throughout the season, to undertake sampling, analysis and observation programs. Scientific and technical personnel from various agencies joined the vessels in accordance with a pre-arranged schedule. The Operations Section was responsible for technical deck operations, entailing the sampling procedures, measurements and recordings of physical parameters, and mooring operations. The manual chemistry determinations and routine weather observations and reports were also carried out by this group.

Monitor Cruises:

The monitor programs in Lakes Ontario and Erie were continuations of 1967's observations. The station positions, sampling procedures and physical parameters were essentially the same. The few changes that were made as a result of the experiences gained during the previous year were designed to obtain better and more comprehensive coverage of the lakes.

Two "special" cruises were carried out in Lake Ontario in the vicinity of the Niagara River. One cruise was primarily designed to support the current studies in the area, and the other to provide ground-truth for the infrared scanning carried out by aircraft.

Lake Huron and Lake Superior were monitored for the first time by CCIW and these programs are expected to continue in the future.

Mooring Cruises:

Several mooring cruises were carried out in Lake Ontario and Lake Erie. The moorings were checked during the monitor cruises and special cruises were scheduled for servicing and re-establishing malfunctioning instruments and/or disturbed moorings. Meteorological buoys were placed in both lakes using large geodyne donut floats fitted with meteorological sensors and equipped with Plessey data storage units. In Lake Ontario the areas under study were off Thirty Mile Point and off Niagara River and in Lake Erie the moorings were placed in various positions in the eastern end of the lake. Temperature observations and drogue trackings were carried out in support of the current studies. One winter mooring remains in the western end of Lake Ontario and one in the eastern end of Lake Erie. Both of these moorings are equipped with a time mechanism set to release in April, 1969.

The proper authorities were always informed about the placing and recovery of moored instruments and shipping was warned through Notices to Mariners. In spite of such precautions, losses of equipment did occur in both lakes. In Lake Ontario barges were seen moving between some of the inshore moorings and large lakers were seen steaming between the offshore positions. In Lake Erie a number of fishing vessels were observed between the moorings in addition to the large lakers. A total of four current meters, one meteorological package, and three surface buoys and floats were lost in the two lakes.

Coring Cruises:

A number of geological sampling cruises were made in Lake Ontario and one in Lake Erie. A 1,200-lb piston corer with up to 90 feet of pipe and also regular gravity corers were used in various locations in both lakes. Numerous sediment samples were collected with Shipek grabs. In order to obtain a picture of the sediment layers in the lakes, large areas were track-sounded using the echo sounders on the ships.

Gravity Cruises:

These cruises were parts of continuing surveys in both Lakes Ontario and Erie, by the Dominion Observatories Branch, to obtain regional gravity measurements for geological and geodetic investigations.

The operation consists of lowering an underwater gravimeter (La Coste & Romberg) to the lake bed on a 10-km grid. Readings are taken at each station while the vessel keeps position over the gravimeter and its connecting cables.

The Hi-Fix electronic navigation system was used for positioning the vessel and consisted of two mobile slave stations operated from selected sites and the Master aboard ship.

During the second gravity cruise in October a Satellite Navigator Receiver (Magnavox 702 CA) was used in conjunction with the ship's radar for obtaining positions. The system was monitored continuously with the initial navigation being done by radar and results computed later from the navigator for comparison with the radar fixes.

Accurate water depths are required for the computation of gravity data. Two echo sounders were used at each station, together with a pressure gauge, within the gravimeter to achieve optimum results. The echo sounders were also operated continuously and monitored while the survey was under Hi-Fix control.

(f) Computer and Data Services

In addition to the continuing job of summarizing data from the 1968 monitoring program, data clerks contributed considerable support in abstracting and plotting data and undertaking statistical analyses for the scientific staff. Original data from 1966 and 1967 were transferred to microfilm for safekeeping and ease of retrieval and reproduction.

The Canadian Oceanographic Data Centre in Ottawa continued to process all thermocheck and bathythermograph data and was responsible for co-ordinating and publishing the CCIW data records. All 1968 major data summaries have been forwarded to CODC with the request that punched cards for all 1966, 1967, and 1968 data records be forwarded to CCIW as soon as they can be made available. BT aperture cards containing errors, were also returned to CODC for reprocessing.

Programs to read and analyze punched paper tape from the Plessey current meter translator and the Hewlett-Packard data acquisition system were written. The solar radiation data from the tower were plotted using these routines.

The CCIW data translator went into full production with the translation of most of the Niagara Tower Plessey tapes and one half of the 1968 current meter tapes - thirty-five tapes total. This was put onto four 2,400-ft reels of computer tape.

All of the solar radiation data, some current meter and some water level data were plotted by the shipboard computer. This represents four months of tower data, some 300 feet of plot with 8 parameters plotted together.

The shipboard computer arrived in March, 1968, and work on this system was begun. The computer is an 8K digital equipment PDP-9 with a plotter.

The installation of a control data type 8130 terminal, connected to a 6400 computer at McMaster University, Hamilton, will be completed early in 1969.

(g) Administration Section

During 1968 the administrative support staff of the Division provided such services as budgeting, financial control, auditing, accounting and procurement of equipment, instruments and material and supplies requirements for all Great Lakes Division Sections. In addition, the Section was responsible for providing drafting, duplicating, central registry, science library, central stores, accommodation, communications and transportation services for all components involved in the Centre's research program and located in temporary quarters on site. It is expected that many of the common-user facilities, i.e. central registry, science library and central stores will be transferred from Great Lakes Division to the CCIW Administration Division early in 1969. The Section was also responsible for security at the site and was successful in implementing an active fire prevention and safety program.

The Administration Section was also responsible for carrying out a number of public relations functions during the year. (See Introduction).

CCIW Library:

The library, although under the administrative direction of the Great Lakes Division during 1968, was called upon to serve all components of the Centre. With the general policy guidance of a CCIW library committee drawn from all agencies at the Centre, a water library is being developed through acquisitions in many water-related fields including biology, limnology, hydrology, economics, chemistry, geology, physics, etc. Mrs. E. Fosdick was appointed librarian in August 1968, and is assisted by a library assistant and a typist.

The library is currently housed in two trailers with a total shelving space of 729 linear feet and the capacity of a further 287 linear feet. This total capacity should house four years' accumulation of 600 periodical titles plus approximately 1,500 books.

The library now has a total collection, either received or on order, of over 6,200 volumes including subscriptions to 645 periodical titles. From this point of view, it is advantageous that so many books are on "semi-permanent" loan to staff members!

By the end of 1968, the library collection was used by an average of 21 persons each day and the librarian was asked an average of 5 reference questions a day (this does not include the questions asked the other library staff members).

The seating capacity of the library (for users) is currently 9 and is occasionally used to full capacity.

The lack of working space for the library staff, i.e. in unwrapping cartons, processing new acquisitions and daily mail, etc. is very noticeable in our present quarters. Likewise the fact that the microfilm reader has to be housed outside the library is a disadvantage.

The library has been visited by several professors, industrial scientists, engineers and limnology students who have expressed an interest in our collection. This indicates that in the near future the collection will be a widely used resource not only by CCIW staff but by university and private sector scientists and students concerned with water resources.

Bibliographic control of the collection took second place to acquisitions during the year, however, cards for more than 1,200 volumes are now in the card catalogue. These are catalogued by the Library of Congress system with specific subject headings being added from the Water Resources Thesaurus. The books are accessible by author, title, or subject. Other books have been catalogued and with the recent arrival of a minigraph card duplicator the card output will increase quickly. The periodical collection is not catalogued but arranged alphabetically with Kardex control of circulation and acquisitions.

Circulation records have been maintained to date in only an elementary manner. As the collection grows a review will be made of the system and when more adequate space becomes available a more sophisticated system will be possible.

The library requested 442 items on inter-library loan between August 1968 and February 1969. Contrary to original hopes the number of requests per month has not decreased as our collection has increased. A survey of the requests reveals that they are from a wide variety of journals over a long span of time and thus it appears that this cannot be changed by purchasing a few journals. However, when back issues now on order have been received the situation may improve.

An exchange of publications has been inaugurated with other institutions in fields similar to CCIW. The exchange list now contains approximately 50 institutions. Annual collections of CCIW "Collected Reprints" will be prepared for exchange with these institutions. It is anticipated that the first collection will be available in April 1969. In addition, a list of scientists and research managers has been prepared by CCIW staff members. Persons on this list will receive a listing of our available reprints periodically and will be able to select those which they would like to receive. Final arrangements for these exchange programs are not yet complete.

The library staff is preparing a list of periodicals held in the CCIW library. This project should be completed by mid-March and will be updated periodically as necessary.

The librarian is assisting in composing an interest profile for two scientific staff members. The National Science Library is inaugurating an experimental current-awareness project in which profiles are matched by computer against the titles of current journal articles and personalized bibliographies are produced. This program should commence in March.

A bi-weekly acquisitions list is currently prepared and distributed to the scientific staff. Other special activities included an initial editing of the bibliography for CCIW's contribution to the IJC report and the compilation of a list of papers written by CCIW staff members.

Water Quality Division:

CCIW Detachment, Analytical Services Section - During 1968, this Division was actively engaged in monitoring and surveillance of Lakes Ontario, Erie, Huron and Superior. Out of a total of thirteen full monitor cruises completed, six were on Lake Ontario, five on Lake Erie and one each on Lakes Huron and Superior.

Approximately 6,000 samples were analyzed on board ship for dissolved oxygen, specific conductance and turbidity by personnel from the Operations Section, Great Lakes Division with technical guidance from Water Quality Division staff.

Water Quality Division personnel analyzed, on board ship, about 1,400 samples for ortho-phosphate, silica, ammonia, and nitrate by the Technicon Auto Analyzer. Two hundred and twenty Great Lakes water samples were analyzed at the Division's shore-based laboratory for calcium, magnesium, sodium, potassium, sulphate, chloride, total alkalinity, total hardness, total dissolved solids, and fluoride; an additional 500 samples were analyzed for total phosphate. To obtain further background information on trace metals about 450 filtered and unfiltered Great Lakes water samples were acidified and from these samples copper, zinc, lead, cadmium, chromium, cobalt, lithium, nickel, strontium, iron and manganese were determined.

During the year a modified automatic procedure for orthophosphate was used in the monitoring program; this modification, overcoming interferences in lake waters, increased the sensitivity and reliability of the method.

In addition the detachment head, Dr. V.K. Chawla, participated with Chemical Limnology Section staff of Great Lakes Division in studies of major ion and trace element distributions in Lakes Erie and Ontario. He also was assisting at year's end in preparation of the Appendix on Methodology for the IJC report.

Marine Sciences Branch:

CCIW Detachment - Activity increased significantly in 1968 with the addition of equipment and personnel to the Centre.

A major event was the commissioning, in May, of C.S.S. Limnos, a 147-foot survey vessel, designed and acquired by the Department specifically for Great Lakes operation. Of unique design, this ice-strengthened ship, driven by two diesel powered Harbourmaster units, essentially giant inboard-outboard drives, features good manoeuvering capability without the benefit of bow thrusters. Also featured are special hoisting facilities, wet and dry laboratories plus accommodation for 12 scientific and operational personnel, in addition to the normal ship's complement of 15 officers and crew.

The 197-foot M.V. Theron was chartered for a second season and the 65-foot tug Lac Erie was chartered for specialized operation in the sedimentology program. The fleet was rounded out with 7 launches of varying dimensions, form and construction.

The fleet build-up was complemented by an increase of operational personnel. In addition to 5 Limnos officers, some seasonal personnel were assigned to the Centre for operation of ships and launches. The need for closer supervision of operation and liaison was also recognized by the assignment of a full-time line supervisor.

As in the case of many specially designed ships, Limnos was plagued during her first year with a number of malfunctions in her equipment. Most of the inherent defects have been remedied and there is every indication that the ship will be fully operational for the 1969 season.

Permanent positions are now being raised to bring the continuing full-time total, excluding ships officers, for 1969-70 to 6, while an additional ship's officer position now being sought will increase that category to 6.

THE FISHERIES RESEARCH BOARD

FRB Burlington Detachment

The Fisheries Research Board of Canada participated in 12 cruises of the Theron and two of the CCGS Porte Dauphine (a Dept. Transport vessel operated for the Great Lakes Institute, University of Toronto), ranging from March to December (Ontario - 6; Erie - 6; Huron - 1; Superior - 1). Continuous records of chlorophyll in surface water were obtained along with plankton collections at monitor sampling stations. The concentration of chlorophyll in the surface waters of Superior was extremely low and there was no patchiness comparable to that observed in Lake Ontario in 1967. The early June surface chlorophyll values in Lake Ontario were lower in 1968 than they were in 1967. One of the most notable findings during 1968 in reference to zooplankton was the unexpectedly high abundance of *Daphnia longiremis* in Lake Erie, a form previously unrecorded from the lake.

A special cruise on Lake Ontario was made in September to determine the abundance of deep-water zooplankters (e.g. Limnocalanus macrurus) and the extent of vertical migrations of zooplankton on a 24-hour cycle. A report of 1967 zooplankton studies on Lake Ontario has been prepared for publication with full details on species and abundance/cm^2 from late spring to autumn. Zooplankton abundance was greatest in the eastern end of the lake, correlated with the higher temperatures and greater depth of the epilimnion there.

A core from the western basin of Lake Erie was examined for chironomid remains. On Hamilton's Great Lakes "trophic condition" scale (0 for extreme oligotrophy to 2.0 for extreme eutrophy), the values were as follows: 2.0 for organisms now living in the western basin; 1.82 for remains in the 0-3 cm depth interval of the core; and values ranging from 1.1 to 1.4 for remains at all core depths from 30 cm to 4 metres. These results show the dramatic recent change in the western basin. For the first time present trophic conditions have been related to pre-settlement conditions in Lake Erie, as inferred from these index fossils.

A special cruise was carried out in conjunction with limnogeology personnel at CCIW to test 12 sediment samplers on three different types of substrate (gravel, sand, mud). Only the Shipek and Ponar samplers operated effectively in sampling the organisms in all three types of substrate. The Franklin sampler was the best of all samplers for sand, and the Ekman for mud.

In addition to the above work on the St. Lawrence-Great Lakes, studies were made on other major Canadian lakes: Great Slave Lake (3 cruises), and Lake Winnipeg (1 cruise). Photosynthesis (C^{14}) was determined and samples collected for analysis of nutrients and plankton.

DEPARTMENT OF NATIONAL HEALTH AND WELFARE

Public Health Engineering Division

During the summer of 1968, staff of the Public Health Engineering Division participated with scientists from the Centre in nine Great Lakes cruises. These were on Lakes Ontario, Erie, Huron and Superior. On these cruises, 1,285 water samples were collected from various depths and were tested for both coliform and fecal coliform concentrations by the membrane filter technique. In addition, total bacterial counts were determined by the standard plate count method with incubation at both 20°C and 35°C.

Data from these, and related studies are being analyzed by the scientific staff at both Kingston and the CCIW, to search for possible relationships between coliform distribution, density, frequency, and specific chemical concentrations. These interrelationships will contribute to a better understanding of pollution and eutrophication processes.

In addition to these surveys and investigations, quantitative bacterial detecting techniques are being studied, with a view to improving both the speed and accuracy of testing. These studies are centred upon (a) a stained membrane filter technique and (b) an electronic counting procedure using a Coulter counter. With improved techniques, more reliable viable and non-viable total bacterial counts will result, which can then be studied relative to nutrient and chemical concentrations in the lakes. All of these studies which are carried on by teams of scientists are contributing to knowledge of Canada's waters which in turn will lead to water quality preservation and efficient management of one of the country's greatest resources.

PAPERS PUBLISHED BY CCIW STAFF, 1968

1. BRUCE, J. P., LANE, R. K., and WEILER, H. S., 1968. Processes at the air-water interface. Proc. Eleventh Conf. on Great Lakes Research, Milwaukee, pp. 268-284.

* 2. BRUCE, J. P., MAASLAND, D. E. L., and SEWELL, W. R. D., 1968. Water Resources Research in Canada. Sci. Sec. Spec. Study #5, Queen's Printer, Ottawa, 169 p.

3. BRUCE, J. P., 1968. The Canada Centre for Inland Waters. Limnos (Magazine of the Great Lakes Foundation, Ann Arbor, Michigan), Vol. 1, No. 4.

* 4. CHAU, Y. K., 1968. Determination of trace amounts of scandium by atomic absorption spectroscopy. Talanta 15, 421-424.

* 5. CHAU, Y. K., and WONG, P. Y., 1968. Determination of scandium in sea water. Talanta 15, 867-870.

* 6. CHAU, Y. K., SIM, S. S., and WONG, Y. H., 1968. Determination of chromium by atomic absorption spectroscopy of chromium acetylacetonate - Determination of chromium in sea water. Anal. Chem. Data 43, 13-18.

7. CHAWLA, V. K., and TRAVERSY, W. J., 1968. Methods of analysis on Great Lakes Waters. Proc. Eleventh Conf. on Great Lakes Research, Milwaukee, pp. 524-530.

8. HAMBLIN, P. F., 1968. Variations in water level in western Lake Ontario. Proc. Eleventh Conf. on Great Lakes Research, Milwaukee, pp. 385-397.

9. HOPE, E. L. V., 1968. A high order solution to the characteristic initial value problem. The Computer J. (U. K.) (in press).

10. KEMP, A. L. W., and LEWIS, C. F. M., 1968. A preliminary investigation of chlorophyll degradation products in the sediments of Lakes Erie and Ontario, Proc. Eleventh Conf. on Great Lakes Research, Milwaukee, pp. 206-229.

11. LANE, R. K., 1968. Physical Limnology. Encyclopaedic Dictionary of Physics. Pergamon Press (in press).

12. LANE, R. K., 1968. Application of remote sensing to pollution studies. Proc. Third Canadian Symp. on Water Pollution Research; Vol. 3, pp. 155-180.

*13. MURTHY, C. R., 1968. Wind tunnel modelling of chimney plumes. Presented at 61st Annual Meeting of Air Pollution Control Assoc., Saint Paul-Hilton, Minnesota (in press).

*14. MURTHY, C.R., 1968. On the settling of dust particles borne by hot chimney plumes. Proc. Am. Soc. Mech. Engrs. Winter Annual Meeting, New York, December 1-5, 1968.

*15. PLATFORD, R. F., 1968. Isopiestic measurements on the system H_2O-NaCl-Na_2SO_4 at 25°C. J. Chem. and Eng. Data 13, 46.

*16. PLATFORD, R. F., 1968. Isopiestic measurements on the system water-sodium chloride-magnesium chloride at 25°. J. Phys. Chem. 72, 4053.

17. WEILER, H.S., 1968. Current measurements in Lake Ontario in 1967. Proc. Eleventh Conf. on Great Lakes Research, Milwaukee, pp. 500-511.

18. WEILER, H.S., and BIRCH, K.N., 1968. Wind speed and temperature profile system utilizing a self-balancing bridge and digital magnetic tape recording system. Proc. Eleventh Conf. on Great Lakes Research, Milwaukee, pp. 360-370.

19. WEILER, R.R., and CHAWLA, V.K., 1968. Chemical composition of Lake Erie, Proc. Eleventh Conf. on Great Lakes Research, Milwaukee, pp. 593-608.

*These papers report on work done by the authors prior to joining the CCIW staff.

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Executive Assistant to Acting Director - T.S. Hillis
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Dr. J. R. Vallentyne, Scientific Leader, Eutrophication Section
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NATIONAL HEALTH AND WELFARE

Liaison Officers - Dr. C.P. Fisher - Ottawa
B.J. Dutka - Kingston

Support Staff: P. Collins, A. Jurkovic, A. Menon, H. Van Otterloo, H.F. Wong.

PERSONNEL ADMINISTRATION

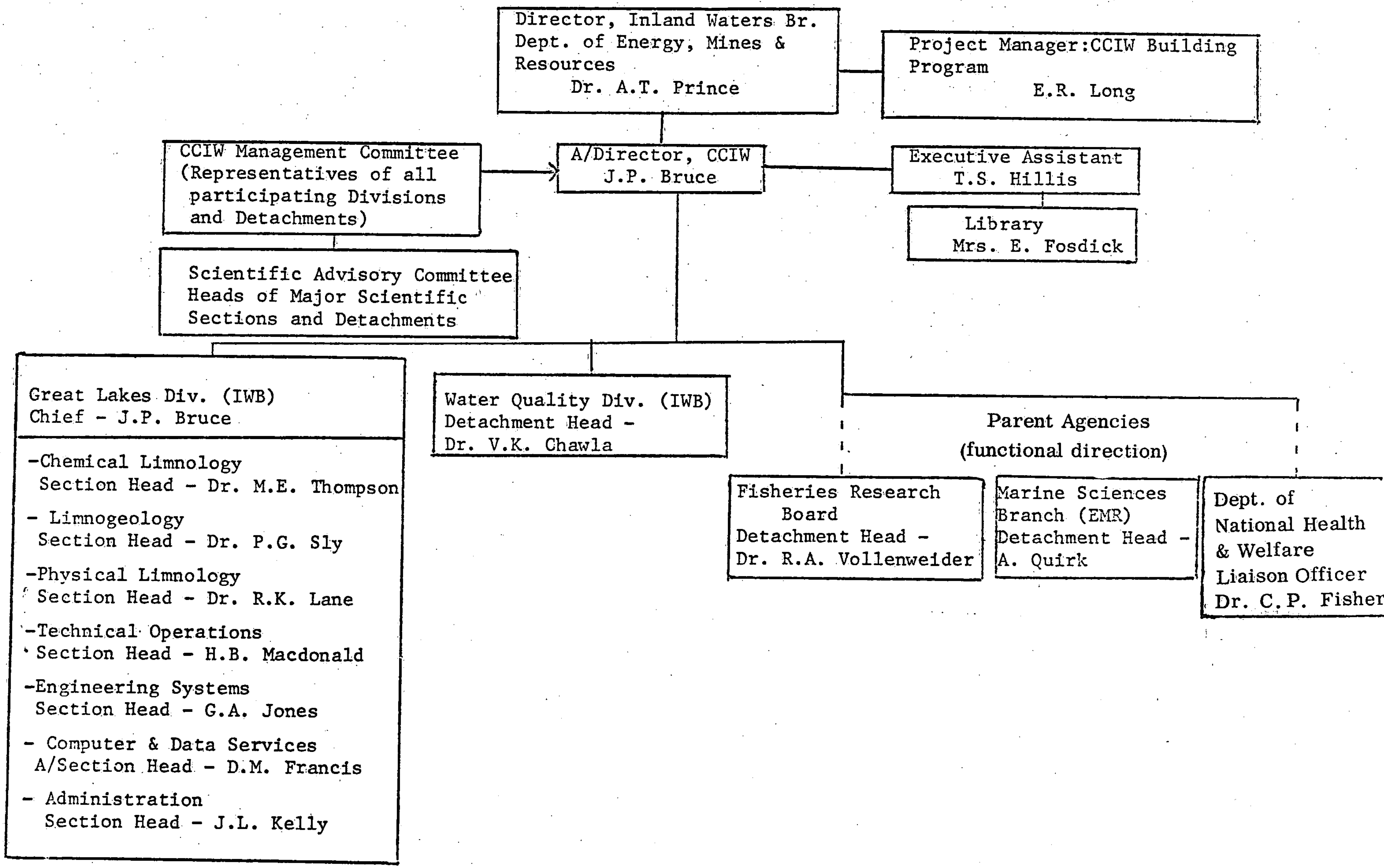
D.A. Cooney
Mrs. J.M.V. Lemire
Miss M.R.J. Warren

WATER QUALITY DIVISION - INLAND WATERS BRANCH, DEM&R

Detachment Head - Dr. V.K. Chawla

Support - H. Alkema, W.D. Blythe, O. El Kei, S. Meszaros, F. Philbert, Y.M. Sheikh.

CCIW ORGANIZATION (AS OF JAN. 1969)



GREAT LAKES STUDIES

1968

C.S.S. LIMNOS

	SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
		1	2	3	4	5	6
	7	8	9	10	11	12	13
APRIL	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	29	30	1	2	3 ARR. CCIW 2000 HRS.	4 CCIW
	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW	11 CCIW
	12 CCIW	13 DEPART CCIW 0830 HRS.	14 GEOLOGY L. ONTARIO	15 ARR. CCIW 1400 HRS.	16 CCIW	17 CCIW	18 CCIW
MAY	19 CCIW	20 CCIW	21 DEPART CCIW 2000 HRS.	22 GEOLOGY L. ONTARIO	23 GEOLOGY L. ONTARIO	24 GEOLOGY L. ONTARIO	25 GEOLOGY L. ONTARIO
	26 GEOLOGY L. ONTARIO	27 GEOLOGY L. ONTARIO	28 GEOLOGY L. ONTARIO	29 ARR. CCIW 1800 HRS.	30 CCIW	31 OPEN HOUSE CCIW	1 OPEN HOUSE CCIW
	2 CCIW	3 DEPART CCIW 1600 HRS.	4 GRAVITY L. ONTARIO	5 GRAVITY L. ONTARIO	6 ARR. CCIW 0800 HRS.	7 CCIW	8 CCIW
JUNE	9 CCIW	10 DEPART 1000 GRAVITY L. ONTARIO	11 ARR. CCIW 1500 HRS.	12 CCIW	13 DEP. CCIW 0830 GRAVITY L. ONTARIO	14 ARR. CCIW 1300 HRS.	15 CCIW
	16 CCIW	17 DEP. CCIW 2200 GRAVITY L. ONTARIO	18 GRAVITY L. ONTARIO	19 GRAVITY L. ONTARIO	20 IN TRANSIT GRAVITY L. ERIE	21 ARR. P. COLBORNE 1530 HRS.	22 P. COLBORNE
	23 P. COLBORNE	24 DEP. P. COLBORNE 0900 GRAVITY L. ERIE	25 GRAVITY LAKE ERIE	26 ARR. P. COLBORNE 1030 HRS.	27 P. COLBORNE	28 P. COLBORNE	29 P. COLBORNE
	30 P. COLBORNE	1 P. COLBORNE	2 P. COLBORNE	3 P. COLBORNE	4 DEP. P. COLBORNE 0800 GRAVITY L. ERIE	5 GRAVITY LAKE ERIE	6 GRAVITY LAKE ERIE
	7 ARR. P. COLBORNE 0930 HRS.	8 P. COLBORNE	9 P. COLBORNE	10 P. COLBORNE	11 P. COLBORNE	12 P. COLBORNE	13 DEP. P. COLBORNE 0800 HRS. RETURN 1200 HRS.
JULY	14 DEP. P. COLBORNE 1300 HRS.	15 MOORING LAKE ERIE	16 MOORING LAKE ERIE	17 MOORING LAKE ERIE	18 ARR. P. COLBORNE 1700 HRS.	19 DEP. P. COLBORNE 0530 HRS. ARR. CCIW 2100	20 CCIW
	21 CCIW	22 CCIW	23 DEP. CCIW 0800 MONITOR L. ONTARIO	24 MONITOR LAKE ONTARIO	25 MONITOR LAKE ONTARIO	26 MONITOR LAKE ONTARIO	27 ARR. CCIW 0800 HRS.
	28 CCIW	29 CCIW	30 CCIW	31 CCIW	1 CCIW	2 CCIW	3 CCIW
	4 CCIW	5 CCIW	6 DEP. CCIW 1000 CORING L. ONTARIO	7 ARR. CCIW 0845 HRS.	8 CCIW TRIALS	9 DEP. CCIW 1900 CORING - L. ONT.	10 CORING L. ONTARIO
AUGUST	11 CORING LAKE ONTARIO	12 CORING LAKE ONTARIO	13 CORING LAKE ONTARIO	14 CORING LAKE ONTARIO	15 ARR. CCIW 1600 HRS.	16 CCIW	17 CCIW
	18 CCIW	19 DEP. CCIW 1000 HRS.	20 MONITOR LAKE ONTARIO	21 MONITOR LAKE ONTARIO	22 MONITOR LAKE ONTARIO	23 ARR. CCIW 1400 HRS.	24 CCIW
	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW	31 CCIW
	1 CCIW	2 CCIW	3 DEP. CCIW 1600 HRS.	4 MOORING LAKE ONTARIO	5 MOORING LAKE ONTARIO	6 ARR. CCIW 2030 HRS.	7 CCIW
	8 DEP. CCIW 1530 HRS.	9 MONITOR LAKE ONTARIO	10 MONITOR LAKE ONTARIO	11 MONITOR LAKE ONTARIO	12 MONITOR LAKE ONTARIO	13 ARR. CCIW 0800 HRS.	14 CCIW
SEPT.	15 CCIW	16 DEP. CCIW 1100 HRS.	17 CORING LAKE ONTARIO	18 CORING LAKE ONTARIO	19 CORING LAKE ONTARIO	20 CORING LAKE ONTARIO	21 ARR. CCIW 1700 HRS.
	22 DEP. CCIW 0830 RETURN 1530	23 CCIW	24 CCIW	25 DEP. CCIW 1530 RETURN 1630	26 CCIW	27 DEP. CCIW 1000 RETURN 1130	28 CCIW
	29 CCIW	30 CCIW	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW
	6 DEP. CCIW 0830 HRS.	7 GRAVITY LAKE ONTARIO	8 GRAVITY LAKE ONTARIO	9 ARR. CCIW 0830 HRS.	10 CCIW	11 NO FURTHER OPERATIONS	12
OCT.	13 CCIW	14 CCIW	15 DEP. CCIW 1020 ARR. D. DOCK 1825	16 PORT WELLER	17	18	19
	20	21	22	23	24	25	26
	27	28	29	30	31	1	2
	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
NOV.	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
DEC.	1	2	3	4	5	6	7

GREAT LAKES STUDIES

1968

M.V. THERON

	SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
		1 ON CHARTER 0800 HRS.	2 HALIFAX FITTING OUT	3 HALIFAX FITTING OUT	4 HALIFAX FITTING OUT	5 HALIFAX FITTING OUT	6 HALIFAX FITTING OUT
	7 HALIFAX FITTING OUT	8 HALIFAX FITTING OUT	9 HALIFAX FITTING OUT	10 HALIFAX FITTING OUT	11 HALIFAX FITTING OUT	12 HALIFAX	13 HALIFAX
APRIL	14 HALIFAX	15 HALIFAX FITTING OUT	16 DEP. 1530 FOR CCIW	17 ON PASSAGE	18 ON PASSAGE	19 ON PASSAGE	20 ON PASSAGE
	21 ARR. CCIW 1415 HRS.	22 CCIW FITTING OUT	23 CCIW FITTING OUT	24 CCIW FITTING OUT	25 CCIW FITTING OUT	26 RETR. W. MOORING LAKE ONTARIO	27 CCIW
	28 CCIW	29 DEP. CCIW 1100 HRS.	30 MONITOR LAKE ONTARIO	1 MONITOR LAKE ONTARIO	2 MONITOR LAKE ONTARIO	3 ARR. CCIW 1415 HRS.	4 CCIW
	5 CCIW	6 DEP. CCIW 1030 HRS.	7 MOORING LAKE ONTARIO	8 MOORING LAKE ONTARIO	9 MOORING LAKE ONTARIO	10 ARR. CCIW 0800 HRS.	11 CCIW
MAY	12 DEP. CCIW 1800 IN CANAL TRANSIT	13 MOORING LAKE ERIE	14 MOORING LAKE ERIE	15 MOORING LAKE ERIE	16 MOORING LAKE ERIE	17 P. COLBORNE ARR. 0745 - DEP. 1155	18 MONITOR LAKE ERIE
	19 MONITOR LAKE ERIE	20 MONITOR LAKE ERIE	21 MONITOR LAKE ERIE	22 MONITOR LAKE ERIE	23 ARR. P. COLBORNE 1800 HRS. IN CANAL TRANSIT	24 ARR. CCIW 0930 HRS.	25 CCIW
	26 CCIW	27 DEP. CCIW 1030 HRS.	28 MONITOR LAKE ONTARIO	29 MONITOR LAKE ONTARIO	30 ARR. CCIW 1900 HRS.	31 CCIW OPEN HOUSE	1 CCIW OPEN HOUSE
	2 CCIW	3 DEP. CCIW 1200 HRS.	4 MOORING LAKE ONTARIO	5 MOORING LAKE ONTARIO	6 MOORING LAKE ONTARIO	7 MOORING LAKE ONTARIO	8 ARR. CCIW 1430 HRS.
JUNE	9 DEP. CCIW 1400 IN CANAL TRANSIT	10 MOORING LAKE ERIE	11 MOORING LAKE ERIE	12 MOORING LAKE ERIE	13 MOORING LAKE ERIE	14 ARR. P. COLBORNE 1215 HRS.	15 DEP. P. COLBORNE 1215 HRS.
	16 MONITOR LAKE ERIE	17 MONITOR LAKE ERIE	18 MONITOR LAKE ERIE	19 MONITOR-L. ERIE IN CANAL TRANSIT	20 ARR. CCIW 0815 HRS.	21 CCIW	22 CCIW
	23 CCIW	24 DEP. 1000 HRS. SPECIAL - L. ONT.	25 ARR. CCIW 1500 HRS.	26 DEP. 0700 HRS. SPECIAL - L. ONT.	27 SPECIAL L. ONTARIO	28 ARR. CCIW 1340 HRS.	29 CCIW
	30 CCIW	1 CCIW	2 DEP. CCIW 1000 HRS.	3 MONITOR LAKE ONTARIO	4 MONITOR LAKE ONTARIO	5 MONITOR LAKE ONTARIO	6 ARR. CCIW 1200 HRS.
	7 CCIW	8 DEP. CCIW 1000 SPECIAL - L. ONT.	9 SPECIAL L. ONTARIO	10 SPECIAL L. ONTARIO	11 SPECIAL L. ONTARIO	12 ARR. CCIW 1000 HRS.	13 CCIW
JULY	14 CCIW	15 DEP. CCIW 1000 HRS.	16 MOORING LAKE ONTARIO	17 MOORING LAKE ONTARIO	18 MOORING LAKE ONTARIO	19 MOORING LAKE ONTARIO	20 ARR. CCIW 0800 HRS.
	21 DEP. CCIW 1300 IN CANAL TRANSIT	22 CORING LAKE ERIE	23 CORING LAKE ERIE	24 CORING LAKE ERIE	25 CORING LAKE ERIE	26 CORING LAKE ERIE	27 ARR. P. COLBORNE 1030 HRS.
	28 P. COLBORNE	29 DEP. P. COLBORNE 1200 HRS.	30 MONITOR LAKE ERIE	31 MONITOR LAKE ERIE	1 MONITOR LAKE ERIE	2 MONITOR LAKE ERIE	3 ARR. WINDSOR 1015 HRS.
	4 WINDSOR	5 DEPART WINDSOR 1100 HRS.	6 MONITOR LAKE HURON	7 MONITOR LAKE HURON	8 MONITOR LAKE HURON	9 MONITOR LAKE HURON	10 MONITOR LAKE HURON
AUGUST	11 MONITOR LAKE HURON	12 MONITOR LAKE HURON	13 ARR. SAULT ST. MARIE 1400 HRS.	14 SAULT ST. MARIE	15 SAULT ST. MARIE	16 SAULT ST. MARIE	17 SAULT ST. MARIE
	18 DEP. 0815 HRS.	19 MONITOR LAKE SUPERIOR	20 MONITOR LAKE SUPERIOR	21 MONITOR LAKE SUPERIOR	22 MONITOR LAKE SUPERIOR	23 MONITOR LAKE SUPERIOR	24 MONITOR LAKE SUPERIOR
	25 MONITOR LAKE SUPERIOR	26 MONITOR LAKE SUPERIOR	27 MONITOR LAKE SUPERIOR	28 SAULT ST. MARIE ARR. 2130 - DEP. 2145	29 ARR. SARNIA 1945 HRS.	30 DEP. SARNIA 0315 ARR. WINDSOR 0840	31 DEP. WINDSOR 1000 HRS.
	1 MONITOR LAKE ERIE	2 MONITOR LAKE ERIE	3 ARR. CCIW 1245 HRS.	4 CCIW	5 CCIW	6 CCIW	7 CCIW
	8 CCIW	9 DEP. CCIW 1030 HRS.	10 CORING LAKE ONTARIO	11 ARR. CCIW 0730 DEP. 1530 HRS.	12 CORING LAKE ONTARIO	13 ARR. CCIW 1500 HRS.	14 CCIW
SEPT.	15 DEP. CCIW 1600 IN CANAL TRANSIT	16 MOORING LAKE ERIE	17 MOORING LAKE ERIE	18 CLEVELAND ARR. 0845 - DEP. 1300	19 MOORING LAKE ERIE	20 ARR. P. COLBORNE 1530 HRS.	21 P. COLBORNE
	22 P. COLBORNE	23 DEP. P. COLBORNE 1100 HRS.	24 MOORING LAKE ERIE	25 MOORING LAKE ERIE	26 ARR. P. COLBORNE 1930 HRS.	27 P. COLBORNE	28 DEP. P. COLBORNE 1200 HRS.
	29 MONITOR LAKE ERIE	30 MONITOR LAKE ERIE	1 MONITOR LAKE ERIE	2 MONITOR LAKE ERIE	3 MONITOR LAKE ERIE	4 ARR. CCIW 0830 HRS.	5 DEP. CCIW 0800 HRS.
	6 MONITOR LAKE ONTARIO	7 MONITOR LAKE ONTARIO	8 MONITOR LAKE ONTARIO	9 ARR. CCIW 0830 HRS.	10 CCIW	11 CCIW	12 CCIW
OCT.	13 CCIW	14 CCIW	15 DEP. CCIW 1030 HRS.	16 MOORING LAKE ONTARIO	17 MOORING LAKE ONTARIO	18 MOORING LAKE ONTARIO	19 ARR. CCIW 2115 HRS.
	20 CCIW	21 CCIW	22 DEP. 0715 HRS. MOORINGS L. ONT.	23 ARR. CCIW 1200 HRS.	24 DEP. 0600 HRS. MOORINGS L. ONT.	25 ARR. CCIW 0930 HRS.	26 CCIW
	27 DEP. CCIW 1030 HRS.	28 MONITOR LAKE ONTARIO	29 MONITOR LAKE ONTARIO	30 MONITOR LAKE ONTARIO	31 ARR. CCIW 1730 HRS.	1 CCIW	2 CCIW
	3 CCIW	4 DEP. CCIW 1000 IN CANAL TRANSIT	5 MONITOR LAKE ERIE	6 MONITOR LAKE ERIE	7 MONITOR LAKE ERIE	8 MONITOR LAKE ERIE	9 MONITOR LAKE ERIE
NOV.	10 ARR. P. COLBORNE 1930 HRS.	11 DEP. P. COLBORNE 1015 HRS.	12 MOORING LAKE ERIE	13 MOORING LAKE ERIE	14 ARR. CCIW 1740 HRS.	15 CCIW	16 CCIW
	17 DEP. CCIW 1430 HRS.	18 MONITOR LAKE ONTARIO	19 MONITOR LAKE ONTARIO	20 MONITOR LAKE ONTARIO	21 MONITOR LAKE ONTARIO	22 ARR. CCIW 0730 HRS.	23 DEP. CCIW 0800 HRS.
	24 MOORING LAKE ONTARIO	25 ARR. CCIW 1730 HRS.	26 DEP. 1000 HRS. ARR. CCIW 1110 (RETR. TOWER)	27 DISMANTLE	28 DISMANTLE	29 DEPART CCIW FOR HALIFAX AT 1600 HRS.	30 ON PASSAGE TO HALIFAX
DEC.	1 ON PASSAGE TO HALIFAX	2 ON PASSAGE TO HALIFAX	3 ON PASSAGE TO HALIFAX	4 ARR. HALIFAX 0820 HRS.	5 OFF CHARTER 1700 HRS.	6	7

Date Due
