CANADA CENTRE FOR INLAND WATERS

[AN]NUAL REPORT 1969

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Department of Energy, Mines and Resources

Fisheries Research Board

Department of National Health and Welfare

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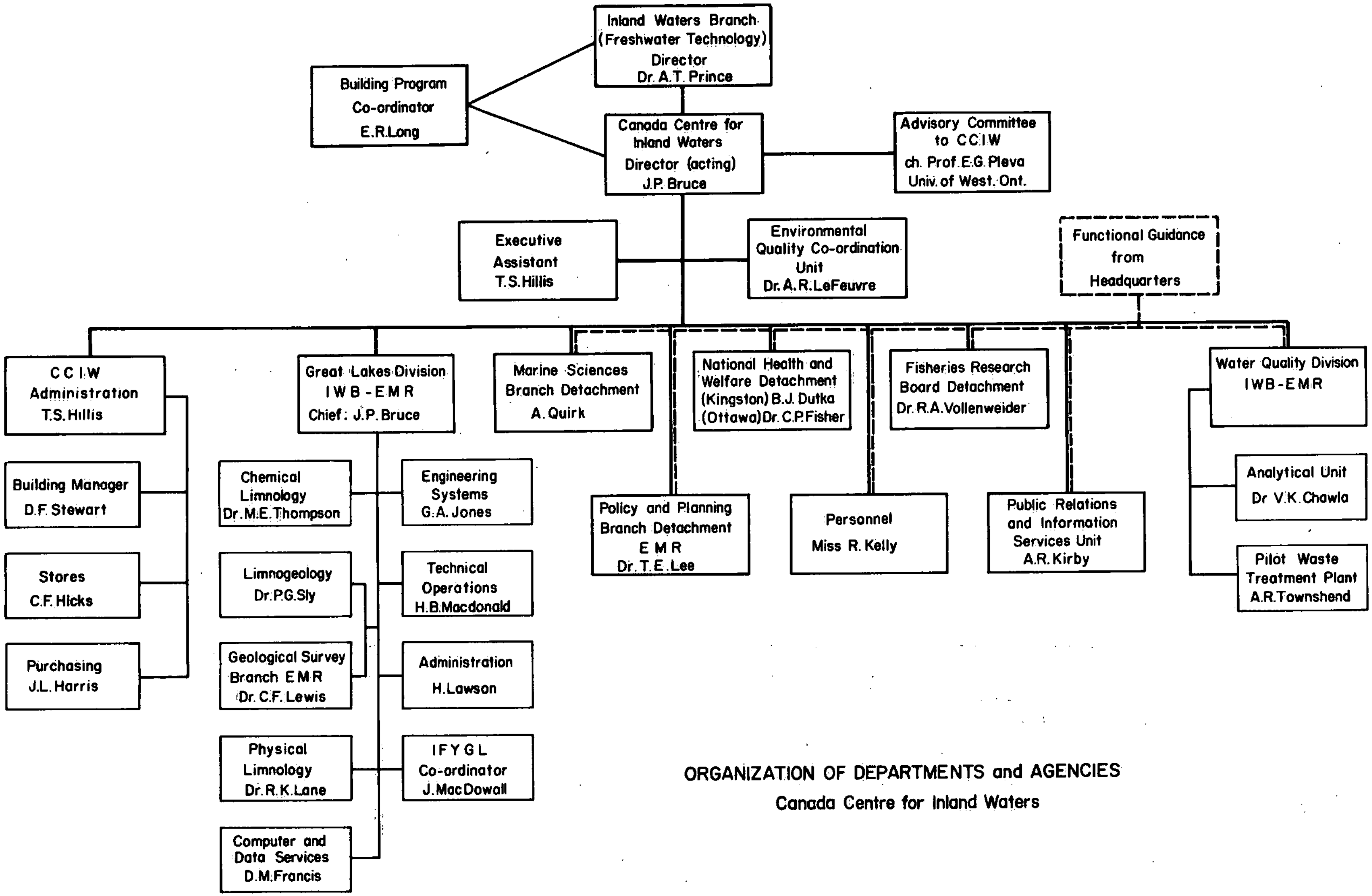
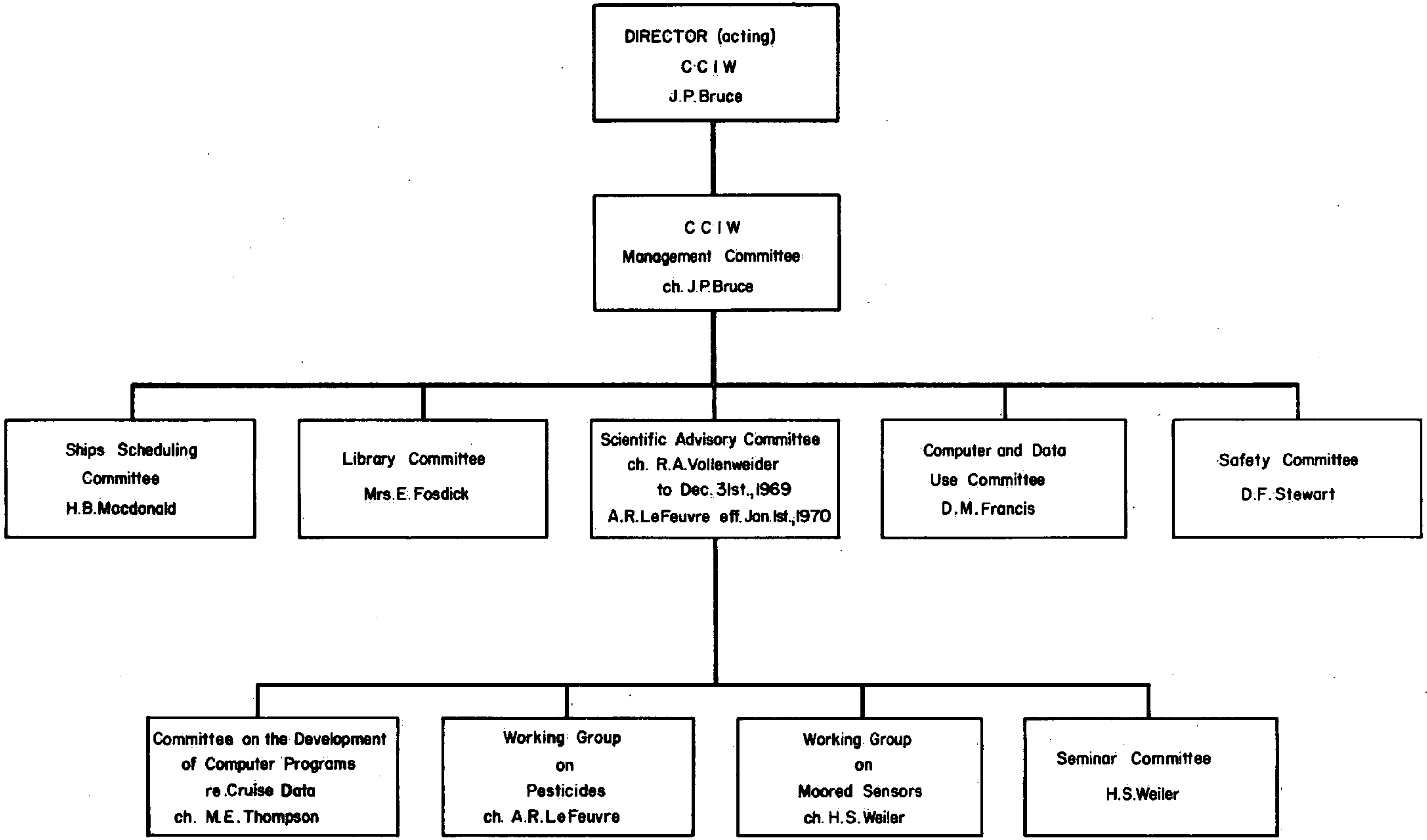


ORGANIZATION OF DEPARTMENTS and AGENCIES
Canada Centre for Inland Waters



INTERNAL COMMITTEE STRUCTURE

Canada Centre for Inland Waters

Dec. 31st., 1969

HIGHLIGHTS 1969

A number of important developments occurred at the Canada Centre for Inland Waters in 1969, the second full year of operation. The reports of the various Sections and Detachments on the following pages outline the more important of these and 10 deserve special mention.

1. Report to the IJC – Volume I (Summary) of *Report to the International Joint Commission on the Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River* was published and released in October.

Much of the Canadian survey work for this report was carried out by the staff of the agencies associated with CCIW, who collaborated with their colleagues of the Ontario Water Resources Commission, other federal agencies and United States representatives.

The following staff members prepared sections of Volumes I, II and III: H.H. Dobson, P.F. Hamblin, Dr. R.K. Lane, Dr. C.F.M. Lewis, M.T. Shiomi, A.J. Stanley-Jones, Dr. H.S. Weiler, Dr. R.R. Weiler.

Dr. A.R. LeFeuvre edited Volume III on Lake Ontario with assistance from H.H. Dobson, Dr. V.K. Chawla and Dr. A. Lerman, under the general direction of the IJC Editorial Committee. Major contributions to the scientific basis of the recommendations concerning nutrient control were made by Dr. R.A. Vollenweider. J.P. Bruce served on the Editorial Committee.

The report contains 19 recommendations for control of pollution on the lakes based on present knowledge, but identifies a number of problems for which fully satisfactory scientific answers were not available. Research programs are under way or are being developed at CCIW to fill many of the identified gaps in our knowledge.

2. Federal Contingency Plan for Oil Spills – At year's end the federal government's contingency plan for dealing with major spills of oil and toxic material in all waters of federal jurisdiction was submitted to the Interdepartmental Committee on Water for approval. It makes provision for cooperative federal department response for containment and clean-up of spills in Arctic and coastal waters and will form the basis for negotiations with the provinces in connection with waters of joint jurisdiction, such as the Great Lakes. Initial plans for oil spill clean-up research were developed to help fulfill the Centre's obligations under the federal contingency plan. J.P. Bruce served as chairman of the Interdepartmental Working Group which developed the plan. Dr. LeFeuvre was appointed interim convener of the Technical Working Group, one of the two working groups established for implementation of the Plan. F.M. Boyce of the CCIW prepared the technical section on oil spill containment and clean-up methods for the report to the IJC, *Potential Oil Pollution Incidents from Oil and Gas Well Activities in Lake Erie, their Prevention and Control.*

3. Socio-economic Unit – A socio-economic research unit was established in November by Policy and Planning Branch of Energy, Mines and Resources. Research programs in economics, sociology and geography complementary to existing natural sciences programs are being developed under the direction of Dr. Terry Lee by the four staff members of the Unit.

4. Public Information – A Public Relations and Information Services Unit was established by A.R. Kirby. In addition to organizing the Centre's response to requests for speakers, radio, TV and press interviews, articles, and visits to the Centre, the Unit developed an initial plan for a longer-range information program.

5. Environment Quality Coordination Unit – The Environmental Quality Coordination Unit was established in June with the appointment of the unit head Dr. A.R. LeFeuvre. This Unit is responsible for coordinating the results of research from the various disciplinary groups of the Centre and for converting these results into reports directed to pollution abatement programs and policies. The Unit has concentrated on completion of the Centre's share of the IJC pollution reference report on the organization of the federal contingency plan and on development of an interdepartmental program of pesticide research.

6. Construction – Construction of the first of the permanent buildings of the Centre began in October. Occupancy of the first-phase buildings, the workshop-warehouse, research and development building and central heating plant is scheduled for summer, 1970. A decision was made to advance the construction schedule for the water quality pilot plant for testing promising new industrial and municipal waste treatment methods. It will now be built during 1970. Mr. A. Townshend joined the staff of the Water Quality Division to coordinate scientific plans for this development.

7. Scientific Papers – Scientific staff members produced many significant papers during the year. At the annual Great Lakes Conference of the International Association for Great Lakes Research in Ann Arbor, Mich., the 17 papers presented by CCIW staff were the largest number from any one research centre in North America. A total of 47 papers were published by staff members during the year (Appendix C).

8. Advisory Committee to CCIW – The Advisory Committee to the Canada Centre (ACCC) chaired by Prof. E.G. Pleva of University of Western Ontario, contains seven university members, six members from the private sector, and six representatives of the federal and provincial governments. At the request of its parent committee, the National Advisory Committee on Water Resources Research, the ACCC developed initial guidelines for a new program of non-university research contracts and grants and made recommendations concerning the first contracts. Once familiar with the Centre's program, this committee will advise CCIW management on research priorities and programs, including the most effective allocation of space and facilities at the Centre for the university community (Appendix D).

9. Contracted Research Programs – In addition to its intramural programs, the Centre contracted 11 research programs to universities or private consultants. These ranged in price from $13,000 to $36,000 and in scope from studies of reasons for die-off of alewives to a survey of waste heat inputs to the Great Lakes projected to the year 2000.

10. Canadian Coordinator – As a contribution to the International Field Year for the Great Lakes, the office of Canadian Coordinator was established in the Great Lakes Division at the Centre. Mr. J. MacDowall took up his duties in this capacity in February.

Some of the activities planned for CCIW during 1970 are:

The central region of the Canadian Hydrographic Service, Marine Sciences Branch, will move to the Centre from Ottawa to carry out its function of charting waterways from Father Point to the Alberta border.

Interdisciplinary, inter-agency task forces will be established to carry out well coordinated studies of lake eutrophication (chairman – planning committee, Dr. R.A. Vollenweider) and of oil spill detection, containment and clean-up (chairman – planning committee, Dr. LeFeuvre).

The first of the permanent buildings will be occupied.

The main laboratory building and the pilot sewage treatment plant will be started. The former is scheduled for completion in 1972 and the latter in early 1971.

Although some work has been done by Centre staff on Lake Winnipeg, the Kenora region lakes and Lake Diefenbaker, the first major project involving Great Lakes Division outside of the Laurentian Great Lakes Basin will be started on Lake Okanagan under a joint Canada-British Columbia agreement.

After the passage of the Canada Water Act, more participation of the Centre's staff is expected in federal-provincial projects across Canada.

ENVIRONMENTAL QUALITY COORDINATION UNIT (EQCU)

The EQCU coordinates the results of research produced by the various disciplinary groups of the CCIW and prepares reports recommending policies on water quality and methods of controlling pollution. The Coordinator advises the Director of the Centre on pollution research and on development of programs in this field. He assists in providing liaison with provincial and federal pollution abatement agencies and with their counterparts in the United States.

The efforts of the EQCU since its formation in June have been directed to three major topics: the development of a national contingency plan for combatting spills of oil or other hazardous materials, establishment of a cooperative pesticide research program in the Great Lakes, and the editing of Volume III (Lake Ontario) of *Report to the International Joint Commission on the Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River.*

The ever-increasing threat of a major spill of oil or other hazardous materials into Canadian waters has prompted the federal government to develop a contingency plan for such an eventuality. This plan is now undergoing formal approval. It was developed in many stages. The many departmental interests were included through the coordinating machinery of the Interim Interdepartmental Committee on Water. The EQCU was responsible for coordinating the preparation of the several drafts of this plan.

Public awareness of the dangers of certain pesticides to the environment and possibly to man himself, particularly the chlorinated hydrocarbons, led to considerable government action. In response to this awareness and also to effect some coordination in the Great Lakes region between various federal departments already active in this research area, a cooperative research program on pesticides in the Great Lakes is being developed. This will involve several federal agencies (National Research Council, Dept. of Agriculture, Canadian Wildlife Service), in addition to those participating in the Centre's regular program. The EQCU has been chairing the working group of the Scientific Advisory Committee charged with development of this program. The program will get under way in 1970.

The reference to the International Joint Commission on pollution of Lake Ontario, Lake Erie and the international section of the St. Lawrence River resulted in the preparation of a comprehensive report. This three-year effort by the federal governments of the United States and Canada and the states and provinces bordering the lakes, is presented in three volumes. Volume I, which is the summary and recommendations of the report, was released to the public in the fall of 1969.

Volumes II and III are the detailed technical reports upon which the summary and conclusions were based. Volume II is on Lake Erie and Volume III is on Lake Ontario and the international section of the St. Lawrence River. The EQCU edited Volume III of this report, under general guidance of the Pollution Reference Board Editorial Committee, in preparation for its printing and release early in 1970. This task, now substantially complete, was a major undertaking of the Coordinator and his staff.

FISHERIES RESEARCH BOARD DETACHMENT (FRB)

During 1969 the Fisheries Research Board participated in 13 cruises of the *MV Martin Karlsen*, six of the *CSS Limnos*, five of the *CCGS Porte Dauphine*, and one hovercraft operation. (Ontario – 15, Erie – 5, Georgian Bay – 2, Huron – 1, Superior – 2); 709 zooplankton and 748 phytoplankton samples were collected. (Ontario – 433 and 437, Erie – 141 and 176, Georgian Bay – 29 and 29, Huron – 51 and 51, Superior – 55 and 55).

On all cruises, chlorophyll distribution was recorded by continuous fluorometer techniques (Turner Model No. 111), as in previous years. A large fraction of the data collected has already been prepared in the form of charts showing spatial distributions. The preliminary results confirm the existence of the strong horizontal and seasonal variations observed in previous years. In addition, it is noted that, generally, the chlorophyll concentrations in Lake Ontario and Lake Erie decrease from west to east, although this is not always the case. The average chlorophyll values of Lake Erie are 2 to 3 times higher than those found in Lake Ontario.

Preliminary studies in a lake-wide monitoring program, to continue in 1970 on primary and secondary production in the lower Great Lakes, has been initiated by new staff members. These studies include also an analysis of limiting nutritional conditions of photo-synthesis in these lakes (bioassays using ^{14}C), and studies of the natural phytoplankton communities. Concurrent studies of nutrient concentrations (nitrogen, phosphorus, trace elements) have been initiated by Water Quality Division and the Chemical Limnology Section.

Although this work is in its first phase only, a number of interesting results have already been obtained. Dr. J. Vallentyne's finding that phosphorus is a strong controlling factor in plankton production in Lake Ontario and Lake Erie appears to be confirmed, but the studies have shown that, at times, micro-elements, in particular manganese, play a limiting role.

Microscopic analyses of phytoplankton from Lake Ontario have shown that in earlier studies nanoplankton, particularly flagellates, have been neglected. Among the new records, *Cryptomonas erosa, Rhodomonas minuta, Carteria cordiformis, Carteria klebsii, Chlamydomonas mucicola, Katablepharis ovalis,* and further, *Scenedesmus bijuga, Oscillatoria limnetica* have been found in larger amounts in the western part of the lake.

Much time has been devoted to improving sampling and analysis techniques. A new device to separate zooplankton from filamentous algae has been developed by a member of the FRB staff, in which advantage is taken of the behaviour pattern (geo- and phototaxis) of zooplankton. The sensitivity of a Furuno Echo-sounder to locate zooplankton and turbidity layers in situ has been tested, and studies on the use of Coulter Counter techniques have been continued. In cooperation with the Engineering Section, an integrating water sampler and a thermo-photostat for primary production measurements onboard ship have been developed.

The FRB Eutrophication Section, Freshwater Institute, Winnipeg, has contributed to Great Lakes studies in a number of ways.

Dr. J. Vallentyne completed a study on the effects of treated and untreated sewage on algal growth using natural water from Lakes Ontario and Erie. Untreated, or treated sewage, which contain high proportions of phosphorus (phosphorus not eliminated, or with phosphorus-reconstituted treated sewage), definitely stimulates algal growth in both lakes in comparison to sewage of low phosphorus concentration (phosphorus eliminated by lime precipitation).

Dr. K. Patalas has studied the material collected during 1968 in Lakes Ontario, Erie, Huron and Superior, investigating species composition, horizontal distribution and amounts of the crustacean plankton in all lakes. Noteworthy correlations between heat content, nutrient load and seasonal cycles of single species, as well as total amount of crustacean plankton under a unit of surface, have been found.

Dr. J. Stockner is analyzing the diatom residuals in two cores from Lake Erie (one from the eastern, the other from the western end) in order to assess changes in the state of eutrophication of this lake during past history.

Mr. W. Warwick, Limnogeology Section, who is on education leave at the University of Winnipeg continues his studies in collaboration with Dr. A. Hamilton, FRB, on bottom fauna of the Great Lakes.

GREAT LAKES DIVISION

Chemical Limnology Section

During the past year, a considerable part of the Section's effort was diverted from purely laboratory studies to field studies, notably in cooperation with Physical Limnology's Project MELON, in western Lake Ontario. Members of the Section also participated in the Lake Erie Time Series study organized by Dr. J.R. Kramer of McMaster University, and the success of that effort has led to the planning of two similar fixed-station studies for 1970.

During 1969 an in-house course in low temperature aqueous geochemistry was begun for and by the staff of the Section; it was also attended by several members of the Limnogeology Section and one from Engineering Systems.

Two postdoctoral research fellows came to the Section during 1969. Dr. M. Munawar, whose interests are biological and chemical, was assigned to the Fisheries Research Board detachment to do research initially under Dr. Vollenweider's guidance. Dr. C.W. Childs, who is interested in the physical chemistry of aqueous solutions, will work closely with Dr. R.F. Platford.

Chemical Monitor Cruises – The Chemical Limnology Section is responsible for the planning and evaluation of the results of the chemical monitor cruises on the Great Lakes. The samples are collected by personnel of the Operations Section, Great Lakes Division, and analyzed by Water Quality Division. Several concurrent research projects of other sections or agencies at the CCIW make use of the cruises or the data from the cruises. During 1969 a contract was arranged with Prof. J.R. Kramer of McMaster University to develop computer programs to facilitate retrieval and analysis of the chemical and related biological and bacteriological data.

Lake Ontario was subjected to intensive monitoring during 1969, cruises being scheduled every four weeks during the year (April 1969 to March 1970), while only one or two cruises were carried out on the other lakes.

Papers were published on trace element distribution in Lake Erie and on water quality in the Great Lakes in collaboration with Water Quality Division staff, based on 1968 field data. Analyses of the 1969 cruise results are under way and will form the basis of cooperative papers with Water Quality Division and Fisheries Research Board on trace elements and chlorophyll *a*, and on nutrients in Lake Ontario.

Lake Erie Time Series – During July 1969, personnel of the Section participated in a time series study in the western basin of Lake Erie. A number of chemical, biological, meteorological and physical parameters were monitored nearly continuously for several weeks, during both calm and stormy weather. The CCIW provided the barge, built a small laboratory hut that was installed on the barge, and provided much of the analytical equipment. Reports on the projects are being prepared for the 1970 Conference on Great Lakes Research in Buffalo. As noted, this project was coordinated by Prof. Kramer of McMaster University. Other participating agencies were the U.S. Bureau of Commercial Fisheries and the Federal Water Pollution Control Administration.

Precipitation Chemistry – During 1969, rain samplers were installed at several stations on the Canadian shore of Lake Ontario: Trenton, Kingston, Toronto Island, Toronto-Woodbridge, Ancaster, and at CCIW, Burlington. The samplers were constructed according to the design of Gambell and Fisher, 1966. (A.W. Gambell and D.W. Fisher, 1966, *Chemical Composition of Rainfall, Eastern North Carolina and Southeastern Virginia:* U.S. Geological Survey Water-Supply Paper 1535 K, 41 p.)

The purpose of the project is to assess the contributions to the chemical budgets of the lakes from atmospheric sources. During 1970, dust collectors will be mounted on *CSS Limnos* and the *MV Martin Karlsen.*

Soluble Organic Compounds in Large Lakes – During 1969 a Micro Tek 220 research gas chromatograph, with dual flame ionization detectors was acquired. This instrument is being used to effect separation of the dissolved organic material, extracted from lake water, into individual compounds. The instrument capability will be enhanced by the addition of flame photometric and thermal conductivity detectors in 1970. These detectors will allow the specific detection of phosphorus- and sulphur-containing organics and the collection of individual components for further analysis.

A Perkin Elmer 457 infrared spectrophotometer was also acquired in 1969 and is used in conjunction with the gas chromatograph for the identification of separated organic compounds.

Surface Area Measurements of Sediments – Adsorption of organic matter of the ions of various elements plays an important role in the lacustrine environment. For example, the concentration of various trace elements can be controlled by adsorption (Krauskopf, Geochim. Cosmochim. Acta 9, 1 [1956]). Also, these adsorbed ions may be transported by sediment movements and released in a different environment (Carritt and Goodal, Deep Sea Res. 1, 224 [1954]). Organic matter adsorbed by sediments, especially argillaceous deposits, may become unavailable for metabolic purposes (Oppenheimer, Geochim. Cosmochim. Acta 19, 244 [1960]).

The amount adsorbed is determined by the surface area available, which depends on the way the total area is distributed between the geometric or external areas of particles and the internal area represented by various sized pores, since some molecules may be too large to enter smaller pores. Hence, both the total and the external areas are important parameters to be measured.

A steady-state flow permeameter was constructed based on the designs of Orr (Anal. Chem. 39, 834 [1967]) and a transient flow unit based on the designs of Kraus and Ross (J. Phys. Chem. 57, 334 [1953]). From steady-state flow, two different types of areas can be calculated. The Poiseuille area represents the geometric or external area of a porous particle and does not include the internal area represented by the pores in the particle. The Knudsen area represents the internal area of a porous particle, excluding the area represented by "blind" pores. The area calculated from transient flow should be equivalent to the BET area measured by gas adsorption.

The equipment was tested using deep sea sediments examined previously (Weiler and Mills, Deep Sea Res., 12, 511 [1956]). The Knudsen areas ranged from 1 to 34 per cent of the BET areas indicating that some types of sediment have very many "blind" pores. The Poiseuille areas ranged from about 5 to 50 per cent of the Knudsen areas. They agreed reasonably (within a factor of 2) with the geometric areas calculated from particle size distributions. The areas obtained when nitrogen was used as the permeating gas agreed with those obtained when helium was used.

Transient flow measurements were done on a few selected samples, using both helium and nitrogen. The helium areas were slightly higher than the BET nitrogen areas, whereas the nitrogen areas were considerably lower. These results agree with those of Kraus and Ross. This method, although the equipment for it is quite simple, was judged to be too slow and cumbersome for routine measurement of surface area and a Perkin Elmer Sorptometer (Model 212-D) was purchased for this purpose.

Computer programs have been written for calculating Knudsen and Poiseuille areas from experimental data and for calculating pore size distributions from desorption isotherms.

Interstitial Water – During the summer of 1969 sediment cores were taken at four stations in western Lake Ontario, using a Benthos Model 2170 gravity corer. Each station was sampled six times at two- to four-week intervals. The core liners were capped and stored in ice chests for later processing on shore. The interstitial water was expressed from the sediment using an all plastic gas-pressured squeezer modified from the design of Reeburgh (W.S. Reeburgh, 1967, An improved interstitial water sampler, Limnol. and Oceanog. 12, 163). Both the interstitial water (during squeezing) and the water trapped in the corer immediately above the sediment were passed through 0.45 μ filters and were analyzed for major ions, iron, manganese, phosphate, nitrate, and silica. Eh and pH were measured by applying the electrodes directly to the mud. The most satisfactory Eh measurements were obtained by inserting a partly shielded gold wire into the centre of the mud core.

Samples from the top two inches of the sediments were sent to B.J. Dutka of Dept. of National Health and Welfare, Kingston for bacteriological studies.

There was little variation in the chemical properties of the sediments over the course of the summer. The pH of the interstitial water varies between 7.5 and 8.2, and the Eh in three of the cores ranges from −200 to −400 millivolts, but in the sandy core taken off Toronto the Eh is about +250 millivolts. In the low Eh samples the sulphate content of the interstitial water is near zero, presumably because it has been reduced to sulphide species; bicarbonate is increased by an amount equivalent to the lost sulphate.

A more complete discussion of the chemistry of the interstitial water will be presented at the 1970 Conference on Great Lakes Research in Buffalo.

Radioisotopes in Lake Sediments – This study is a preliminary assessment of the distribution of fallout radionuclides in the sediment for the purpose of determining rates of sedimentation diffusion through the sediment pore space.

Sediment cores were taken in deep parts of Lake Ontario and Lake Superior. Benthos corers were used, with butyrate core liners of $2^5/_8$ in. ID. In order to facilitate the separation of narrow layers of sediment, the core liners were pre-cut into centimetre-long sections, and sealed together again with teflon tape. The reconstituted core liners then contained about

170 subsections, but were strong enough to take satisfactory mud cores. The samples are being counted at the Radiation Protection Division, Dept. of National Health and Welfare, Ottawa, in Dr. H. Tanaguchi's laboratory.

Geochemistry of Brines – The primary problems of this study are modes of formation of various brines by such processes as evaporation and chemical reactions between sediments and ground waters. An early stage in the formation of the brines in which the predominant anion is chloride, are reactions between ground waters and limestone rocks, in the course of which the brine becomes relatively enriched in calcium and depleted in magnesium. When this process results in the calcium concentration becoming higher than the concentration of sulphate and carbonates in the brine, loss of water from the brine leads to precipitation of calcium carbonate and sulphate minerals. The residual brine becomes progressively richer in chloride until eventually sodium chloride (mineral halite) may begin to precipitate.

A computational model for this process is in good agreement (Lerman, 1969) with experimental data on the saturation of brines with respect to halite.

Methods are at present being developed for assessing the development of sulphate-rich lake brines and prediction of the precipitation of sodium sulphate minerals.

Trace Element Studies – A Jarrell-Ash atomic absorption spectrophotometer unit (Model 820-528) arrived in February. The instrument is equipped with two gratings covering the wavelength 1,850-9,000A° and an eight-speed electrical wavelength scanning device.

Microanalytical methods for determination of molybdenum and vanadium in lake water have been developed (Chau and Lum-Shue-Chan, 1969, 1970) and studies of these elements in the lakes are in progress. Recently, a sensitive method for mercury detection was developed, based on atomic absorption of the mercury vapor. Mercury in water is concentrated by dithizone extraction. Sensitivity for water is 0.008 $\mu g/1$ (.008 ppb). This method will be used to study the distribution and occurrence of mercury in the lake water and aquatic organisms.

Other equipment used for the trace element studies include a Nuclear-Chicago gamma counting system (Model 4454), with a thallium activated NaI well, and a Geiger counter for counting both gamma and beta radiation. The system is used in radiochemical experiments to assess the recovery of a trace element from water and yield in a chemical process.

Phosphorus Cycle in Lake Ontario – Only very limited work has been done on the fractionation of the forms of phosphorus in Lake Ontario waters. This study was designed to determine the relative size and importance of, and seasonal changes in, the soluble organic phosphorus fraction in western Lake Ontario waters. The project was coordinated with the Physical Limnology Section's project MELON. Lake water samples were collected at ten stations in the western basin of Lake Ontario at approximately two-week intervals from May to September. The water samples were filtered through 0.45 micron membrane filters onboard ship, then immediately frozen in dry ice for subsequent analysis at the CCIW.

A secondary aim of this project was to compare two methods of analyzing for soluble organic phosphorus in natural waters: the determination by the difference between total soluble phosphorus and soluble reactive phosphate and the U.V. irradiation technique (Armstrong, *et al.*, 1966, Nature **211**, 481-483).

The soluble organic phosphorus makes up a significant part of the total soluble phosphorus fraction in the surface waters of western Lake Ontario – at times when the soluble reactive phosphate concentrations are extremely low there can be up to 30 ppb (as PO_4) soluble organic phosphorus. This is a potential source of phosphorus for algae nutrition via bacterial conversion of the organo-phosphorus compounds to inorganic phosphate.

Use of the U.V. irradiation technique was started late in the field season; however, the preliminary indications are that it determines the same quantity in Lake Ontario waters as does the difference method. A more detailed evaluation will be undertaken in 1970.

Physical Chemistry of Aqueous Solutions – This program is concerned with the measurement of thermodynamic properties of aqueous mixed salt solutions in the temperature range from the freezing point to 25°C. Both an isopiestic vapor pressure apparatus and a freezing point apparatus are available, each of which can be used to determine the water activity of aqueous solutions containing involatile solutes. The isopiestic apparatus is particularly well suited for low-temperature measurements, and is now being used to study salt solutions at 15°C and 0°C. The freezing point apparatus can be used to temperatures for 0°C down to –4°C.

The activity coefficients of both salts in a two-salt system can usually be calculated from either of these measurements. The primary quantity measured, the water activity can be determined for most aqueous solutions with an inaccuracy of less than one part in 10^4.

The following systems have been or are being studied.

at 25°C

$H_2O - Na_2B_4O_7$
$H_2O - K_2B_4O_7$
$H_2O - NaBF_4$
$H_2O - KBO_2$
$H_2O - H_3BO_3$
H_2O – paraquat dichloride
$H_2O - CaCl_2 - Ca(NO_3)_2$
$H_2O - CaCl_2 - Mg(NO_3)_2$
$H_2O - MgCl_2 - Ca(NO_3)_2$
$H_2O - MgCl_2 - Mg(NO_3)_2$
$H_2O - Ca(NO_3)_2 - Mg(NO_3)_2$

at 15°C

$H_2O - NaCl$
$H_2O - Kcl$
H_2O – Urea
$H_2O - NaCl - MgSO_4$
$H_2O - NaCl - Na_2SO_4$

at 0°C

$H_2O - NaCl$

Particulate Organic Matter – A program carried out on Lake Ontario during the summer of 1969 has led to the development of a technique for measuring the rate of fall (cm/day) and settlement rate (gm/m^2 day) of organic particles in the water column. An example of obtainable values is shown in Figure 1. This technique makes possible the calculation of the rate of decay of organic matter at different depths and an estimation of the quantity of organic matter settling onto the bottom of a lake. This information will then be used in a study of the carbon cycle in lakes.

Computer and Data Services

Computer Terminal – A Control Data Corporation 200 user terminal was installed at CCIW in March. The 200 is capable of handling 300 cards per minute and 300 lines per minute. During 1969 more than 7,000 computer runs were made via the terminal which is tied to McMaster University's Control Data 6400.

Shipboard Computer – Field trials were held during April and the PDP-8 computer performed satisfactorily. The computer was placed aboard *CSS Limnos* in September and used until December to reduce and record various laboratory-determined parameters and temperatures. Next year the computer will be installed in a van for easier and safer transportation.

Programs – A program to reduce and analyze the reversing thermometer data was developed and has been in production. Other programs written during the year were for:

- current meter data, quality control and analysis
- curve fitting and trend surface analysis
- Hymet. recorder data analysis
- STAR data quality control, editing, retrieval and analysis (in conjunction with McMaster University) – for limnological data collected from monitor cruises.
- lake circulation modelling programs
- a generalized time-series data storage and retrieval system (under development).

During 1969, data from 35 Lake Ontario cruises, 11 Lake Erie cruises, three Lake Huron cruises and one Lake Superior cruise were processed for computer listing and analysis. Additional data from shore-based analysis and from other agencies were added to 1968 data summaries and punched-card files. Data records of the 1966 monitor cruises were published

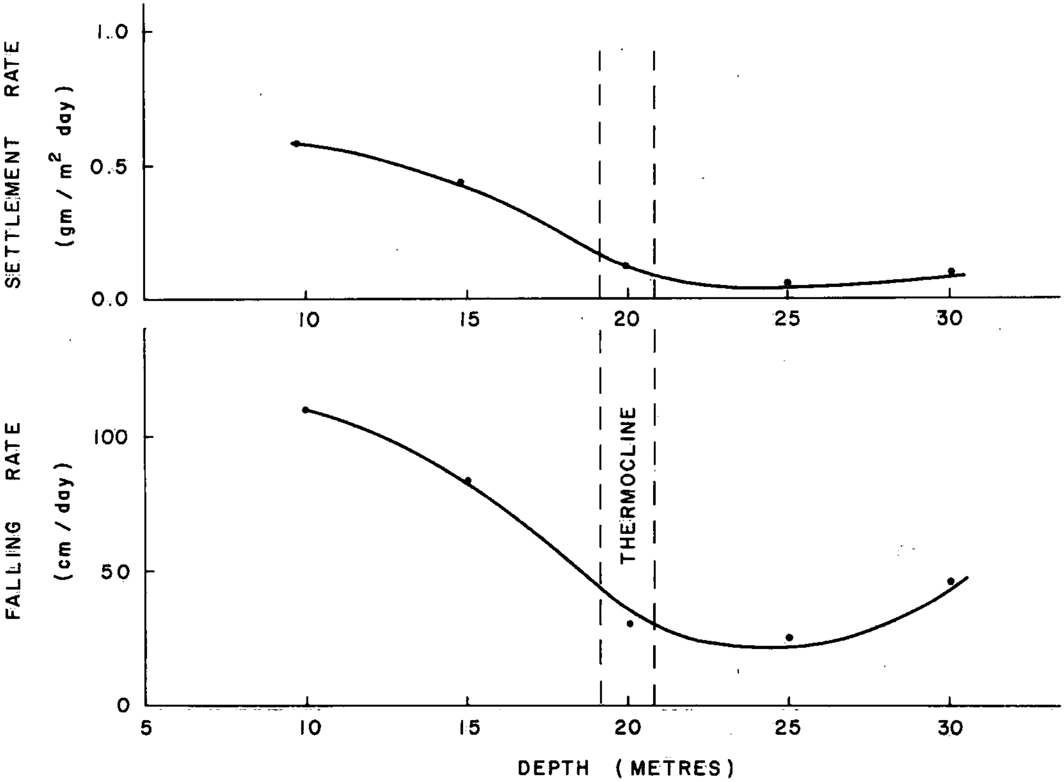


Figure 1. Settlement rates and falling rates or organic matter in western Lake Ontario – July 15, 1969.

(Appendix C). Data from 1967 monitor cruises will be published in 1970.

Although the Canadian Oceanographic Data Centre in Ottawa continued to process bathythermograph data, the thermocheck program and keypunching and listing of data in preparation for provisional reports are now being carried out at CCIW. This permits an earlier comparison of the temperature, physical and chemical parameters measured with those of preceding cruises or in past years. Immediate reviews of reversing thermometer and bathythermograph performances were implemented to permit recalibration of instruments for shipboard use whenever necessary.

Engineering Systems Section

Generally, the Section provides engineering services to all divisions and agencies of the three federal departments of the CCIW and to the scientists of the Association of Universities and Colleges of Canada participating in the research programs of the Centre. Engineering services are provided for research and data collection programs in the disciplines of bacteriology, biology, chemical limnology, hydraulics, limnogeology and physical limnology. These services include the design, development, implementation and maintenance of limnological instrumentation systems and automatic data acquisition and processing systems. A description of some of the more novel projects and activities follows.

Data Translator – To translate data from $^1/_4$-in. magnetic tapes, produced by Plessey and Geodyne current meters, and punched paper tapes, produced by the automatic data acquisition systems onboard the major ships, a "translator", comprising a PDP-8 computer and the necessary hardware and software, has been assembled. The data are translated to computer-compatible format on $^1/_2$-in. magnetic tape for data reduction and processing in a large computer. The programming of the translator's computer is such that a "diagnostic" of the input data tapes is printed out, which gives an indication of errors in the data and thus assists in the editing of data and the assessment of meter performance.

Current Meters – Plessey current meters were serviced on 113 occasions for lake moorings, during the field season. Test and documentation procedures were developed and established to ascertain and improve the reliability of the current meters.

Twenty-two Geodyne current meters were received and passed through incoming inspection. Eighteen Geodyne current meters were serviced for mooring in the lakes, with good results. Documentation and test procedures were also established for these current meters.

Maintenance and service manuals were written for both types of current meters and steps were taken to initiate external maintenance and servicing by contract.

^{14}C Apparatus – This is an incubator for nutrient bio-assay involving measurement of photosynthesis rates of phytoplankton. The rates are determined by the amount of Carbon 14 absorbed. The incubator consists of a counter-balanced light bank and exhaust hood (for cooling) which gives a high intensity light source approaching daylight over a 6-square-foot open tank. The tank is fed to a constant height with raw lake water in which are submersed two rotating bottle racks with capacity for 40 sample bottles. The apparatus was made for the Fisheries Research Board and is now installed on the *MV Martin Karlsen.*

Microbiological Sampler – A prototype microbiological sampler was designed and manufactured for the Department of National Health and Welfare to obtain uncontaminated water samples at various lake depths and to use these samples for bacteriological studies. The instrument consists of a sealed, evacuated and sterilized flask mounted in a frame. The inlet to the flask has a length of folded rubber hose connected to it, which is sealed by a glass plug. In operation, the microbiological tester is mounted on a taut wire and lowered to a known depth at which time a dead-weight messenger is dropped to break the glass seal of the evacuated flask and also to release one end of the rubber hose so that water is drawn into the flask from a point remote from the apparatus thus avoiding contamination of the sample. Field testing has been successful and six more units are under construction.

Meteorological Packages – A "met. pack" was designed for remote meteorological observations from buoys, lake towers and shore stations. Ten units were built and tested during the field season with reasonably good results. The met. packs consist of a water-tight cylinder containing a magnetic tape digital recorder and battery pack. Arms are provided which carry wind speed, wind direction, humidity, and temperature sensors. The met. pack is suitable for taking a set of meteorological data at 10-minute intervals for 40 days of unattended operation in a remote location.

Tests undertaken by the Physical Limnology Section indicate that while the system meets the minimum design requirements, development work continues toward improving its reliability and accuracy.

ADAPS – The "automatic data acquisition and processing systems" automatically and continuously measure and process meteorological, limnological and navigational data gathered during CCIW's ship operations. This project also includes various dedicated data-logging systems. Specifications have been written and approved for both the sensors and the data-logging portions of the system to these specifications for the 1970 field season. Important features of the system are ease of data quality checking, data processing and capability of manual data entry.

Installation, Repair and Maintenance – About 60 per cent of the Engineering Systems Section's man-hours are used on installation, repair and maintenance functions. On the mechanical side, the major effort was on ship and launch equipment, particularly winches. On the electronics side, the major effort was in current meter maintenance and data acquisition systems on ships, launches, towers and buoys. It is anticipated that contracting of current-meter maintenance in 1970 will permit much more time for development of water quality sensor packages and other related instrumentation systems.

Physical Limnology Section

Introduction – The Physical Limnology Section plays a role within the framework of CCIW by conducting research on the hydrodynamic and thermodynamic behaviour of lakes, by undertaking studies of applied limnology in circumstances where short-term studies are required, and by providing climatological and descriptive services in various aspects of physical limnology.

Niagara River Plume Studies – Data collected during 1967 and 1968 by current meters, drogues, infrared scanning, temperature surveys, and dye plume studies were employed to study circulation, thermal and diffusional characteristics of the Niagara River effluent. The orientation of the heavily polluted plume was found to be most responsive to wind direction, yet fairly insensitive to wind speed. Winds during and one day prior to the day of measurement were most closely related to the response of the plume although some effect of winds for three prior days was noted. The plume close to the river mouth was vigorously mixed. Outside the mouth area the warmer plume was found to spread horizontally over cooler lake water.

Air-lake Interaction – Wind, temperature, and humidity profile data collected during 1967 at the tower near Burlington and during 1968 at the tower near the mouth of the Niagara River, have been analyzed. The vertical wind profile up to 12 metres height could be predicted with a simple model to within a standard deviation of 3 per cent. However, investigation reveals that successful models for prediction of vertical air temperature profiles will be more complex.

Instrumentation for 1969 studies, consisting of heated film anemometers, resistance-wire temperature sensor, Lyman $\propto$ hygrometer and Thornthwaite unit parcel momentum flux meters, was assembled for the direct measurement of heat, moisture, and momentum flux over a lake surface from a rigid tower. Periods of observations were conducted to obtain an evaluation of the instrumentation and of the observational techniques. Several days of continuous measurement of the time variation of momentum flux affecting water movements were obtained. Indicated changes in experimental methods will be effected prior to the IFYGL program (1971-72).

MELON (Massive Effort in Lake Ontario) – The 1969 MELON experiments were designed mainly to examine the structure and variability of water movements in the western end of Lake Ontario (Figure 2). Theoretical models of lake circulation have been dominated by the boundary value problem approach, leading to relatively simple mean flow patterns. While it is possible that such motions do exist, an increasing body of evidence indicates that complex, seemingly random, large-scale motion, similar to turbulence, may be more important in determining the movement and ultimate dispersal of any substance in the lakes.

The core of the experiments consisted of arrays of moored self-recording current meters. The distribution of the moorings was chosen so that horizontal and vertical coherence of motion could be tested at a variety of scales. The arrays were maintained during two periods, the first from May 1 to June 27 when the lake progressed from isothermal to weakly stratified conditions, and the second from August 14 to September 21 when the lake was strongly stratified into two layers. Routine monitor cruises involving fixed-point physical and chemical sampling were carried out during and between the current meter experiments. Other experiments relating to air-sea interaction and diffusion, were conducted at the time of the current meter experiments.

Two drogue experiments were conducted during the first MELON experiment. Twelve drogues were tracked for almost four days in late April, and again for one day in early June. A modification of Okubo's (1969) technique for calculating large-scale diffusion coefficients from drogue data was proposed by Hamblin, and has been applied to the experiments. In addition, current-meter data taken in the vicinity of the drogue experiments were obtained to estimate large-scale diffusion parameters. Values for horizontal eddy diffusivity for large-scale turbulence, suitable for physical modelling are given as 5000 $cm^2\ sec^{-1}$ for homogeneous conditions and $10^5\ cm^2 sec^{-1}$ during the strongly stratified conditions.

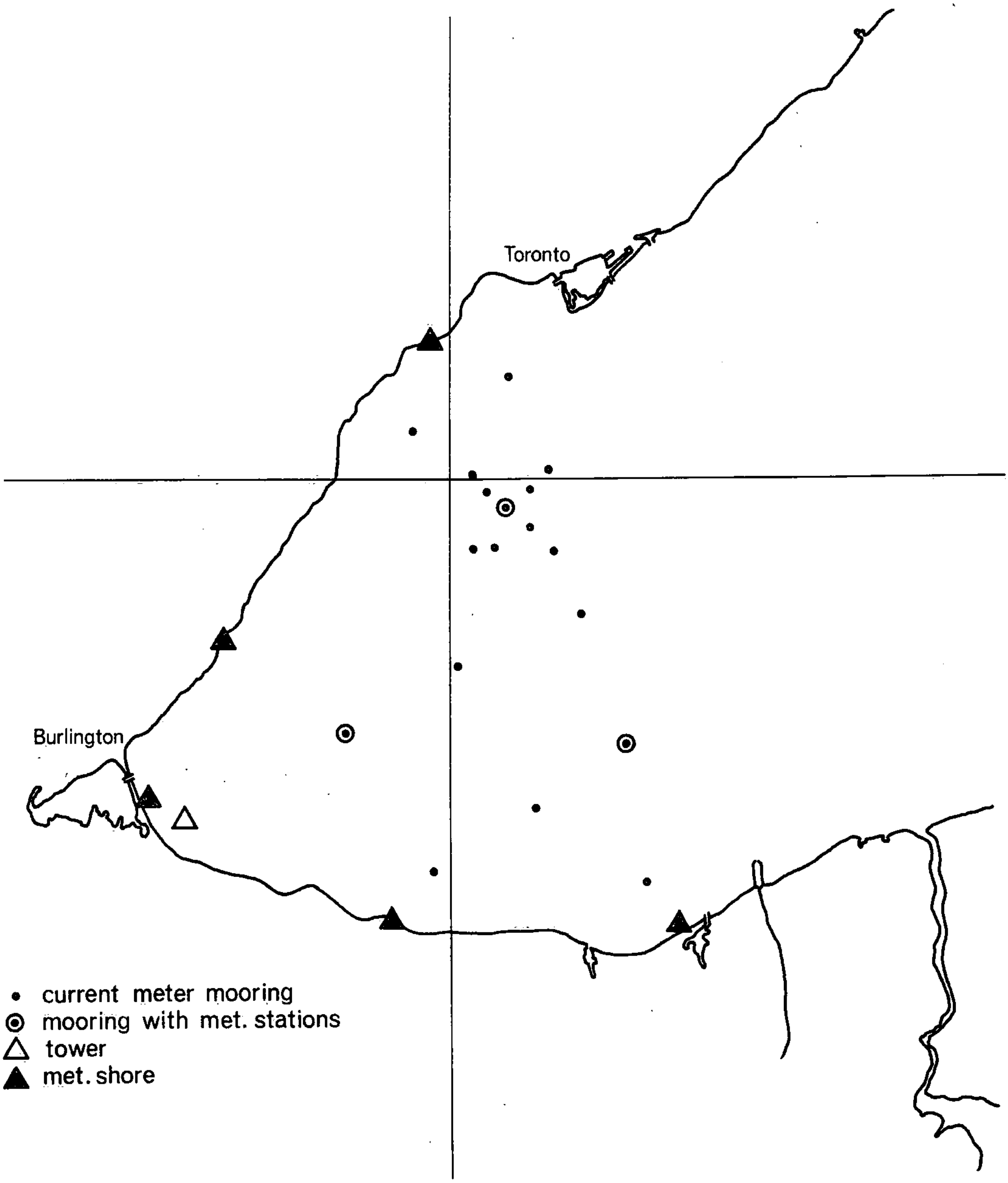


Figure 2. Station locations, MELON I, May 1 – June 27, 1969.

Three dye-patch diffusion experiments, in early May, mid-June and late August, were carried out to study large-scale horizontal diffusion in the upper layers of the open lake under isothermal and stratified conditions. The concentration of dye (Rhodamine B) in the "patch" was measured for about 60 hours using shipborne fluorometers as the diffusion processes caused it to spread out and become more dilute. Airphotos were taken at intervals while the dye remained visible. Measurements of current and temperature structure were made simultaneously in order to study the effects of these phenomena on the diffusion. An example of horizontal concentration distribution is shown in Figure 3. The ship's tracks along which continuous recordings of concentration were made are also indicated. The diffusivities computed from these concentration distributions are typically of the order of $10^4 - 10^5$ $cm^2\ sec^{-1}$, two orders of magnitude greater than reported values based on short-term, continuous dye plume studies.

Extensive measurements of lake currents in the western end of Lake Ontario were made during each of the two parts of MELON. Initial results indicate that the currents in the Toronto-Hamilton-Niagara River area were clockwise in nature (confirming earlier studies), and that the postulated "cellular" nature of the flow may not exist during weak stratification. The prominent counter-clockwise quasi-circular motions of periods of about 17.5 hours (one-half pendulum day) appear primarily when stratification becomes present, indicating that the motions probably are associated with motions near the thermocline. Coherence analyses are continuing.

The area of Lake Ontario west of a Toronto to Niagara line was mapped using 8-13 micron infrared imagery on several closely spaced days during May 1969 (Figure 4). The imagery

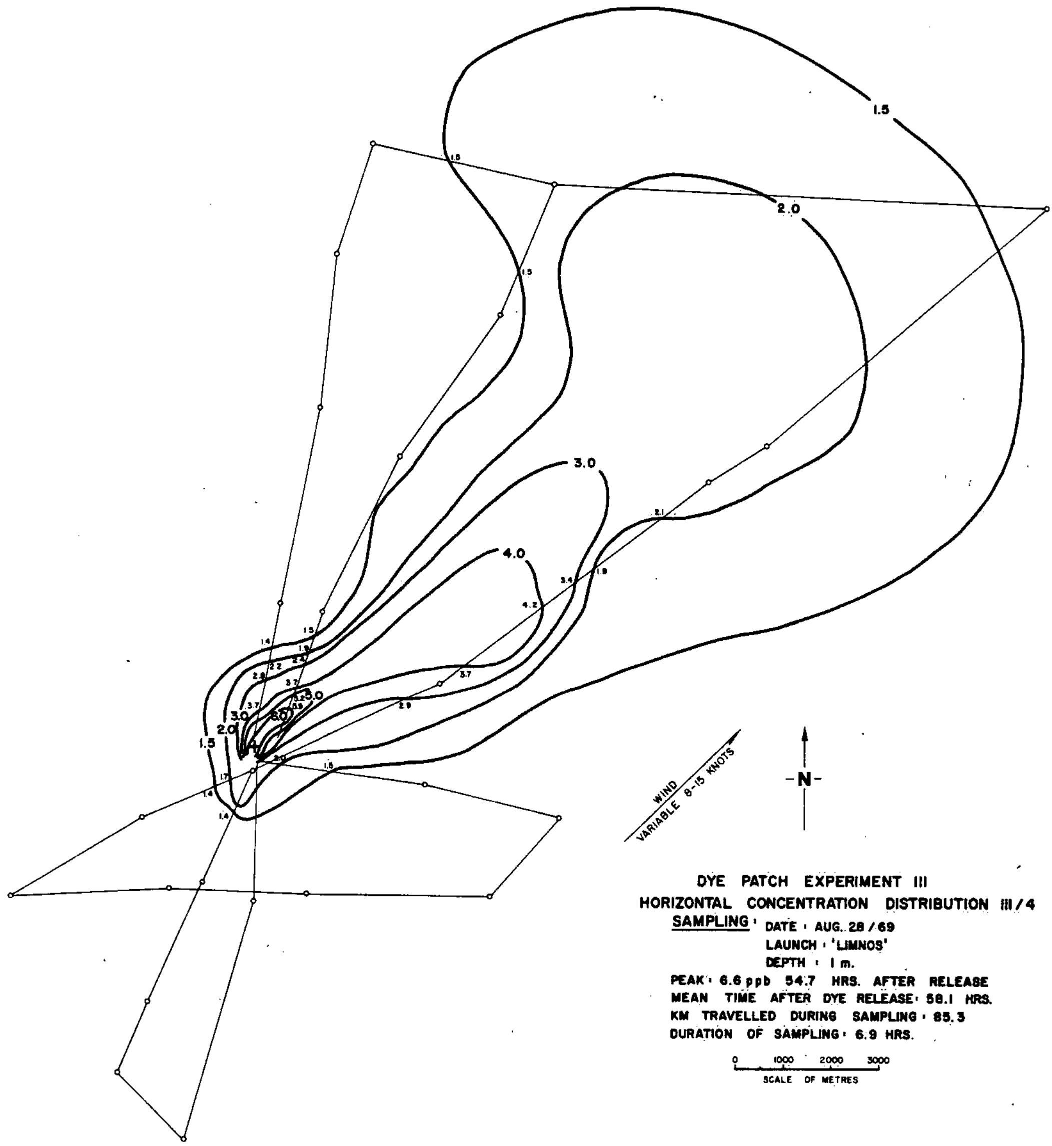


Figure 3. Example of results of dye patch experiment, MELON, 10 km off Port Credit, Ontario.

indicates large temporal and spatial variations of surface temperature over a wide range of scale sizes.

The larger scales show persistence over the days of measurement but the finer scales show large variations between periods, and even within a given day. Examination of the prevailing meteorological conditions on each of the days of observation shows that the fine detail in surface temperature patterns can be related to the local wind plus air-water temperature differences. The effects of variations in solar insolation are less well related.

Remote Sensing – Periodic surveys, mainly of western Lake Ontario, using the modified Singer Reconofax scanner, an airborne thermometer (RT) and various cameras, continued during 1969 (Table I). Data analyzed thus far have been incorporated in the MELON program (e.g. Figure 4).

Descriptive Projects – The preparation of an atlas of Great Lakes data continued during 1969. Summaries in map form of all available temperature and dissolved oxygen information will be complete by the end of 1970. Bathythermograph temperature profiles have been coded and are being keypunched. Temperature and dissolved-oxygen data are being computer-printed onto plots for contouring and gridding. Summarization of data at grid points is proceeding. Most of the steps completed have been for CCIW data. Data from the Great Lakes Institute, University of Toronto, initially processed by that group, are now being introduced into the atlas charts.

Kenora – In association with the small lakes eutrophication program of the Fisheries

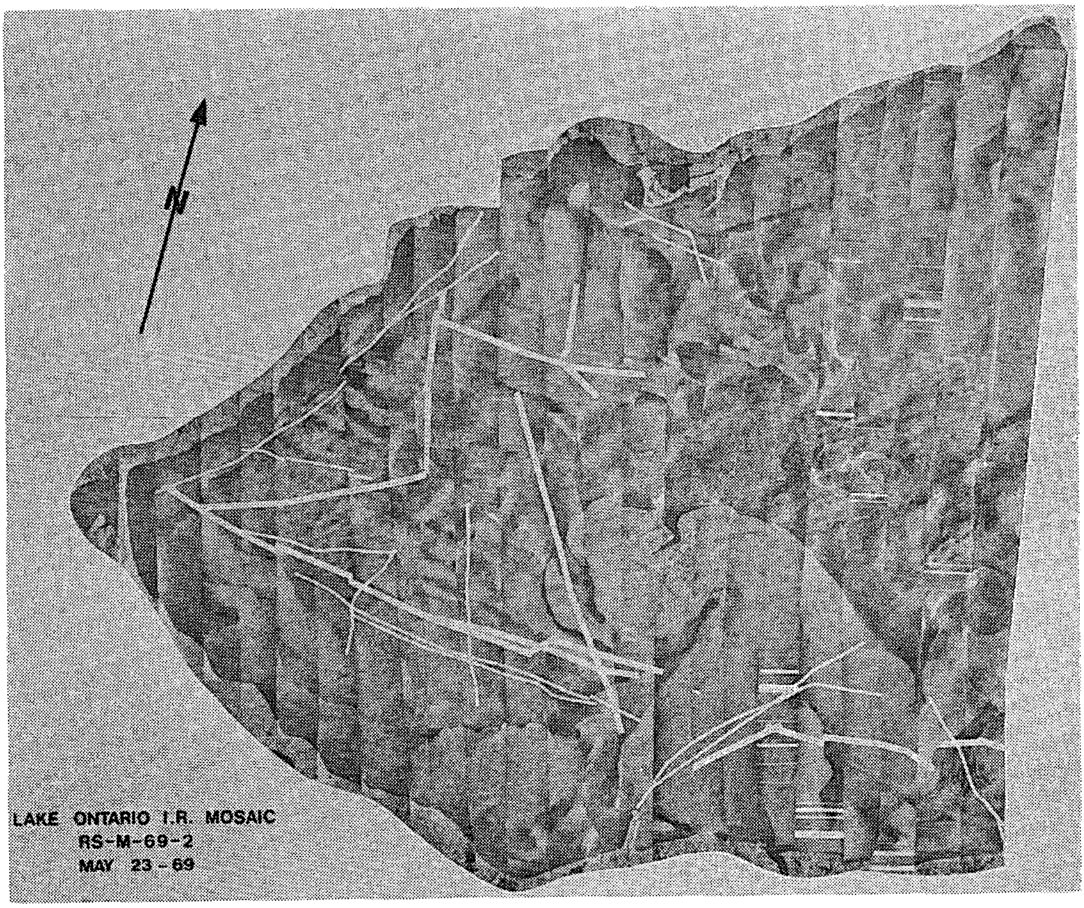


Figure 4. Example of infrared (thermal) imagery, western Lake Ontario (Niagra River mouth, at bottom, right of centre). White strips cover ship tracks.

TABLE I
Infrared Scanner Survey

Date 1969		Location	Altitude (feet)	RT	Air Photos	Comments
May	21	W. Lake Ontario	7,000	yes	35 mm blk & wht MK 7 camera	35 mm photos are poor quality.
	23	W. Lake Ontario	7,000	yes	" "	Hand held Pentox photos successful.
	26	W. Lake Ontario	7,000	yes	" "	
	27	W. Lake Ontario	7,000	yes	" "	
July	8	W. Lake Ontario	7,000	no	35 mm color MK 7 RC8 blk & wht	Scanner breakdown.
	11	W. Lake Ontario	7,000	yes	" "	Terminated – cloudiness.
	14	W. Lake Ontario	7,000	yes	F95 70 mm color F95 70 mm false color	
	15	W. Lake Ontario	7,000	yes	" "	
July	24	Lake Winnipeg	6,000	no	MK 7 35 mm color	RT malfunction.
August	22	W. Lake Ontario	7,000	yes	35 mm color MK 7	MK 7 malfunction.
September	3	W. Lake Ontario	7,000	yes	35 mm color MK 7 RC8 color	
	3	Lakeview Power Generating Station	1,500	yes	35 mm color MK 7 RC8 color	
	8	W. Lake Ontario	7,000	yes	35 mm color	Terminated – cloudiness.
December	5	E. Lake Ontario	500–1,000	yes	nil	Special tests over *MV Martin Karlsen* off Oswego.

Research Board, near Kenora, Ont., studies of lake hydrology were undertaken by Inland Waters Branch, Meteorological Branch (DOT), and the University of Manitoba. In collaboration with the Engineering Systems Section, the Physical Limnology Section established and maintained a tower instrumented to record standard meteorological parameters, as well as incoming, reflected, and diffuse solar radiation, and net total radiation over one of the major lakes (Figure 5). Data have been provided for heat and water budget computations.

Instrument Development Work – During 1969 the Physical Limnology Section has been involved, with the assistance and collaboration of the Engineering Systems Section, in the design and development of instruments. The most substantial project involved a towed thermistor array intended to give continuous temperature profiles in the upper 30-40 metres of water while being towed from a moving ship. Encapsulated thermistors plug into 13 breakouts located at intervals along a faired cable, which incorporates both electrical conductors and strength members. The free end of the cable is held down by a depressor fin which also houses a pressure sensor. The upper end terminates mechanically in a specially designed winch. A digital data acquisition system has been acquired for the array which is capable of sampling up to 20 channels 10 times/second.

The Bedford Institute of Oceanography has developed a towed undulating body capable of carrying a variety of sensors. A prototype of this body carrying temperature and depth sensors was tested in Lake Ontario in July 1969. The trials were conducted jointly between the Bedford Institute of Oceanography and CCIW (Technical Operations Section and Physical Limnology Section). The system was found to have useful applications to Great Lakes work. Further trials of an improved system will be held during the 1970 field season.

Other instrument development work has been undertaken on a moored, self-recording temperature profiler device to measure near-surface temperature profiles and drogues.

Modelling – A steady state model of hydraulically induced circulation in a rotating homogeneous circular lake was prepared. Numerical solutions, based on assumptions of constant lateral and vertical eddy diffusivity coefficients, were obtained for conditions of constant depth, for a parabolic basin, and for conditions of uniform wind stress.

Applications of simple statistical models to nearshore current measurements (within about 10 km from shore) show that prediction of such currents from winds measured on shore, shows some promise. The models also show sensitivity to averaging periods in reducing the data. Investigation, testing and evaluating of such models are continuing.

Oil Pollution – A member of the Section undertook during 1969, to review current methods of combatting massive oil pollution. A visit was made to Santa Barbara, Calif. in February 1969 to observe the effects of the oil spill there and to study the techniques used to clean up the oil.

Contracted Research

Department of Mechanical Engineering, University of Waterloo – During 1969, a field study of the predicted "coastal jet" phenomenon, was provided with funds. Measurements of current profiles (speed, direction, temperature) were made offshore in Lake Ontario, near Oshawa. Results indicated that the current patterns were quite complex, and that time series measurements would have to be made in conjunction with the measurements made over space and time, in order to fully evaluate the significance of the observed patterns. Continued support for this program is planned for 1970.

H.G. Acres Co. Ltd. – A survey of the magnitudes and locations of present thermal in-

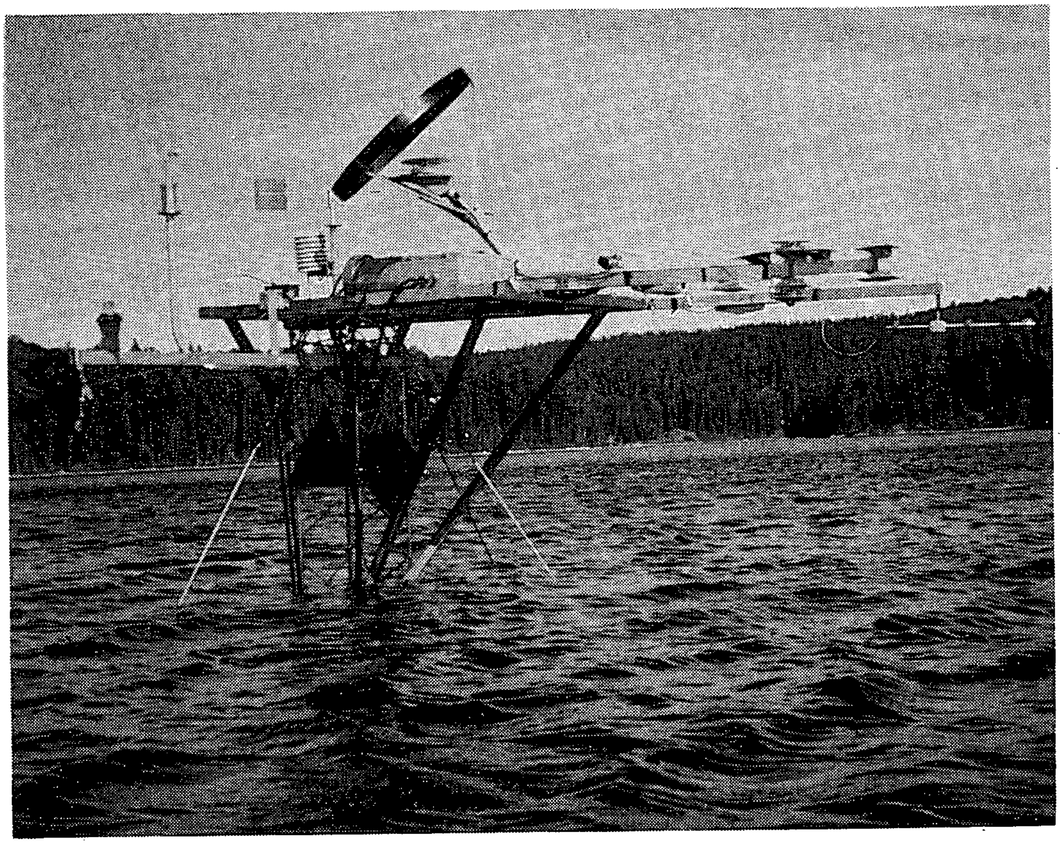


Figure 5. Radiation tower in Lake 239, near Kenora, Ontario.

puts to the Great Lakes and a projection of these inputs to the year 2000 has been completed through contract with the H.G. Acres Co. Ltd. The present total input to the Great Lakes is estimated to be about 10^{10} Btu/hr. This input is expected to increase by greater than an order of magnitude by the year 2000.

A simple model employing an "equilibrium surface temperature" approach has been applied to arrive at estimates of lake temperature that can be expected as a result of the increased thermal input. Results of this part of the study are not conclusive at this time.

H.G. Acres Co. Ltd. – Inland Waters Branch sponsored a study of requirements for ice research in Canada and the Great Lakes Division participated in support and monitoring of the program. The study is providing summaries of the state of present knowledge and recommendations for priorities for future ice research efforts.

Geography Department, McMaster University – A study was undertaken, under contract, to measure incoming, reflected and diffuse solar radiation and net total radiation at a nearshore tower adjacent to Grimsby on Lake Ontario. Analyses are proceeding and will include evaluations of empirical techniques for estimating radiation values, measurement procedures, and estimates of emissivity values under varying lake conditions.

Great Lakes Institute, University of Toronto – Several studies, including the provision of limnological data in support of MELON, thermal bar studies, and data atlas developmental work, were performed during 1969, under contract.

Limnogeology Section

The Limnogeology Section is responsible for undertaking two different, though interrelated types of research on the bottom sediments and suspended particulate matter of major Canadian lakes. In one, inventory data is obtained which will permit categorizing and plotting of distribution maps and diagrams, to show, for example, what types of material are present in the lake sediments, how much material there is and where it occurs.

The second line of research is related to process studies. Included under this heading, for example, are studies of the physical problems of erosion, transportation and deposition of sediments and the organic and inorganic chemical processes involved in sediment diagenesis and authigenesis, and the various geobiological interactions involved between the sediments and the biota. Of particular importance are exchanges of phosphates and other nutrients and micronutrients between the sediments and the overlying waters.

1. In a sediment inventory study along the north shore of Lake Ontario, bottom samples were collected on a 2-km grid, and echo soundings and transit sonar surveys were made perpendicular to the shore at 2-km intervals. Much of the nearshore zone, between Whitby and Wellington is floored by glacial sediments and bedrock. Glacial materials and lag deposits predominate in the area west of Colbourne, and bedrock to the east.

Throughout most of the area, unconsolidated sediments occur as a thin discontinuous wedge adjacent to the shoreline, widening locally in the vicinity of creek and harbor entrances. In the area immediately east and west of the peninsula, however, sediment does cover a major part of the nearshore zone, mostly as sand or silty sand. The concentration of sediment in the eastern part of the nearshore zone and the consistent accumulation of sediment on the west side of shore structures indicates that the net sediment drift is from west to east. The dividing zone between eastward and westward shore region drift appears to occur between Frenchman Bay and Whitby along the north shore of Lake Ontario.

Figure 6 shows the distribution of various bedrock and unconsolidated deposits, west along the shoreline, between Whitby and Niagara. This summarizes results of the field survey in 1968.

2. About 560 bottom samples and cores have been taken during 1969 in the areas selected for statistical sampling. One of these is in the heavily polluted Niagara River mouth area and the other in the relatively clean Georgian Bay–Bruce Peninsula region. Sedimentological, geochemical, and biological analyses (courtesy Fisheries Research Board) are now partly completed. In Georgian Bay, very low rates of deposition are evident in much of

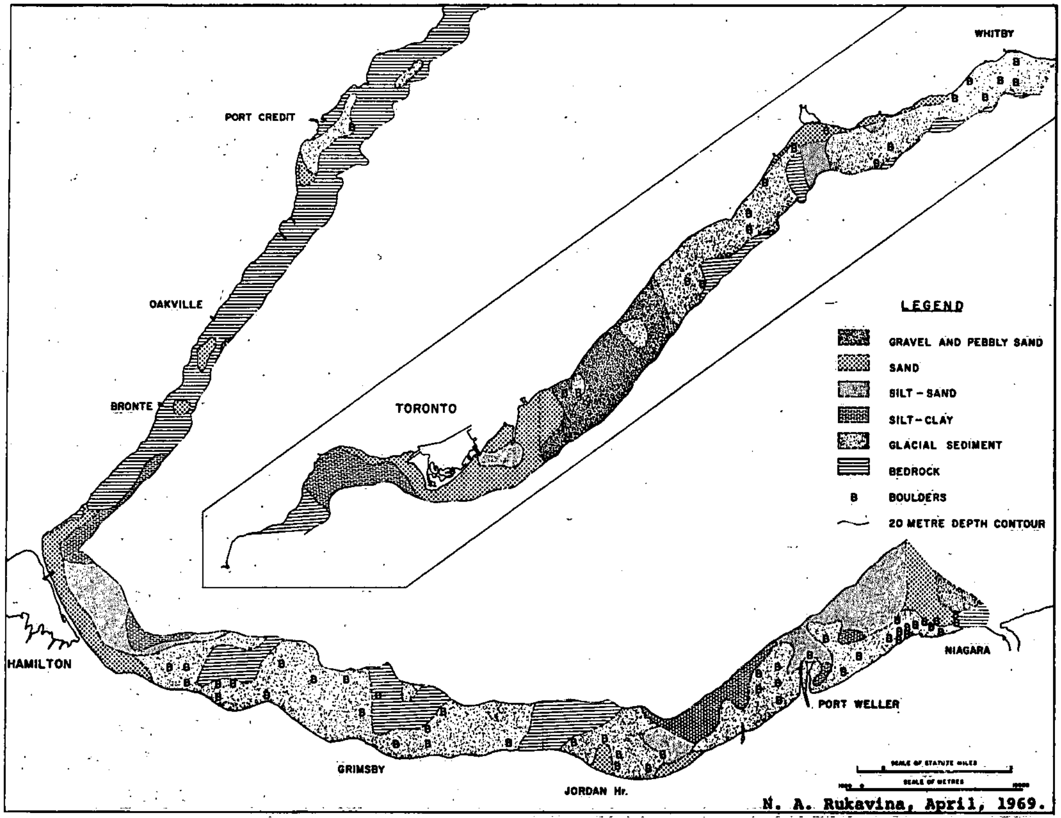


Figure 6. Distribution of various bedrock and unconsolidated deposits, west along the shoreline, between Whitby and Niagara.

the study area, Holocene deposits often being only a few centimetres thick (Figure 7). There are, however, thicknesses of more than 2 metres in the deepest parts. The Holocene deposits overlie glaciolacustrine sediments which are considerably more than 30 metres thick in several places. In the Niagara area of Lake Ontario, the high energy environment of the nearshore zone is typified by a thin and discontinuous cover of sands and silty sands which overlie bedrock and glacial till. Sampling in these two contrasting areas will provide valuable information for guidance of "process" studies on the spatial variations of physical, chemical and biological parameters within the sediments.

3. In the area of Lake Ontario between Hamilton and Toronto, variations in the textural and mineralogical characteristics of sandy sediments were used as natural traces to determine the net direction of transport and the provenance of near-shore sand deposits. Trials were also conducted in the same area using artificial fluorescent sand tracers. The lake shoreline appears to be a prime source of the materials found. Fluorescent tracers deposited at three locations indicate that the sediment movement is not consistent throughout the area.

4. Paleoecological studies have been restricted largely to an area at the west end of Prince Edward Bay, in Lake Ontario. Here chironomids were taken from samples of bottom sediments and also, in specially designed traps as they hatched. The prime objective has been to capture a number of different species and to rear them for morphological observations and identification at different stages in the life cycle. Additional material for chironomid studies was also obtained from the western end of Lake Erie and from the western part of Georgian Bay. However, the particularly

high population counts of chironomids observed both in Prince Edward Bay and in the western Georgian Bay area are of note. Chironomid distribution is related to the degree of pollution of the sediments and can, it is hoped, be used as indicator organisms. This program received substantial biological guidance and support from Fisheries Research Board Staff.

5. Detailed continuous profiling surveys were run over much of the western basin of Lake Erie, using a boomer source. These were controlled by sediment cores taken at selected stations. The profiling was specifically designed for shallow penetration to provide a better understanding of the complex stratigraphy of the unconsolidated deposits. This is a continuation of earlier work by the Geological Survey of Canada.

6. During the summer of 1969, the *CSS Limnos* undertook a seven-week sediment reconnaissance cruise in Lake Huron. Over 7,000 nautical miles of survey line were covered using echo sounding, side scan sonar, and air-gun seismic reflection profiling. In addition, bottom sediments were sampled at 196 stations for geochemical and sedimentological analysis. Sediment distribution in Lake Huron is extremely complex and is mostly controlled by the solid geology of the region, which also controls much of the relief.

The lithology of the near-shore zone of the lake is variable, with complex interrelationships between gravel, bedrock, glacial clays and tills, and sands (which frequently occur as rippled streamers or ribbons over glacial surfaces).

In addition to these major surveys several smaller projects were undertaken.

1. In the early part of the summer, a team of divers undertook a preliminary evaluation of underwater sampling, and survey operations, using an underwater habitat. The site location was at Little Dunk's Bay near Tobermory on the Bruce Peninsula, and operations were conducted at the Sub-Limnos Habitat of Dr. J. McInnes. Because of several unfortunate setbacks, particularly the lack of on-site power, the operations using the habitat were not fully successful. Further evaluation will be necessary before the value of habitat techniques can be properly assessed.

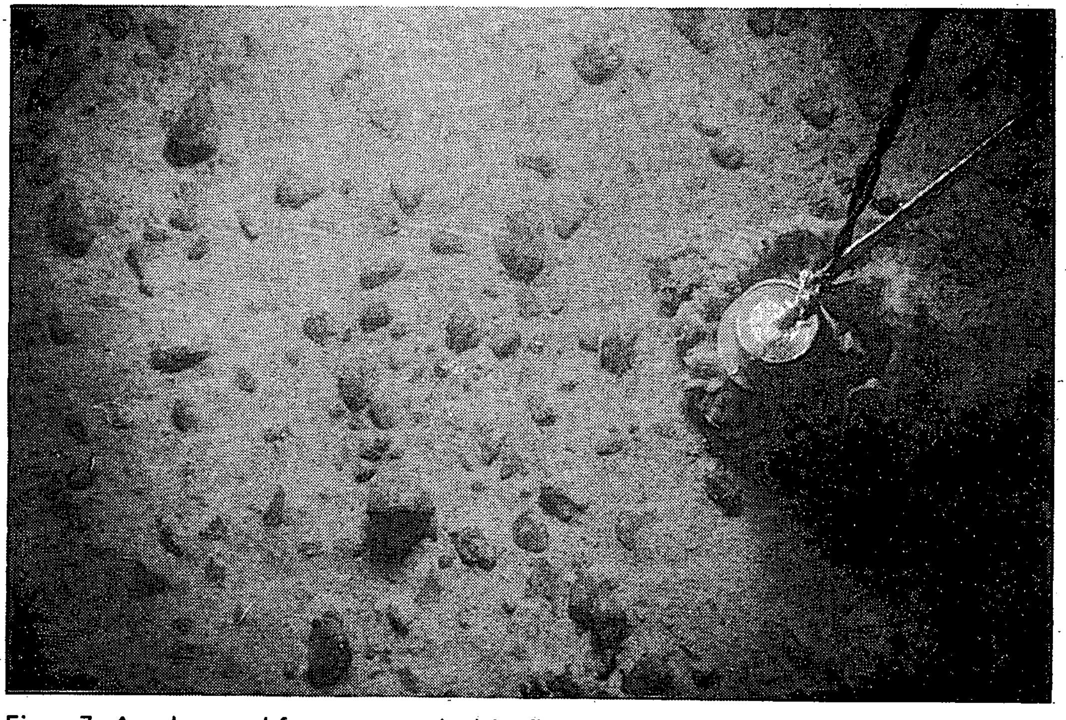


Figure 7. Angular gravel fragments on the lake floor in Georgian Bay, east of Bears Rump Island in 42 metres of water. Underwater compass on right.

2. During the late summer, a cooperative program was undertaken with members of the Fisheries Research Board, Freshwater Institute, on Lake Winnipeg. Here comparative tests were made using different bottom sampling and coring devices to determine the most efficient equipment for obtaining biological, and geological materials. In addition, further assistance was afforded to the University of Manitoba in connection with a preliminary survey of the geology of Lake Winnipeg.

Contract Study – The Department of Geology of Lakehead University undertook a survey by contract of the near-shore zone of Lake Superior. Sampling equipment, a small boat with outboard motor, and some field training were provided by CCIW, and arrangements were made through the good offices of the University of Michigan for the use of the research vessel, *Inland Seas*. Surveys started at the southeastern end of the lake and were extended as far north as Michipicoten Harbour on the Canadian shore. Studies involved observations and sampling of shoreline material, detailed sampling and echo sounding in the near-shore zone, and some control sampling and coring, and echo sounding in the offshore areas. One particularly important observation from the results so far available is that the sand deposits in the near-shore zone rarely extend to depths greater than 5 metres, rapidly giving way to silts and silty muds in deeper water. This may suggest that the high energy environment associated with wave action in the near-shore zone of this particular part of Lake Superior is restricted to areas where water depth is some 5 metres or less. This is a little surprising since the sand area appears to be similarly depth-controlled in Lake Ontario, where wave energy and fetch are expected to be generally less.

Laboratory Operations – The laboratories of the Section have continued to develop methods for quantitative and qualitative geochemical and sedimentological analyses of sample material. The sedimentology laboratory processed 20 short pipet analyses; 55 1-phi sieve analyses; 70, $^{1}/_{4}$-phi sieve analyses, and has made up some 550 slides for clay X-ray analyses. In addition, it has completed 60 carbonate determinations and 150 heavy mineral separations.

Unfortunately, due to a breakdown in the X-radiography unit, only a few cores have been logged so far by radiography. It is hoped, however, to have the system in operation again in the near future. The use of sedimentation tubes for rapid sand analysis has been temporarily abandoned because of problems with the recording equipment. The inorganic geochemistry laboratory has completed some 500 dry analyses and about 3,100 wet analyses. Among the substances analyzed were: total quartz, total clay, clay minerals, Al_2O_3, K_2O, Na_2O, CaO, MgO, P_2O_5, TiO_2, MnO, FeO, Fe_2O_3, Ca, Zn, Pb, and N.

The organic geochemistry laboratory has so far completed about 1,500 dry analyses, 30 chromatographic analyses, and about 400 extractions and wet analyses. Most of the work involved analysis of: organic carbon, inorganic carbon, nitrogen, extractable phosphate, nitrate, ammonium, chlorophylls and their degradation products, humic and fulvic acids, bitumens and kirogens.

Technical Operations Section

Major Ships – Two major ships, the *CSS Limnos* and the charter vessel *MV Martin Karlsen*, were used for Great Lakes monitoring and scientific data collection in 1969.

The *CSS Limnos* is owned by the Department of Energy, Mines and Resources and operated by the Marine Sciences Branch. During the field season many varied cruises, using a variety of scientific equipment, were carried out. These included a two-month extensive limnogeological survey of Lake Huron, a type of work for which *Limnos* is particularly suited. Unfortunately, mechanical problems have continued to plague the ship, necessitating a stay in drydock and the cancellation of several cruises. Late season work was extended because of stormy weather conditions, particularly on the upper lakes.

The *MV Martin Karlsen* (Figure 8) was chartered in April 1969 for three years with an option for a further two years. Before leaving Halifax, the vessel was fitted out with a deck house, laboratory, oceanographic winch and sampling platform, and laboratory in the

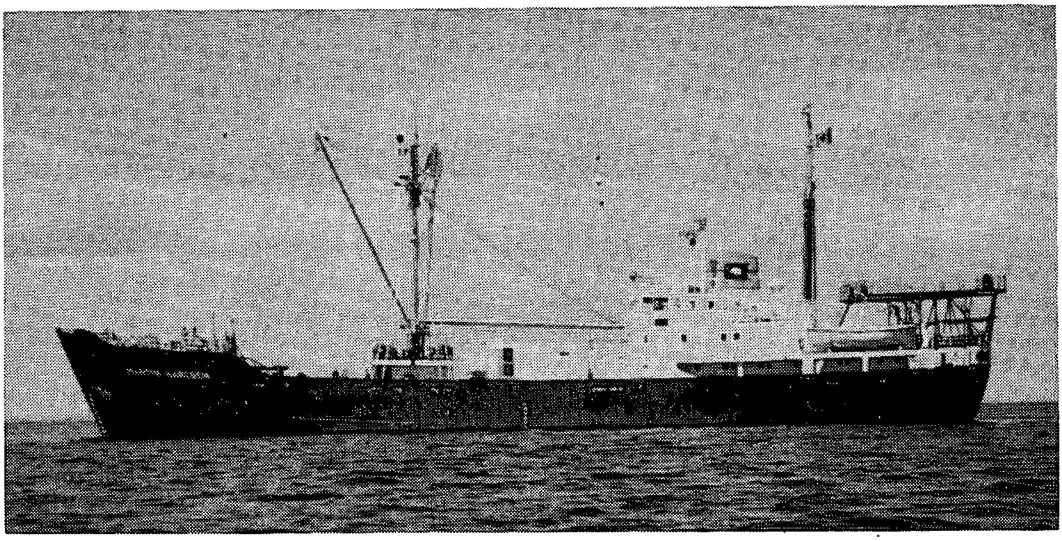


Figure 8. Chartered vessel *MV Martin Karlsen.*

between-deck area. She arrived at CCIW on April 22, 1969 and after the installation of scientific equipment, commenced regular operations on April 28, 1969. Greater emphasis was placed on monitoring cruises on *Karlsen* as the accommodation and laboratory space were ideal for this type of operation. However, other types of cruises were also performed successfully.

Personnel from Technical Operations were assigned to both the major ships on a continuing basis throughout the season. Scientific personnel from other agencies joined vessels in accordance with prearranged schedules coordinated by the Technical Operations Section.

Technical Operations personnel were responsible for all deck observations (sampling, measurements, recording of physical parameters, mooring, coring and manual chemistry).

Routine meteorological observations and reports were also carried out by this group, and transmitted regularly to Meteorological Branch forecast centres.

SK-5 Hovercraft – During February a survey was carried out in the eastern basin of Lake Erie using an SK-5 hovercraft (Figure 9) chartered from Bell Aerosystems, Buffalo, to evaluate the usefulness of such a craft as a survey vehicle on icy lakes in winter. Operations commenced on February 6, and finished on February 28 with a total of 46¼ hours flying-time.

The hovercraft was accompanied by a DOT Bell Jet Ranger helicopter. During the period of operation, 16 stations were occupied, 14 on ice and 2 on open water. But the use of an SK-5 hovercraft was found to be not practicable at present for CCIW purposes on Lake Erie, primarily because of the height of ridges in the ice and onboard space limitations together with logistic difficulties.

Small Craft – The Technical Operations Section continued to coordinate the assignment of the fleet of CCIW small craft to various sections at CCIW and to outside agencies.

OPERATIONAL TABLE 1969

Ship	Started Operations	Completed Operations	Miles Steamed	Total Days	Away on Operations	Per cent
CSS Limnos	March 31	December 18	16,944	263	152	58
MV Martin Karlsen	April 28	December 6	21,620	223	173	77

(complete schedules are given in Tables II and III)

TABLE II

1969 Great Lakes Studies – *CSS Limnos*

	SUN	MON	TUE	WED	THU	FRI	SAT
APRIL	30 CCIW	31 DEP CCIW 1020 MOORING L. ONT.	1 ARRIVE CCIW 1305 HRS	2 CCIW	3 CCIW	4 CCIW	5 CCIW
	6 CCIW	7 CCIW	8 DEPART CCIW 0813 HRS	9 MOORING LAKE ERIE	10 ARRIVE CCIW 1625 HRS	11 CCIW	12 DEPART CCIW 0800 HRS
	13 MONITOR LAKE ONTARIO	14 MONITOR LAKE ONTARIO	15 MONITOR LAKE ONTARIO	16 ARRIVE CCIW 1410 HRS	17 CCIW	18 CCIW	19 CCIW
	20 CCIW	21 CCIW	22 CCIW	23 CCIW	24 DEPART CCIW 1000 HRS	25 MOORING LAKE ONTARIO	26 MOORING LAKE ONTARIO
	27 MOORING LAKE ONTARIO	28 MOORING LAKE ONTARIO	29 MOORING LAKE ONTARIO	30 MOORING LAKE ONTARIO	1 ARRIVE CCIW 1800 HRS	2 CCIW	3 CCIW
MAY	4 DEPART CCIW FOR PORT WELLER	5 PORT WELLER	6 PORT WELLER	7 PORT WELLER	8 PORT WELLER	9 PORT WELLER	10 PORT WELLER
	11 PORT WELLER	12 PORT WELLER	13 PORT WELLER	14 PORT WELLER	15 PORT WELLER	16 PORT WELLER	17 PORT WELLER
	18 PORT WELLER	19 PORT WELLER	20 PORT WELLER	21 PORT WELLER	22 PORT WELLER	23 PORT WELLER	24 PORT WELLER
	25 PORT WELLER	26 ARRIVE CCIW 2000 HRS	27 CCIW	28 DEPART CCIW 1225 HRS	29 MOORING LAKE ONTARIO	30 MOORING LAKE ONTARIO	31 MOORING LAKE ONTARIO
JUNE	1 MOORING LAKE ONTARIO	2 ARRIVE CCIW 1220 HRS	3 DEPART CCIW 0905 MELON MONITOR	4 ARRIVE CCIW 1403 MELON MONITOR	5 CCIW	6 CCIW	7 CCIW
	8 CCIW	9 DEPART CCIW 0905 HRS	10 LIMNOGEOLOGY LAKE ERIE	11 LIMNOGEOLOGY LAKE ERIE	12 ARRIVE SARNIA 1530 HRS	13 SARNIA	14 DEP SARNIA 0138 HRS
	15 LIMNOGEOLOGY LAKE HURON	16 LIMNOGEOLOGY LAKE HURON	17 LIMNOGEOLOGY LAKE HURON	18 LIMNOGEOLOGY LAKE HURON	19 LIMNOGEOLOGY LAKE HURON	20 LIMNOGEOLOGY LAKE HURON	21 ARR GODERICH 1530 HRS
	22 DEP GODERICH 0800 HRS	23 LIMNOGEOLOGY LAKE HURON	24 LIMNOGEOLOGY LAKE HURON	25 LIMNOGEOLOGY LAKE HURON	26 LIMNOGEOLOGY LAKE HURON	27 LIMNOGEOLOGY LAKE HURON	28 ARR OWEN SOUND 1535 HRS
JULY	29 OWEN SOUND	30 DEP OWEN SOUND 0830 HRS	1 LIMNOGEOLOGY LAKE HURON	2 LIMNOGEOLOGY LAKE HURON	3 LIMNOGEOLOGY LAKE HURON	4 LIMNOGEOLOGY LAKE HURON	5 LIMNOGEOLOGY LAKE HURON
	6 LIMNOGEOLOGY LAKE HURON	7 LIMNOGEOLOGY LAKE HURON	8 LIMNOGEOLOGY LAKE HURON	9 LIMNOGEOLOGY LAKE HURON	10 LIMNOGEOLOGY LAKE HURON	11 ARR OWEN SOUND 1440 HRS	12 OWEN SOUND
	13 OWEN SOUND	14 DEP OWEN SOUND 2145 HRS	15 LIMNOGEOLOGY LAKE HURON	16 LIMNOGEOLOGY LAKE HURON	17 LIMNOGEOLOGY LAKE HURON	18 OWEN SOUND 1210 – 1700	19 LIMNOGEOLOGY LAKE HURON
	20 LIMNOGEOLOGY LAKE HURON	21 LIMNOGEOLOGY LAKE HURON	22 LIMNOGEOLOGY LAKE HURON	23 LIMNOGEOLOGY LAKE HURON	24 LIMNOGEOLOGY LAKE HURON	25 LIMNOGEOLOGY LAKE HURON	26 LIMNOGEOLOGY LAKE HURON
	27 ARR SARNIA 1110 DEP SARNIA 1400	28 IN TRANSIT	29 ARRIVE CCIW 0800 HRS	30 CCIW	31 CCIW	1 CCIW	2 CCIW
AUG	3 CCIW	4 CCIW	5 DEPART CCIW 1440 HRS	6 MELON PROJECT LAKE ONTARIO	7 MELON PROJECT LAKE ONTARIO	8 ARRIVE CCIW 0045 HRS	9 CCIW
	10 CCIW	11 CCIW	12 CCIW	13 CCIW	14 DEPART CCIW 1150 HRS	15 MOORING LAKE ONTARIO	16 MOORING LAKE ONTARIO
	17 MOORING LAKE ONTARIO	18 ARRIVE CCIW 1845 HRS	19 CCIW	20 CCIW	21 DEP CCIW 0933 MELON MONITOR	22 ARR CCIW 1611 MELON MONITOR	23 CCIW
	24 CCIW	25 DEPART CCIW 1010 HRS	26 DYE PATCH DIF. LAKE ONTARIO	27 DYE PATCH DIF. LAKE ONTARIO	28 DYE PATCH DIF. LAKE ONTARIO	29 ARRIVE CCIW 1800 HRS	30 CCIW
SEPT	31 CCIW	1 CCIW	2 CCIW	3 CCIW	4 DEPART CCIW 0600 HRS	5 SURFACE TEMP. LAKE ONTARIO	6 ARRIVE CCIW 1615 HRS
	7 CCIW	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW
	14 CCIW	15 CCIW	16 CCIW	17 DEPART CCIW 0000 HRS	18 MOORING LAKE ONTARIO	19 ARRIVE CCIW 1605 HRS	20 CCIW
	21 CCIW	22 DEPART CCIW 1910 HRS	23 GRAVITY LAKE ONTARIO	24 GRAVITY LAKE ONTARIO	25 ARRIVE CCIW 1125 HRS	26 CCIW	27 CCIW
	28 CCIW	29 DEPART CCIW 1200 HRS	30 GRAVITY LAKE ERIE	1 GRAVITY LAKE ERIE	2 GRAVITY LAKE ERIE	3 ARR LEAMINGTON 1920 HRS	4 LEAMINGTON
OCT	5 DEP LEAMINGTON 0620 HRS	6 GRAVITY LAKE ERIE	7 ARRIVE CCIW 2100 HRS	8 CCIW	9 CCIW	10 CCIW	11 CCIW
	12 CCIW	13 CCIW	14 CCIW	15 CCIW	16 CCIW	17 CCIW	18 CCIW
	19 CCIW	20 CCIW	21 CCIW	22 CCIW	23 CCIW	24 CCIW	25 CCIW
	26 CCIW	27 DEPART CCIW 1555 FOR L. SUPERIOR	28 IN TRANSIT	29 IN TRANSIT	30 ARR SAULT STE. MARIE 0600 HRS	31 DEP SOO 0800 LAKE SUPERIOR	1 IN TRANSIT FOR CCIW
NOV	2 ARR SARNIA 1400 HRS	3 DEP SARNIA 0700 HRS	4 IN TRANSIT	5 ARRIVE CCIW 0600 HRS	6 DEPART CCIW FOR PORT WELLER	7 PORT WELLER	8 PORT WELLER
	9 PORT WELLER	10 PORT WELLER	11 PORT WELLER	12 PORT WELLER	13 PORT WELLER	14 PORT WELLER	15 PORT WELLER
	16 ARRIVE CCIW 1000 HRS	17 CCIW	18 DEP CCIW 0910 FOR LAKE HURON	19 IN TRANSIT LAKE ERIE	20 IN TRANSIT LAKE ERIE	21 IN TRANSIT LAKE ERIE	22 MONITOR LAKE HURON
	23 MONITOR LAKE HURON	24 MONITOR LAKE HURON	25 MONITOR LAKE HURON	26 MONITOR LAKE HURON	27 MONITOR LAKE HURON	28 ARR OWEN SOUND 0845 HRS	29 DEP OWEN SOUND 0800 HRS
DEC	30 MONITOR LAKE HURON	1 MONITOR LAKE HURON	2 MONITOR LAKE HURON	3 MONITOR LAKE HURON	4 MONITOR LAKE HURON	5 ARR SARNIA 1700 DEP SARNIA 1830	6 ARR WINDSOR 1006 HRS
	7 DEP WINDSOR 1000 HRS	8 MONITOR LAKE ERIE	9 MONITOR LAKE ERIE	10 MONITOR LAKE ERIE	11 MONITOR LAKE ERIE	12 MONITOR LAKE ERIE	13 ARR CCIW 0900 HRS
	14 CCIW	15 CCIW	16 DEP CCIW 0900 HRS	17 MOORING LAKE ONTARIO	18 ARRIVE CCIW 1345 HRS	19 END OF	20 FIELD SEASON

TABLE III

1969 Great Lakes Studies *MV Martin Karlsen*

	SUN	MON	TUE	WED	THU	FRI	SAT
	30	31	1 ON CHARTER HALIFAX 0800	2 FITTING OUT	3 FITTING OUT	4 FITTING OUT	5 HALIFAX
APRIL	6 HALIFAX	7 FITTING OUT	8 FITTING OUT	9 FITTING OUT	10 FITTING OUT	11 FITTING OUT	12 HALIFAX
	13 HALIFAX	14 FITTING OUT	15 DEP HALIFAX 2000 HRS	16 ON PASSAGE	17 ON PASSAGE	18 ON PASSAGE	19 ON PASSAGE
	20 ON PASSAGE	21 ON PASSAGE	22 ARR CCIW 0630 HRS	23 CCIW	24 CCIW	25 CCIW	26 CCIW
	27 CCIW	28 DEP CCIW 1300 LAKE ONTARIO	29 MOORING LAKE ONTARIO	30 ARR CCIW 1830	1 DEP CCIW 0930 MELON MONITOR	2 ARR CCIW 1900 MELON MONITOR	3 CCIW
	4 DEP CCIW 0900 HRS	5 MELON PROJECT LAKE ONTARIO	6 MELON PROJECT LAKE ONTARIO	7 MELON PROJECT LAKE ONTARIO	8 MELON PROJECT LAKE ONTARIO	9 ARR CCIW 1520 HRS	10 CCIW
MAY	11 CCIW	12 DEP CCIW 1300 HRS	13 MONITOR LAKE ONTARIO	14 MONITOR LAKE ONTARIO	15 MONITOR LAKE ONTARIO	16 MONITOR LAKE ONTARIO	17 MONITOR LAKE ONTARIO
	18 ARRIVE CCIW 1200 HRS.	19 CCIW	20 DEPART CCIW 1100 MELON PROJECT	21 MELON PROJECT LAKE ONTARIO	22 MELON PROJECT LAKE ONTARIO	23 MELON PROJECT LAKE ONTARIO	24 MELON PROJECT LAKE ONTARIO
	25 MELON PROJECT LAKE ONTARIO	26 MELON PROJECT LAKE ONTARIO	27 ARRIVE CCIW 2100 HRS.	28 CCIW	29 DEPART CCIW 1000 HRS.	30 MONITOR LAKE ERIE	31 MONITOR LAKE ERIE
	1 MONITOR LAKE ERIE	2 MONITOR LAKE ERIE	3 MONITOR LAKE ERIE	4 MONITOR LAKE ERIE	5 ARRIVE CCIW 0800 HRS.	6 CCIW	7 CCIW
	8 CCIW	9 DEPART CCIW 0900 HRS.	10 MONITOR LAKE ONTARIO	11 MONITOR LAKE ONTARIO	12 MONITOR LAKE ONTARIO	13 MONITOR LAKE ONTARIO	14 ARRIVE CCIW 1800 HRS.
JUNE	15 CCIW	16 DEPART CCIW 1000 HRS.	17 MELON PROJECT LAKE ONTARIO	18 MELON PROJECT LAKE ONTARIO	19 ARRIVE CCIW 1430 HRS.	20 DEPART CCIW 0900 MELON MONITOR	21 ARRIVE CCIW 1600 HRS.
	22 CCIW	23 DEPART CCIW 0930 MELON MOORINGS	24 ARRIVE CCIW 2100 HRS.	25 CCIW	26 DEPART CCIW 0900 ARRIVE CCIW 2100	27 CCIW	28 CCIW
	29 CCIW	30 CCIW	1 CCIW	2 DEPART CCIW 0900 HRS.	3 TEMP. SURVEY LAKE ERIE	4 TEMP. SURVEY LAKE ERIE	5 TEMP. SURVEY LAKE ERIE
	6 TEMP. SURVEY LAKE ERIE	7 ARRIVE CCIW 1000 HRS.	8 DEPART CCIW 1000 HRS.	9 MONITOR LAKE ONTARIO	10 MONITOR LAKE ONTARIO	11 MONITOR LAKE ONTARIO	12 MONITOR LAKE ONTARIO
JULY	13 ARRIVE CCIW 1800 HRS.	14 CCIW	15 CCIW	16 DEPART CCIW 1035 HRS.	17 FIELD TESTS LAKE ONTARIO	18 FIELD TESTS LAKE ONTARIO	19 ARRIVE CCIW 1600 HRS.
	20 CCIW	21 DEPART CCIW 1215 HRS.	22 FIELD TESTS LAKE ONTARIO	23 FIELD TESTS LAKE ONTARIO	24 ARRIVE CCIW 1540 HRS.	25 CCIW	26 CCIW
	27 CCIW	28 DEPART CCIW 0930 HRS.	29 COOT-MONITOR LAKE ERIE	30 COOT-MONITOR LAKE ERIE	31 COOT-MONITOR LAKE ERIE	1 COOT-MONITOR LAKE ERIE	2 ARRIVE CCIW 1000 HRS
	3 CCIW	4 CCIW	5 DEPART CCIW 1100 HRS	6 MONITOR LAKE ONTARIO	7 MONITOR LAKE ONTARIO	8 MONITOR LAKE ONTARIO	9 MONITOR LAKE ONTARIO
AUG	10 ARRIVE CCIW 0950 HRS	11 CCIW	12 DEPART CCIW 0950 HRS	13 CORING LAKE ONTARIO	14 CORING LAKE ONTARIO	15 CORING LAKE ONTARIO	16 ARRIVE CCIW 1130 HRS
	17 CCIW	18 DEPART CCIW 0928 HRS	19 CORING LAKE ERIE	20 CORING LAKE ERIE	21 CORING LAKE ERIE	22 ARR P. COLBORNE 1200 HRS	23 P. COLBORNE
	24 P. COLBORNE	25 DEP. P. COLBORNE 1210 HRS	26 COOT-MONITOR LAKE ERIE	27 COOT-MONITOR LAKE ERIE	28 COOT-MONITOR LAKE ERIE	29 COOT-MONITOR LAKE ERIE	30 ARRIVE CCIW 0720 HRS
	31 CCIW	1 CCIW	2 CCIW	3 CCIW	4 DEPART CCIW 1200 HRS	5 MONITOR LAKE ONTARIO	6 MONITOR LAKE ONTARIO
SEPT	7 MONITOR LAKE ONTARIO	8 MONITOR LAKE ONTARIO	9 MONITOR LAKE ONTARIO	10 ARRIVE CCIW 1045 HRS	11 CCIW	12 CCIW	13 DEPART CCIW 0800
	14 MONITOR LAKE ERIE	15 MONITOR LAKE ERIE	16 MONITOR LAKE ERIE	17 MONITOR LAKE ERIE	18 ARR WINDSOR 1130 HRS	19 WINDSOR	20 WINDSOR
	21 WINDSOR	22 DEPART WINDSOR 0800 HRS	23 MONITOR LAKE HURON	24 MONITOR LAKE HURON	25 MONITOR LAKE HURON	26 MONITOR LAKE HURON	27 MONITOR LAKE HURON
	28 MONITOR LAKE HURON	29 MONITOR LAKE HURON	30 MONITOR LAKE HURON	1 MONITOR LAKE HURON	2 ARR CCIW 0100 DEP CCIW 1700	3 MONITOR LAKE ONTARIO	4 MONITOR LAKE ONTARIO
	5 MONITOR LAKE ONTARIO	6 MONITOR LAKE ONTARIO	7 MONITOR LAKE ONTARIO	8 ARR CCIW 1240 HRS	9 CCIW	10 CCIW	11 CCIW
OCT	12 CCIW	13 CCIW	14 DEPART CCIW 1000 HRS	15 TEMP MONITOR LAKE ERIE	16 TEMP MONITOR LAKE ERIE	17 TEMP MONITOR LAKE ERIE	18 TEMP MONITOR LAKE ERIE
	19 TEMP MONITOR LAKE ERIE	20 TEMP MONITOR LAKE ERIE	21 ARRIVE CCIW 0100	22 DEPART CCIW 1020 HRS	23 SEDIMENT SAMPLING	24 LAKE ONTARIO	25 SEDIMENT SAMPLING
	26 SEDIMENT SAMPLING	27 LAKE ONTARIO	28 SEDIMENT SAMPLING	29 LAKE ONTARIO	30 ARRIVE CCIW 1200 HRS	31 DEPART CCIW 1235 HRS	1 MONITOR LAKE ONTARIO
	2 MONITOR LAKE ONTARIO	3 MONITOR LAKE ONTARIO	4 MONITOR LAKE ONTARIO	5 ARRIVE CCIW 0945 HRS	6 CCIW	7 CCIW	8 CCIW
NOV	9 CCIW	10 CCIW	11 CCIW	12 DEPART CCIW 1000 HRS	13 TEMPERATURE SURVEY	14 LAKE SUPERIOR	15 TEMPERATURE SURVEY
	16 LAKE SUPERIOR	17 TEMPERATURE SURVEY	18 LAKE SUPERIOR	19 TEMPERATURE SURVEY	20 LAKE SUPERIOR	21 TEMPERATURE SURVEY	22 LAKE SUPERIOR
	23 TEMPERATURE SURVEY	24 LAKE SUPERIOR	25 TEMPERATURE SURVEY	26 LAKE SUPERIOR	27 ARRIVE CCIW 1845 HRS	28 CCIW	29 CCIW
	30 CCIW	1 DEPART CCIW 1205 HRS	2 MONITOR LAKE ONTARIO	3 MONITOR LAKE ONTARIO	4 MONITOR LAKE ONTARIO	5 MONITOR LAKE ONTARIO	6 ARRIVE CCIW 1120 HRS
DEC	7	8	9	10	11	12	13

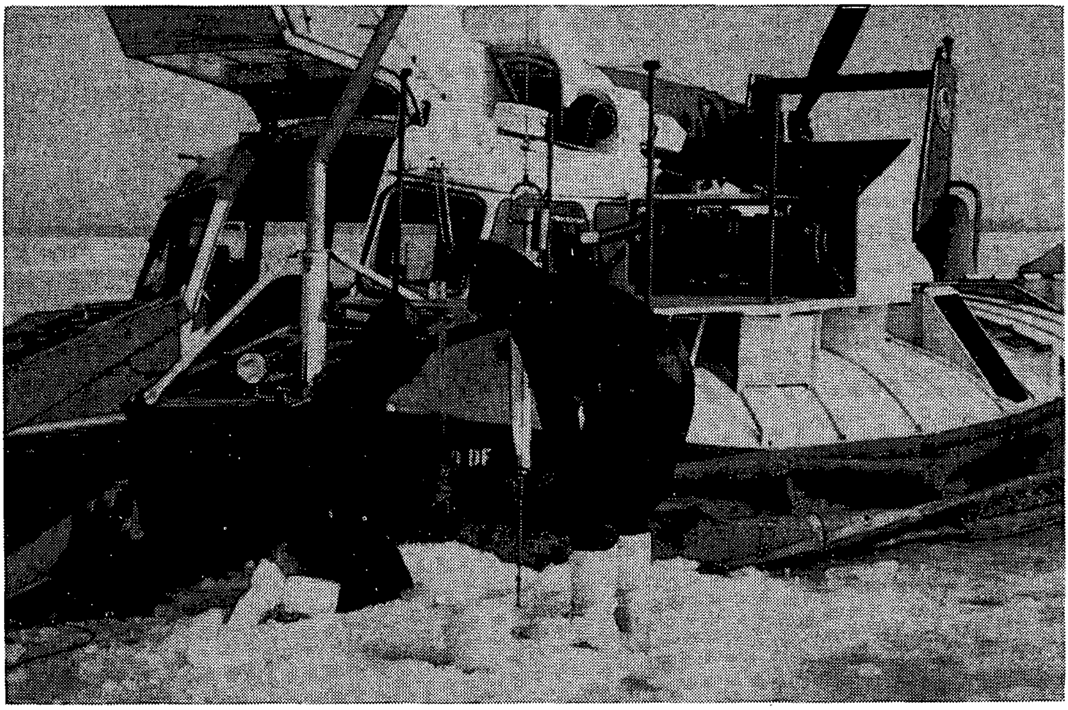


Figure 9. Sampling on Lake Erie from SK-5 Hovercraft, February 1969.

Scientific Towers – Technical Operations Section coordinated the erection of four scientific towers for measurement of water conditions and related meteorological factors in lake locations at Oshawa, Hamilton Beach, Grimsby (Jordan Harbour) and Lake 239, Kenora.

Administration Section

During 1969, the administrative support staff provided services such as budgeting, financial control, auditing, accounting and procurement of equipment, instruments, and material and supplies requirements for all sections of the Great Lakes Division. In addition, the Section was responsible for duplicating, typing service and accommodation for all components involved in the research program located in temporary quarters on site.

The Section has also been actively involved in procuring furniture and equipment, and planning of accommodation and facilities for the new buildings, now under construction.

Coordinator's Office for International Field Year for the Great Lakes (IFYGL)

Beginning in February 1969, CCIW provided staff and facilities for an office for the coordination of the Canadian scientific programs in the International Field Year for the Great Lakes. This program is part of the International Hydrologic Decade and the coordinator has close contact with the office of the Canadian secretariat of the Canadian National Committee for the IHD, in Ottawa.

IFYGL is a joint United States–Canadian study which has been planned for several years, to provide a better understanding of basic physical processes in the lakes for improvement of Great Lakes water resource management. It is to take maximum advantage of capabilities of both Unites States and Canadian research groups in a fully coordinated intensive attack on Lake Ontario physical problems.

The ongoing activities of both Canadian and United States agencies and researchers will gain through this coordinated program.

The opportunity is also being taken to use Lake Ontario as a model ocean to undertake investigations of air-water interactions needed to improve long-range weather forecasting techniques. The intensive data collection phase, scheduled to start on January 1, 1972, will last for 12 months. A number of provincial, federal and university agencies are contributing to the program.

The general program guidance for IFYGL is the responsibility of an eight-man steering committee, with four representatives from each country. Scientific program recommendations to the steering committee are provided by bi-national working groups chaired by Dr. G.T. Csanady, University of Waterloo, Dr. G.K. Rodgers, Great Lakes Institute, University of Toronto, Mr. J.A.W. McCulloch, Meteorological Branch, Department of Transport, and Mr. D.F. Witherspoon, Engineering Division, Inland Waters Branch, Department of Energy, Mines and Resources. The program will consist of "core" projects in lake meteorology, water movement, energy budget and water budget. Special research projects can be carried out by workers from many countries to take advantage of the core program data.

The Canada Centre for Inland Waters has endorsed the proposed core program and has committed part of its ship, launch, tower, buoy and current-meter resources to the program. The Department of Transport has committed the *Porte Dauphine* to the Great Lakes Institute, University of Toronto which in turn has committed this to the Field Year. Meteorological Branch, Department of Transport has agreed to undertake the Canadian part of the meteorological aspects of the core program.

The IFYGL program addresses itself to the physical aspects of the basin. The biological and chemical community will take the opportunity to intensify their work in Lake Ontario in 1972. CCIW ship cruises are being planned to provide accommodation and facilities to biologists and chemists.

Scientists from all nations have been invited to participate in the Field Year. CCIW will play a major role in providing facilities for such workers.

The CCIW library, in collaboration with the coordinator, is providing a continuing abstracting service for the Field Year and is making the abstracts available to all interested parties.

A data centre is being established at CCIW as the Canadian Data Centre for management, dissemination and custody of core data from the program.

LIBRARY

The library collection is being developed toward the goal of CCIW eventually having a comprehensive library on water resources, with special emphasis in the Centre's fields of water pollution, lakes and hydraulics.

The collection now consists of 4,000 books and 955 serials (these include 105 data series, 75 reports-in-series, 20 major abstracting services and the remainder, periodicals). Sixteen hundred back volumes of selected periodicals have been obtained (on microfilm where possible). Twelve hundred reprints from older journals have been requested by scientific staff members and obtained for them. Translations of 16 foreign language articles were made for staff members during the year by the federal government's Translation Bureau.

Exchanges of publications have been arranged with 75 other institutions and CCIW produced a first volume of collected reprints during 1969 for exchange purposes.

A revised list of serial holdings has just been completed, the acquisitions list continues to be produced twice monthly and the staff is cooperating with Mr. MacDowall in producing an annotated IFYGL bibliography. A bibliography of staff articles is also compiled annually for distribution to interested persons who can obtain reprints of those articles of interest. The librarian acts as search editor for scientists' computer profiles; two profiles were composed during the year and further ones will be developed in 1970. Planning for a computer-produced index to our reports-in-series is under way. The library has recently taken responsibility for CCIW's collection of slides and organization of these is in progress.

The library is open to persons engaged in water research and a number of university students and other research workers used the collection during the year. An increasing number of requests for inter-library loans are being received as the library grows. Cooperation with other libraries is continually being expanded.

Plans for the new permanent library facilities are being made; some systems analysis of library procedures is planned prior to detailed specifications for the work area in the new library.

MARINE SCIENCES BRANCH DETACHMENT

The increase in field activity at the Centre was reflected in the expansion of Branch support, both in fleet strength and in personnel.

Three new craft, a 44-ft aluminum vessel, a 34-ft steel launch and a 40-ft pontoon boat, were acquired bringing the total launch complement to 10.

CSS Padel II, a 113-foot Fairmile class cutter was transferred to the Marine Sciences Branch from National Research Council and assigned to CCIW.

The ice-strengthened *MV Martin Karlsen* (ex-*KRISTA-DAN*) was chartered for a three-year period. The tug *Lac Erie* was also chartered for a similar period.

Two Decca minifix positioning systems were operated in support of field programs. The extensive survey control and calibration required for one of these chains was provided by George Wimpey & Co. Ltd. under contract.

DEPARTMENT OF NATIONAL HEALTH AND WELFARE

Public Health Engineering Division – Part of the Division bacteriological staff participated in eight Great Lakes monitor cruises during 1969; five cruises were made on Lake Ontario, two cruises on Lake Erie; and one on Lake Huron. Five of the cruises were made to obtain information on the distribution and density of "health-oriented bacteria"; i.e., coliforms, fecal coliforms, and the Proteus group. The other three cruises were made to obtain information on the distribution and density of specific autotrophic bacteria and to obtain information on bacterial biomass distribution. During the above cruises, 1,536 samples of lake water were collected and a total of 5,728 tests were performed on these samples.

The Kingston bacteriological laboratory participated in a project designed to examine the surface and colloidial properties of lake sediments in selected Lake Ontario sites. This project was carried out under the overall title of MELON I. A total of 208 tests were performed on 27 core samples shipped to our laboratory. Listed below are the parameters for which the core samples were tested:

1. Methane production, MPN;
2. Iron oxidizing bacteria, MPN;
3. Sulphur reducing bacteria, MPN;
4. Aerobic viable (MF) counts at 35°C, 20°C and 4°C;
5. Anaerobic viable (MF) counts at 20°C;
6. Determination of dehydrogenase activity; and
7. Autotrophic ammonium – oxidizing bacteria.

A taxonomic study of the heterotrophic bacteria found in Lake Ontario was initiated in 1969. This is an ongoing project that is expected to take three to four years.

POLICY AND PLANNING BRANCH DETACHMENT

This unit, under the direction of Dr. T. Lee, will be responsible for developing research programs concerning water use complementary to existing natural science programs. The unit will examine aspects of the social and economic role of the Great Lakes in relation to water management problems.

Present staff of the unit, four members, are qualified in economics, sociology and geography. An overall research program for the unit is presently being developed and individual members will be taking part in ongoing research programs at the Centre.

PUBLIC RELATIONS AND INFORMATION SERVICES

Effective water management depends on cooperation at all levels of the community. Public understanding of the objectives of the Centre is therefore vital to their achievement and to the ultimate application of the Centre's research findings.

From the Centre's beginning, there has been no shortage of public interest in its activities. Journalists representing both printed and electronic media, civic interest groups, university students, teachers, service clubs, school children and others have made many hundreds of enquiries concerning the Canada Centre for Inland Waters, its purpose, work and achievements.

The Centre's need to tell and the public's need to know, resulted in the appointment in late spring of a public relations officer and the subsequent establishment of a public relations unit at the Centre.

During the year, stories and feature articles on the Centre and its work appeared in various newspapers and magazines, and in radio and television programs.

A major article appeared in the Hamilton Spectator in June. Time magazine included a report on CCIW in a special article on pollution in a July issue. An article on the Centre's activities as related to, and assisted by small-boat owners was prepared in July for the magazine, Canadian Boating. The Burlington Gazette interviewed the acting director of the Centre for a special article on pollution. Radio station CFOS reported a special story on the Lake Huron cruise of *Limnos* and Dofasco public relations staff ran a story and pictures of the Centre in its staff magazine.

The Lake Erie Time Study project was the subject of a special news conference and was widely reported in newspapers throughout the Niagara Peninsula as well as in publications in the United States. The same study was also featured in a later report by a Hamilton Spectator reporter who was flown to the barge for exclusive interviews with the scientists involved.

A visit to the Centre in August by the Minister then responsible for water, Hon. Otto Lang also provided an opportunity for interviews and stories which were given good coverage by all the local media.

In September, television viewers throughout the Peninsula were introduced to the Centre and its work through a Saturday evening program which was doubled in length for the occasion. Filmed over a three-day period earlier in the summer, it focussed on a cruise of the *MV Martin Karlsen* and the associated research work involved.

During September, the Toronto Star, the Toronto Telegram and radio station CHAM in Hamilton also carried stories based on interviews with CCIW officials.

Public speaking engagements for the public relations officer and for various other staff members, included service clubs, professional associations and civic interest groups.

To increase the effectiveness of public tours of the laboratories and ships, a slide show was produced, early in the year which by year's end had been shown to audiences which totalled several thousand.

Schools and universities were especially interested in the CCIW and in the last three months of 1969, requests for literature, for visits to the Centre and for speakers from the Centre resulted in young audiences alone totalling more than 970.

In October talks were begun with Hamilton school teachers with a view to developing more effective ways of communicating with students. At the close of the year, these talks had produced enthusiastic response and some original and promising ideas for further consideration.

Design of a logogram to instantly identify CCIW on signs, letterheads, vehicles, ships and buildings was completed. Moreover, as the year closed, a comprehensive public relations program had been drafted, including detailed planning for a number of new publications, audio-visual aids and other communications vehicles.

SUPPORT SERVICES

Building Program

The year 1969 saw the completion of the site development and prime site services for the permanent Canada Centre for Inland Waters. These facilities include underground water distribution, storm sewers, an underground high-voltage electrical service, gas mains, a launch basin, a breakwater, major ship berthing facilities, main roadways and electrical distribution for the buildings and outside lighting.

The design of the heating and cooling plant, the research and development building, the warehouse workshop building, and the main laboratory and administration building was completed during the year. Design of the water quality pilot plant progressed to an advanced stage and the hydraulics research building design concept was near completion.

A contract was awarded in September 1969 for the construction of the first buildings. This contract covers the heating and cooling plant, the research and development building and the warehouse workshop building. Construction work is on schedule and the initial buildings will be occupied by the Centre's personnel during 1970.

Foundations for the main laboratory and administration building were contracted for in November 1969, and tenders for the construction of the building will close in January 1970. This building should be completed in the spring of 1972.

Construction of the water quality pilot plant is expected to commence in the spring of 1970. Completion of this plant is scheduled for early 1971.

The hydraulics laboratory will be the final building to be constructed. Present schedules call for its completion during the calendar year 1972.

WATER QUALITY DIVISION DETACHMENT

The CCIW detachment of the Water Quality Division is responsible for coordinating, planning, organizing and conducting chemical analyses of Great Lakes waters for water quality and pollution studies, and for research and development of analytical methodology for these waters.

During 1969 this Detachment was actively engaged in coordinating analytical requests and conducting the chemical monitoring of Great Lakes waters. Intensive studies were made on Lake Ontario while some analytical background data on water quality for lakes Erie, Huron and Superior were obtained. The chemical monitoring program is carried out to provide information on changes and trends in water quality of the main body of the Great Lakes and to provide base-line data to permit assessment of the impact of pollution abatement programs. Completed projects of the Detachment for the year are:

1. Chemical Monitoring — Twelve full chemistry monitor cruises; 9 on Lake Ontario, 2 on Lake Erie and 1 on Lake Huron were completed. Approximately 2,600 water samples from these cruises were analyzed for orthophosphate, silica, nitrate, ammonia, alkalinity and total phosphate. About 6,000 samples were analyzed by Technical Operations Section personnel for specific conductance, turbidity and dissolved oxygen for which the reagents, techniques, and instruments as well as the technical supervision were provided by the Water Quality Division Detachment. About 1,100 water samples collected from lakes Ontario, Erie and Huron were analyzed at the shore laboratories for cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, vanadium and zinc by atomic absorption spectrophotometry using solvent extraction techniques.

2. Water Quality Network — As part of the total sampling program, 60 designated water quality network stations on lakes Ontario, Erie, Huron and Superior were visited once during the year for assessing long-term continuous water quality trends in these lakes. Samples from these stations were analyzed for nutrients and other major constituents.

3. Interstitial Waters — About 170 samples of interstitial waters from sediments of western Lake Ontario were analyzed for major and minor constituents for the Great Lakes Division.

4. Rain Water Quality — A joint investigation with the Chemical Limnology Section, was carried out on the quality and treatment of glass wool for use as filter plugs for collecting rain water samples. Investigations indicated that even the pyrex glass wool not treated with acid and adequately washed with double distilled water was a source of contamination of rain waters in which nutrients and trace metals were determined. About 15 rain water samples collected by the Chemical Limnology Section from five meteorological stations during August, September and October were analyzed for major ions, nutrients, and trace elements composition.

5. Scientific Training — Nine technical personnel from the Technical Operations Section, were trained for a period of one week on instrument methods and techniques to determine pH, conductance, turbidity, and dissolved oxygen. Two persons from the Chemical Limnology Section, were trained on the automated analyses of nutrients, and were provided with methods to analyze samples connected with the MELON project. Three post-graduate students from the University of Guelph were

also trained on automated methods for determining nutrients and on the operation of automatic analyzers. The students are working under a contract between their University and CCIW on ecological studies in the Grand River mouth–Lake Erie region. The training was provided to ensure that uniform analytical methods are used in the study of Great Lakes and its tributary waters.

6. Special Studies

i. A special survey of Hamilton Bay was conducted to check on the effects of hydrochloric acid on the waters of this Bay.

ii. Analyses for oil and grease were made on samples collected of Great Lakes waters by McMaster University for the contracted project to study the emissivity of the water surface under various conditions (see Physical Limnology Section of this report).

iii. Special micronutrient analyses were made for bio-assay projects of the Fisheries Research Board to study the limiting micronutrients for algae.

7. Research and Development on Methodology and Instrumentation — To determine very small amounts of increased or decreased annual pollution loads it is essential that continual research and development of analytical methods be made and in this regard the following studies were conducted:

i. A simultaneous, four-channel, continuous automated assembly was developed for measuring soluble nutrients onboard ships.

ii. A multiple filtration assembly was developed for quick and continuous filtration of samples for trace-element analyses.

iii. Two new instruments, an organic carbon analyzer and a submersible water-quality monitor, were evaluated and calibrated for Great Lakes studies.

iv. An automated colorimetric method for the determination of less than 5 ppm sulphate was evaluated, modified and is under investigation.

v. Automatic atomic absorption methods for manganese, molybdenum and vanadium were investigated and set up to determine these metals which are found in trace quantities in Great Lakes waters; methods are sensitive to 0.1, 0.1 and 0.2 part per billion respectively.

These methods are being described for publication.

APPENDIX A

CCIW Staff (as of December 1969)

Acting Director, CCIW – J.P. Bruce
Secretary – Miss L.F. Leiper
Executive Assistant to A/Director, CCIW – T.S. Hillis
Librarian – Mrs. E.A.C. Fosdick
Building Services Superintendent – D.F. Stewart
Support Staff, CCIW – Miss A.E. Boerchers, Mrs. C.E. Davidson, C.F. Hicks, G.M. Mowbray, Mrs. B.D. Titley, Mrs. E. Vos

Environmental Quality Coordination Unit

Head, Dr. A.R. LeFeuvre
Technical Support – H.H. Dobson
Personnel Administration, CCIW – Miss R. Kelly, Mrs. C. Shepherd, Miss M.R.J. Warren

DEPARTMENT OF FISHERIES AND FORESTRY

Fisheries Research Board Detachment

Head, Dr. R.A. Vollenweider
Support Staff – G.F. Carpenter, R.H. Collins, J.K. Leslie, J.E. Moore, H.F. Nicholson, Miss L.L. Sully
Postdoctoral Fellow – Dr. M. Munawar (jointly with Chemical Limnology Section, Great Lakes Division)
Senior Scientific Staff of Freshwater Institute, Winnipeg, working on Great Lakes Problems

Director, Dr. W.E. Johnson
Scientific Leader, Eutrophication Section, Dr. J.R. Vallentyne
Dr. A.L. Hamilton
Dr. K. Patalas
Dr. J. Stockner

DEPARTMENT OF NATIONAL HEALTH AND WELFARE

Public Health Engineering Division

Liaison Officers – Dr. C.P. Fisher, Ottawa; B.J. Dutka, Kingston
Support Staff – P. Collins, A. Jurkovic, A. Menon, H. van Otterloo

DEPARTMENT OF ENERGY, MINES AND RESOURCES

Great Lakes Division, Inland Waters Branch

Chief, J.P. Bruce

Chemical Limnology Section

Scientific Staff	Research Fields
Head, Dr. Mary E. Thompson	specific-ion electrodes; low temperature aqueous geochemistry
Dr. N.M. Burns	physical chemistry of water; carbon cycle in lakes
Dr. Y.K. Chau	trace elements in the lake environment
Dr. A. Lerman	geochemistry of brines; radioisotopes in lake sediments
Dr. R.F. Platford	physical chemistry of aqueous solutes
Dr. R.R. Weiler	surface chemistry of sediments
Postdoctoral Fellow – Dr. C.W. Childs	physical chemistry of aqueous solutes

Chemists

M.E. Fox	soluble organic compounds in large lakes
H. Saitoh	trace elements
M.T. Shiomi	atmospheric precipitation chemistry; nutrient cycles in large lakes

Technical Staff – R.D. Coker, R.W. Kuntz

Computer and Data Services Section

Acting Head, D.M. Francis
Programmers – Miss P. Lloyd Jones, H.C. Pulley
Support Staff – W. Nagel, Mrs. P.A. Moody, Mrs. K.M. Schopf, Mrs. M. Kinder

Engineering Systems Section

Head, G.A. Jones
Electronics Unit Head – A.E. Eatock
Electronics Engineers – K.N. Birch, K.R. Peal
Mechanical Unit Head – A.E. Pashley
Mechanical Engineer – P.M. Ward-Whate
Technologists – J.A. Diaz, D.P. Fekyt, M. Pedrosa, J.G.M. Laroque, H.A. Savile, R. Boucher, J.D. Heidt
Drafting Office – W. Finn, Miss S. Longstaffe

Physical Limnology Section

Scientific Staff	Research Fields
Head, Dr. R.K. Lane	remote sensing, heat exchange
Dr. H.S. Weiler	circulation, air-lake interaction
Dr. C.R. Murthy	diffusion, circulation
F.C. Elder	air-lake interaction; thermal effluents
F.M. Boyce	internal waves, heat content, oil slicks
P.F. Hamblin (educational leave)	circulation, seiches
D.G. Robertson	descriptive limnology, climatology
H.W. MacPhail	electronics

Technical Staff – D.C. Beesley, R.G. Chapil, F. Chiocchio, R.K. Dolling, K.C. Miners, W.J. Moody, W.D. McColl H.K. Nicholson, Mrs. V. Jackson

Limnogeology Section

Scientific Staff	Research Fields
Head, Dr. P.G. Sly	distribution and variance of lake bottom sediments
Dr. C.F.M. Lewis (GSC)	post-glacial uplift and stratigraphic correlation of recent sediments
Dr. A.L.W. Kemp	distribution and diagenesis of organic compounds in recent sediments
Dr. N.A. Rukavina	interpretation of sediment distributions in nearshore zone
Dr. R.L. Thomas	distribution, occurrence and authogenesis of minerals, major elements and trace metals in recent sediments
J.P. Coakley	distribution, occurrence and relation to erosion, transportation and deposition of active sediments
C. Gray	diagenesis of recent organic compounds
W. Warwick	palaeoecological interpretation of chironomids

Technical Staff – W. Booth, G. Duncan, Mrs. M. Hicks, Mrs. M. Istvanov, Mrs. L. Mansey, Mrs. A. Mudrochova, R. Sandilands

Technical Operations Section

Head – H.B. Macdonald
Special Assignments – D.J. Cooper
Senior Operations Officer, *CSS Limnos* – A. Holler
Senior Operations Officer, *MV Martin Karlsen* – H.W. MacPhail (transferred to Physical Limnology, Oct. 1969)
Senior Operations Officer – D. Hanington (relieving duties, *CSS Limnos* and *MV Martin Karlsen*)
Technical Staff – K. Barnes, L. Benner, H. Cho, H. Gschwind, P. Healey, M. Mawhinney, B. Moore, H. Ng, L. Piniuta, P. Seidenberg, F. de Vree, S. Withers, P. Youakim

Administration Section

Head – H. Lawson
Support Staff – J.L. Harris, Mrs. S.M. Horne, D.G. Jefferson, A.W. Mayes, Miss I. O'Connor

International Field Year for Great Lakes

Canadian Coordinator – J. MacDowall

Marine Sciences Branch Detachment

Head – A. Quirk
Support Staff – Capt. T. Mangan, J.E. Parsons, Miss L.A. Thomson, K.D. Robertson, J. Allan, H.E. Greencorn, F.M. Morrison, J.G. Delorey, D.G. Ashdown, N.L. Keeping, N.L. Goulden, G.A. Boutillier, J.H. Maccabe, G. Sproule (23 ships crews – seasonal)

Policy and Planning Branch Detachment

Miss M.R. Sinclair
J.N. Thomson
Miss N.M. Wakulin

Public Relations and Information Services

A.R. Kirby

Water Quality Division Detachment, Inland Waters Branch

Head – Dr. V.K. Chawla
Technical and Scientific Support – H. Alkema, W.D. Blythe, O. El Kei, S. Meszaros, F. Philbert, Y.M. Sheikh

APPENDIX B

Committees and Associations

American Meteorological Society, Committee on Water Resources – Dr. R.K. Lane
American Water Resources Association, Board of Directors – J.P. Bruce
Canadian Aeronautics and Space Institute, Founder member of the Hydronautics Section – J. MacDowall
Committee on Water Resource Applications, Program Planning Office for Interdepartmental Committee on Resources Satellites and Airborne Remote Sensing, Chairman – Dr. R.K. Lane
Instrumentation Advisory Committee, Mohawk College – G.A. Jones
Interdepartmental Committee on Submersibles – Dr. P.G. Sly
Interdepartmental Working Group on Contingency Plans, Chairman – J.P. Bruce; Members – F.M. Boyce, Dr. A.R. LeFeuvre
International Association for Great Lakes Research (IAGLR), Vice-president – J.P. Bruce; Editorial Board, Proceedings of 13th IAGLR Conference – Dr. R.K. Lane, Dr. P.G. Sly; Exhibits Committee, 13th IAGLR Conference, Canadian Chairman – G.A. Jones
International Field Year for the Great Lakes, Canadian Coordinator – J. MacDowall;
Energy Budget – Dr. R.K. Lane, F. Boyce;
Lake Meteorology Working Group – F.C. Elder;
Steering Committee – J.P. Bruce;
Terrestrial Water Balance – Dr. R.K. Lane;
Water Movement Working Group – Dr. H.S. Weiler.
24th International Geological Congress – 1972, Montreal – Excursion Planning – Dr. P.G. Sly, Dr. C.F.M. Lewis
National Research Council Associate Committee on Avionics – J. MacDowall
National Research Council Subcommittee on Hydrology – Dr. R.K. Lane
North American Working Group on Manganese – Dr. R.L. Thomas
Solid Earth Science, Marine Geology Committee of the Science Secretariat – Dr. P.G. Sly

APPENDIX C

Publications and Presentations

Boyce, F.M., 1969, "Technical Aspects of Oil Spill Clean-up", Contribution to the Intern. Lake Erie Water Pollution Board report to IJC, Oct. 1969.

Bruce, J.P., *et al.*, Working Group of the World Meteorological Org. Comm. for Hydrometeorology, 1969, *Estimation of Maximum Floods*. World Meteorological Organization, Tech. Note No. 98, 228 p.

Bruce, J.P., 1969. "The Science Secretariat Study of Water Resources Research in Canada". *Proc. Colloquium on Water Resources Res. in the Atlantic Region*, Fredericton, Mar. 1969, p. 62-75, U.N.B., 1969, 112 p.

Chau, Y.K. and Lum-Shue-Chan, K., 1969. "Errors in the use of Volumetric Flasks for Extraction in Atomic Absorption Spectroscopy". *Anal. Chim. Acta.*, v. 48, p. 434-7.

Chau, Y.K. and Lum-Shue-Chan, K., 1969. "Atomic Absorption Determination of Microgram Quantities of Molybdenum in Lake Water". *Anal. Chim. Acta.*, v. 48, p. 205-212.

Chawla, V.K. and Chau, Y.K., 1969. "Trace Elements in Lake Erie". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 742-747.

Coakley, J.P. and Hamblin, P.F., 1969. *Preliminary Investigations of Lake Diefenbaker, Sask., Aug. 19-23, 1968.* CCIW paper (in press).

Cooper, D.J., 1969. *SK-5 Hovercraft Trials.* CCIW paper, 30 p.

Elder, F.C., 1969. "What *is* Water Pollution?". *Sea Harvest and Ocean Science.* Dec. 1969/Jan. 1970, p. 35-37.

Elder, F.C., 1969. "Critical Review of the Book *Water Resources of Canada*". *Bull. Am. Met. Society*, v. 50(10), p. 810-811.

Elder, F.C., Harris, D.L. and Taylor, A., 1969. "Some Evidence of Organized Flow over Boundary Waves". Boundary Layer Met. (in press).

Hamblin, P.F., 1969. *Circulation and Water Movement in Lake Erie.* Inland Waters Branch Scientific Series (in press).

Hamblin, P.F., 1969. "Hydraulic and Wind Induced Circulation in a Model of a Great Lake". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 567-582.

Hobson, G.D., Herdendorf, C.E., Lewis, C.F.M., 1969. "High Resolution Reflection Seismic Survey in Western Lake Erie". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, p. 226-240.

Kemp, A.L.W., 1969. "Organic Matter in the Sediments of Lakes Ontario and Erie". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 237-249.

Kirby, A.R., 1969. "Thanks, Boat Owners". *Canadian Boating* (in press).

Lane, R.K., 1969. "Great Lakes Thermal Studies Using Infrared Imagery", *Limnology & Oceanography* (in press).

Lane, R.K., 1969. "Discussion on 'Infrared Remote Sensing' by T.L. Richards". *Proc. 7th Can. Hydrology Symp.* (in press).

Lane, R.K., 1969. "Remote Sensing: A Valuable Technique for Studying our Waters", *Science Forum*, v. 10(4), p. 31-33.

Lerman, A., 1969. "Identification and Analysis of Phosphate Minerals". In *Anal. Chem. of Phosphorus Compounds*, MM. Halman, ed., N.Y., Wiley, 1969.

Lerman, A., 1969. "Sea water – Geochemical Balance". In *Encyclopedia of Earth Science* (in press).

Lewis, C.F.M., 1969. "Late Quaternary History of Lake Levels in the Huron and Erie Basins", *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 250-270.

Lewis, C.F.M., 1969. "Late Holocene Uplift of Manitoulin Island, Ontario." (Submitted to *Can. J. Earth Sci.*).

Murthy, C.R., 1969. "Large Scale Diffusion Studies at Niagara River Mouth, Lake Ontario". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 635-651.

Murthy, C.R. and Csanady, G.T., 1969. "An Experimental Study of Relative Diffusion in Lake Huron". *J. Physical Oceanography* (in press).

Platford, R.F., 1969. "Osmotic and Activity Coefficients of Some Simple Borates in Aqueous Solution at 25°". *Can. J. Chem.*, v. 47(12), p. 2271-3.

Prince, A.T. and Bruce, J.P., 1969. "Canadian Scientific Programs for Optimum Management of Great Lakes Water Resources". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 849-854.

Rukavina, N.A., 1969. "Nearshore Sediment Survey of Western Lake Ontario, Methods and Preliminary Results". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 317-324.

Rust, B.R. and Coakley, J.P., 1969. "Physio-Chemical Characteristics and Post-Glacial Desalination of Stanwell-Fletcher Lake, Arctic Canada". (Submitted to *Can. J. Earth Sci.*)

Sly, P.G., 1969. "Sedimentological Studies in the Niagara Area of Lake Ontario and in the Area Immediately North of the Bruce Peninsula and Georgian Bay". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 341-346.

Sly, P.G., 1969. "Bottom Sediment Sampling". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 855-870.

Thomas, R.L., 1969. "A Note on the Relationship of Grain Size, Clay Content, Quartz and Organic Carbon in some Lake Erie and Lake Ontario Sediments", *J. Sed. Petrol.*, v. 39(2), p. 803-809.

Thomas, R.L., 1969. "The Qualitative Distribution of Feldspars in Surficial Bottom Sediments from Lake Ontario". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 364-379.

Vollenweider, R.A., 1968/69. *Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors of Eutrophication.* OECD Tech. Rept. OECD/DAS/CSI/68.27, 220 pages, 34 illustrations. Translated into German, French and English.

Vollenweider, R.A., 1969. *A Manual on Methods for Measuring Primary Production in Aquatic Environments.* IBP Handbook No. 12. Blackwell Scientific Publications, Oxford and Edinburgh, 244 pages, 23 illustrations.

Vollenweider, R.A., 1969. "Moglichkeiten und Granzen elementarer Modelle der Stoffbilanz von Seen (Possibilities and limits of elementary models concerning the budget of substances in lakes)". *Arch. Hydrobiol.* 66(1): 1-36.

Vollenweider, R.A., 1969. "Models for Calculating Integral Photosynthesis and Some Implications Regarding Structural Properties of Community Metabolism of Aquatic Systems". IBP/PP Tech. Meeting: Productivity of Photosynthetic Systems, Prague, Sept. 14-21, 1969 (in press).

Weiler, H.S., 1969. "Prediction of Vertical Profiles of Wind Speed over a Lake". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 492-503.

Weiler, R.R. and Chawla, V.K., 1969. "Dissolved Mineral Quality of Great Lakes Waters". *Proc. 12th Conf. Great Lakes Res.*, Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich., p. 801-818.

Papers Reporting on Work Done Prior to Joining CCIW Staff

Bloxam, T.W. and Thomas, R.L., 1969. "Palaeontological and Geochemical Facies in the Gastrioceras Subcrenatum Marine Band and Associated Rocks from the North Crop of the South Wales Coalfield", *Quart. J. Geol. Soc.*, London, v. 124, p. 239-281.

Bloxam, T.W. and Thomas, R.L., 1969. "Fluorine on Carboniferous Shales from the South Wales Coalfield", *Chem. Geol.* (in press).

Chawla, V.K., 1969. "Available Nitrogen and Phosphorus Status of Saline-Sodic Soils of Punjab (India)". *Agronomy J.*, v. 61, p. 361-2.

Childs, C.W., 1969. "Equilibria in dilute aqueous solutions of orthophosphates". *J. Phys. Chem.*, v. 73(9), p. 2956-2960.

Elder, F.C. and Soo, H.K., 1969. *Some Wind Stress Measurements over Wave Surfaces.* Spec. rept. #42, Great Lakes Res. Div., U. of Mich., vi, 32 p.

Elder, F.C. and Davidson, K.L., 1969. "Some Evidence of Momentum Flux over Wave Surfaces in Lake Michigan". Presented at 2nd Oceanographic Symposium, Victoria, Nov. 17-21 (unpublished).

Thomas, R.L. and Bloxam, T.W., 1969. "Some Observations in the Distribution of Quartz, Organic Carbon, Sulphur and Iron in the Gastrioceras Subcrenatum Marine Band of the South Wales Coalfield". Conf. in Carboniferous Stratigraphy, 1967 (in press).

Unpublished Papers and Reports

Birch, K.N. and Francis, D.M., 1969. "Performance of Current Meters used in the Great Lakes". Presented at 2nd Nat. Oceanographic Symp., Nov. 17-21, Victoria, B.C.

Boyce, F.M., 1969. "The Santa Barbara Channel Oil Spill", CCIW Report, Feb. 1969, 21 p.

Coakley, J.P., 1969. "Machine Filing of Great Lakes Sediment Data". Presented at 12th Conf. Great Lakes Res., Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich.

Lane, R.K., 1969. "Large Scale Processes – Circulation, Heat Budget, Sea State, and Ice Formation". Presented at 12th Conf. Great Lakes Res., Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich.

Lerman, A., 1969. "Chemical Equilibria and Evolution of Chloride Brines". Paper presented at Mineralogical Soc. of Amer., Nov. 1969.

Murthy, C.R. and Weiler, H.S., 1969. "The Mixing of Niagara River Plume in Lake Ontario". Presented at 2nd Nat. Oceanographic Symp., Victoria, Nov. 17-21.

Murthy, C.R., 1969. "An Experimental Study of Dispersal Processes in Lake Currents". Presented at 32nd Annual Meeting of Limnology & Oceanography, San Diego, Calif., Sept. 8-12.

Warwick, W.F., 1969. "Diving Practices in the Limnogeology Section of the Canada Centre for Inland Waters". Presented at 12th Conf. Great Lakes Res., Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich.

Weiler, H.S., 1969. "Measuring Lake Currents for Long Term Studies". Presented at 12th Conf. Great Lakes Res., Intern. Assoc. for Great Lakes Res., Ann Arbor, Mich.

Freshwater Institute, Winnipeg
Publications on Great Lakes Studies

Patalas, K., 1969. "Composition and Horizontal Distribution of Crustacean Plankton in Lake Ontario". *J. Fish. Res. B. Canada*, 26(8): 2135-2164.
Vallentyne, J.R., 1969 "Sewage Treatment and Algal Growth in Lakes Erie and Ontario" (in press).

Great Lakes Limnological Data Reports

No. 1, 1966, Lake Ontario, Cruise 66-1, June 1-5; Cruise 66-2, June 7-10, (Sept. 1969).
No. 2, 1966, Lake Ontario, Cruise 66-3, June 15-19, (Sept. 1969).
No. 3, 1966, Lake Ontario, Cruise 66-4, June 21-25, (Sept. 1969).
No. 4, 1966, Lake Ontario, Cruise 66-5, June 26-30, (Oct. 1969).
No. 5, 1966, Lake Ontario, Cruise 66-6, July 4-10, (Oct. 1969).
No. 6, 1966, Lake Ontario, Cruise 66-7, July 12-15; Cruise 66-8, July 19-24, (Oct. 1969).
No. 7, 1966, Lake Ontario, Cruise 66-9, July 26-29; Cruise 66-10, Aug. 2-7, (Oct. 1969).
No. 8, 1966, Lake Erie, Cruise 66-11, Aug. 8-14, (Oct. 1969).
No. 9, 1966, Lake Ontario, Cruise 66-12, Aug. 15-19; Cruise 66-14, Aug. 29-Sept. 2 (Oct. 1969).
No. 10, 1966, Lake Ontario, Cruise 66-15, Sept. 6-11; Cruise 66-16, Sept. 12-16 (Nov. 1969).
No. 11, 1966, Lake Ontario, Cruise 66-17, Sept. 20-24, (Nov. 1969).
No. 12, 1966, Lake Ontario, Cruise 66-18, Sept. 26-29; Cruise 66-19, Oct. 1-3 (Dec. 1969).

APPENDIX D

National Advisory Committee on Water Resources Research
Advisory Committee on the CCIW

MEMBERSHIP LIST – January 29, 1970

Dr. A.T. Prince, Convener	Director, Inland Waters Branch, Dept. of Energy, Mines and Resources, Ottawa, Ont.
Dr. E.G. Pleva, Chairman	Department of Geography, Middlesex College, University of Western Ontario, London, Ont.
Secretariat	
Dr. H.F. Fletcher	Executive Secretary, National Advisory Committee on Water Resources Research, Policy and Planning Branch, Dept. of Energy, Mines and Resources, Ottawa, Ont.
T.S. Hillis	Executive Assistant to the Acting Director, Canada Centre for Inland Waters, Dept. of Energy, Mines and Resources, P.O. Box 5050, Burlington, Ont.
Members	
Dr. P.M. Bird	Director, Environmental Health Centre, Dept. of National Health and Welfare, Tunney's Pasture, Ottawa, Ont.
Dr. C.P. Fisher, Alternate	Associate Chief Research, Public Health Engineering Division, Dept. of National Health and Welfare, Tunney's Pasture, Ottawa, Ont.
J.P. Bruce	Acting Director, Canada Centre for Inland Waters, Dept. of Energy, Mines and Resources, P.O. Box 5050, Burlington, Ont.
J.W. MacLaren	James F. MacLaren Ltd., Consultant Engineers, 321 Bloor St. E., Toronto, Ont.
Dr. A.D. Misener	Director, Great Lakes Institute, University of Toronto, Toronto, Ont.

Prof. W.K. Oldham	Department of Civil Engineering, University of British Columbia, Vancouver 8, B.C.
Dr. G. Prevost	5626 Woodbury Avenue, Montreal, Que.
T.L. Richards	Superintendent of Hydrometeorology, Meteorological Branch, Department of Transport, 315 Bloor St. W., Toronto, Ont.
Dr. G. Shane	Director, Research, Shell Oil Canada Limited, Box 400, Terminal A, Toronto 1, Ont.
Dr. D.R. Stanley	Stanley and Associates Engineers Limited, 11810 Kingsway, Edmonton, Alta.
F.A. Voege	Assistant General Manager, Ontario Water Resources Commission, 135 St. Clair Ave. W., Toronto, Ont.
T.E. Weber	Director, Water Control and Conservation Branch, Dept. of Mines and Natural Resources, 693 Taylor Ave., Winnipeg 9, Man.

Observers

J.B. Bryce	Hydraulic Engineer, The Hydro Electric Power Commission of Ontario, 620 University Ave., Toronto, Ont.
Dr. N.E. Cooke	Principal Chemical Engineer, Canadian Industries Limited, 630 Dorchester W., Montreal, Que.
Prof. J.H. Dales	Department of Political Economy, University of Toronto, Toronto, Ont.
Prof. K.S. Davar	Dept. of Civil Engineering, University of New Brunswick, Fredericton, N.B.
R.K. Fraser	President, Fleet Manufacturing Ltd., Box 300, Fort Erie, Ont.
J.P. Gourdeau	Vice-President, Surveyor, Nenniger and Chenevert Inc., 1550 O. Boul. de Maisonneuve, Montreal, Que.

J.B. Hooper	City Engineer, City of Peterborough, City Hall, Peterborough, Ont.
Dr. W.E. Johnson	Director, Freshwater Institute, Fisheries Research Board of Canada, 501 University Cresc., Winnipeg 19, Man.
Prof. J.R. Kramer	Department of Geology, McMaster University, Hamilton, Ont.
Prof. A. Leclerc	Head, Division of Sanitary Engineering and Hydrology, Ecole Polytechnique, 2500, Ave. Marie Guyard, Montreal 250, Que.
Prof. H. Lees	Head, Department of Microbiology, University of Manitoba, Winnipeg 19, Man.
Roy A. Walker, Alternate	Assistant Hydraulic Engineer (Studies)
Dr. A. DesMarais	Principal Science Adviser, Science Secretariat, Privy Council Office, East Block, Parliament Buildings, Ottawa, Ont.
H.C. Kingstone	Deputy Head, U.S.A. Division, Department of External Affairs, Ottawa, Ont.
J.L. MacCallum	Assistant to the Chairman and Legal Adviser, International Joint Commission, 151 Slater St., Ottawa 4, Ont.
M.S. Slivitzky	Université du Québec, 220 Est Grande-Allée, Quebec 4, Que.
Dr. E.Y. Spencer	Director, Research Institute, Canada Department of Agriculture, London, Ont.
H.G.P. Taylor	Director, Resource Programs Division, Department of Finance, Confederation Building, Ottawa, Ont.

APPENDIX E

Contracts Entered Into by the Great Lakes Division — 1969

The contracts let by the Great Lakes Division are for specific research projects designed to supplement the total research program of GLD.

Contracts are entered into when resources are not available at the Centre for allocation to projects which provide an important supplement to the ongoing program. The following contract programs were initiated in 1969:

1. Analysis of the long-term effects of the disposal of waste heat from electric power production and industrial plants into the waters of the Great Lakes Basin, including an assessment of the quantity of waste heat to be absorbed and the pattern of its disposal.
(H.G. Acres & Co. – $36,000)

2. To provide an evaluation of research related to ice on rivers and lakes, including the Laurentian–Great Lakes System, according to the following, surface freezing, growth and dissipation of an ice cover and its effects, ice in water, ice floods, ice forces, shipping problems, trafficability, environmental effects, instrumentation, physical properties, control methods and treatment systems.
(H.G. Acres & Co. – $35,000 – in collaboration with other Divisions of Inland Waters Branch)

3. To provide limnological data for lakes Ontario, Erie, Huron and Superior and Georgian Bay.
(Great Lakes Institute, Univ. of Toronto – $25,500)

4. To provide limnological data for the eastern end of Lake Ontario from monitor cruises and from a special cruise to support infrared scanner flights. To provide a report on the movement and thermal turbidity characteristics of the thermal bar as it occurs this spring in the western end of Lake Ontario in the MELON project area.
(Great Lakes Institute, Univ. of Toronto – $35,000)

5. To carry out an investigation at the coastal jet phenomenon in an area to the west of Lake Ontario, off Oshawa.
(Waterloo University – $22,750)

6. To develop programs for the processing of data obtained from CCIW Chemical and Bacteriological Monitor Cruises on the Great Lakes.
(McMaster University – $26,650)

7. To carry out a research project on the geological studies of the nearshore zone of Lake Superior from Sault Ste. Marie to Wawa in accordance with the Lake Superior, Sedimentological Reconnaissance Program.
(Lakehead University – $14,000)

8. To study seasonal thermal changes in the susceptibility of alewives and correlation of heat resistance to factors of lake temperature and characteristics of fish, which will be done in laboratory experiments, using fish from Lake Ontario since alewife die-off is a form of pollution which seriously impairs recreational and water supply uses of Lake Ontario.

To undertake a preliminary study of the role of temperature as a directive factor in movement and distribution of alewives in the Lake.

To prepare a bibliography on alewives.

To undertake a feasibility study on possible investigation of alewife response to temperature gradients rather than warm or cold temperature.
(Waterloo Lutheran – $13,000 – in collaboration with Fisheries Research Board)

9. To carry out a program of short-term measurements of incoming solar radiation, solar radiation reflected from the lake surface, diffuse solar radiation, net total radiation, and total incoming radiation, commencing during May and continuing through October 1969 at a location in Lake Ontario.
(McMaster – $16,000)

10. To install tower(s) at sites – A, B, and C in Lake Ontario in order to carry out combined research programs in the areas of (1) air-water processes (2) radiation studies and (3) diffusion studies.
(Young and Forbes Diving and Marine Spec. – $10,000)

11. To supply a team of two divers for a period of April 21 to September 19, 1969.
(John T. Roe Underwater Salvage & Recovery – $12,000)

12. To conduct a study: i) to assess the estuarial waters where the Grand River enters Lake Erie with respect to (a) physical-chemical changes in river water, disposition of suspended solids, accumulation of insecticide residues and other pollutants, (b) productivity with respect to bottom fauna, plankton, and nekton, including energy transfer; ii) to determine the significance of the discharge of the Grand River with respect to its influence on the water quality and eutrophication of Lake Erie.
(University of Guelph – $13,800)

Date Due
