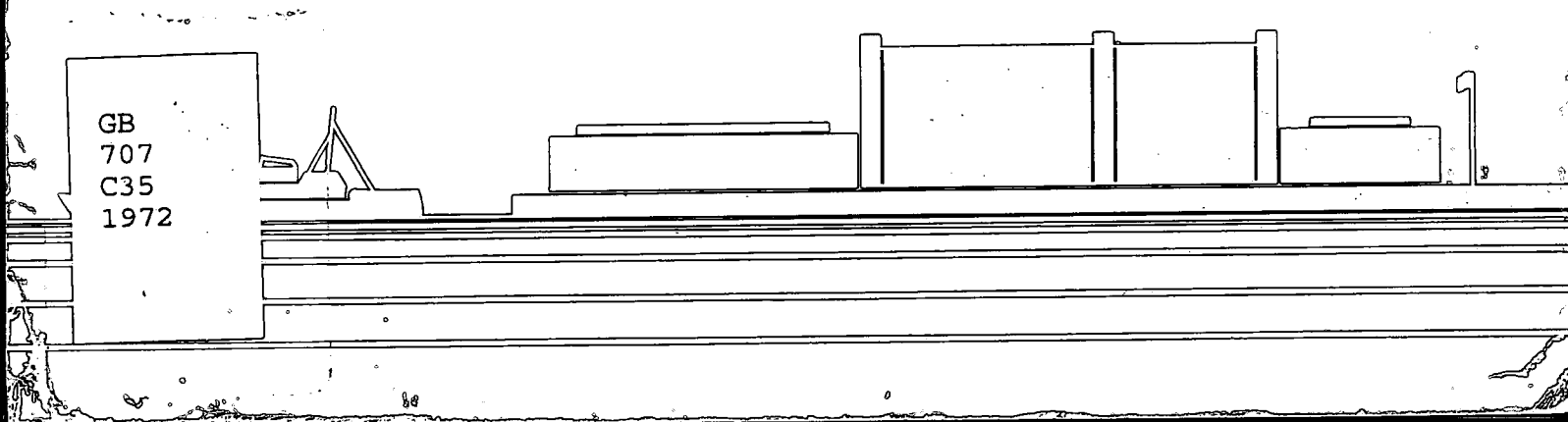
Environment Canada
Environnement Canada

CANADA CENTRE FOR INLAND WATERS

1972



Environment Canada | Environnement Canada

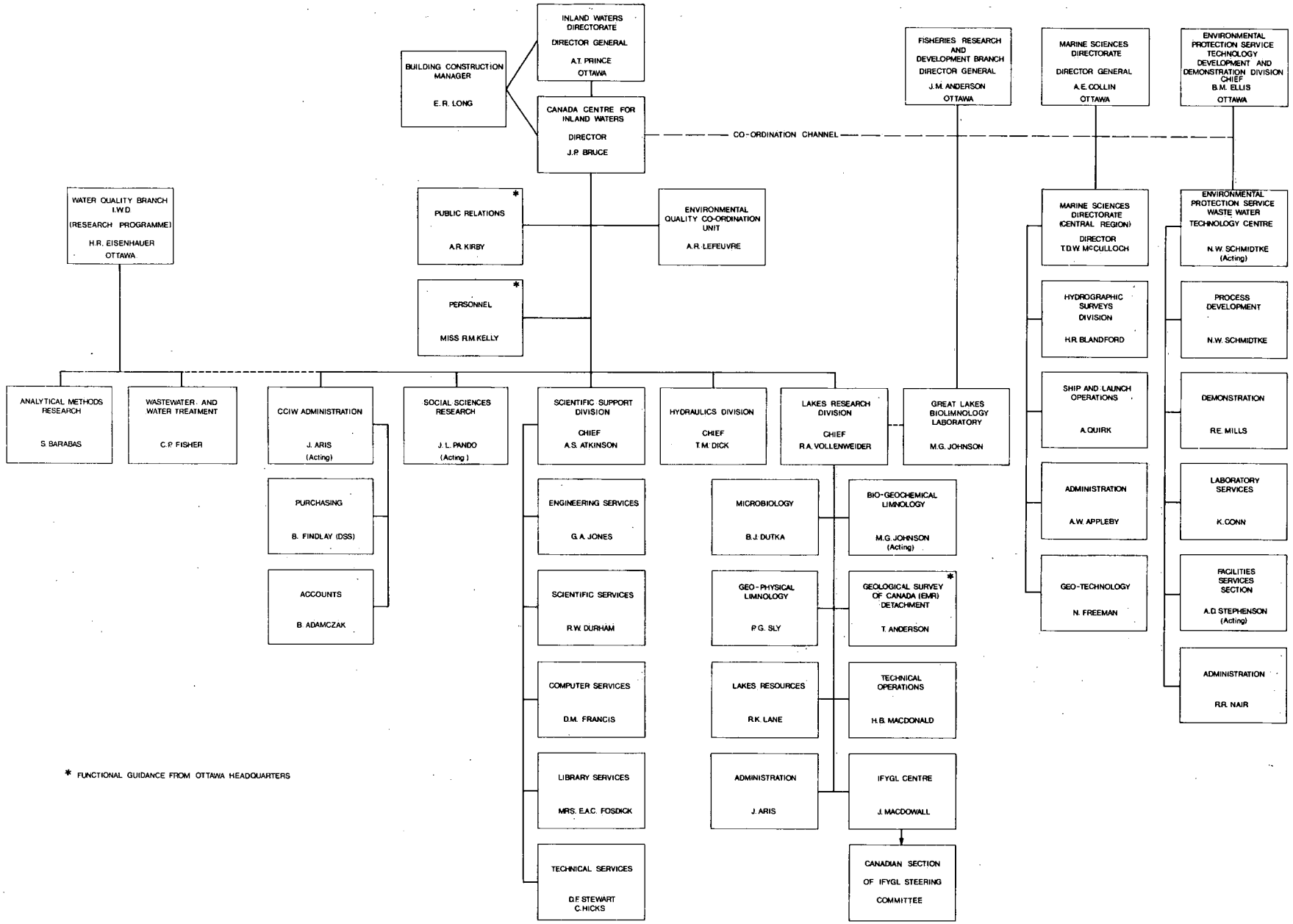
CANADA CENTRE FOR INLAND WATERS

1972

Cat. No.: EN39-172

Imprimerie Gauvin Limitée, Hull, P.Q.

Contents



CCIW Organization, December 31, 1972

Highlights

CANADA-U.S. AGREEMENT ON GREAT LAKES WATER QUALITY

A milestone in water quality control of the Great Lakes, and a major turning point in the work of CCIW, was reached April 15th with the signing by Prime Minister Trudeau and President Nixon of this Agreement, to which CCIW made many technical contributions. CCIW staff participated actively in the negotiations of the Agreement. The report on Project "Hypo"* concerning oxygen depletion in the bottom waters of central Lake Erie and subsequent nutrient budget evaluations significantly influenced design of the nutrient control program incorporated in the Agreement. In addition to the water quality objectives and pollution control programs required under the Agreement, a number of additional studies are called for which will involve extensive work by CCIW staff. These include establishment of specific water quality criteria for waste heat, radioactivity and host of toxic substances, criteria for characterizing polluted dredged materials, vessel waste treatment systems, studies to reduce costs of pollution control from combined storm and sanitary sewer systems, and studies designed to reduce chances of shipping accidents and improve Great Lakes contingency plan operations.

OFFICIAL OPENING OF CCIW BUILDINGS

The official opening of the Main Laboratory Building and the Water Quality Pilot Plant—Wastewater Technology Centre took place on May 5. The Honourable Jack Davis spoke at the opening to 300 visitors and guests and by closed circuit TV to staff members of CCIW. Mr. Davis and other visitors toured CCIW after the unveiling of the plaque, and saw displays set up by all components of the Centre illustrating their work. In a press conference Mr. Davis drew attention to the outstanding contributions made by Centre scientists and staff towards achieving the Great Lakes Water Quality Agreement with the United States and to phosphate control policies in Canada. A public Open House was held on the weekend following the official opening, which was attended by 9 - 10,000 citizens.

*Project Hypo Report (1972). "Project Hypo – An Intensive Study of the Lake Erie Central Basin Hypolimnion and Related Surface Water Phenomena", CCIW paper no. 6 (U.S. E.P.A. Technical Report TS-05-71-208-24). 182 pages.

SUPPORT OF INTERNATIONAL JOINT COMMISSION GREAT LAKES WATER QUALITY ACTIVITIES

The IJC was given primary responsibility for overseeing implementation of the international water quality agreement on the Great Lakes. To carry out the various provisions of the Agreement the Commission has established a number of Boards, Reference Groups and Task Forces. CCIW staff members have been appointed by IJC to each of these groups. In addition many staff members are actively participating in studies required under the Agreement and in monitoring and surveillance programs. R. A. Vollenweider (FRB-IWD) is a member of the Great Lakes Water Quality Board, chaired by A. T. Prince, Water Director-General, IWD; J. P. Bruce (IWD) is Canadian Chairman of the Research Advisory Board; R. K. Lane (IWD) is Canadian Chairman of the Upper Lakes Reference Group, responsible for major studies of Lakes Huron and Superior and for recommending on pollution control measures needed; M. G. Johnson (FRB) is Canadian Chairman and R. L. Thomas (IWD) member of the Land Drainage Reference Group undertaking a study of control of pollution from agricultural, forest and urban land drainage; and P. G. Sly (IWD) is a member of the Task Force on characterization and disposal of polluted dredged sediments. A. R. LeFeuvre and the staff of the Environmental Quality Coordination Unit are supplying the technical secretariat for the Canadian portions of all of these Boards and Reference Groups, which permits close coordination of activities and reports.

HYDROGRAPHIC CHARTING AND ASSOCIATED ACTIVITIES

Nineteen Seventy Two was an eventful year for the Central Region, Marine Sciences Directorate. For the first time, in response to urgent requests, the region mounted a major hydrographic survey in James Bay. This major move into the salt water was closely allied to an oceanographic study conducted solely by the regional organization.

A successful exchange of staff took place between Lake Survey Centre, NOAA, Detroit and the Hydrographic Service Division of the Region. It will be repeated and perhaps expanded in 1973.

The high lake levels on Lake Ontario in the summer and Lake Erie in the winter were responsible for consider-

able activity on the part of both Shore Property Studies and Hydrodynamics. In particular, the storm surge of mid-November at the western end of Lake Erie caused considerable public concern. The Region was able to respond immediately with an on-the-spot assessment of the damage. Better methods of ensuring accurate maximum level gauging records are still being sought. Meanwhile, the region has commenced studies, in conjunction with Inland Waters Directorate units located at the Centre, AES in Toronto and Ontario Hydro into the feasibility of issuing Storm Surge Forecasts.

A hydrographic survey of a portion of Georgian Bay was contracted out, a first for the region and for the Canadian Hydrographic Service nationally. The results of the survey are under assessment. If acceptable, it could mean the gradual development of a competent hydrographic survey industry – a requirement desirable from two stands – hydrographic surveying of Canadian waters can be mainly completed within a reasonable time frame without contemplating massive expansion of the Canadian Hydrographic Service – a new viable secondary industry would be created in Canada.

Our most northerly survey party was engaged in an international project in Nares Strait between Danish territory and Canadian territory. The positioning of Hans Island, one of the assignments of this group, has of course considerable significance in the race to establish sovereignty over the submerged land in the Strait.

The HAAPS system got a thorough and successful field test during the bathymetric survey of Lake Ontario, IFYGL Project 79F, and was completed in the late fall of 1972.

A new high speed cutter, CSS "Advent" came on regional strength in the dying days of 1972.

CANADA-ONTARIO AGREEMENT

The research provisions of the Canada-Ontario Agreement are designed to reduce construction and operating costs of extensive pollution control facilities for the Lower Great Lakes (Canada's share of responsibilities under the international agreement). Under this research program, 17 contracts were let to the private sector and universities for studies of waste treatment processes, including nutrient removal, and for treatment and disposal of chemical sludges. CCIW is managing these contracts on behalf of the Canada-Ontario Review Board which administers the agreement. The Environmental Protection Service – Wastewater Technology Centre at the Centre made excellent progress on studies under this agreement, of (1) use of quicklime for precipation of phosphates on a pilot plant scale, (2) assessment of availability, costs and quality of chemicals in Ontario for phosphate removal, (3) chemical sludge characterization and land disposal of sludges and (4) effects of NTA on phosphate precipitation in treatment plants. Special research strategies were developed by the Technical Committee of the Review Board for land disposal of sludges from sewage plants with nutrient removal programs, and on combatting pollution from combined storm and sanitary sewer systems. J. P. Bruce (IWD) is federal co-chairman of the Technical Committee and E. E. Shannon (EPS) is technical secretary.

INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES (IGYGL)

Six years of international planning culminated on 30 March, 1972, in the official opening at CCIW of the field program of the IFYGL, a major International Hydrological Decade program in the Lake Ontario Basin. The year 1972 has seen the execution of the international field program, largely in accord with plans published in the IFYGL Bulletin #2. Ontario agencies, universities and several components of Environment Canada are active participants.

Throughout the year Canadian and U.S. research ships, aircraft and lake towers were used together with 21 buoy systems to collect an unprecedented amount of information about a major lake; a program of a magnitude only possible through cooperative efforts of the two countries. International intercomparisons of observing and analytical techniques will be of great continuing value in all Great Lakes work. A special Decca "Navigator" position-fixing system was deployed under contract to the Marine Sciences Directorate, and the U.S. National Oceanographic and Atmospheric Administration.

The field operations phase will be completed in March, 1973. Preliminary results are available from several projects, in particular, assessments of terms in the energy budget, and of biological production of the lake. Among the many objectives of the program is a baseline assessment of the state of health of Lake Ontario prior to introduction of major pollution control measures under the Canada-U.S. Great Lakes Water Quality Agreement; assessment of temperature and energy budgets to assist in regulating waste heat discharges; much better water budget data and evaporation estimates to improve lake level and water supply forecasting; information to permit improved marine and shoreline weather forecasts; and a file of data needed to verify mathematical models of the biological-chemical-physical behaviour of a major lake system.

OKANAGAN BASIN STUDIES

Studies in chemical, geochemical and physical limnology of Okanagan Valley lakes were completed as inputs to the Canada-B.C. study under the Canada Water Act. The geochemical studies showed that phosphates were being effectively removed from the waters of the major lakes by formation of apatite, indicating that phosphate control programs should result in rapid, favourable changes in lake conditions. The CCIW Public Relations office provided extensive special assistance in the public participation aspects of the Okanagan studies.

DETERGENT PHOSPHATE REPLACEMENT EVALUATION

Extensive evaluation and monitoring programs on NTA (nitrilotriacetic acid) and sodium citrate were coordinated by CCIW to provide scientific advice to the Minister on environmental effects, and in coordination with the Department of National Health and Welfare on health aspects. The NTA evaluation program in 1972, following on from the 1971 studies, included assessments of NTA effects on sewage treatment plants (negligible), transport and mobilization of heavy metals by NTA, effects of NTA and NTA-metal complexes on aquatic organisms, microbiological degradation of NTA and nature of breakdown products, development of a special strain of NTA degrading bacteria, and predictions of environmental concentrations if additional use of NTA is permitted in detergents. An extensive study of effects on sewage treatment and effluent streams of use of various detergent formulations by families and staff of Gloucester Armed Forces Base was completed by EPS staff. A number of technical meetings were held with industry and with U.S. agencies on these matters. Summaries of study results and evaluations of the national need for reduction of phosphates were prepared for senior Departmental officials and the Minister. A Ministerial decision was made to limit phosphates in laundry detergents to 5% (as P_2O_5) effective January 1, 1973. No restrictions were placed on NTA use but a monitoring program to ensure that environmental and tap water NTA levels remain as low as predicted, was instituted by CCIW and Water Quality Branch, IWD.

TOXIC SUBSTANCE RESEARCH

Work continued on national surveys of importation, mining, manufacturing and industrial uses of substances potentially environmentally hazardous. Survey papers were completed on mercury, pesticides, lead, cadmium, beryllium and selenium, and are already proving valuable in pinpointing locations of potential environmental problems. Work is underway on antimony and chromium. Reconnaissance surveys were completed on PCB's (polychlorinated biphenyls), pesticides, and heavy metal concentrations in water, sediments and biota of the Lower Great Lakes. Information on PCB's was incorporated in comprehensive summaries for IJC prepared by CCIW staff, on PCB's in the Great Lakes, including input data from Canadian and U.S. sources. Studies on microbiological degradation and toxicity to algae of PCB's indicated which of the Aroclors which make up PCB's are least degradable and most harmful to algae. Further work was completed on mercury, fallout radioisotopes and other metals distributions, and on interactions of metals with sediments of Lakes Huron, St. Clair, Erie and Ontario. Contracted studies were completed on costs and effectiveness of various possible methods for removal of contaminated sediments. Work on natural "chelators" in lake waters suggests that their concentrations in lakes has a profound effect on the extent to which potentially toxic metals can affect biota in lake systems.

HYDRAULICS LABORATORY

The new hydraulics laboratory building and offices were occupied in early summer and work has proceeded on installing major equipment and facilities. By year's end the towing tank and carriage for calibration of current meters had been installed and work was proceeding on the major wind-wave flume, and the 1m and 2m sediment flumes.

ENVIRONMENTAL MONITORING INSTRUMENTATION

In support of all phases of the 1972 CCIW environmental-measurement program, a total of more than 60 major data-acquisition systems were provided for field use by Engineering Services. These data-gathering systems . . .mounted on a variety of platforms such as ships, moored buoys, towers, towed bodies, bottom structures, barges, etc. . . .were equipped with arrays of environmental sensors measuring effects ranging from solar-radiation to deepwater internal waves. More than 100 million effectively, independent environmental measurements and samples were taken with these systems, most of which after scientific analysis will be stored in the IFYGL Data Bank. More than $2 million worth of such instrumentation was deployed; the major proportion of which functioned reliably and within design tolerance. Despite hazards ranging from ice to major shore erosion, no instruments were lost in 1972.

MICROBIOLOGICAL AND ANALYTICAL METHODS

The analytical methods research section of Water Quality Branch was transferred from Ottawa to CCIW during the year and continued development work on methods for use in the national water quality network. Work was continued by the Microbiology Subdivision on development of better indicators than total coliform counts of microbiological — health aspects of water pollution. Sampling methods and preservation of samples are also under examination. In addition, the Microbiology Subdivision developed much more efficient oil-degrading bacteria than hitherto available, which will undergo field tests in 1973-4.

SHORELINE STUDIES

Marine Sciences Directorate continued updating of shoreline survey data on the Great Lakes, initiated originally by the Department of Public Works for IJC lake level studies. These data and charts have proven extremely valuable in 1972, along with Lakes Research Division studies of shore erosion, shoreline sediment characteristics and movements, and nearshore diffusion studies, to Conservation Authorities involved in developing shoreline land use

plans along Lake Ontario from east of Toronto to Grimsby.

ORGANIZATIONAL DEVELOPMENTS

Departmental Organization

A new departmental organization was announced in December 1972 which promises to affect the development of CCIW programs in 1973. Inland Waters Directorate becomes a part of a new Environmental Management Service, and Marine Sciences Directorate and Fisheries Research Board components of the Centre are now part of the Fisheries and Marine Service.

Inland Waters Directorate — Regional Organization

Transfer to CCIW of Ontario Region operational staff of Water Quality Branch and Water Planning and Management Branch was completed and J. P. Bruce was appointed as Regional Director, IWD, for Ontario.

Lakes Research Division

This Division was reorganized largely along "problem" lines rather than disciplinary lines, incorporating staff of both Inland Waters Directorate and Fisheries Research Board. However, towards the end of the year a new working arrangement was developed between IWD and FRB that necessitated some further organizational changes, to take place early in 1973.

Advisory Committee to CCIW

The Advisory Committee, under the Chairmanship of Prof. E. G. Pleva, University of Western Ontario, and its subcommittees continued to provide valuable advice on CCIW programs and on non-federal government use of CCIW facilities. At its meeting of November 7th the ACCC recommended some major changes in its method of operation and reporting procedures in the light of DOE and CCIW organizational changes and these are now under review in the Department.

Inland Waters Directorate Research Components

HYDRAULICS DIVISION

COMMISSION

The Hydraulics Division is responsible for the inception and implementation of a research programme in hydraulics, which is national in scope. To do this, research work is undertaken either directly or through contracts in fluid dynamics, sediment transportation, wave dynamics and ice and cold weather hydraulics. The Division is also responsible for the operation of a national calibration service for hydrometric instruments, particularly current meters. Meters are calibrated to suit the specifications of users.

The emphasis in the Hydraulics Division is to provide estimates of the changes in regime caused by developments and to seek the most efficacious practice and design methods wich will mitigate environmental changes.

ORGANIZATION AND MAJOR EQUIPMENT

Since the previous report, the Hydraulics Unit was organized as a Division with a strength for 1972 of 22 man-years. By the year end, all the positions were filled including the transfer of personnel from Calgary. The laboratory building was virtually completed in September enabling contractors to begin installation of major equipment.

By the end of December, the towing carriage was all but completed and the interim acceptance tests indicated that the primary specifications which follow were met.

Minimum Steady Velocity	0.5 cm per sec
Maximum Steady Velocity	600 cm per sec
Allowable variation in velocity	±1%

In the tests, the variation in the velocity was much less than 1% for all speed ranges.

Designs for the 1 meter x 26 meter long tilting flume and the 2 meter x 27 meter long sediment flume, sediment traps and sediment handling equipment were completed and installation began before the end of the year. All this equipment should be operational by the spring of 1973.

Designs and specifications were drawn up for a large and unique wind tunnel for the wind wave flume which is 4.5 meters wide by 114 meters s long. Design work was undertaken by Dilworth, Secord, Meagher and Associates to meet the specifications of the Division. Performance specifications for new experimental cold rooms were drawn up for construction in 1973. The rooms will have a minimum temperature of -35°C and will be 40 feet x 20 feet and 10 feet x 20 feet. It is expected these rooms will provide valuable experimental facilities for the study of ice and its effects on flowing water and structures.

HYDROMETRY UNIT

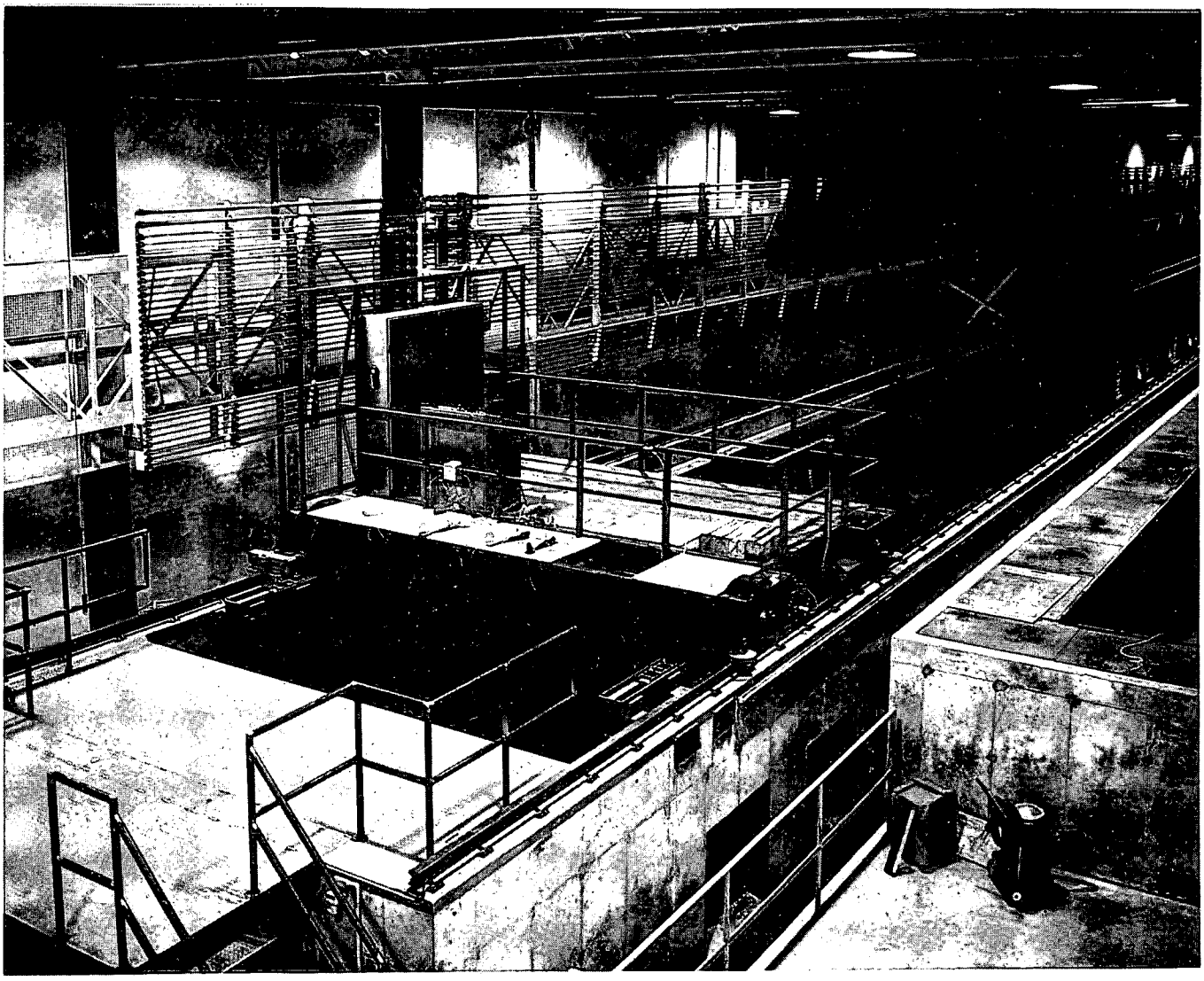
The year 1972 was devoted to the preparation, construction and installation of the towing carriage and its controls on the new 122-meter-long towing tank. The tank, carriage and its controls were completed in early December leaving only the data acquisition package to be installed in February 1973.

To complete the installation, plans were drawn up for a loading platform and skimming device for polishing the water surface. Operating procedures and policies for calibration have been prepared and computer programmes written to convert calibration data directly to calibration certificates. Methods for the calibrating of Plessey and Geodyne current meters were considered and discussions held with Engineering pertaining to their needs and schedules of current meter usage. For certain problems, a closed circuit television service was obtained so that visual data can be analyzed at leisure.

An on-going literature review of hydrometric literature is being undertaken to keep up to date with new instruments. Plans have been made to conduct experiments in the towing tank to study the effects of current meter suspension on performance and also to study the performance of different types of current meters. A separate series of tests will be run to ascertain the accuracies and performance of suspended sediment samplers.

TECHNICAL SERVICES UNIT

The Technical Services Unit is responsible for providing assistance to scientists and engineers of the Hydraulics Division with the construction, operation and analyses of their research projects. In addition to assigning technicians to projects, a "light" machine shop is provided to repair current meters and to make small parts for the day to day operation of the laboratory. An electronic shop was also



View of towing carriage and loading platform at end of 122-meter towing tank

organized to liaise with other electronic and electrical units at the Centre and repair and maintain electronic installations within the laboratory.

RESEARCH ACTIVITIES

A review was made of the mechanism of oxygen absorption into flowing waters and methods of predicting the reaeration rate. It was shown that none of the existing theoretical models and empirical equations satisfactorily predicted the reaeration rate over a wide range of flow conditions. Using dimensional analysis and by examining existing data, a new prediction was proposed. However, more data are required to completely verify this equation and experiments for such an investigation have been planned.

A conceptual design of a recurculating tilting flume 60 centimeters wide and 31 meters long was made for the study of the reaeration problem and the engineering design was completed by the C.C.I.W. Engineering Sub-division. Construction and installation of this flume is expected to be completed by the end of February 1973.

Research into the effect of bends on diffusion in rivers was initiated to continue work begun in the previous year. A computer programme was written for the numerical solution of the convective diffusion equation to investigate the effect of secondary currents on the spreading of a plume across a river. This numerical solution has been found to provide correct solutions for known simplified conditions.

A study of the exchange flow between Lake Ontario and Hamilton Harbour which was begun in 1971 has been continued in 1972. More field data on the thermal wedge was collected and compared with theoretical predictions. Exchange flow because of lake level fluctuations has been

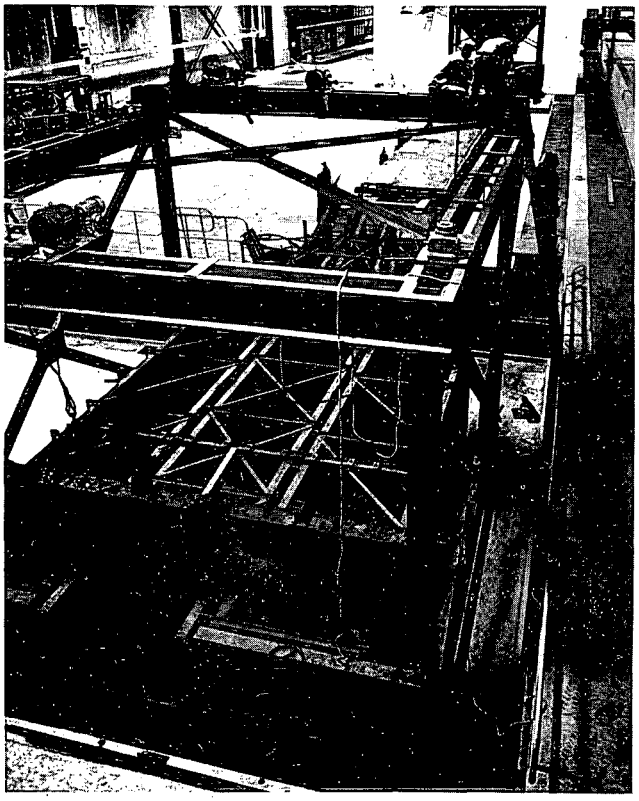
simulated by a mathematical model in the absence of stratification. Using water level data for Lake Ontario the fluctuations of water levels in Hamilton Harbour have been calculated and the exchange flow estimated. The factors which influence the exchange flow have been studied, especially the effect of landfilling operations. Results of these calculations were made available to Hamilton Region Conservation Authority and others.

A critical literature study examining the methods of abatement of pollution due to combined sewer overflows has been completed and published as an internal publication (*"Abatement of Pollution Due to Combined Sewer Overflows"*, Technical Bulletin No. 66). The report puts emphasis on those abatement schemes which may provide better and more economical protection for the environment than the conventional sewer separation. Several ideas for forther research were identified and some of them were submitted to the Technical Committee on the Canada/ Ontario Agreement.

Design parameters for a wave machine were finalized and detailed calculations of geometric, kinematic and dynamic parameters were made available to potential suppliers. Tenders were called, evaluated and a contract was awarded. The design utilizes up to date technology to provide a fully programmable wave machine so that wave simulation in the wind wave flume will be as correct as possible.

A field study of shoaling waves was initiated in the summer of 1972. Simultaneous measurements and intercomparisons of deep and shallow water waves have been carried out. Many technical problems and difficulties have been encountered during the study. Since the climatic conditions suitable for the measurements occur on the average only one day per month, it will be necessary to continue the data collection for another year.

In the sediment transport field, a substantial engineering effort was expended in liaison, monitoring, specification preparation and supervision for the supply and installation phases of the sediment flumes including all the auxiliary equipment. A field review of existing and presently used sediment measurement technology was undertaken during the spring runoff. As a result, research into using hydrophone methods by which the acoustic noise



Two-metre sediment transport flume and sediment traps under construction

generated by impacting bed particles will be correlated with the quantitative transport of sediments is being actively pursued. Field and laboratory studies will be undertaken in order to evaluate the hydrophone method.

Work on ice and cold phenomena was of necessity conducted out of doors. A project to measure the drag forces on an ice cover was undertaken on the Grand River near Hamilton where a number of survey stations were installed and the sections surveyed. Other studies on the production of frazil by waves were begun by the construction of a small recirculating flume which can be placed out of doors if required. The studies on ice and cold weather hydraulics problems are just beginning but it is expected this field will develop an importance especially in relation to northern development.

LAKES RESEARCH DIVISION

The objective of Lakes Research Division, within the broad terms of reference of the Department of the Environment and the Environmental Management Service, is to provide the government with the scientific knowledge needed for managing the freshwater resources stored in lakes in Canada. Accordingly, Lakes Research Division has two basic functions: (a) to perform basic research with a view to increasing scientific knowledge in the field of limnology, i.e., the science of lakes and lake behaviour or processes; (b) to deliver the scientific tools needed by management to solve present and future environmental problems related to lakes.

During 1972, a new organization of Lakes Research Division has become operative in order to better cope with the different requirements of the Division, and in addition,

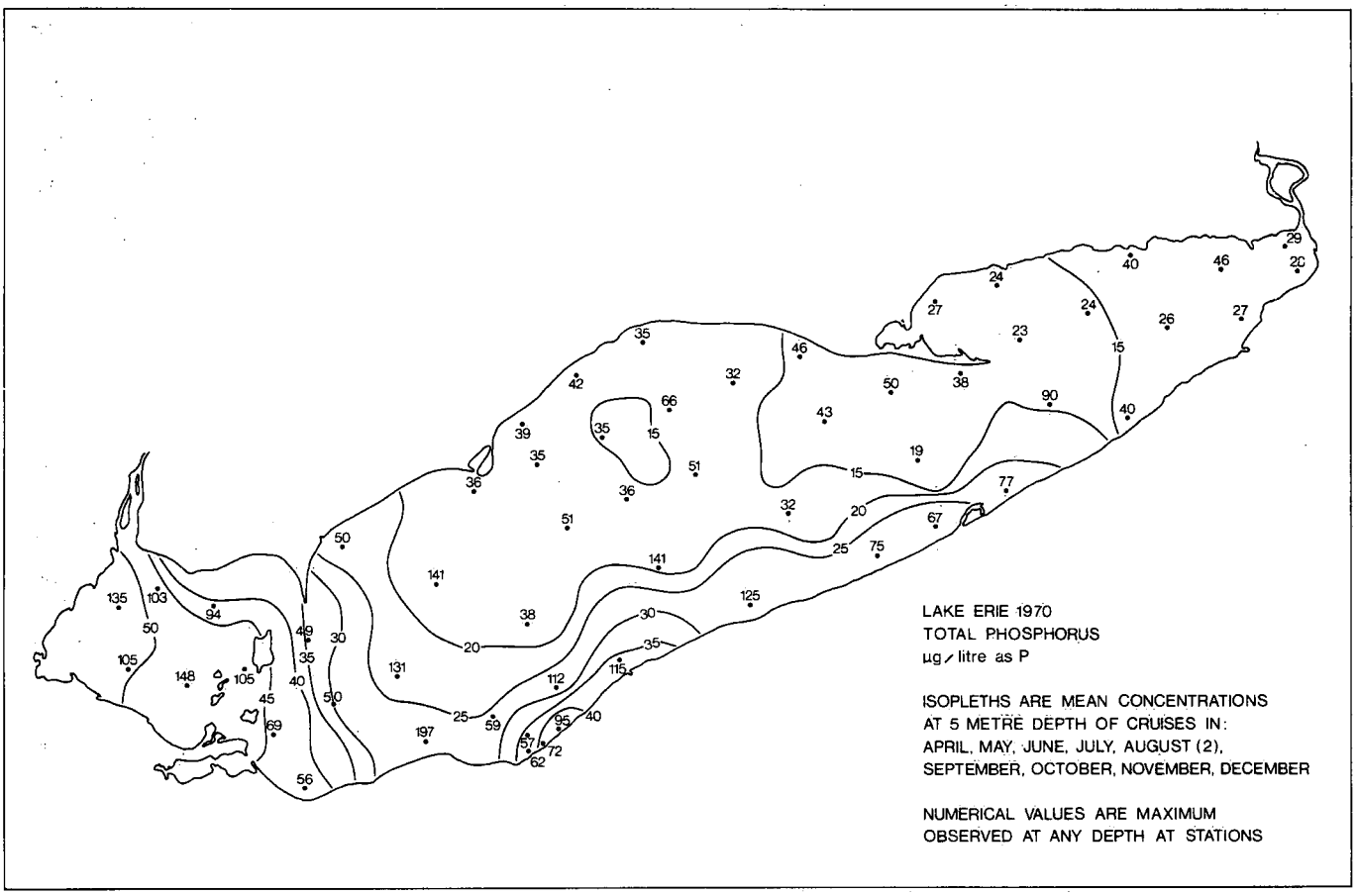


Figure 1. The average total phosphorous concentrations based upon the most recent year of significant record for each of the Great Lakes.

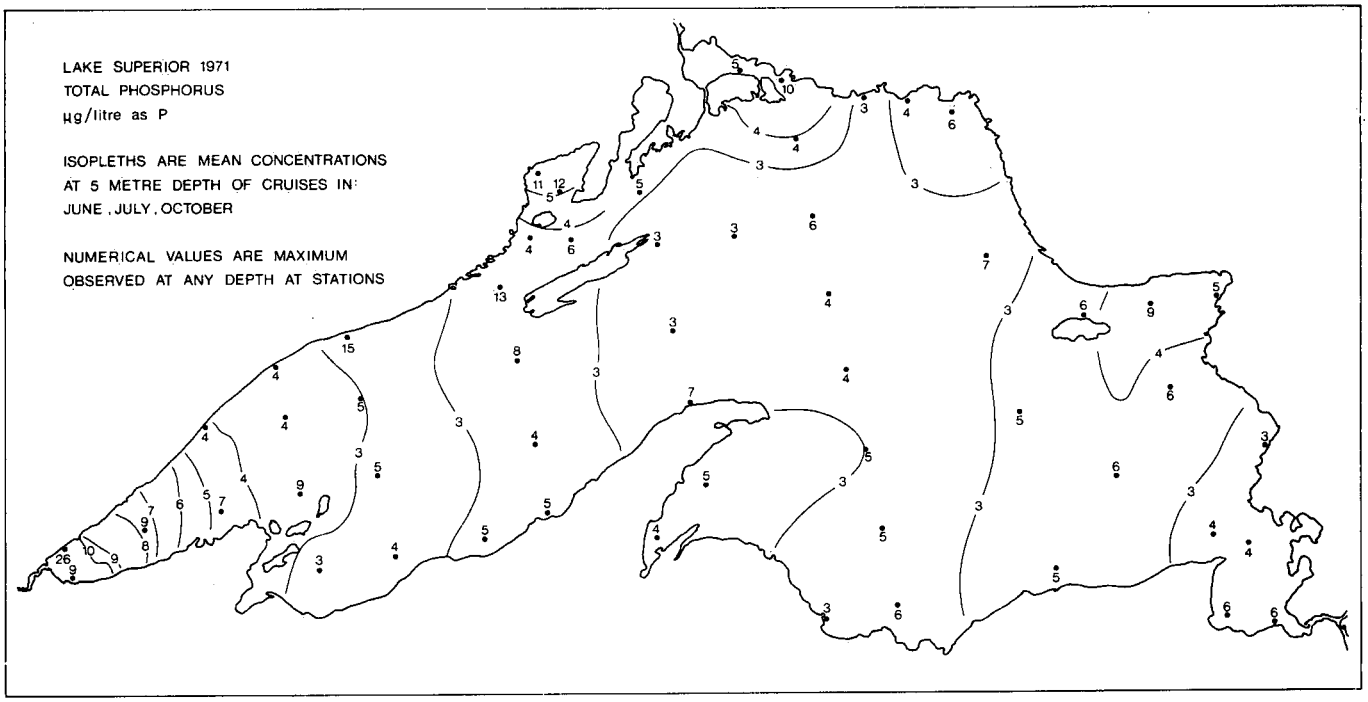


Figure 1 (cont.).

to separate more clearly the responsibilities for resource survey and description (Lakes Resources Subdivision) from process-oriented research (Geophysical Limnology Subdivision and Biogeochemical Limnology Subdivision). For various reasons the transition and adaptation to the new organization has been relatively slow but during the course of the year, benefits from the regrouping became apparent. However, toward the end of 1972 the program of Fisheries Research Board group was separated from Lakes Research Division and a new coordination arrangement developed for limnological research. During the year, Lakes Research Division assumed responsibility for microbiological research.

In the research areas of the 1972 field program, the Division has been heavily involved in the International Field Year for the Great Lakes (IFYGL). The Canadian contribution to the joint program with agencies of the United States has been most successful, resulting in a data return which was beyond expectation. High credit for this success has to be paid to the Operations Subdivision, as well as to the efforts of the Ships and Launches Division of the

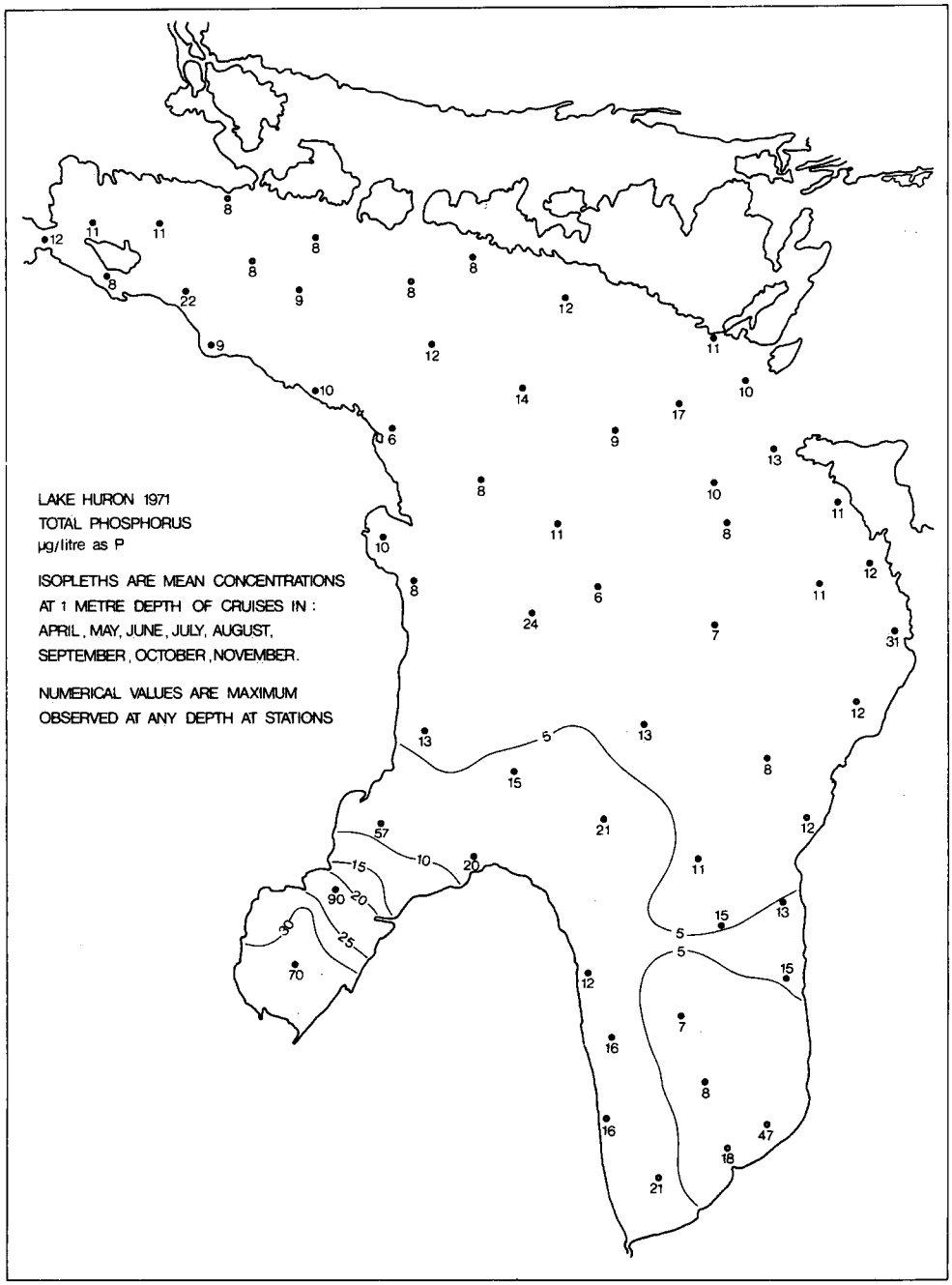


Figure 1 (cont.).

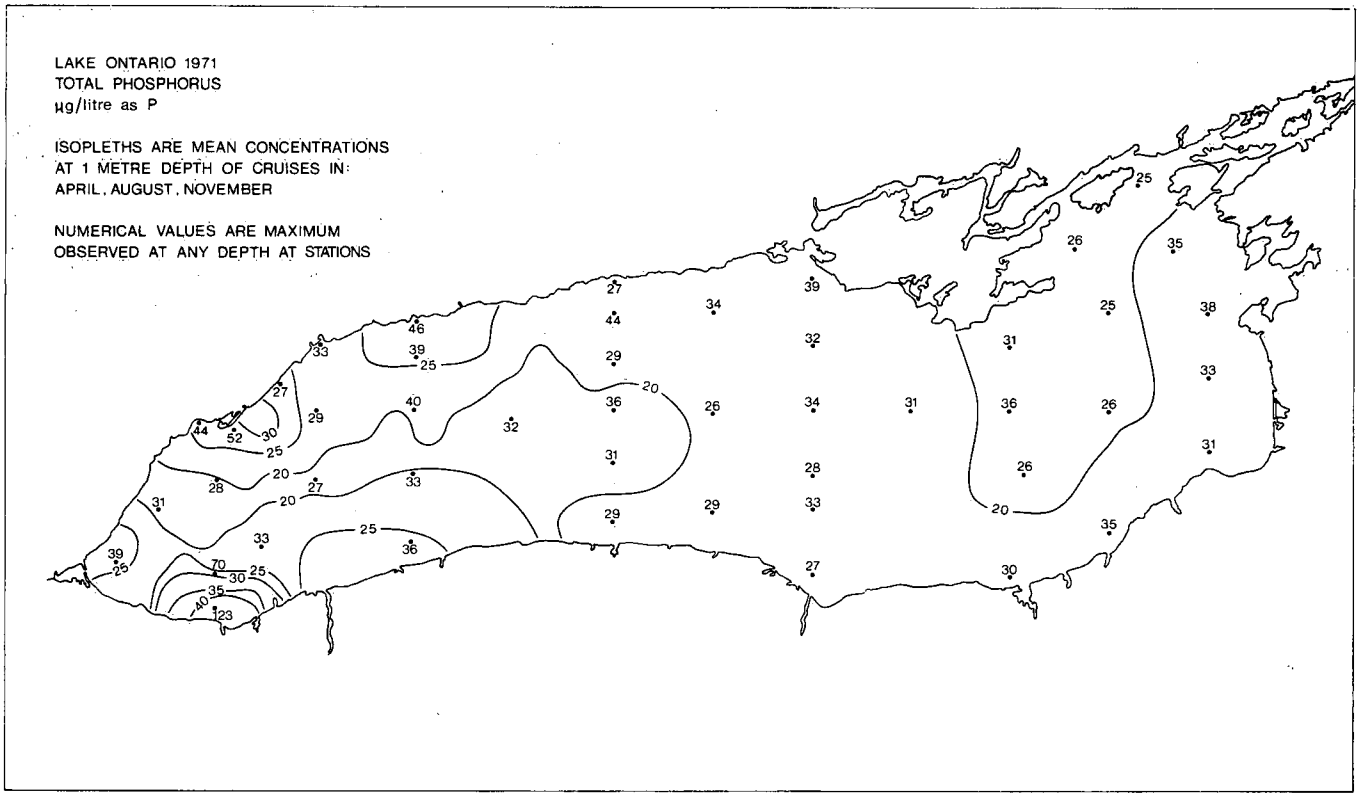


Figure 1 (cont.).

Marine Sciences Directorate—Central Region, and of the Scientific Support Division.

In addition to the continuing laboratory studies in the different Subdivisions, a large fraction of the staff has become heavily committed to program developments related to the Canada-U.S. Great Lakes Water Quality Agreement and to other departmental tasks. From a summary review, these activities in task forces, reference groups and committee of various sorts, has been estimated to take about one third of the Division's total activity.

LAKE RESOURCES SUBDIVISION

The functions of Lake Resources Subdivision are: lead responsibility and participation in multi-disciplinary descriptive research, and multi-agency, national and international limnological programs, and the development of descriptive techniques and methods; limnological data processing, in support of Lakes Research Division; and coordination and supervision of regional establishments of the Division.

These functions are carried out by three groups: the *Descriptive Limnology Section*, the *Data Processing and Display Unit*, and a detachment at the Freshwater Institute (Fisheries Research Board), Winnipeg. A second detachment, in the Pacific Region, was being formed at the close of the year.

Descriptive Limnology Section

Great Lakes Surveillance

Surveillance of the Great Lakes has been carried out during 1972 by water sampling from the ship cruises as listed in Tables 5 to 8. These cruises covered all of the international portion of the Great Lakes with the exception of Lake Superior and included some sampling in Upper Lake Michigan.

The chemical constituents of the waters of each of the lakes were studied with major emphasis on the nutrient elements. Calculations of the total quantities of nutrients contained in the lake at the times of cruises have been carried out. In some cases, these computations are done for different zones of a total lake. Contour maps have been prepared of the horizontal distribution of concentrations for different depth zones. A list of the total amounts of silica, nitrogen and phosphorous contained in Lake Huron is shown in Table 1.

Studies of Nutrients in the Great Lakes

During 1972, studies continued of major nutrients, particulate organic matter, and dissolved oxygen in the Great Lakes, using mainly the new CCIW data but also older information.

A preliminary study of nutrients in Lake Superior was completed as a preparation and stimulus for the Upper

Table 1. A list of total amounts of silica, nitrogen and phosphorus contained in Lake Huron.

Parameter		Whole Lake	Epilimnion	Mesolimnion	Hypolimnion
Silica	Quantity g. SiO_2 Mean Concentration $\mu g/l$ SiO_2	3.085×10^{12} 1161	5.221×10^{11} 753	6.138×10^{11} 1014	1.949×10^{12} 1436
Nitrate & Nitrite	Quantity g.N Mean Concentration $\mu g/l$ N	5.864×10^{11} 221	1.203×10^{11} 173	1.334×10^{11} 1209	3.327×10^{11} 251
Phosphorus	Quantity g.P Mean Concentration $\mu g/l$ P	1.149×10^{10} 4.3			

Lakes IJC reference and also a comparative summary of nutrient conditions in Lakes Superior, Huron, Erie and Ontario was produced. An example of a treatment of these data is contained in Figure 2.

Particle Sedimentation in Lake Ontario

This project was carried out to gain some idea of the rate of settling and flux of organic particles in Lake Ontario. The equipment for measuring settling rates has finally been developed to the stage where reproducible results can be obtained as required. The net settling rates of particles at depths greater than 80 m were usually in the order of 1 meter day^{-1}. Perhaps the most significant finding was that the net settling (or movement) in the surface waters was frequently upward and not downward, due probably to phytoplankton and zooplankton migration. On July 19, 1972, the upward flux at the upper thermocline boundary was measured at 4.4 mg P m^{-2} day^{-1} which represented an increase of 5.5% per day in the phosphorus present in the epilimnion.

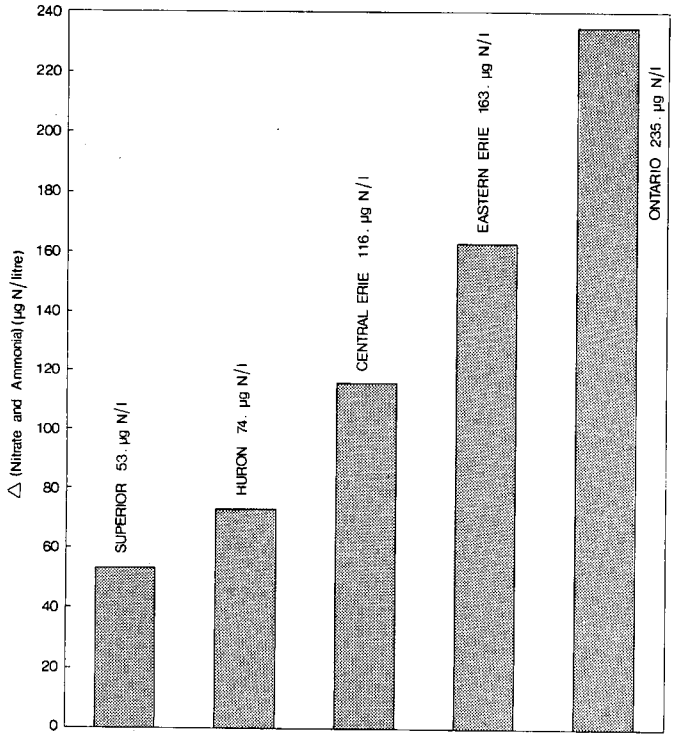


Figure 2. A comparative summary of nutrient conditions in Lakes Superior, Huron, Erie and Ontario. (Nitrate & ammonia) in surface waters, 1969-1971, winter maximum minus summer minimum.

Precipitation Chemistry

New snow sampling equipment was completed and installed at a number of stations during 1972. These new samplers are intended to overcome the sampling difficulties encountered in the winter by conventional samplers.

A computerized data storage and retrieval system was developed for the data as well as a number of basic statistical programs including a linear regression program, a histogram plot program and a t-test program. About 3 years of data have been accumulated on the Lake Ontario basin stations and about 2 years of data on the rest of the rain chemistry stations. Data for 1970 and 1971 from 7 stations in the Lake Ontario basin have been summarized and a report on the results has been completed. Table 2 lists some of the results reported in the summary. The annual deposit rate of nitrogen by rainfall indicates that in the Lake Ontario basin it is a significant if not a major source of nitrogen to the lake when compared to the total basin loading from other sources. For phosphorus it is a less significant source. The heavy metal deposition rates cannot be compared because there are no estimates available of the total basin loading of these parameters. However, the large ratio of rain water to lake water concentrations for many of the metals suggests that rainfall may be an important source of these metals, especially lead and zinc.

Recording Current Meter Data

Measurements: Most of the current flow measurements in 1972 were part of the IFYGL study of Lake Ontario. A total of approximately 200 months of data was obtained from sixteen moorings at the locations shown in Figure 3. Measurements in other lakes were limited to a monitoring

Table 2. Some results of the summary of rain chemistry station data.

Parameter	Mean Deposition Rate $mg/m^2/mo.$	Mean Conc. mg/1	Median Conc. mg/1
Total Phosphorus P	2.94	0.058	0.027
Reactive Phosphate P	1.41	0.024	0.006
Nitrate + Nitrite N	55.16	1.53	1.20
Ammonia N	29.00	0.62	0.48
Sodium	106.12	2.69	1.82
Potassium	25.90	0.56	0.40
Calcium	216.26	5.04	4.40
Magnesium	34.16	0.82	0.70
Chloride	63.12	1.60	0.90
Sulphate SO_4	431.25	10.0	8.8
Lead	1.08	0.20	0.007
Iron	1.71	0.034	0.019
Zinc	4.20	0.080	0.066
Copper	0.33	0.006	0.005
Cadmium	0.07	0.001	0.001

of the flow in Main Channel, between Georgian Bay and Lake Huron.

Data Processing: The development of a new system for the reduction, editing and summarizing of current meter data was completed early in the year. The system was used for processing the IFYGL data and some of the data collected in previous years. In addition, limited data processing services were provided for MSD (CCIW) and MOE (Ontario).

Over-Lake Meteorological Measurements

A network of eleven meteorological measurement systems was operated on buoys at the locations shown in Figure O throughout the period April through December. A single system continues to operate at Station 3 through the winter. Meteorological measurements were obtained on a nearly continuous basis throughout the period. A record of data obtained (Fig. 4) shows that about 90 percent of possible measurements were successfully obtained.

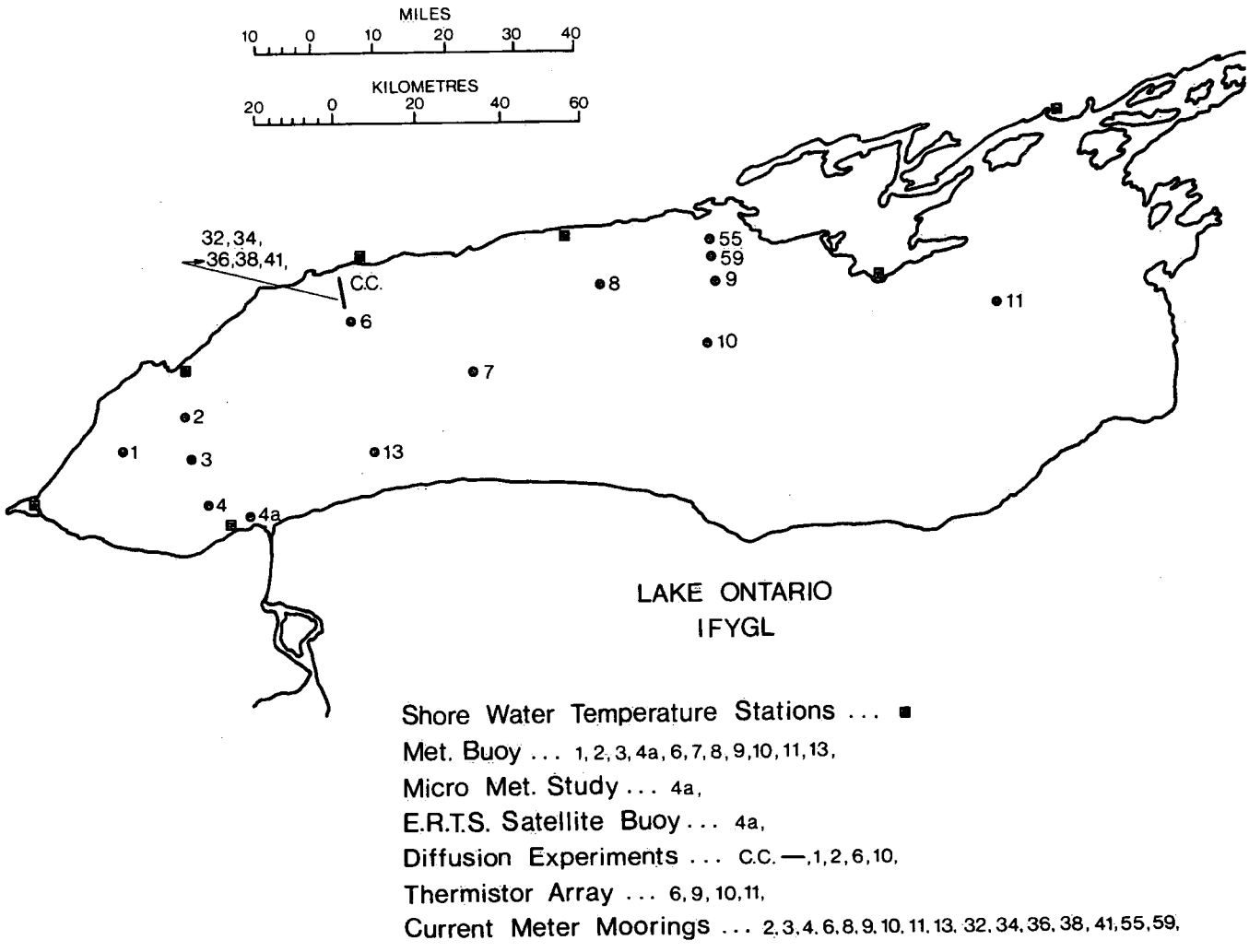
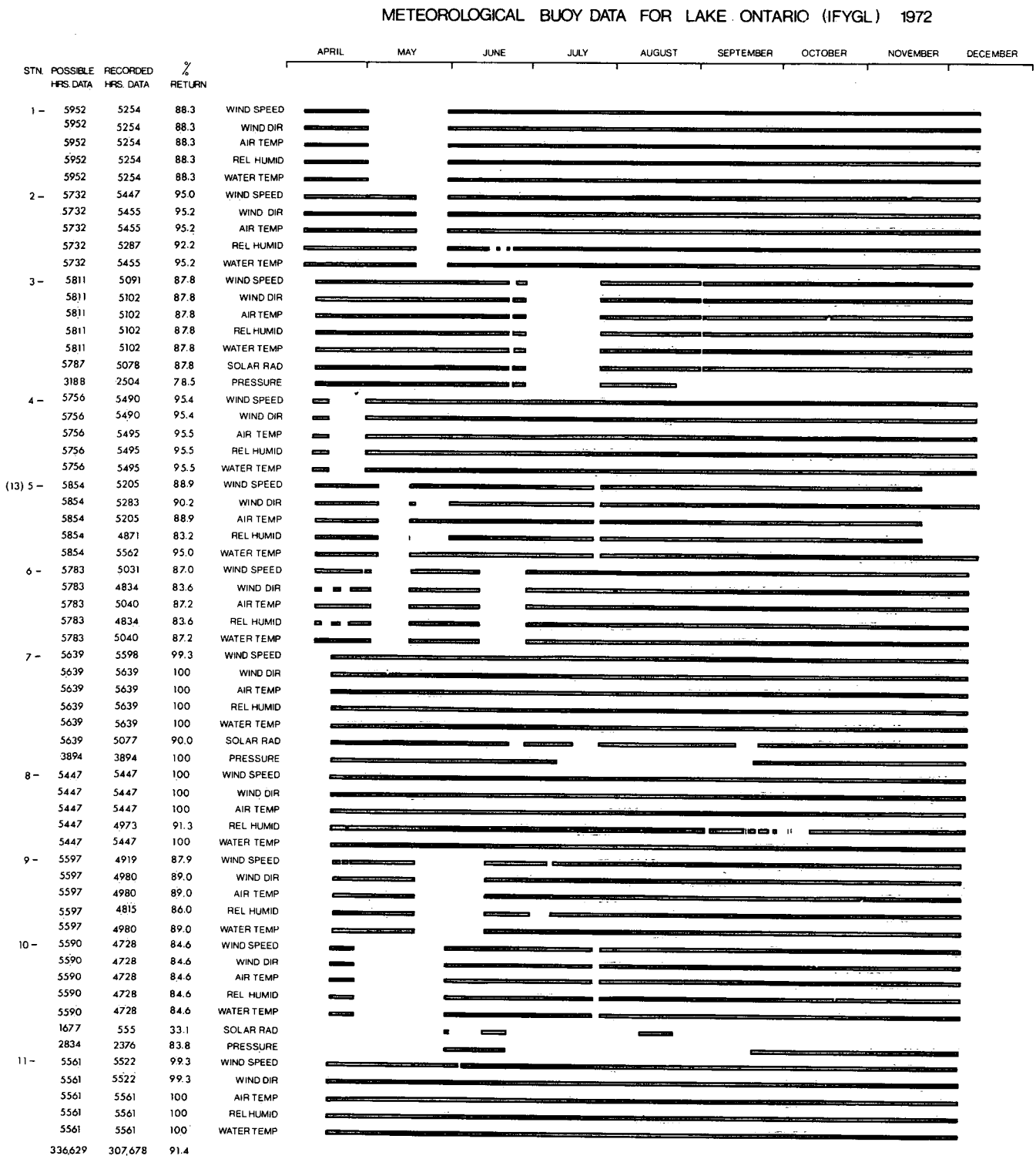


Figure 3. Map of meteorological measurements systems operating in Lake Ontario.



STN.	POSSIBLE HRS. DATA	RECORDED HRS. DATA	% RETURN	
1 –	5952	5254	88.3	WIND SPEED
	5952	5254	88.3	WIND DIR
	5952	5254	88.3	AIR TEMP
	5952	5254	88.3	REL HUMID
	5952	5254	88.3	WATER TEMP
2 –	5732	5447	95.0	WIND SPEED
	5732	5455	95.2	WIND DIR
	5732	5455	95.2	AIR TEMP
	5732	5287	92.2	REL HUMID
	5732	5455	95.2	WATER TEMP
3 –	5811	5091	87.8	WIND SPEED
	5811	5102	87.8	WIND DIR
	5811	5102	87.8	AIR TEMP
	5811	5102	87.8	REL HUMID
	5811	5102	87.8	WATER TEMP
	5787	5078	87.8	SOLAR RAD
	3188	2504	78.5	PRESSURE
4 –	5756	5490	95.4	WIND SPEED
	5756	5490	95.4	WIND DIR
	5756	5495	95.5	AIR TEMP
	5756	5495	95.5	REL HUMID
	5756	5495	95.5	WATER TEMP
(13) 5 –	5854	5205	88.9	WIND SPEED
	5854	5283	90.2	WIND DIR
	5854	5205	88.9	AIR TEMP
	5854	4871	83.2	REL HUMID
	5854	5562	95.0	WATER TEMP
6 –	5783	5031	87.0	WIND SPEED
	5783	4834	83.6	WIND DIR
	5783	5040	87.2	AIR TEMP
	5783	4834	83.6	REL HUMID
	5783	5040	87.2	WATER TEMP
7 –	5639	5598	99.3	WIND SPEED
	5639	5639	100	WIND DIR
	5639	5639	100	AIR TEMP
	5639	5639	100	REL HUMID
	5639	5639	100	WATER TEMP
	5639	5077	90.0	SOLAR RAD
	3894	3894	100	PRESSURE
8 –	5447	5447	100	WIND SPEED
	5447	5447	100	WIND DIR
	5447	5447	100	AIR TEMP
	5447	4973	91.3	REL HUMID
	5447	5447	100	WATER TEMP
9 –	5597	4919	87.9	WIND SPEED
	5597	4980	89.0	WIND DIR
	5597	4980	89.0	AIR TEMP
	5597	4815	86.0	REL HUMID
	5597	4980	89.0	WATER TEMP
10 –	5590	4728	84.6	WIND SPEED
	5590	4728	84.6	WIND DIR
	5590	4728	84.6	AIR TEMP
	5590	4728	84.6	REL HUMID
	5590	4728	84.6	WATER TEMP
	1677	555	33.1	SOLAR RAD
	2834	2376	83.8	PRESSURE
11 –	5561	5522	99.3	WIND SPEED
	5561	5522	99.3	WIND DIR
	5561	5561	100	AIR TEMP
	5561	5561	100	REL HUMID
	5561	5561	100	WATER TEMP
	336,629	307,678	91.4	

Figure 4. Record of meteorological measurement data.

The meteorological measurements are used in computation of the wind stress, evaporation and heat transfer. These values are then used in lake energy budget computations or as inputs to models of lake processes. A typical evaporation computation for the week of 19 – 25 April is shown as Figure 5.

Figure 5. A typical evaporation computation.

Lake Optical Studies

A study of the characteristic optical parameters of Lake Ontario was carried out during the Ontario Organic Particle Study (OOPS).

The parameters measured included: upwelling and downwelling light intensities, colour index, and attenuation coefficient as a function of depth and wavelength. The downwelling light intensity measurements were a vital input to the photosynthesis and carbon 14 assimilation studies.

A number of interesting correlations were obtained between the optical parameters (Fig. 6) and variations in the total particulate concentrations obtained from water quality measurements.

This was the first extensive optical study carried out by CCIW and the results obtained should have an important impact on future monitoring programs on the Great Lakes.

Shore Stations

Water temperature sensors were installed as a portion of the Atmospheric Environment Service system at seven stations around Lake Ontario (Figure 3). Three problems encountered which have been resolved are the mooring system, the electric field effect from thunderstorms, and radio frequency interference from radio beacons near some of the sites. One problem that is still presenting difficulty is the viability of the cable coming out of the water in the surf zone. There has been about a 70% return of usable data from all seven sites since their installations. A sample of the temperatures measured at the Burlington site is shown in Figure 7.

Remote Sensing

The 1972 remote sensing program was heavily involved with IFYGL (Table 3) on Lake Ontario. The main objectives were the continuation and improvement of the photographic program, and the conduct of surveys in support of limnological studies.

Time scale studies of lake surface thermal features were carried out using both low and high altitude overflights (Fig. 8). Previous evaluation of infrared line scanners, during the 1971 program, has resulted in better quantitative analysis of the imagery (Fig. 8).

Remote sensing operations in support of other programs included: support of dye diffusion studies in Lake of the Woods and Lake Ontario; support for the Oshawa Coastal Diffusion Study; support for the Air Water Interaction experiment at the Niagara test site.

Further work on the biological aspects of remote sensing were conducted on Lake Memphremagog in cooperation with McGill University, Department of Biology.

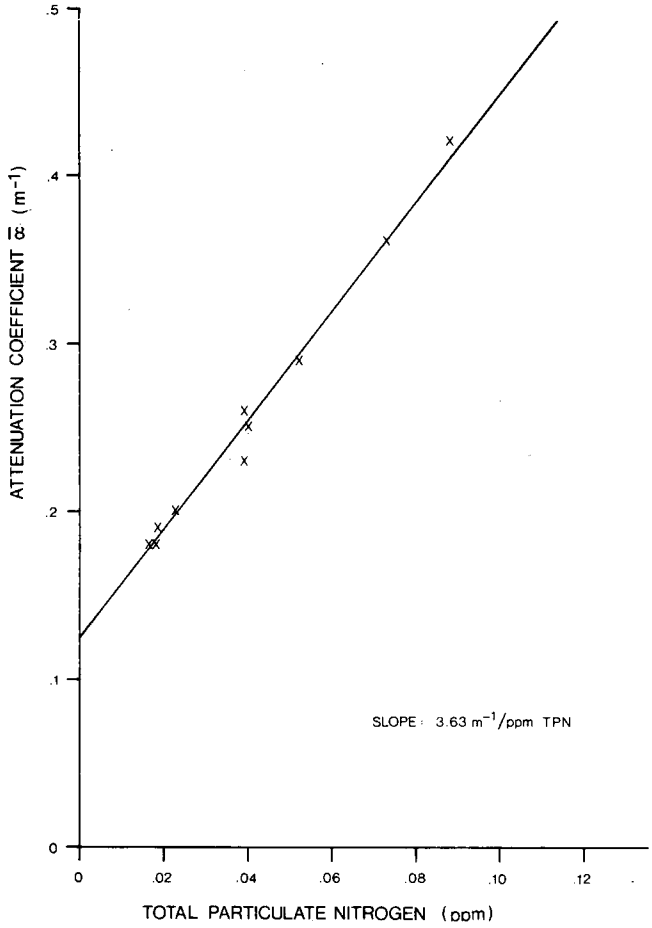


Figure 6. Attenuation coefficient of surface water determined with a wideband photometer versus total particulate nitrogen for the surface 10 metres.

On July 25, 1972, Earth Resources Technology Satellite – 1 was successfully launched into a geocentric polar orbit. The multi-spectral scanner aboard has functioned perfectly since launch, providing four-channel imagery of the earth's terrain on a synoptic basis. Imagery which has been observed thus far appears quite encouraging although imagery obtained over the Great Lakes since launch has suffered from extensive cloud cover, a situation which should alleviate as the winter season passes. Analysis of ERTS imagery at CCIW will continue to proceed along visual photointerpretative techniques. In addition automated photo-interpretation is planned for the near future utilizing digital magnetic tapes supplied through the Canada Center for Remote Sensing.

Data Retransmission via Satellite

A program has been initiated to assess the collection of scientific data via a satellite telemetry link. An application (to NASA) was approved to commence this program using the ERTS-1 satellite.

A small buoy was instrumented with air temperature, water temperature (using a Rosemount platinum resistance

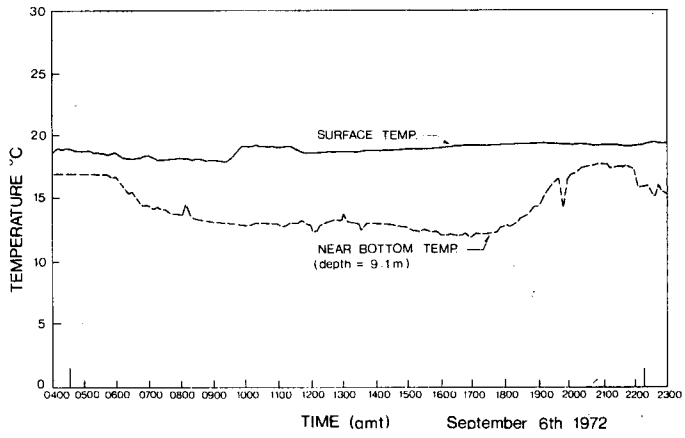


Figure 7. A graph of the temperatures measured by the water temperature sensors at the Burlington site.

sensor) and a Hygrodynamics relative humidity sensor. This was matched with a data collection platform designed for use with ERTS-1. The buoy was moored off the Niagara Bar (Fig. 3) and operated during the period July 31 to December 10, 1972.

The present system averages four transmissions per orbit and three orbits are received (on an average) every twelve hours. When comparing ground truth data with that received over the retransmission link, the errors were in order of 0.5%.

An "IRLS" (Interrogation, Recording and Locating System) experiment was a cooperative program between CCIW and the NASA-Lewis Research Centre, located in Cleveland, Ohio, involving a data collection platform (DCP) and a special constructed buoy, supplied by NASA-Lewis. The logistic support and data evaluation was carried out by CCIW.

The object of the experiment was to evaluate the positioning capabilities of the system to measure large scale surface currents, while transmitting actual data. During the period July to October, the buoy was released free-floating for three separate two week periods. For the first two periods the buoy anchored itself in shallow water (a small anchor was connected to the buoy, on fifty feet of line). During a severe storm (weekend of October 14), the buoy finally came ashore and was damaged. The experiment was then terminated. The number of successful interrogations during the study was in the order of 60%.

Data Processing and Display Unit

The Data Processing and Display Unit has the functions of filing, processing, running quality control on, and storage of, data collected by the Division, especially those data obtained by Technical Operations Subdivision. Eighty-five cruises for chemical and temperature surveys on Lake Ontario and eleven monitor cruises of the other Great Lakes were processed this year. Processed data has also

been provided to outside users, such as the Institute of Environmental Sciences and Engineering, University of Toronto; Biology Department of McMaster University; Department of Mechanical Engineering, University of Waterloo; and the H.G. Acres Consulting Engineers firm in Niagara Falls.

Computer programs were written to interpolate and grid data from a few observations and to determine average values of parameters retrieved from the "STAR" data file according to temperature and geographic locations. Two heat content computer programs, two editing programs for the bathythermograph nine point digitization and a spectral analysis program were converted for use on the CDC 3300 computer.

Several programs were written for the Hewlett Packard digitizer, namely programs to digitize electronic bathythermographs at one metre intervals, to digitize hourly averages of analogue records of temperature shore stations, to digitize and calculate the integrals and first and second differentials of graphed profiles of any parameter.

The Summary Data Atlas of temperature data and oxygen concentration for Lake Ontario and Lake Erie was essentially completed at the end of the year and will be published in early 1973.

Additional assistance has been provided to the Physical Limnology Section and the Descriptive Limnology Section in the processing and displaying of data for their projects by

Table 3. Involvement of 1972 remote sensing program on Lake Ontario with IFYGL.

Project	Location	Dates	Sensors	Ground Truth Measurements
1. Thermal gradient temporal evolution	Oshawa Lake Ontario	5/10/72 5/18/72 5/19/72 8/21/72 8/25/72 9/27/72 9/28/72 10/2/72 10/4/72	Infrared scanner 8-14μ Infrared radiometer 9-11μ Photographic	Survey launch surface temperature and bathythermograph recordings
2. Synoptic mapping of thermal and dynamic structures of Lake Ontario	Lake Ontario Hamilton to Kingston	6/7/72 8/28/72 8/29/72 10/27/72	Infrared scanner 8-14μ Photographic	Surface temperature infrared radiometer 9-11μ underflight, meteorological moored buoys
3. Dye Diffusion				
a) Patch b) Continuous flow	Oshawa Area Lake Ontario	6/5/72 6/27/72 6/28/72	Photographic	Fluorometer measurement of dye concentration profiles, surface drogues
c) Plume	Lake of the Woods, Ontario	7/28/72 7/29/72 7/31/72 8/1/72 8/3/72 8/4/72	Photographic	Lake current profiles, surface waves, winds, bathythermograph recordings
4. Experimental Survey	North Shoreline Lake Ontario	5/24/72 6/7/72	Photographic	Depth penetration Hydrographic charts
5. Algae and macrophyte concentrations and distributions	Lake of the Woods and Lake 227 Kenora	8/3/72	Photographic	Algae concentration Lake 227, FRB
	Lake Memphremagog, P.Q.	9/20/72	Photographic	Chlorophyll concent. McGill Biological Dept.
6. Atmospheric humidity profiles & lake surface radiometric temperature	Lake Ontario Niagara-on-the-Lake	5/25/72 5/26/72 6/16/72 10/10/72 10/12/72 10/13/72	Infrared radiometers 8-14μ and 19-11μ, air temperature, dew point temperature	Fixed tower surface water and air temp, dew point and winds

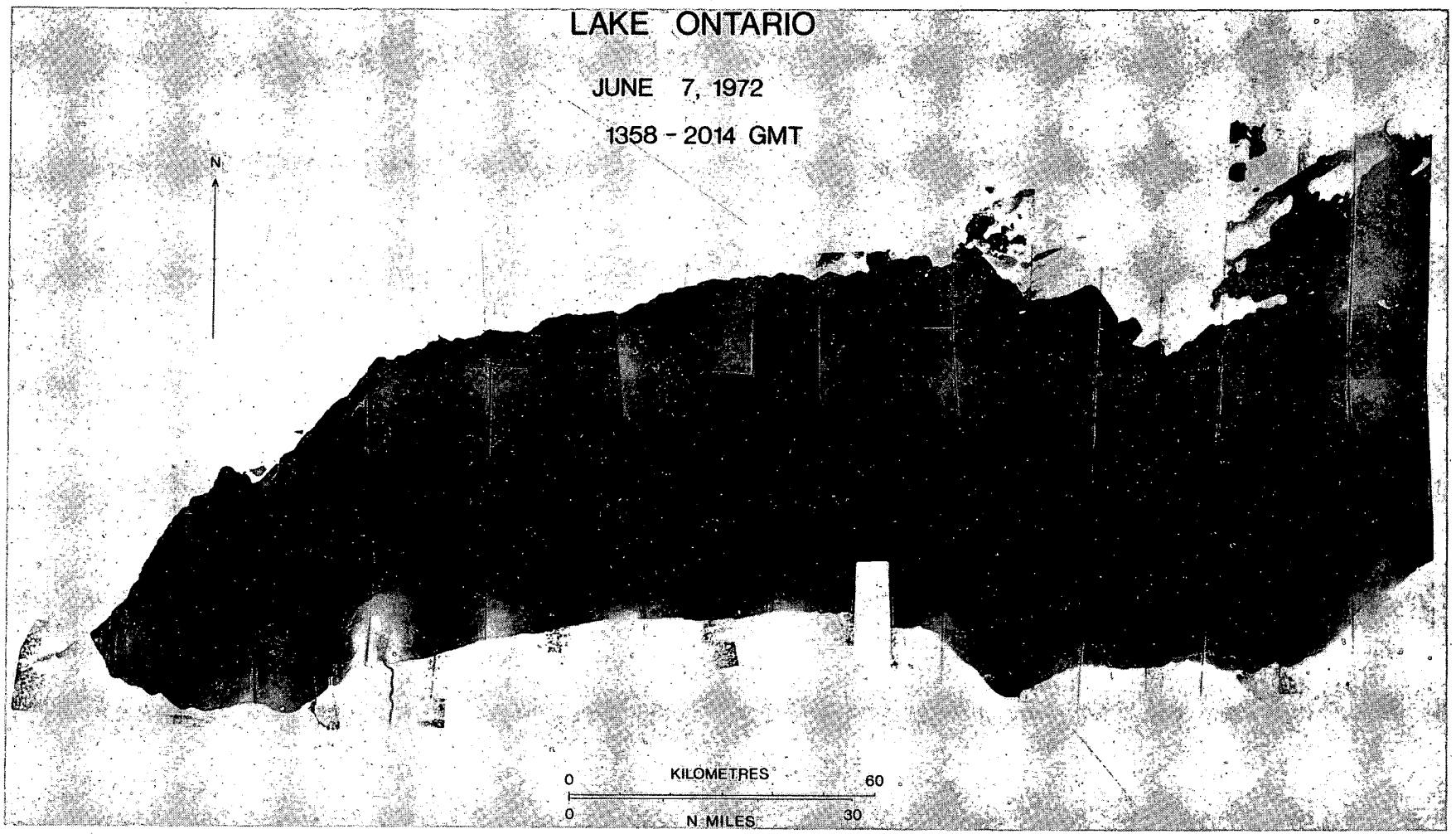


Figure 8. Infrared scanner mosaic and analysis of the imagery.

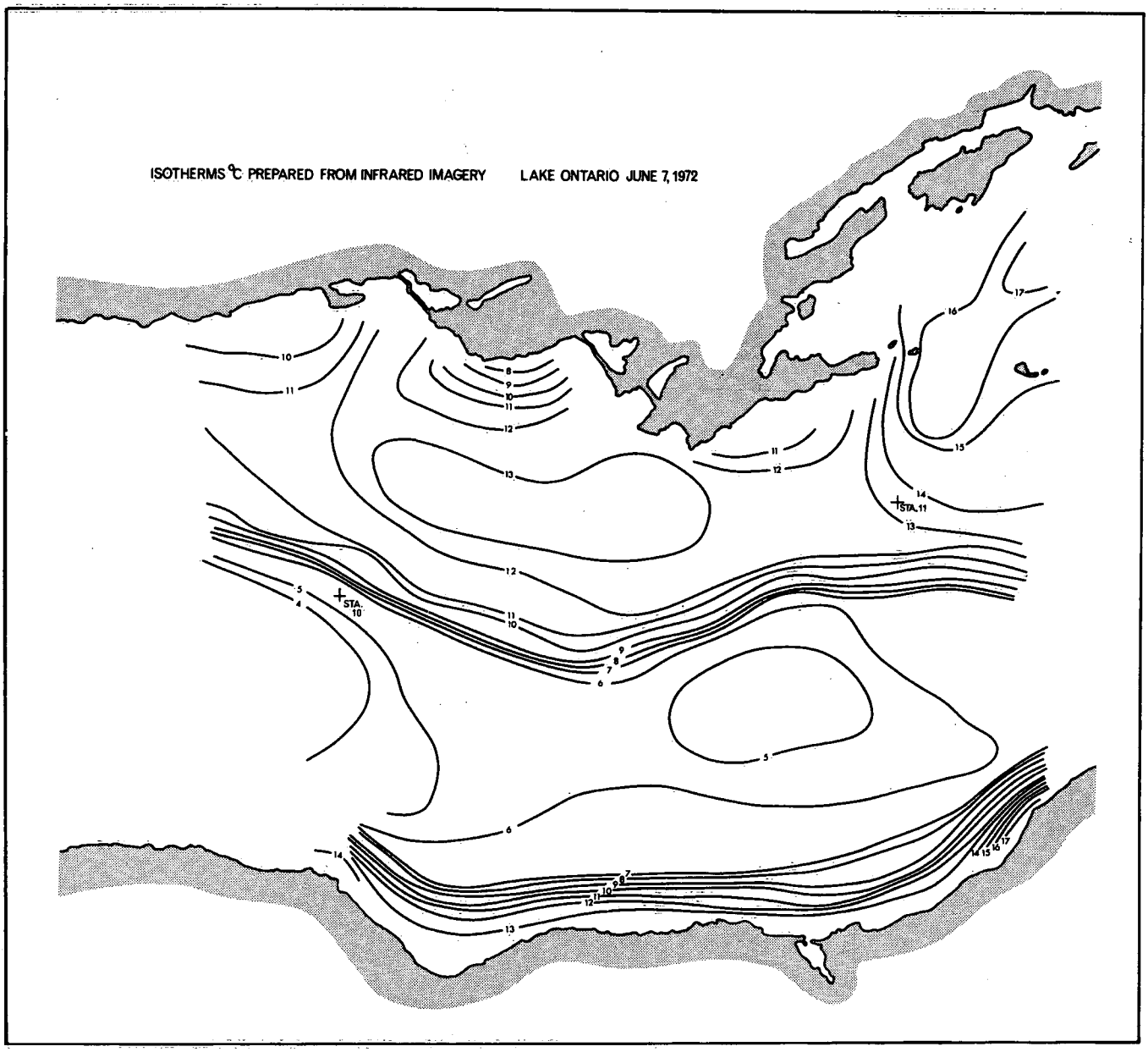


Figure 8 (Cont.)

processing data input to computer programs and analysis, correcting and displaying output. Some of the projects involved are:

1. Hydrodynamical modelling
2. Energetics
3. Heat content of Lake Ontario
4. Energy flux computations of Lake Ontario
5. Lake Erie nutrient data analysis
6. Nutrient studies of the Great Lakes

Regional Laboratories

Freshwater Institute Experimental Lakes Area

Work in physical limnology was conducted at the FRB Experimental Lakes Area near Kenora on the following aspects:

Lakewide circulation experiments at Rawson Lake, using radar-tracked drogues, produced an averaged velocity profile in the upper 6 metres. Initial results are consistent with a dependence between horizontal kinetic energy and the vertical distribution of Brunt-Vaisala frequency.

Detailed analyses of the spatial variation of both relative and absolute diffusion have resulted from dye experiments in selected lakes.

Near surface Eulerian current measurements were conducted in a small shallow lake. Comparisons of data with those from other lakes, in order to compare energy dissipation rates are being performed.

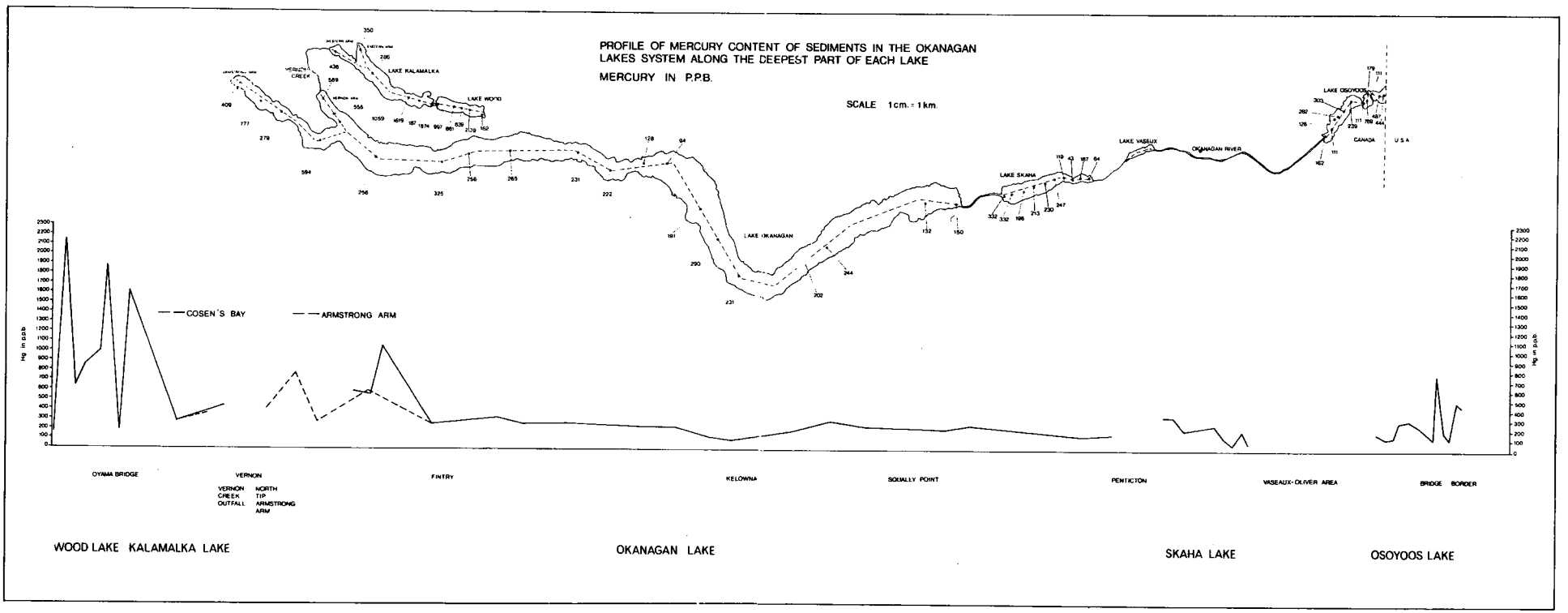


Figure 9. Profile of mercury content of sediments in the Okanagan Lakes system along the deepest part of each lake.

An electromagnetic EPCO current meter was used to measure horizontal and vertical velocity components. The horizontal component was dominated by quasi-periodic fluctuations correlated with Langmuir circulations. Attempts will be made to estimate the contribution of these to the momentum flux.

From continuous temperature measurements, determinations of energy concentrations at periods of 35 to 67 minutes have been related to the effects of bottom topography in Rawson Lake. Concentrations at 4.5 minutes are related to progressive Brunt-Vaisala waves. The latter were also recorded with amplitudes up to 2 metres from a triangular sensor array in a smaller lake.

A biogeochemical research program is also being organized at the Freshwater Institute, Winnipeg, where a laboratory is now being equipped for this purpose. The research planned for 1973 will consist largely of investigation of the role of clay minerals, humus, and clay-organic interactions in the budget and sediment-water interchange of phosphorus and iron, and its possible implications for eutrophication. Field work for the project will be performed at the Experimental Lakes area in western Ontario.

Okanagan Basin Study: Geological Investigations

The Geological Study of the federal-provincial Okanagan Basin Study (Task 121) was completed in June with the submission of a Final Report. The findings of the geological study were diverse, and resulted in the provision of a very large amount of basic data on the sedimentation processes in Okanagan, Wood, Kalamalka, Skaha, and Osoyoos Lakes. Highlights included the delineation of some areas in which the sediments appear to be enriched in mercury (Fig. 9) and the elucidation of the sediment phosphorus cycle in Skaha Lake. Wood, Okanagan and Osoyoos Lakes appear to have been undergoing eutrophic deterioration for much of the last century, but Skaha Lake started a sharp deterioration only 25 years ago with the onset of the sewage outfall from Penticton. Kalamalka Lake shows few signs of deterioration in the sediment record, and may have been somewhat "protected" from such a deterioration by its annual cycle of calcite precipitation. Although a "regional" study, this project was conducted out of CCIW by the Descriptive Limnology Section.

GEOPHYSICAL LIMNOLOGY SUBDIVISION

Components of the Limnogeology and Physical Limnology Sections of 1971 were brought together at the start of 1972, with the intention of improving the cross flow of activity and ideas, particularly as related to the nearshore zone and the interaction of lacustrine processes and shoreline materials. Although both sections carried forward pre-existing programs and commitments, such as those related to IFYGL and IJC references, steps were taken for joint planning of research activities, and the first developments of Physical and Geological Limnology programs were beginning to take effect at the end of the year.

Geolimnology

Regional Lake Sedimentology and Geochemistry

No large scale sampling program was initiated during the year and work has been restricted to the reduction of existing data, covering Lakes Ontario, Erie, and Huron. Major sediment distributions in Lake Huron showed considerable similarity to those recorded in Lake Ontario; in both these deepwater lakes, bathymetry is the major factor controlling particle size distribution. Sediment distribution data from Lake Erie suggests that response to wind/wave action and fetch is considerably more important. Major element analyses have been completed for Ontario, Erie, Huron and Lake St. Clair and are at present being prepared for publication. Trace metals (Hg, Pb, Cu, Zn, Ni, Co, Cr, Cd, Be, V, and Sr) have also been determined for Lake Ontario, Lake Erie and Lake St. Clair.

Nearshore Studies

During 1971 the nearshore inventory program in Lake Erie was extended westwards from Nanticoke to Port Burwell along the Canadian shore. (Figs. 10 and 11). The bottom sediment composition comprised 5% bedrock, 40% glacial material, and 55% unconsolidated material. Long Point Bay deposits varied from clean sands inshore to silts and muds offshore. Textural gradients alongshore suggest net westward transport towards the bay head, along both the north and south shores; probably source materials are the glacial drift exposed as bluffs and offshore in the north part of the bay, and the south shore spit deposits.

South of Long Point, the Long Point-Erie moraine is expressed as a major shoal which extends across the basin. Continuous sand deposits along the crest of this moraine appear to be derived from local reworking of underlying glacial drift and from erosion of glacial deposits on the shelf to the west.

West of the moraine, there is a broad offshore shelf of exposed glacial drift and derivative lag deposits, and a narrow shore slope composed of inshore sands and offshore muds. The sands are derived from the erosion of adjacent shore bluffs. Net drift is towards the east and acts as the supply for the accretion of Long Point. The survival of a band of shallow-water muds in what appears to be a zone of high energy has yet to be explained.

In Lake Ontario, a simple jetting procedure was used to establish the thickness and basal material of the Lake Ontario nearshore sediments at Burlington, Niagara, Toronto, Brighton and Wellington and to provide the basis for a coring program in 1973. Thickness gradients found were consistent with the net transport directions proposed for the basin. Maximum thickness measured was 18 metres at a site just north of the Burlington Canal entrance. Figures 12, 13 and 14 show the changes in the sedimentary

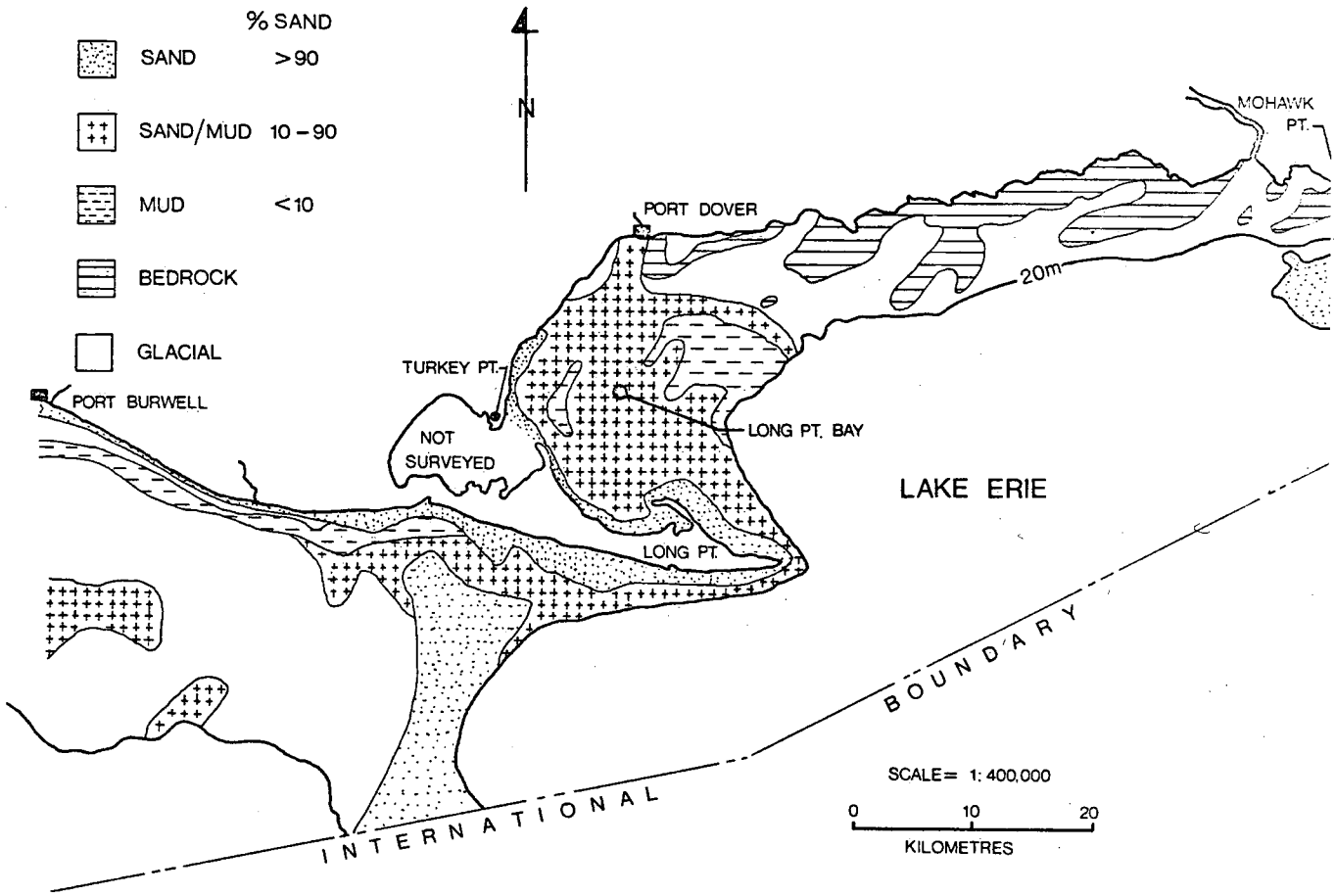


Figure 10. Nearshore inventory program, eastern Lake Erie.

deposits of the Wellington Bay area of Lake Ontario, which are evident from the comparison of Kindle's 1915/16 data and that of CCIW obtained in 1971. Jetting data was used to complement the previous year's data and to confirm the implied changes.

Project MOSES (Monitor Sediment Survey), which was designed to investigate the annual variations in sediment distributions in the nearshore zone off Burlington, has shown that the average depth of the survey area varied by 1.6 metres during the survey period. Of this, 0.6 metres was the result of water level changes; the remainder was due to sediment loss or gain in the area. Depth was greatest during the summer months, and least during the winter. There appears to have been a net decrease in depth of 0.8 metres during the survey year, which corresponds to a sediment influx of approximately 50,000 cubic metres.

The overall average sediment texture varied by less than 5% during the survey year but significant changes did occur in the distribution of the sand, silt and clay components. The tendency was for poor differentiation of sand and sub-sand size material during the winter and spring and good separation during the summer and fall.

Changes in textural pattern and depth appear to correlate with seasonal changes in wind direction and intensity. Shoaling and homogenization of texture corresponds to the period of most intense onshore storms; deepening and textural differentiation occurs during lower energy condition.

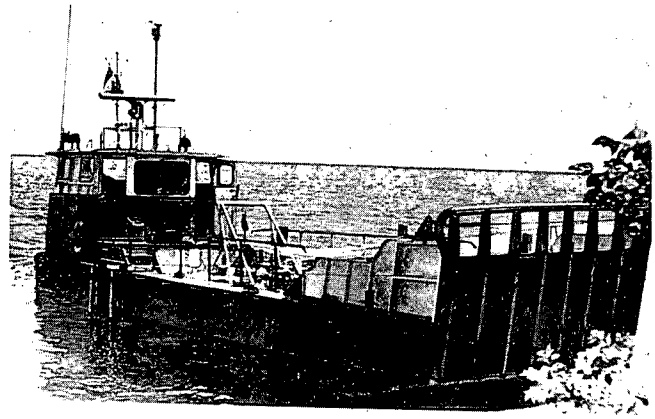


Figure 11. Vessel support for inventory program.

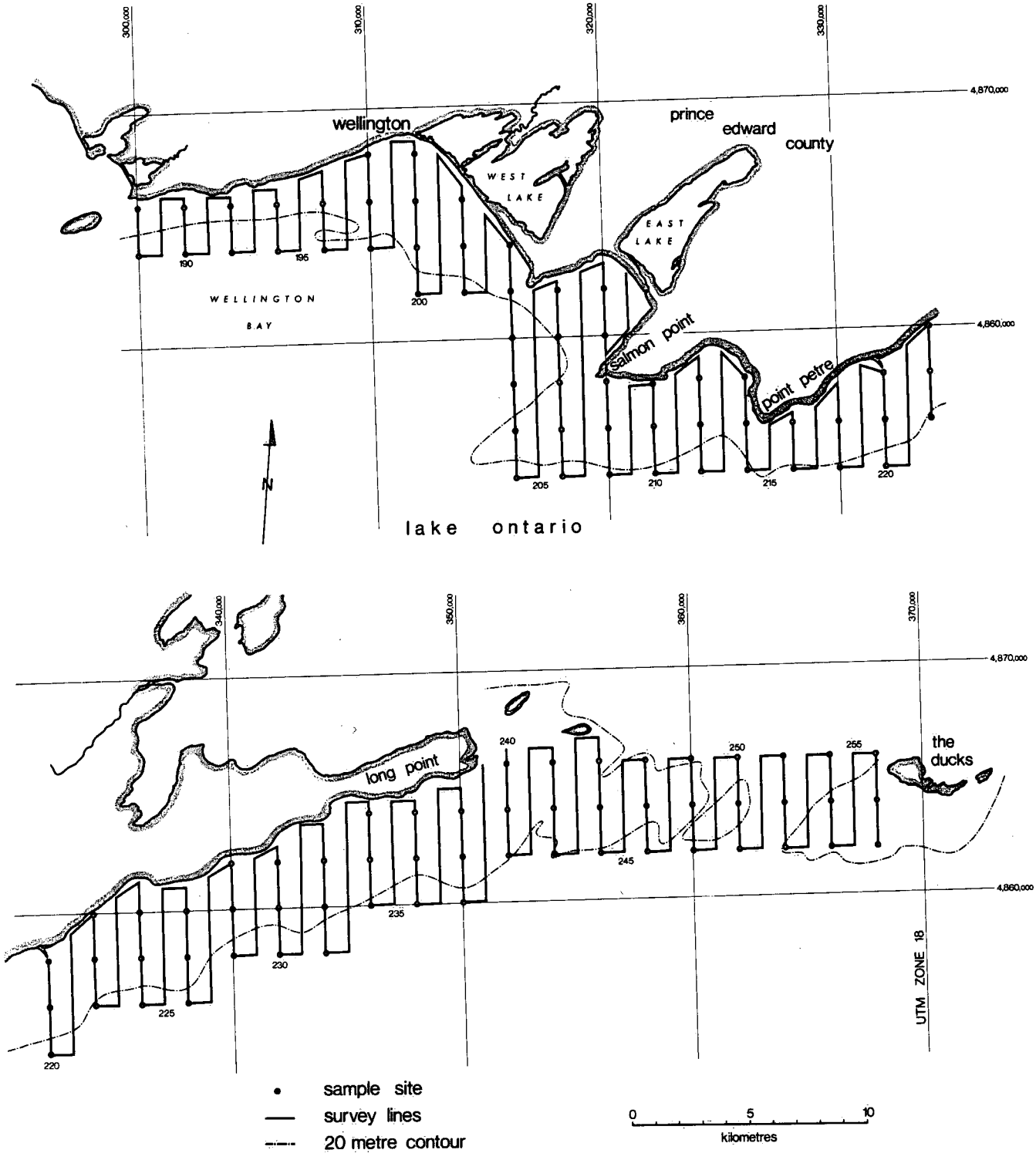


Figure 12. Map of sampling grid, Wellington Bay area, Lake Ontario.

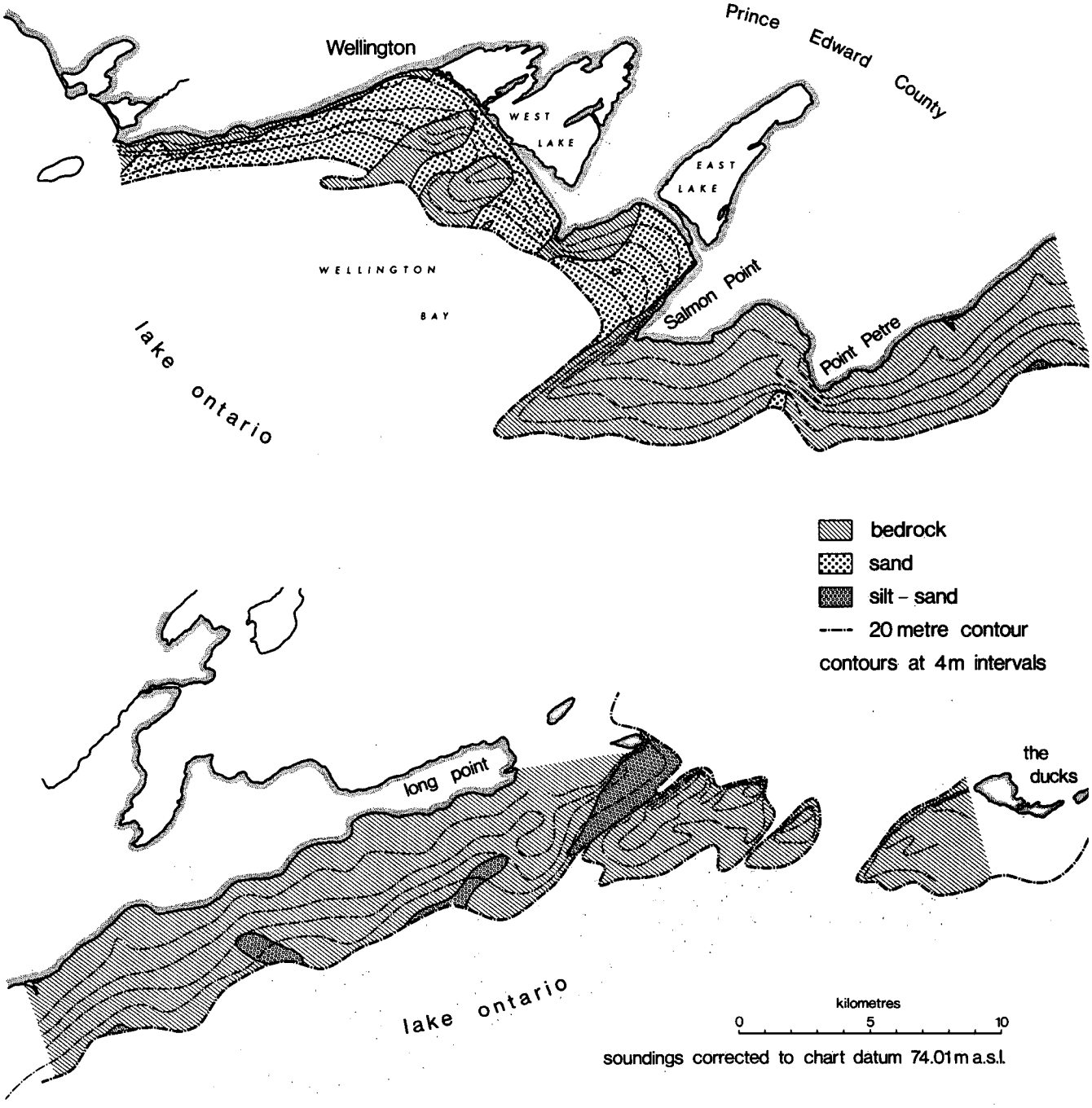


Figure 13. Map of sediment distribution, Wellington Bay area.

Tracer Studies

A pilot sediment tracing program was carried out in October 1972 offshore from Hamilton's Confederation Park, western Lake Ontario (Fig. 15). After an exhaustive literature review of tracing techniques used worldwide, it was decided to use a synthetic glass "sand" containing 3.4% of the element antimony (Sb). The field operations and sampling were supported by Scuba divers and analysis of the samples collected was carried out using neutron activation techniques. Results of the tracer experiment were complemented by shore-based monitoring of beach and wave-related parameters and confirmed that long-shore sediment movement is quite small when compared to movement perpendicular to the shoreline. At the tracer site, a strong net onshore movement predominated, probably reflecting the over-riding influence of storm waves from the east. The beach at this site was found to remain stable under all wave regimes.

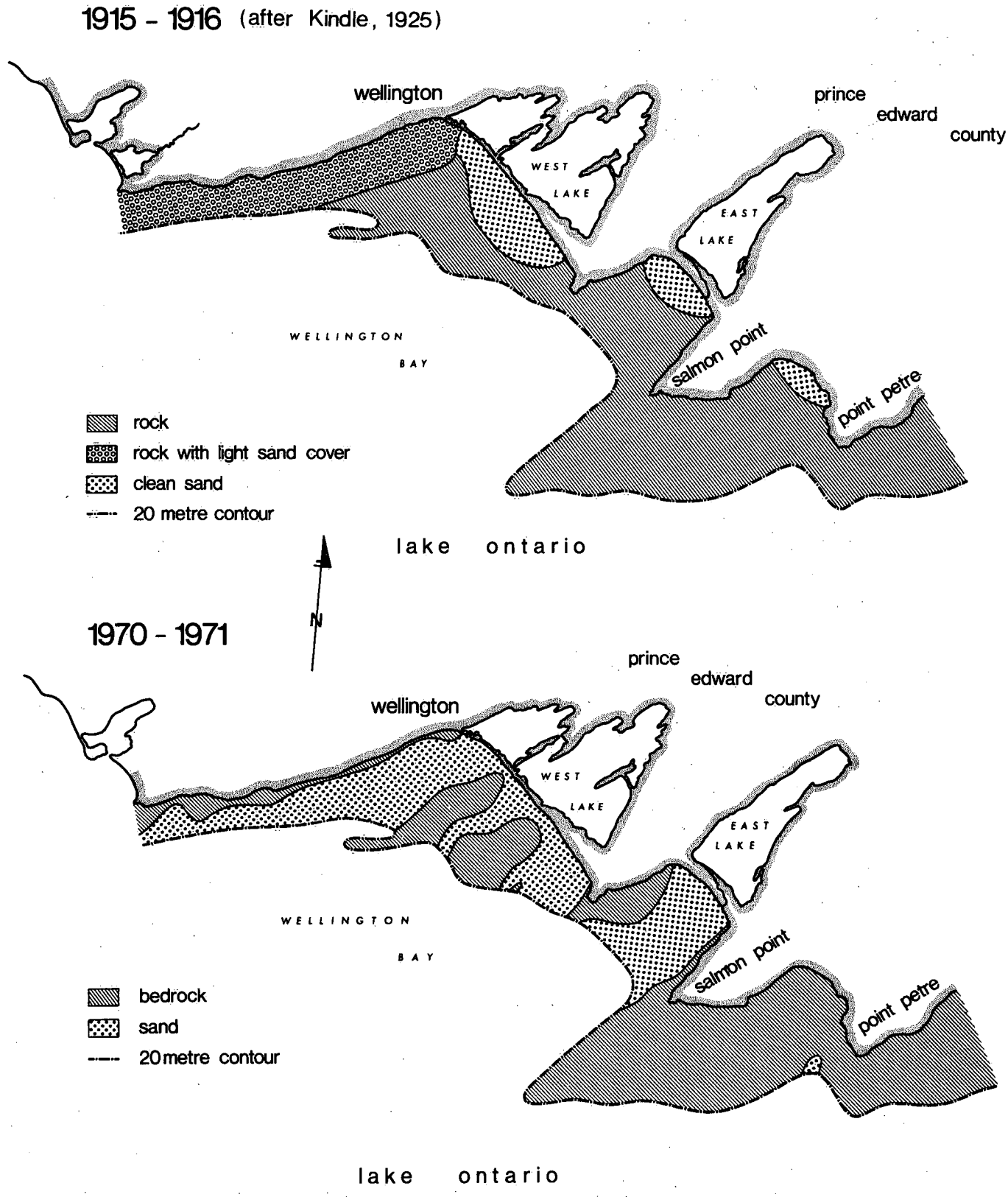


Figure 14. Changes in bottom sediments 1915-16 to 1971 Wellington Bay area.

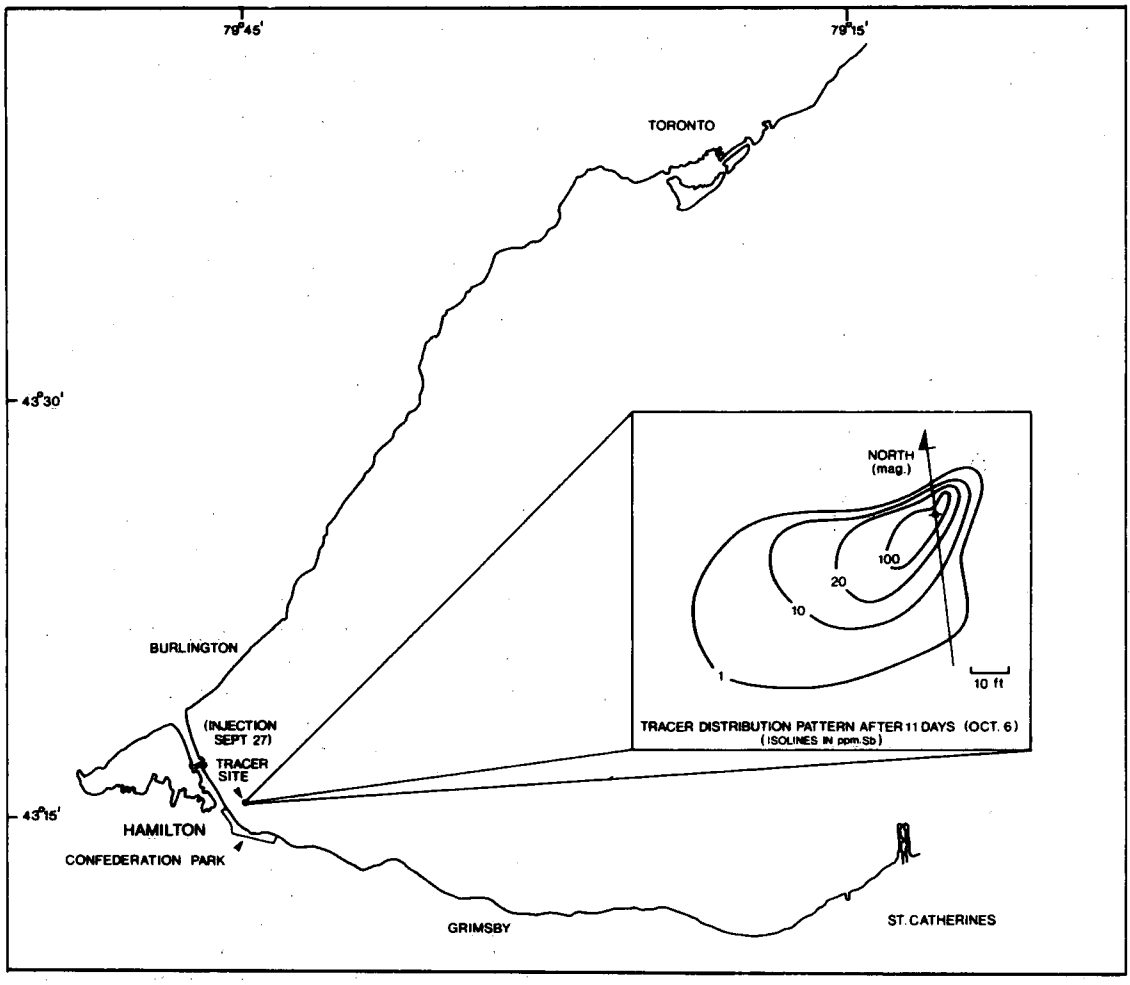


Figure 15. Sediment tracer experiments, western Lake Ontario, 1972.

Geophysical Studies

During the early part of the year an experimental, very shallow water, seismic reflection survey was run in conjunction with the University of Waterloo and the Atomic Energy Commission (Chalk River) at Perch Lake, Ontario. The results, however, were disappointing.

Further seismic surveys were run in cooperation with the GSC in the Mackenzie Delta-Beaufort Sea area, and to provide improved resolution of Lake Ontario "problem areas" in the eastern parts of the Rochester basin of Lake Ontario. Side scan sonar tests were completed in eastern Lake Ontario, after an extensive rebuilding of the existing equipment and installation of a new towed body. Assistance was also provided to the Earth Physics Branch for Heat Flow Studies in Lake Ontario (IFYGL).

Priority was given to the design and development of specialist geophysical equipment to be used in support of studies on recent sediment lithological and stratigraphic variations. This included a shallow underwater refraction system, an *in situ* and laboratory velocimeter, a core resistivity logger, an underwater resistivity profiler and an *in situ* resistivity probe. Much of this equipment is close to becoming operational.

Suspended Sediment Studies

These were restricted to a series of laboratory and test programs designed to evaluate the photo-extinction equipment for use in quantifying the low concentrations of suspended sediment from the Lake Systems. Drift in the order of 2-5% per 24 hours appeared to be related mainly to component quality; anomalous background levels observed during fluorometry tests have yet to be defined but are believed to have been related to impurities in the water supply used.

GSC (Geological Survey of Canada) – CCIW Activities

Palynological investigations were carried out on selected cores from the Great Lakes and from the Okanagan Valley lakes of British Columbia.

Pollen analyses were completed on a sediment core from South Georgian Bay to interpret the Quaternary

stratigraphy. Four pollen horizons provide a time-stratigraphic zonation of the sediments. One of these horizons, the spruce-pine transition (Ca. 9,500 years B.P. here), occurs at the contact between glaciolacustrine red clays and overlying grey silty clays. This transition dates these sediments and also the low-level stage of Georgian Bay, Lake Hough.

In Western Lake Huron piston cores have intersected peat, believed to have been deposited during low-level Lake Stanley (when Lake Huron drained northward). The spruce-pine transition occurs at the base of the peat.

Pollen analyses on piston cores collected by the Consumer's Gas Company from north-central, nearshore, Lake Erie, demonstrate a major hiatus, possibly amounting to 4000 years, between the glacial and post glacial sediments. This inferred hiatus presumably corresponds to an unconformity and lack of sedimentation during the low-level Early Lake Erie Phase (Ca. 12,500 years B.P.). However, preliminary pollen studies on cores collected in offshore areas imply uniform and continuous sedimentation.

A post-*Ambrosia* (related to European settlement and the advent of agriculture about 120 years ago,) decline in *Castenea* (chestnut) pollen, is being identified in six cores from Lakes Ontario and Erie. The *Castanea* decline correlates with the final die-out of chestnut trees about forty-five years ago.

Consistent pollen changes have been observed in sediments from the Okanagan Valley lakes, Okanagan, Wood, Kalamalka, Skaha and Osoyoos. These changes correspond to historically known changes in the flora and land use, such as the transition from cattle ranching to agriculture. This event took place about 1890 and hence serves as a convenient marker to date these sediments.

An extensive coring and sampling program was undertaken by the Consumer's Gas Company in Central Lake Erie in order to study and locate adequate bearing strata for jack-up drilling rigs. This study is of interest since it provides good quality cores of lake sediments (to bedrock) which were previously unavailable. Furthermore, this study will provide measurements and interpretations on engineering properties of the sediments with particular reference to their bearing capacity for offshore structures. A discussion of this program and interpretations and conclusions from preliminary data have been published in a report by Lewis, Wootton and Davis (Geological Survey, Report of Activities, Paper 73-1 PT.A., 1973).

Data Handling

During the early part of the year three sub-files designed for specific data handling were established. They correspond to shipboard sediment data (CCIW-SHIP), sedimentological laboratory data (CCIW-SEDPET), and geochemical data (CCIW-GEOCHEM). Geophysical and biotic data may be included in the near future.

Implementation of a merged file will be initiated early in 1973, in the form of a computer data file, for lake sediment data to be maintained at the Canada Centre for Inland Waters. Using the SAFRAS data file system, developed at the University of Western Ontario, the file will be compatible with similar geological data banks at the Geological Survey of Canada and the Ontario Department of Mines and Northern Affairs. The prime purpose of the file will be to serve as a continuing archive of sediment information for scientific and general use. However, the potential of such a computerized system of data records for data base management and analysis will greatly aid studies of regional scope.

Contract and Cooperative Studies

At the invitation of the University of Geneva a senior research staff member from the Section spent eight months on exchange, working on sedimentological and geochemical problems in Lake Geneva (Lac Leman). This exchange resulted in additional studies on the distribution of mercury in parts of the Rhone River system, in Lake Geneva, and also in selected isolated and alpine lakes. The effects of prevailing winds and associated rainfall were observed to be significant controlling factors in the atmospheric introduction of mercury into otherwise uncontaminated environments.

During the latter part of the year Section staff cooperated in programs of the Royal Ontario Museum designed to try to locate archeological evidence and remains of two important wooden sailing vessels lost off the Niagara Peninsula during the war of 1812. The program cooperation provided an excellent opportunity to test-evaluate modifications completed to the side scan sonar equipment. A number of targets were located in deep water offshore of the St. Catherines – Welland area, but subsequent follow-up with underwater television working at extreme depth were not confirmatory. At the present time it is believed that the targets so far located do not typify those of the search objective.

An extensive program of shoreline erosion studies was initiated jointly with the Civil Engineering Department of the University of Waterloo, and has been specifically designed to differentiate the control exerted by such factors as material composition, groundwater seepage, slope control, vegetation, wave forces, wave incidence, water level, and offshore bathymetry. It is hoped that results from this study, which is primarily concerned with the Niagara Shoreline of Lake Ontario, may be directly applied to other similar shoreline areas. Bearing in mind the impact of continuing high water levels in the Lower Great Lakes since predicted high levels during 1973, this information should be of considerable value in properly understanding the impact of high lake levels.

A contract with the Department of Geology of Lakehead University was extended into 1972, under terms similar to that existing during the previous year. Particular

attention was given to the shoreline and nearshore areas of the northshore of Lake Superior, and to the more isolated bays east of Thunder Bay, which had been neglected during previous surveys because of logistical problems. Evidence of environmental degradation appears to be significant only in very limited areas, such as around Marathon.

An extensive contract report was completed by H.G. Acres Limited (Niagara Falls, Ontario) on "The evaluation of procedures for recovering and decontaminating bottom sediments in the Lower Great Lakes." In this report details of the various aspects of dredging material processing and treatment, and cover by use of inert materials as they relate to the Great Lakes and similar environments were reviewed. Case history examples of studies undertaken at Placentia Bay (Newfoundland), Chedabucto Bay (Nova Scotia), New Jersey estuaries, Lake Washington, with the Great Lakes (by both U.S. and Canadian agencies), and from selected sites in Sweden, Germany, England, and Japan, were used to define the approaches which had been made to various sediment pollution problems such as oil spills, mercury contamination, and other industrial outputs; the success of each approach taken was appraised. In the light of Great Lakes problems, an example of a sediment pollution problem was chosen and then the various possible remedial approaches were evaluated in the light of present day technology and economics.

Some of the major points which arose from the report appear to be: (1) the need to lessen environmental impact by the use of improved and more efficient dredging technology; (2) the limited effectiveness of present technology in its ability to decontaminate or process polluted materials, particularly fines; (3) the inability of presently-available plant to effectively remove polluted materials once they have been allowed to settle out as a fine cover over a wide area.

It is expected that this report and its references will provide an important basis for much of the work necessary in proposing improvement to Great Lake dredging activities, and quality standards, as required by the IJC.

Physical Limnology

Physical or mechanical energy at all scales is ultimately responsible for the distribution of dissolved and suspended material within a lake. Studies of chemical and biological processes important in the life cycles of lakes must take into account the accompanying physical regime if full insight is to be gained into the dynamics of these processes. The role of the Physical Limnology Section is primarily one of research into basic physical processes affecting the distribution of energy and materials across the surface and within lakes.

The bias of the group as a whole is toward experimental work in the natural environment for which the Centre provides excellent facilities.

The greater part of the Section's work in 1972 was in support of the International Field Year for the Great Lakes (Fig. 16). A large body of field data has been successfully collected and is now being analysed.

Diffusion Experiments

Several diffusion experiments were carried out in 1972 in coastal waters, and offshore in both the epilimnion and hypolimnion of Lake Ontario. The basic technique consisted of injecting a marker dye (Rhodamine B) into the water either in a single blob or as a continuous stream, and then tracing, the time and space changes of the dye concentration field using fluorometers (for concentrations as low as 1 part dye to 10^{11} parts water) and aerial photography.

The nearshore experiments were of the continuous plume type with the dye being injected from a specially equipped raft. The depth of injection varied from the surface to 10 m and for these latter depths a bottom-moored diffusing apparatus was used (simulated outfall experiment). The dye concentrations in the resultant plume were measured from a 40-foot launch (C.S.L. AQUA) using a pump and continous flow-through fluorometer (launch-mounted) for each sampling level.

The offshore experiments were conducted from C.S.S. LIMNOS in collaboration with Professor G. Kullenberg of Copenhagen University and H. Westerberg of Goteborg University (see work supported under contract). Single patches of dye were released and the diffusing patch tracked using Kullenberg's *in situ* fluorometer. It was possible to continue some of these experiments through time and space scales as large as 80 hours and 15 km respectively.

The dye concentration measurements were complemented wherever possible with measurements of meteorological parameters, local current structure and thermal structure.

A preliminary analysis of the data in which effective horizontal eddy diffusivities were calculated as a function of the spatial scales, suggests that the diffusivities range from 10^2 to 10^6 cm^2/s in such a way that Richardson's "4/3 power law" dependence of eddy diffusivity upon spatial scale is approximately verified (Fig. 17).

The experiments in which dye was released in the thermocline zone are particularly revealing as to the complex" sheet and layer" structure of the thermocline. The dye was observed to spread within a narrowly-confined layer having the same density as the initial dye solution. The vertical position of this layer varied due to internal wave activity but could be identified from an examination of the thermal structure. Dye appeared to diffuse across the vertical boundaries of the layer where local current sheer is expected to be high (Woods, 1968). Further study of diffusion processes in a thermocline would greatly benefit

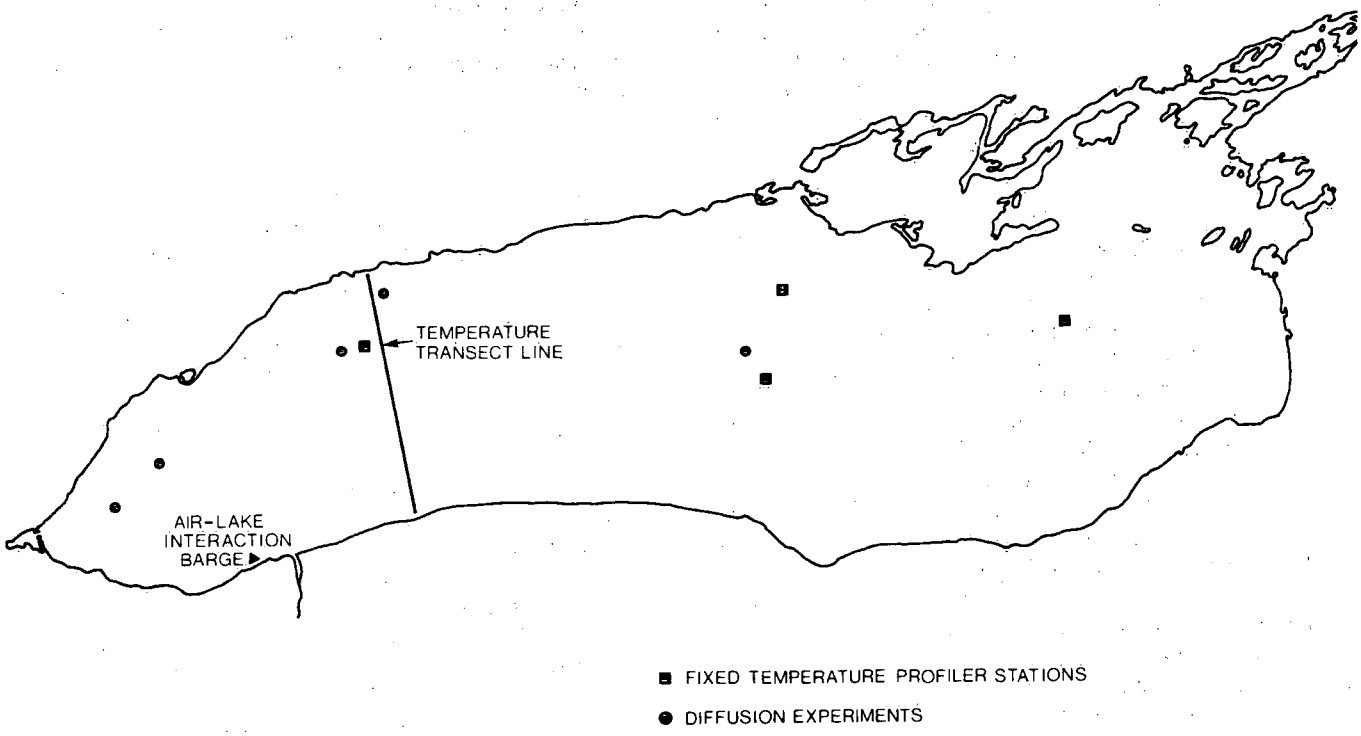


Figure 16. Map of Lake Ontario showing approximate locations of 1972 field operations of projects undertaken by the Physical Limnology Section.

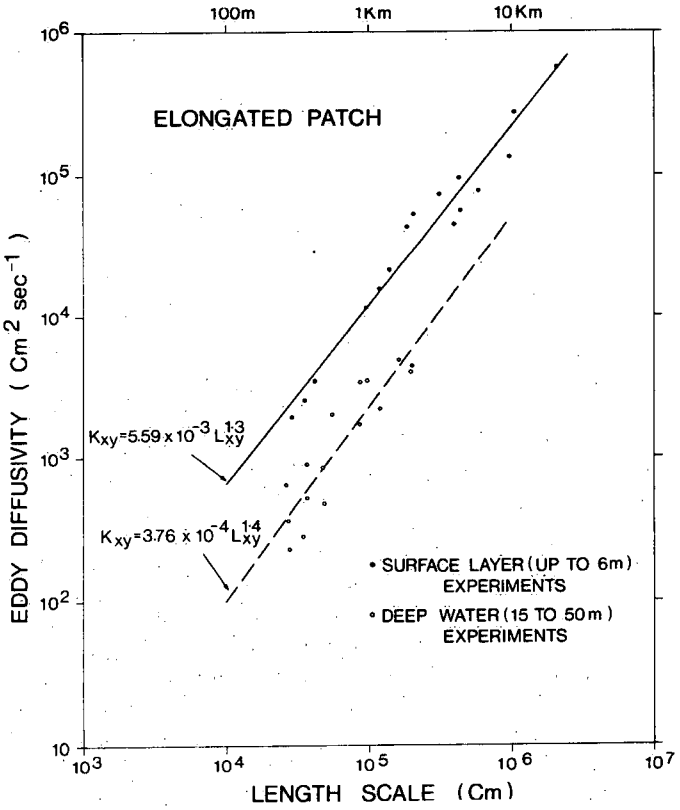


Figure 17. Apparent eddy diffusivity as a function of length scale based on 1972 field experiments.

from a technique permitting the accurate measurement of the current " fine structure".

Air – Lake Interaction

The main effort of the program consisted of the planning and execution of a complex series of experiments in Lake Ontario near the mouth of the Niagara River. The experimental facility (Fig. 18) consisted of three 80-foot bottom-mounted towers in 40 feet of water, on which were mounted meteorological instruments. Underwater power and signal cables ran from the towers to a barge anchored nearby. The barge was equipped with diesel generators for electrical power, shelters for recording instruments, and rough living accommodation for the investigators. The installation and maintenance of this facility was a challenging task in itself and could not have been achieved without the large and sustained efforts of the Scientific Division, Technical Operations Subdivision, and Marine Sciences Directorate at the Centre.

The primary objective of the experiments was the measurement of the exchange of momentum, heat, and moisture between the air and the water over a wide range of natural conditions. Particular emphasis was placed on the effects of atmospheric stability and wind speed immediately above the water surface upon the direction and rate of these transfers. Conditions in Lake Ontario vary from strongly stable in the spring (warm air, cold water) to

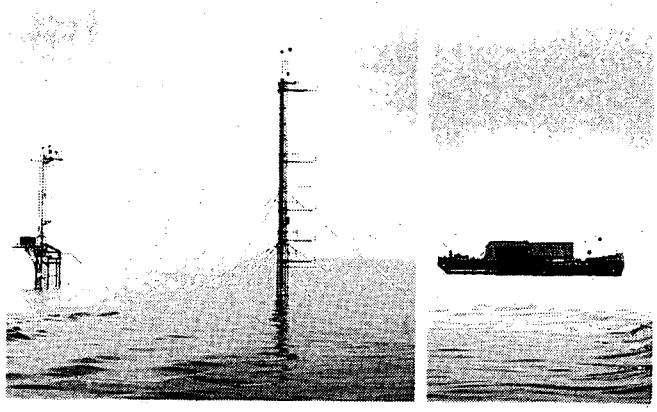


Figure 18. The Niagara micrometeorological facility. Sonic and hot-wire anemometers and wave gauges are mounted in tower at left; tower at right is the profile tower. Recording equipment was housed in the barge, anchored several hundred feet away.

strongly unstable in the fall (cold air, warm water) and the possibility of obtaining such a wide range of conditions at a single site alone makes the data particularly valuable. The application of these measurements, in addition to possible new insights into the physics of air-water transfers, is towards an improved ability to estimate the net exchange of momentum, moisture and energy (mechanical and thermal) between air and water from measurement of a few well-selected and simply-obtained parameters such as mean wind speed and air-water temperature differences at fixed reference heights.

With this latter aim in view, measurements have been made with a variety of instruments ranging from rapid response probes, from which the turbulent fluxes may be measured directly, to the standard moored meteorological system which measures wind speed, air temperature and humidity at a fixed (4 m) height above water level.

Data were gathered during four periods of about two weeks each, in May, June, August and October. Three of the periods were marked by occurrences of strong winds. At times this caused delays because of the difficulty in landing people safely on the barge from small boats. Nevertheless a large and valuable collection of data was made.

The barge and tower facility served as a platform for other investigators from the Atmospheric Environment Service of Canada, the Atlantic Oceanographic Laboratory at Dartmouth, N.S., and the Pennsylvania State University. The measurements will be used also for comparison with similar data gathered during the overflights of research aircraft.

Heat Content and Thermal Structure of Lake Ontario

One of the core projects of the International Field Year is a detailed thermal energy balance of Lake Ontario. This balance will allow estimates to be made of lakewide transfers of latent (evaporation) and sensible heat across the water surface. These estimates in turn will serve as bases for the comparisons of other, independent, measurements of these transfers and so help to refine present methods of estimating air water transfers from standard meteorological observations.

A key term in the energy balance equation is the time rate of change of quantity of the heat stored in the lake. For Lake Ontario this term has a mean daily value comparable in size to the other heat fluxes. In principle, the quantity of heat stored in the lake may be computed from synoptic temperature profile data by constructing an approximate integral of the temperature field over the lake volume. Simple estimates show that useful accuracy can be obtained with a 93-station sampling grid and using two vessels equipped with standard EBT's to obtain a temperature profile at each grid point within a 50-hour period. Starting April 4, 32 such surveys were carried out during 1972 with both Canadian and U.S. vessels. The raw data in the form of graphs of temperature versus depth have been edited and processed at CCIW, and preliminary computations of the stored heat content at the midpoint of each survey have been made. From these calculations it appears that Lake Ontario took longer to warm up in 1972 than in other years but that the total stored heat (change from minimum to maximum) was not significantly different from past values. The program is being carried on through the early part of 1973.

A useful by-product of these surveys is the series of near-synoptic pictures of the lakewide thermal structure (Table 4) which may be readily assembled (cross-sections, surface distributions, etc.) from the temperature profile data. A series of preliminary reports has been issued describing this structure and attempting to relate it to meteorological events. The same data set have been used also to estimate available potential energy and its changes as they relate to mechanical energy transformations within the lake.

River outflow temperatures were collected at the mouths of the Credit, Humber, Ganaraska, Trent, and Moira Rivers along the north shore of Lake Ontario as part of a program to estimate the quantity of heat advected into the lake by its tributaries. Local observers were recruited to maintain thermographs and to take a daily surface temperature. The field measurements were made from early April through late November.

It was recommended by the IFYGL Energy Balance and Water Movements panels that long-time series data on the thermal structure be collected at some points in the lake. The Section, together with the Engineering Systems Section and the Technical Operations Section, undertook the design, procurement and emplacement of four fixed temperature profilers in Lake Ontario. The technical aspects of this program have been described in an En-

gineering Report (Harrison & Watson 1972). As is usual with prototype systems, there were some failures, but the gross data return is estimated to be about 60% and should prove to be a valuable contribution to the total collection.

The Section contributed to the Water Movements Program of the IFYGL via three temperature transect cruises conducted aboard C.S.S. LIMNOS. The purpose of the cruises was to detect long standing internal waves of the Poincaré type, thought to be a dominant feature in the offshore zone under stratified conditions. These waves can be detected by measuring the time and space changes of the thermal structure (notably the position of the main thermocline) along a transect of the lake. Two towed systems were deployed from LIMNOS, an undulating vehicle carrying a temperature and a pressure (depth) sensor (Bedford Batfish), and an array of thermistors mounted on a faired cable. The LIMNOS crossed the lake repeatedly on a line from Oshawa, Ontario, to Olcott, New York at a speed of 7 knots. Each experiment lasted 4 1/2 days and comprised roughly 22 crossings of the lake.

In all 3 cruises, evidence of basin-wide internal standing waves has been observed (Fig. 19), as well as much revealing data on the nature and possible sources of some of the short progressive internal waves.

Hydrodynamic Modelling

Extensive investigations were carried out with a three-dimensional model of Lake Ontario in order to take full advantage of the IFYGL data. Model verification using this data was started as soon as the observations became available. The occurrence of tropical storm Agnes in the second half of June constituted a singular event well suited to this verification. A detailed analysis was made of the observed wind stress and atmospheric pressure fields in order to provide suitable input to the model. In general, the water levels and currents computed by the model are in good agreement with the field observations.

In order to illustrate the applications of numerical models, a film entitled "Computer Simulation of Water Movements in Lake Ontario" was made at the National Centre for Atmospheric Research in Boulder, Colorado. The film was made using the computer facilities in Boulder and runs about 12 minutes. A copy of the film may be borrowed from the CCIW library.

A more specialized model has been developed (Hamblin, 1972) with the purpose of studying the causes and characteristics of lake seiches. A general numerical method permits an examination of the effects of the earth's rotation, realistic bathymetry, and shoreline configuration on the frequencies, free-surface topography and current distribution of lake seiches. The method was first applied to the five lowest mode gravitational seiches and the lowest rotational seiche in Lake Ontario. Work has continued on the mechanisms of generation of surface and internal seiches by atmospheric and tidal forces, and an analysis of observed water level fluctuations in Lake Ontario is in

Table 4. Average temperature (0°C) of horizontal layers in Lake Ontario computed from 1972 Heat Content Survey data.

LAYER	Cruise Dates													
	6/4	11/4	18/4	25/4	2/5	9/5	16/5	25/5	1/6	6/6	14/6	21/6	28/6	6/7
0 → 10m	1.37	1.47	1.90	2.16	2.71	3.14	3.57	5.61	6.12	7.39	7.25	9.83	10.47	13.16
10 → 25	1.38	1.48	1.77	2.02	2.46	2.78	3.02	3.64	4.26	4.38	5.37	5.75	6.78	7.15
25 → 50	1.46	1.52	1.74	1.94	2.31	2.49	2.75	3.22	3.54	3.75	4.00	4.09	4.60	4.68
50 → 100	1.57	1.57	1.77	1.94	2.19	2.38	2.44	2.99	3.21	3.55	3.73	3.85	3.99	4.05
100 → 150	1.98	1.99	1.89	2.04	2.31	2.36	2.49	2.90	3.13	3.37	3.37	3.64	3.85	3.91
150 +	2.01	2.38	2.36	2.32	2.34	2.40	2.50	3.10	3.21	3.25			3.89	3.91

LAYER	Cruise Dates											
	18/7	2/8	29/8	5/9	13/9	19/9	26/9	11/10	17/10	26/10	7/11	22/11	28/11
0 → 10m	17.47	18.61	19.01	19.16	18.86	17.56	16.69	12.19	9.39	9.41	8.75	6.94	6.00
10 → 25	8.08	10.37	13.09	13.57	13.60	14.65	13.31	11.70	9.24	9.04	8.52	6.91	5.95
25 → 50	4.68	4.76	5.52	5.61	5.69	6.15	5.69	8.38	8.25	7.83	7.53	6.69	5.95
50 → 100	4.04	4.02	4.10	4.12	4.10	4.12	4.16	4.24	4.97	4.71	4.90	5.41	5.68
100 → 150		3.88	3.90	3.92	3.92	3.93	3.99	3.88	3.91	3.91	3.96	4.09	4.64
150 +		3.85	3.89	3.88	3.86	3.85	3.96	3.82	3.76	3.80	3.84	4.00	4.02

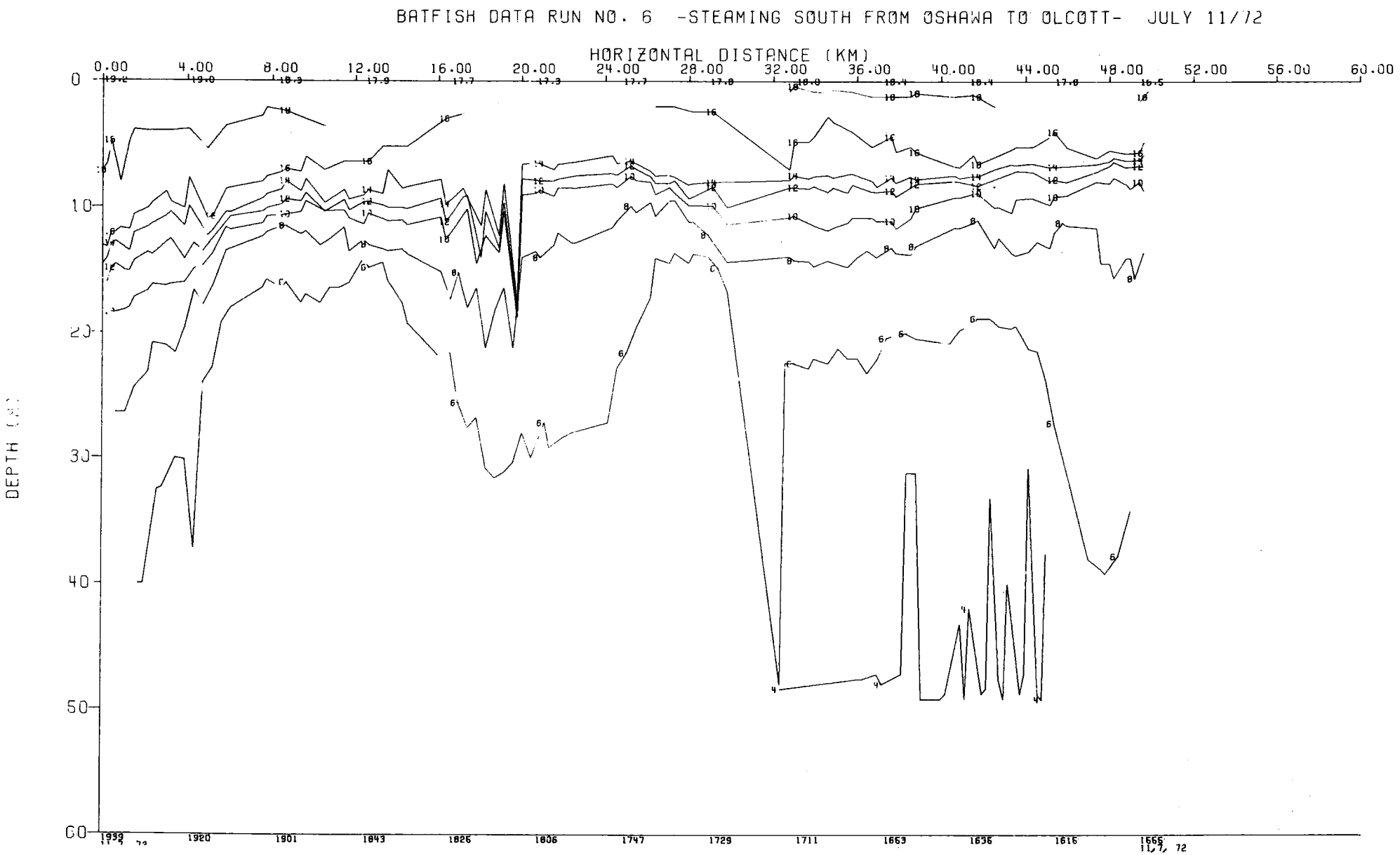


Figure 19. A temperature cross-section of Lake Ontario assembled from measurements made with the Batfish system during the transect experiment of 10-14 July 1970. The origin of the horizontal scale is Olcott, New York.

progress with a view to using it as a basis for comparison between predicted and observed behaviour.

Project Oshawash

From 1969 through to 1972 a large amount of data has been collected in the vicinity of Oshawa, Ontario, by the University of Waterloo (Coastal Chain Project) supported under contract from CCIW, and by CCIW scientists themselves. The tacit aim of these experiments has been to study the nearshore regime at a site which is relatively free from large topographical variations and local influences such as major rivers. Due to Field Year preparations and other commitments, the detailed analyses of these records had been previously postponed; this year it has been possible to make a start.

The current meter data of 1970 from the nearshore area off Oshawa has been edited and transformed into a more accessible form. Some analyses have been completed and others are under way. The total kinetic energy of horizontal motion (mean speeds plus variance) increases over the field season from May to late October. There is a tendency for the energy to decrease with distance offshore in the spring and summer records but such a tendency was not observed in the fall records, although it may well be that the measurements did not extend far offshore (Fig. 20). Most of the total energy occurred at periods in excess of three days, but significant quantities were found at or near the local inertial period (17.5 h). It is interesting to note that while the total and the long-period energy decrease with distance offshore, the energy in the inertial period range tends to increase offshore. This last observation would be consistent with the reflection of long internal waves from a sloping shoreline.

Instrumentation Development

The Section, in collaboration with the Centre's engineers, is active in developing new instrumentation ap-

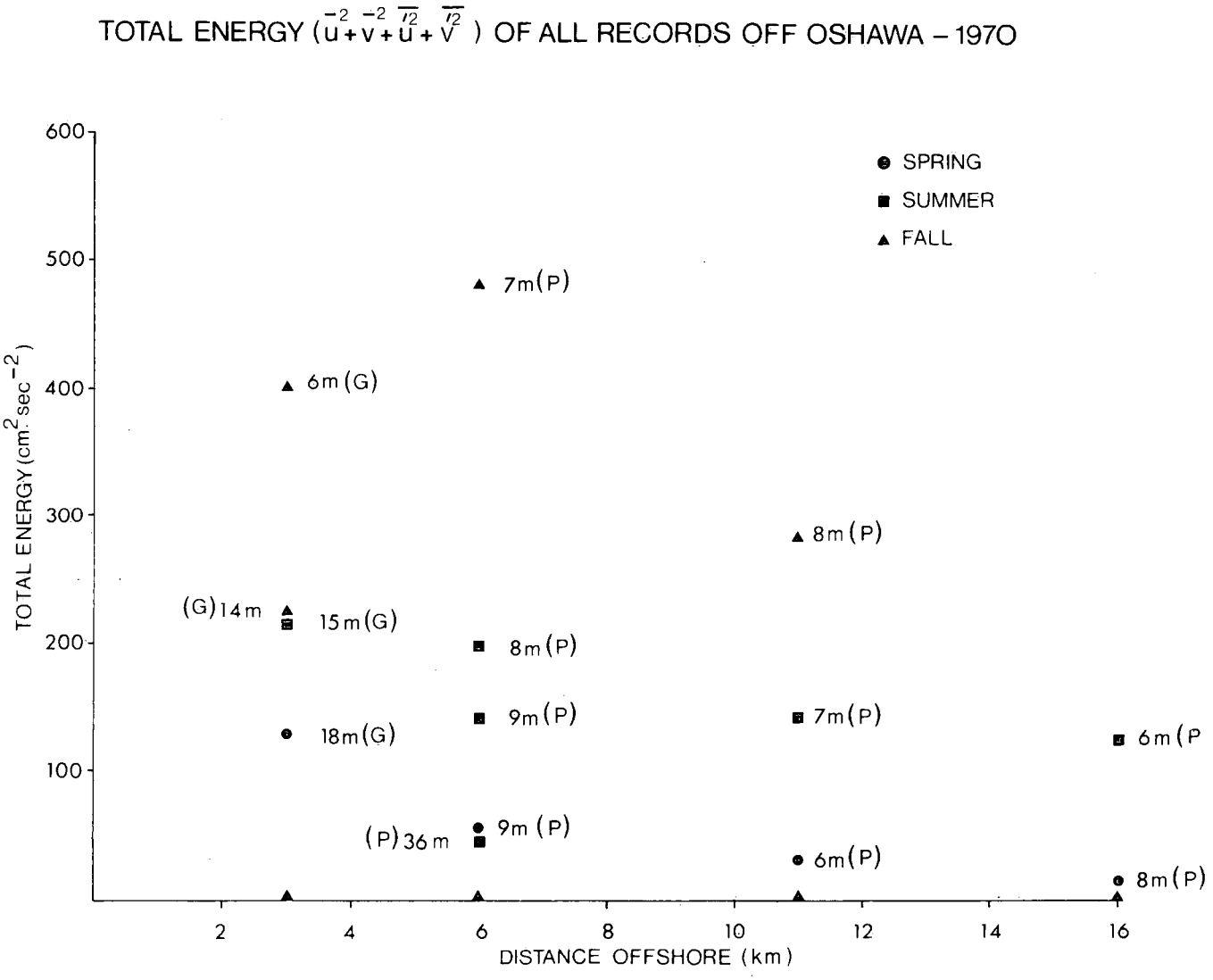


Figure 20. Total horizontal kinetic energy in a frequency band from 0 to 1 cycle per hour measured with current meters in the Oshawa region of Lake Ontario in 1970 and plotted as a function of distance offshore.

propriate to its field activities. The towed thermal profiling system, Batfish and towed array, have been carried forward, with the former system now considered to be operational not only for temperature profiling but also as a general platform for *in situ* instrumentation. Development of the fixed temperature profiling system continued through 1972. The Section is investigating the techniques of *in situ* fluorometry of obvious advantage for diffusion studies. The needs of the micro-meteorology program have promted many developments, notably in the remote positioning of tower mounted sensors. Trials were made on an electromagnetic current meter designed to measure the orbital velocities of surface wave motion.

Contract and Cooperative Studies

Professor G.T. Csanady of Waterloo University carried out an experimental program, code-named "Coastal Jet Project", to obtain detailed information on the structure of nearshore currents. Two coastal chains (15 km long with 12 stations) normal to the shoreline were established off Oshawa and Presqu'ile, Lake Ontario. Three periods of four weeks intensive measurements of currents and temperature were taken (using the flag station technique) at time and space intervals. A detailed report upon these contract investigations will be available in 1973.

CCIW also supported work by the Great Lakes Institute under the direction of Dr. G.K. Rodgers. Water temperature measurements were made at the mouth of the Humber River from April through November 1972 as a contribution to the Energy Balance Program of the IFYGL. Two recording thermographs were maintained on a bottom-mounted tower off Toronto. A number of detailed temperature surveys were conducted on the northwest shore of Lake Ontario from the C.G.S. PORTE DAUPHINE in July and August in order to document episodes of lake upwelling in response to westerly winds. A report is forthcoming on this last project.

The contributions of Professor Kullenberg and Mr. Westerberg to the IFYGL diffusion program were also supported under CCIW contract. A detailed report of their work will be available shortly.

The Niagara barge facilities were made available during July to a group headed by Professor G. Harris from the Biology Department of McMaster University. In addition to biological studies on the diurnal fluctuations of primary production, this group investigated the occurrence and vertical circulations associated with Langmuir vortices. Results of this work were reported to CCIW in a seminar given by Professor Harris in November.

An additional cooperative program with the Department of Civil Engineering of the University of Waterloo has made possible the extension of activities related to nearshore diffusion studies. It is expected that Mr. E.L. Skiba will contribute significantly to the Section in his capacity as a doctoral student.

REFERENCES

Hamblin, P.F. 1972. Some free oscillations of a rotating natural basin. Ph.D. thesis, University of Washington, Seattle.

Harrison, E.J. and A.S. Watson. 1972. Development and performance of the CCIW fixed temperature profiling system. CCIW Report.

Woods, J.P. 1968. J. Fluid Mech. 32, 791.

BIOGEOCHEMICAL LIMNOLOGY SUBDIVISION

The subdivision carries out studies on the impact of introductions of natural and man-made substances into lake systems, with special emphasis on their limnological behaviour, complex interactions and relationship to lake water quality. This group of specialists within the broad field of chemistry provides the fundamental understanding of chemical processes in lake waters as a basis for the work of others engaged in water quality management.

The projects carried out in the Geochemistry Section range from measurements of the partial pressure of carbon dioxide in air over Lake Ontario, and a survey of the stable isotope composition of sulfate sulfur in waters of four of the Great Lakes, to laboratory studies on the thermodynamics of some synthetic phosphates of lead and zinc and their associated dissolved species, and several projects on the properties of lake sediments, including sedimentation rates, organic carbon, nitrogen, phosphorus and mercury, amino acids and amino sugars, humic and fulvic acids, chlorophylls and chlorophyll derivatives. In addition, studies were made on various forms of phosphorus, and several heavy metals (Zn, Cu, Ni, Cd, Pb and Mn) in cores from Okanagan Lake as well as some of the Great Lakes.

The Environmental Impacts and Developmental Chemistry Section includes a group engaged in assessing the environmental impact of new substances, generally working in close co-operation with colleagues in the Fisheries Research Board Detachment. Studies in this area include research on a bacterial mutant capable of rapidly degrading NTA, and on the ability of natural populations of bacteria to degrade certain PCB's; a monitoring program for NTA in Hamilton Harbour and western Lake Ontario; and development of a new and convenient analytical method for EDTA and NTA.

Other laboratory projects of the Section include oil/water studies; the physical chemistry for multicomponent brines; and study of the complexing properties of humic materials with mercury and copper.

Field-and-laboratory projects include a study of carbon and phosphorus dynamics in lake water; study of the chelation capacity and chemical form of several heavy metals in a number of lakes near Sudbury, Ontario; a study

of the occurrence of methyl mercury; research on methods for concentrating, extracting and identifying dissolved organic compounds.

Carbon Dioxide in Air over Lake Ontario

This study was off to a late start with the arrival in August of a UNOR 2 infrared carbon dioxide analyzer. With this instrument carbon dioxide over the lake can be measured with a precision of about 2 ppm. The equipment was set up on the MV MARTIN KARLSEN for two of the IFYGL OOPS cruises, in September and October. The mean value in September in the middle of Lake Ontario, averaged over twenty four hours, was 322 ppm. A diurnal cycle, with low values in the afternoon, was observed. In October, after there had been several frosts, no cycle was observed, and the mean value was higher, 330 ppm. The carbon dioxide content of air fluctuates considerably, especially in the vicinity of cities. Extremes of 315 to 360 ppm have been observed.

Stable Isotopes of Sulfate Sulfur in Great Lakes Waters

A general survey of the isotopic abundance of sulfur in (dissolved) sulfates in Lakes Michigan, Huron, Erie and Ontario has been made. (Sample analyses were done by contractual arrangement with J. Monster of the Chemistry Department, McMaster University.) The results obtained so far indicate that whereas the isotopic abundance in Lake Erie shows both regional and temporal variations, Lakes Michigan, Huron and Ontario remain homogeneous with respect to their sulfur isotopic compositions. Average δS^{34} values for the lakes are: Lake Michigan + $4.6^0/_{00}$, Lake Huron + $6.3^0/_{00}$, Lake Erie +$5.5^0/_{00}$ (range + 4.9 – +$6.6^0/_{00}$) and Lake Ontario + $5.9^0/_{00}$. These results may be compared with the sulfate concentrations, which generally show a progressive increase eastward from Lake Michigan to Lake Ontario (mean sulfate levels: L. Michigan 19.5 ppm, L. Huron 16.2 ppm, L. Erie 21.4 ppm and L. Ontario 27.6 ppm).

A VG Micromass 602C mass spectrometer capable of determining stable isotope ratios of carbon, nitrogen, oxygen and sulfur with a precision of $0.2^0/_{00}$ or better is on order and a more intensive study on the isotopic composition of the Great Lakes is planned for next year.

Lead and Zinc Phosphates

Because of the possible geochemical and ecological importance of lead, a study was made of the solubilities of a number of lead phosphates and hydroxides, and the associated equilibria in solution, in order to improve our understanding of the behavior of these species in the environment. It was found that lead phosphates, particularly the pyromorphites, are very stable, and are the lead minerals most likely to be precipitated in aerobic soils and lake sediments.

Solubility product constants and free energies of formation were determined for the solid phases.

Phase	pK_{sp}	ΔG_f° (K cal mol^{-1})
$PbHPO_4$	11.4	-281.8
$Pb_3(PO_4)_2$	44.5	-565.0
$Pb_4O(PO_4)_2$	–	-617.3
$Pb(OH)_2$	20.4	-108.8
$Pb_5(PO_4)_3OH$	76.8	-902.0
$Pb_5(PO_4)_3Cl$	84.4	-905.2
$Pb_5(PO_4)_3F$	71.6	-942.0
$Zn_3(PO_4)_2 \cdot 4H_2O$	35.3	-867.3

Association constants for some ion pairs were determined:

Ion pair	log K_a
$PbH_2PO_4^+$	1.5
$PbHPO_4^0$	3.1

The data for the zinc phosphate indicate that it is too soluble to be likely to form in the lake environment.

Geochemical Inputs to Great Lakes Sediments

Sedimentation rates, organic carbon, nitrogen, phosphorus and mercury have been measured at close intervals in 14 cores from Lakes Ontario, Erie and Huron. Sedimentation rates range from a low of 0.6 mm of sediment per year in northern Lake Huron to a maximum of 1.6 cm per year in the deep eastern basin of Lake Erie. Preliminary estimates of the present day inputs to the three lakes are shown below.

Lake	Total sediment	Organic carbon	Total nitrogen	Total phosphorus	Mercury
	10^3 metric tons				
ONTARIO	4,360	256	29	7.6	.0127
ERIE	21,260	746	102	27.6	.0137
HURON	3,840	161	21	4.6	.012

The concentrations of organic carbon, nitrogen, phosphorus, and mercury increase towards the surface of each core from a level representing deposition around 50 years BP. The increases are mainly due to increased loading to the sediments in recent years. The sediment enrichment factor (SEF) is defined as the ratio of the geochemical concentration in the top cm of sediment to the concentration representative of deposition 120 years BP. SEF values for the three lakes are shown below.

Lake	Organic carbon	Nitrogen	Phosphorus	Mercury
ONTARIO	3.10	3.10	2.34	52.0
ERIE	2.41	3.18	1.79	3.4
HURON	1.29	1.48	1.30	1.5

It can be seen that present day inputs to the Lake Huron sediments are little different to that of 120 years ago, whereas the Lakes Ontario and Erie sediments are receiving 1.8 to 52 times the natural load.

Sediment Organic Matter Studies

The distribution of amino acids and amino sugars in the surface sediments of Lake Ontario is similar to that found in Canadian soils and in ocean sediments. The changes in the amino acid content and reactivity towards proteolytic enzymes suggest that the pathway of degradation and transformation of amino acids in Lake Ontario is as follows: (1) lake cellular materials → (2) water soluble organic matter, containing soluble amino acids → (3) fulvic acids → (4) humic acids.

The molecular weight distribution of humic and fulvic acids from the surface sediments of Lakes Ontario and Erie ranges from less than 700 to over 200,000. The molecular weights of the humic and fulvic acids occur in three distinct ranges: (1) fractions with molecular weight over 200,000 (23–49%), (2) fractions from 5000 to 50,000 (31–58%) and (3) fractions less than 700 (0–22%).

Studies on chlorophyll were carried out as part of an M.Sc. Thesis at Queen's University, in conjunction with Dr. R. J. Daley and Prof. S. R. Brown. An integrated quantitative method was developed for the determination of chlorophylls and chlorophyll degradation products in freshwater phytoplankton and sediments. The pigments are extracted in acetone and separated by reverse phase thin-layer chromatography. Using three chromatographic systems, artefact-free separations of chlorophylls a, b and c, and eighteen of their derivatives are obtained. The procedures are rapid, simple and highly reproducible. Chlorophyll pigments are being currently determined in cores from Lakes Ontario, Erie and Huron.

Heavy Metals and Forms of Phosphorus in Lake Sediments

The fine-grained sediment of Lake Erie contain approximately one half of the total phosphorus as apatite, equivalent to 300-600 ppm P. The apatite appears to be entirely of detrital origin, as indicated by mineralogical studies, constancy with depth in sediment cores, and decreasing sediment content with increasing distance from shore. Much of the apatite is probably derived from eroding bluffs along the north shore. The bluffs contain 420-680 ppm P, over 95% of which is present as apatite. Detrital apatite contributes significantly to the total phosphorus sedimentation budget in Lake Erie.

The distribution of total phosphorus in the surficial sediments of lakes from the Okanagan valley, British Columbia, could be interpreted by considering the individual distributions of the three major forms of phosphorus in sediments. Apatite content declined with distance from stream and river mouths and distance from shore, indicating a predominantly detrital origin. Content of organic forms of phosphorus and inorganic forms of phosphorus other than apatite ("sorbed orthophosphate") increased with increasing water depth and/or distance from shore, and were closely related to contents of organic carbon and acid-extractable iron, respectively.

Diagenetic processes affecting phosphorus in sediments of the Great Lakes and the Okanagan lakes include mineralization of organic phosphorus and release of orthophosphate from combination with ferric iron (attendant on the decrease in Eh which results from the burial of material initially at the oxidized microzone by further additions of sediment). In addition, in two Okanagan lakes conversion of organic phosphorus to apatite appeared to be occurring. The frequently observed increase in total phosphorus towards the top of a sediment core is at least partly attributable to these processes rather than changes in loadings of phosphorus into the overlying water. However, in Lake Erie increases in organic phosphorus and sorbed orthophosphate content of recently deposited sediments apparently reflect chiefly the increase of phosphorus loadings into this lake in recent years.

Profiles of acid-extractable quantities of iron, manganese, copper, nickel, zinc and lead in sediment cores from the same lakes indicate a large enrichment of manganese in the oxidized microzone. The excess manganese is probably derived from underlying sediment by diffusion through the water column. Declining content of acid-extractable copper, nickel, lead and zinc in Lake Erie sediment cores appear to reflect increased loadings of these elements in recent years, as this feature was absent in the Okanagan sediment cores.

A contract with the Research and Productivity Council, Fredericton, New Brunswick was started to determine whether the forms of phosphate present in lake sediments can be identified by mineralogical methods on a routine basis. Two locations, from the western and eastern ends of the Central Basin of Lake Erie, were examined. Apatite was present in the sand-, silt- and clay-sized fractions. The origin, based on the morphology of the largest grains, was detrital. In addition, large amounts of fly-ash, a glassy material containing around 1% P and originating in the industrial region around Detroit, were found in the western station. Apart from this, the only other material of high phosphate content detected was two or three grains (out of several hundreds of grams of sample examined) of a material high in phosphorus and iron, possibly vivianite ($Fe_3(PO_4)_2 \cdot 8H_2O$).

Nutrient Dynamics

It seems that the most popular approach to lake pollution problems is to measure the *quantity* of some substances, e.g., phosphorus, chlorophyll, zooplankton, mercury etc. These measurements provide no information on the dynamics of lake processes or the turnover times of

the various components. To measure transport rates, experiments were conducted (in collaboration with University of Toronto, Department of Zoology and the Freshwater Institute, F.R.B., Winnipeg) on lake water using radioisotopes ^{32}P and ^{14}C. A model for phosphorus movement in the open water has been developed and the central role of a colloidal phosphorus form identified. Future work will be conducted in the Bay of Quinte. Ultimately the flux of the major nutrients (C, N and P) between the principal components of a lake ecosystem will be included in this model.

Complexing Capacity of Lakes

A method had been worked out to study the complexing capacity of lake water. It is measured by the amount of copper taken up by a water sample plus the complexed copper originally present in water. The method has been applied to the study of Sudbury lakes where the metals were abundant and yet the waters are still productive; obviously complexation is playing an important role. The complexing capacity of lake water has been found to relate closely to the amount of total dissolved organic matter in the water.

Work in progress includes measurement of the complexation capacity of typical lakes with an attempt to establish a complexation scale which when used with the trace metals data, gives us a better understanding of the trace element chemistry of the lake. In addition, work on the characterization of the complexing materials in lake water and the determination of the metal to ligand ratios which determine the relative availability of metals are also being carried out. Some typical complexation capacity values are listed as follows:

Sample	Complexing capacity μmole Cu equi/l.
Hamilton Harbour water	1 – 3
Niagara River (Niagara Falls)	0.6
Lake Ontario water	0.3 – 2
Sudbury lakes:	
Simon Lake	2.5
Johnnie Lake	0.4
Wanapitae Lake	1.4
Vermilion Lake	2.0
Loon Lake	2.4
Joe Lake	0.5
Makada Lake	1.3
Meatbird Lake	0.7 (No Cu uptake)
Whitefish Lake	0.29 (No Cu uptake)

In the course of complexation studies, the chemical state of some trace metals was also investigated. A method has been developed to measure the free and complexed metals in water (Zn, Pb, Cd, Cu) which has been applied to some 30 lakes in Sudbury area. In general, for lakes of normal pH (7-8) only Zn has been found to exist in free form whereas Mn, Cd and Cu are predominantly in complexed forms. Free Pb, Cd and Cu are most often observed in lakes of pH 5 or less. Under this low pH condition, the organic ligands are protonated and the complexation reactions are probably very much hindered. Metals like Cu which have a strong tendancy to form complexes can only exist in free form in water of low pH and low organic matter. From the survey of about 30 lakes in Sudbury area, only a very few lakes contained free copper. These are for example, Joe Lake pH 5, free copper 0.32 μmole/litre, complexed copper 0.34 μm/litre, Johnnie Lake pH 4.4, free copper 0.09 μm/litre, complexed copper 0.38 μmole/litre.

Organic Mercury Compounds in Lake Water

A very sensitive gas chromatographic technique has been developed to determine organo mercury compounds in lake water. The detection limits are extremely low: methyl mercury (0.02 ng/l), ethyl mercury (0.2 ng/l) and phenyl mercury (20 ng/l).

The technique has been applied to samples from St. Clair Lake and River, Saskatchewan River, Pinchy Lake, B.C., and Clay Lake, Kenora where very high mercury in fish has been reported. Methyl mercury was found only in the following samples:

St. Clair	0.6 ng/l
Clay Lake, Kenora	0.5 ng/l (Central lake)
	1 ng/l (near shore)
Pinchy Lake, B.C.	1.7 ng/l

Complexing Reactions of Humic Compounds

An equilibrium study of the Hg(II)-fulvic acid system using a solid state iodide electrode and a glass electrode indicates that the Hg (II)-fulvic acid complexes are in the order of 100 times more stable than those of Cu (II)-fulvic acid. This study also shows that fulvic acid is a very strong natural chelating agent. The Cu-NTA complexes are only about 1000 times more stable than those of Cu-fulvic acid.

Multicomponent Brines

Solubilities and activity coefficients in aqueous systems containing three salts are now being measured in the temperature range 0-25°C. The ultimate aim is to collect such data for the aqueous system containing the following ions: Na^+, Mg^{++}, K^+, Ca^{++}, Cl^-, $SO_4^{=}$, and HCO_3^-, as this system is representative of many of the world's natural waters.

Statistical Assessment of Monitor Cruise Data

A statistical examination of chemical monitor cruise data was undertaken. The average standard deviations from 22 1971-72 cruises (6 for particulate nitrogen and particulate organic carbon) were:

dissolved oxygen	.19	mgm O_2/l
pH	.04	log units
turbidity	.6	J.T.U.
specific electrical conductance	4.	μmho-cm^{-1}
soluble ammonia, filtered	.003	mg/l N
total nitrate, filtered	.012	mg/l N
total nitrogen, filtered	.021	mg/l N
particulate nitrogen	.010	mg/l N
particulate organic carbon	.062	mg/l C
soluble reactive phosphate, filtered	.0007	mg/l P
total phosphate, filtered	.0010	mg/l P
total phosphate, unfiltered	.0015	mg/l P
reactive silica	.070	mg/l SiO_2
chlorine, filtered	.2	mg/l Cl
total alkalinity, filtered	.7	mg/l as $CaCO_3$

Also, it was shown that there is no statistically significant difference for these parameters between the bottle and pump sampling methods employed at the Centre.

Organic Compounds in Lake Water

A Finnigan 1015 gas chromatograph-mass spectrometer with a systems industries 150 data system was acquired during the year. After some start-up difficulties, an identification level of 25 ng for methyl stearate injected on column was achieved. The instrument is being used to examine and identify organic compounds in water samples obtained by chloroform extraction and freeze concentration techniques. A telephone linked, computerized mass spectra library system (N.I.H., Bethesda, Md., U.S.A) of some 9,000 spectra is being investigated as a means of identification of the spectra obtained from environmental samples. Tentative identification of phthalate and fatty acid esters in Lake Erie waters has been accomplished.

The buffered hydrolysis of phytic acid (inositol hexaphosphate) to give orthophosphate has been undertaken. Rates of phosphate formation at pH 4.7 have been obtained and further work is underway at pH values up to 9.

Chlorinated biphenyl isomers have been tested for biodegradability and the chemical nature of their metabolites investigated. The 2- and 4- monochlorobiphenyls were degraded to give a variety of lower molecular weight metabolites most of which do not appear to contain chlorine.

A spectrophotometric method for the differentiation and determination of EDTA and NTA has been developed. Individual detection limits of 10 ppb for both compounds were achieved. An analytical method for the direct determination of residual methanol (down to 0.5 ppm) in waste waters has also been developed for sewage denitrification processes.

During July, 1972, the monthly sampling of seven stations in western Lake Ontario and of seven stations in Hamilton Harbour was resumed. The samples are taken by staff of the Technical Operations Section from the M.V. Lac Erie, and are analysed by staff of the Water Quality Branch. Some cross-confirmation of analytical results is done by the subdivision. A tendency for somewhat higher values observed during the severe winter weather of 1971-72 has not yet been observed this year.

Bacterial Degradation Studies

A bacterial mutant was found to be capable of using only NTA as a carbon and energy source for growth at concentrations as high as 2.5 per cent without acclimatization and at a wide range of temperatures, pH, ionic concentrations in both lake waters and sewage. It was able to degrade NTA from an initial concentration of 290,000 μg/l of NTA to less than 50 μg/l in 45 minutes, representing a rate of 486 μg NTA degraded per hour per mg dry weight of cells. The maximal temperature for the degradation was 50°C. The ability of the mutant to metabolize NTA resided mainly in the cell membrane fraction.

Bacteria isolated from Lake Ontario sediments were capable of degrading lower molecular weight components of the PCB's Aroclor 1221 and 1242. With purified isomers, bacteria were found to degrade 2-monochlorobiphenyl at a faster rate than 4-monochlorobiphenyl. These and other results suggest that not only the percent of chlorination but also the position of chlorine in the benzene ring are important in the bacterial degradation.

Oil-Water Studies

Laboratory studies have been completed on the formation of water-in-oil emulsions. The data await field evaluation during the 1973 season.

A survey of benzene extractable materials in Burlington Bay indicate a fairly uniform distribution in the water column at concentrations of about .4 ppm. The distribution of these materials in the sediment increases with depth to a maximum value of about one percent of dried sediment.

A technique was developed for the evaluation of oil herding agents in the laboratory. Tests on C_{16} and C_{18} alcohols and a commercial herding agent indicated that these materials are ineffective on aged oil slicks.

In co-operation with EPS personnel at the Centre a draft was prepared for the federal guidelines for oil spill dispersants.

MICROBIOLOGY SUBDIVISION

The Microbiology Subdivision moved into its new quarters in the Administration and Laboratory Building in March, 1972. Immediately after the move, the Microbiology Unit was separated into two units, one which was

oriented towards Water Management Service-Inland Waters Directorate programs and the other towards Environmental Protection Service programs. The two units continued to share the same facilities and equipment and often supported each other's projects through technical support and internal discussions. With the move to new quarters, the Microbiology Subdivision also undertook the tasks of (a) providing a media, chemical and glassware service to all Microbiology Units and (b) providing a glassware wash-up and sterilization service to the Centre.

The Microbiology Subdivision through various units became involved in a large number of very diverse studies. Some of these studies involved field work such as (a) an International Joint Commission study of the Rainy River, (b) a bacteriological study of the Ontario and Minnesota Pulp and Paper Company lagoon in Fort Frances, Ontario, (c) a bacteriological study of the St. Lawrence River from Kingston to Cornwall, Ontario, (d) a bacteriological study of Indian Reserve drinking water supply and (e) a microbiological research program on the Grand River and Burlington Bay. Other studies involved the provision of microbiological support to a variety of CCIW projects of which the following are representative: (a) lake organic particle studies, (b) Iron-manganese study in Lake Erie sediments, (c) sewage treatment nitrification study, (d) studies on the efficiency of the Attisholz sewage treatment system and (e) an acid mine waste study.

Microbiology Subdivision staff also initiated research studies in the following areas, nitrilotriacetic (NTA) degradation, hydrocarbon (oil) degradation, parameter development and sampling frequency for assessment of microbiological water quality and nutritional adaptions of sediment bacteria.

Other areas of involvement were the review of over thirty grant applications, contract proposals and papers, the testing of water and sewage samples from CCIW vessels, the chairing of an international meeting to draft a report to the IJC on the virus incidence and their role in the Great Lakes, the presentation of ten papers at various conferences and the serological identification of Klebsiella isolated from the Rainy River.

Parameter Development and Sampling Frequency Studies

Several reports were prepared on Design Guidelines for a Bacteriological Water Quality Network and Design Guidelines for a Bacteriological Sediment Quality Network, for inclusion in Guidelines for the Planning and Operation of Water Quality Network and the Interpretation of Data and the initiation of the following research projects.

In October a year-long joint project was initiated with the Water Quality Branch and Bacteriological Laboratories, EPS, Ottawa. Weekly samples were collected from the Grand River, Lake Ontario and the Ottawa River, and tested for total carbohydrates, ammonia-N, sulfate, fecal sterols, D.O., pH, temperature, rainfall, river flows, coliform MF, fecal coliform MF, fecal streptococci MF, direct count by fluorescent microscopy, 20°C spread plate count, Pseudomonas aeruginosa MPN, ammonifying bacteria, organic sulfur reducing bacteria, Salmonella incidence in water and mud, and Acinetobacter densities (Fig. 21). Superimposed on the weekly sampling program are eight weeks of daily sampling plus a.m.—p.m. sampling at one sampling site.

Figure 21. Illustrating the multitude of inoculations required during the testing of samples for various microbial physiological groups.

Project goals are the establishment of parameters most suitable for microbiological water quality assessment, seasonal effect on bacterial and chemical parameters, and optimal sampling frequency and minimum number of samples required for establishing the water quality of a specific water body.

One of the problems in water microbiological studies is the necessity to process water samples as soon as possible

after collection because of die-off an multiplication problems. This problem is very important especially if bacteriological studies are to be carried out in support of the Canada Water Quality Network. Therefore in conjunction with the above project a year-long study was initiated to study the effect of storing water samples up to 48 hours in ice, on microbiological and chemical parameters used in the above study.

Water sample collection sites chosen represent waters containing high nutrient and high bacterial populations and low nutrient and relatively low bacterial populations.

Detergent Degradation Studies

Because of the limited knowledge available on the mechanism of microbiological degradation of nitrilotriacetic acid (NTA), pure culture studies were initiated to more adequately delineate the basic mechanism involved. In studies using NTA as a sole carbon and energy source for known pure cultures, little or no degradation occurred. Bacteria from sewage were then mutagenized by UV irradiation and selected with penicillin. By this technique a novel bacterial mutant with a high affinity for NTA was isolated (Fig. 22). Each warburg flask contained 50μ moles of phosphate buffer (pH 7.0), 3.9 mg (dry wt) of sewage, (2) 6μ moles of NTA, (3) 6μ moles of citrate, (4) 1 ml of filter sterilized sewage. Total volume was 3 ml at 25°C. Additional 3μ moles of NTA were added after 180 minutes as indicated in the figure. The mutant could use high concentrations of NTA (up to 2.5%) as sole carbon, nitrogen and energy source without acclimatization at a wide range of temperatures and pH, with the probable intermediate products being glycine and acetic acid. This organism, under ideal conditions, could degrade 323 ppm NTA to much less than 10 ppm after 1 hours incubation at 25°C, representing over 96% degradation. In cyanide and azide addition studies, it was found that the energy-generating system and consequently the NTA accumulation was suppressed. The ability of bacteria to concentrate NTA suggests that the mutant could utilize very low NTA levels in receiving waters.

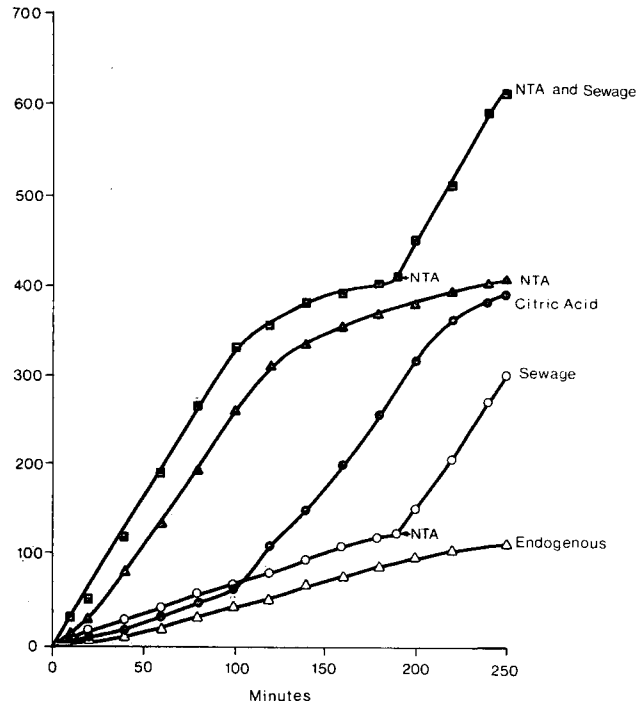


Figure 22. Comparison of sewage, NTA and citric acid oxidation by NTA degrading bacterial mutant.

The results of these studies with the bacterial mutant indicate that the mutant could be used to seed sewage to remove excess NTA and that its enzymes could be incorporated directly into a detergent for "in-tub" degradation. Because of the above possibilities an application was made to the Canadian Patent office for patenting this mutant.

Hydrocarbon Degradation Studies

Success with the isolation and cultivation of a potent NTA-degrading bacteria that could be used as a seed in sewage treatment processes rekindled our interest in the role and importance of bacteria in natural and controlled degradation processes. A study was initiated of microbial oil degradation with the goal of trying to determine the feasibility of using seeding techniques to aid in oil spill clean up operations.

A simplified method was developed for rapidly screening and isolating potent oil-degrading bacteria. This technique led to the isolation of several bacterial strains that rapidly degraded kerosene, crude oil, bunker 6C and commercial oil dispersants (Fig. 23). During laboratory studies it was found that these bacteria could degrade hydrocarbon and oil-dispersants simultaneously. These studies indicated that the oil dispersants did not affect the degradation of oil by our culture, in fact they stimulated the rapid biodegradation of kerosene (Fig. 24). In kinetic studies, crude oil degrading bacterial culture CCIWCM01 was found to degrade crude oil rapidly and efficiently without the use of emulsifying agents and the rate of oil degradation was a function of oil concentration in the test medium.

In a comparison study between culture CCIWCM01 and a commercially available mixed culture, our bacteria CCIWCM01 was found to be much superior. Steps are now being taken to purify and classify these oil degrading bacteria in preparation for patent application.

Paper Mill and Rainy River Studies

Using a mobile laboratory, two studies of the Ontario and Minnesota Pulp and Paper Mill lagoon in Fort Frances and one of the Rainy River for the IJC were performed by CCIW Microbiology staff.

In the paper mill studies, a low incidence of E. coli and a relatively high incidence of *Enterobacter* strains were

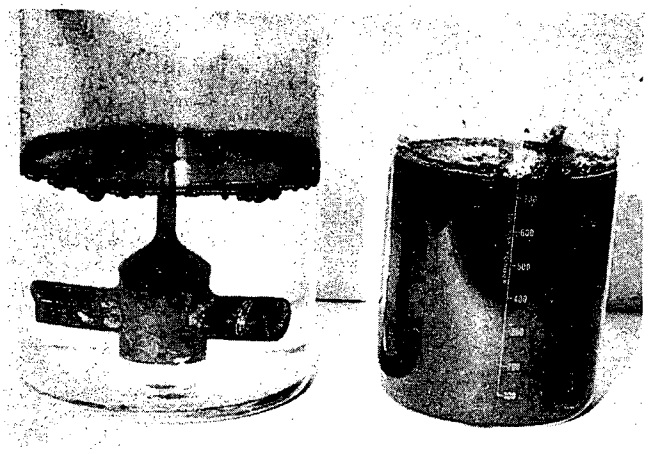


Figure 23. Isolation of Bunker 6C fuel oil-degrading bacteria using Bellco flask. Left: before growth. Right: two days after bacterial growth.

found in the kraft mill effluents, an indication that sanitary wastes were not present in these process wastewaters. The paper mill lagoon contributed a large input on non-fecal coliforms (predominantly *Enterobacter*) and nutrients to the Rainy River. These lagoon wastes contained high concentrations of sulfur substrates that promoted growth of sulfur oxidizing and sulfate reducing bacteria in the river below the mill outfalls. These bacterial parameters appear to be relatively sensitive indicators of industrial pollution. During this study it was found that a portion of fecal coliform populations were *Klebsiella* species, some of which

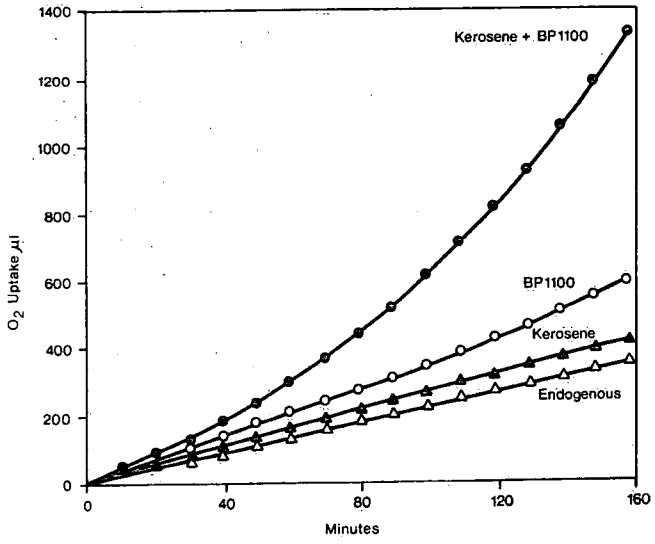


Figure 24. Effects of BP1100 on oxygen uptake by culture CCIWKO1. Each Warburg flask contained 6.2 mg (dry weight) of kerosene grown cells, 0.5 ml of 0.05 phosphate buffer (pH 7.0) and various substrates. All substrates were added at 0 hour after a preincubation of 15 min. The final volume of liquid in each flask was 3.0 ml and the temperature was 20C.

were *K pneumoniae* and gave a positive mouse pathogenicity test.

Results of the IJC Rainy River study indicated that the Rainy River downstream from the Fort Frances-International Falls area was grossly polluted with coliform bacteria. The isolation of enteric pathogens from this area confirmed that these waters are a potential health hazard. The major source of pollution was found to be the waste discharges from the two pulp and paper mills, occasional inefficient operation of the two sewage treatment plants and runoff from storm sewers and the surrounding watershed.

TECHNICAL OPERATIONS SUBDIVISION

Major Ships

As in previous years, the C.S.S. LIMNOS and the chartered vessel M.V. MARTIN KARLSEN were used for the scientific data collection and monitor cruises on the Great Lakes. The programs were augmented from time to time, with work done by the C.C.G.S. PORTE DAUPHINE, through contract arrangements with the Great Lakes Institute (GLI), University of Toronto.

The implementation this year of the IFYGL (International Field Year for the Great Lakes) program on Lake Ontario placed a much increased load on both ship and personnel requirements, so that the field season which normally terminates in early December continues through the winter months to March, 1973.

The C.S.S. LIMNOS carried out a great variety of specialized cruises, thirty being completed by the end of 1972. These cruises can be broken down as follows:

5 Mooring Cruises,
3 Temperature Transect Cruises,
4 Bathymetric Surveys,
9 Heat Budget Surveys, and
6 Dye Diffusion Cruises.

There were also several smaller additional surveys, including Engineering Instrument trials and IFYGL intercomparison studies.

The M.V. MARTIN KARLSEN continued to be the work horse for CCIW and carried out all the monitor cruises and "Organic Particle" (OOPS) cruises as follows:

7 OOPS Cruises – Lake Ontario
1 Monitor Cruise – Lake Ontario
5 Monitor Cruises – Lake Erie
3 Monitor Cruises – Lake Huron

The three extended monitor cruises into Lake Huron included a spring and fall excursion into Lake Michigan and Georgian Bay, representing the first time that a major research vessel from CCIW has monitored these regions.

Operational Table, 1972.

Ship	Started Operations	Completed Operations	No. Cruises	Miles Steamed	Total Active Days	Days On Survey	%
M.V. MARTIN KARLSEN	Mar. 13/72	Dec. 2/72	24	15,835	265	180	68
C.S.S. LIMNOS	Mar. 27/72	Dec. 20/72	30	17,480	270	169	63

(Complete schedules are given in Tables 5, 6, 7 and 8)

The remainder of the twenty-four cruises was divided between the launching of DECCA and meteorological buoys, Decca chain calibrations, heat content surveys, plus two intercomparison studies (Canada and U.S.) of shipboard data acquisition systems and methods.

The C.C.G.S. PORTE DAUPHINE, in addition to carrying out work for the GLI, was under contract when our major ships were unavailable for monitor work. These cruises, staffed by personnel from GLI and CCIW, were coordinated by Technical Operations and augmented the regular monitor program.

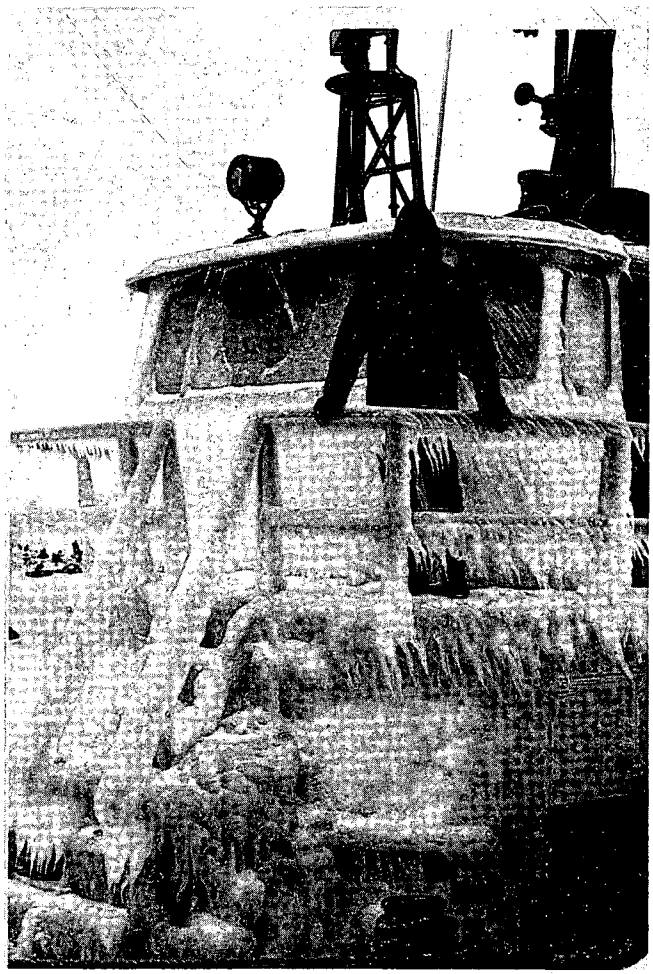


Figure 25. Winter operations MV LAC ERIE.

Minor Ships

Although not considered a major research vessel, the tug M.V. LAC ERIE, staffed by Technical Operations personnel, played a very important role during the field year, not only in carrying out many of the "special" cruises (Meteorological and FTP programs, NTA study, "MOSES" program, Pesticide study, Fe-Mn study), but also in supporting many of the "shore-based" field programs. Although not very large, she always managed to get the job done, often despite adverse weather conditions. (See Fig. 25).

The diving tender C.S.L. SHARK supported all diving programs in Lake Ontario in 1972, including the installation and maintenance of underwater sensors along the Canadian shore of the lake, installation and removal of the Niagara Towers, and operational support to the Oshawa Dye Diffusion project.

The chartered 100-foot barge HANDY BOY, containing a laboratory detachment from the Atmospheric Environment Service (AES), was moored for most of the season adjacent to the Niagara Towers.

An intermediate 80-foot vessel, the C.S.S. ADVENT, was delivered to CCIW during the latter part of the year and is expected to join the "fleet" in early 1973.

Small Craft

As in previous years, Technical Operations continued to coordinate, through the Marine Sciences Directorate, the assignment of smaller research craft to various subdivisions at CCIW, universities, and other outside agencies.

IFYGL

Much of the IFYGL program and liaison with the participating U.S. agencies were coordinated by Technical Operations. Staff were involved in the preparation of the IFYGL "Operational Procedures Manual", together with finalization of the IFYGL cruise plans and operational movement of ships.

Diving Section

During the 1972 field season, the Diving Section supported twenty programs totalling 184 diving days in Lakes Ontario, Erie, and Huron. Tasks performed ranged

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
FEB	30	31	1	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
MAR	27	28	29	1	2	3	4
	5	6	7	8	9	10	11
	12	13 Depart CCIW 1115 hrs	14 Lake Ontario	15 DECCA Buoys	16 Arrive CCIW 1000 hrs	17 CCIW	18 CCIW
	19 CCIW	20 CCIW	21 Depart CCIW 0930 hrs	22 Lake Ontario	23 Met. Buoys	24 Arrive CCIW 0840 hrs	25 CCIW
APR	26 CCIW	27 CCIW	28 CCIW	29 Depart CCIW 1405 Lake Ontario	30 Met. Buoys Arr. CCIW 1335	31 CCIW	1 CCIW
	2 CCIW	3 Depart CCIW 1023 hrs	4 Lake Ontario DECCA Chain	5 Arrive CCIW 1145 hrs	6 Depart CCIW 1900 hrs	7 Lake Ontario	8 DECCA Chain Calibration
	9 Arrive CCIW 1615 hrs	10 Depart CCIW 1425 hrs	11 Lake Ontario	12 Organic Particle	13 Study	14 Arrive CCIW 2310 hrs	15 CCIW
	16 CCIW	17 Depart CCIW 1110 hrs	18 Lake Ontario	19 Organic	20 Particle	21 Study	22 Arrive CCIW 0850 hrs
	23 CCIW	24 Depart CCIW 0950 hrs	25 Lake Erie	26 Monitor	27 Lake Erie	28 Arrive Sarnia 2250 hrs	29 Sarnia
MAY	30 Sarnia	1 Depart Sarnia 1740 hrs	2 Lake Huron	3 and Georgian Bay	4 Monitor and	5 Moorings	6 Lake Huron
	7 and Georgian Bay	8 Monitor	9 Moorings	10 Lake Huron and	11 Georgian Bay	12 Arrive CCIW 0830 hrs	13 CCIW
	14 CCIW	15 CCIW	16 CCIW	17 Depart CCIW 1215 hrs	18 Lake Ontario Equipment Trials	19 Arrive CCIW 1705 hrs	20 CCIW
	21 CCIW	22 CCIW	23 Depart CCIW 1110 hrs	24 Lake Ontario	25 Organic Particle	26 Study	27 Arrive CCIW 1230 hrs
	28 CCIW	29 Depart CCIW 1135 hrs	30 Lake Ontario	31 Organic	1 Particle	2 Study	3 Arrive CCIW 0730 hrs
JUNE	4 CCIW	5 Depart CCIW 0945 hrs	6 Lake Erie	7 Monitor	8 Lake Erie	9 Monitor	10 Lake Erie
	11 Arrive CCIW 1440 hrs	12 CCIW	13 CCIW	14 Re-fitting	15 CCIW	16 CCIW	17 CCIW
	18 CCIW	19 Depart CCIW 1150 hrs	20 Lake Ontario	21 Organic Particle	22 Study	23 Arrive CCIW 1440 hrs	24 CCIW
	25 CCIW	26 Depart CCIW 1010 hrs	27 Lake Ontario	28 Intercomparison and	29 Organic Particle	30 Studies	1 Arrive CCIW 1245 hrs
JULY	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW
	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW	14 CCIW	15 CCIW
	16 CCIW	17 Depart CCIW 1040 hrs	18 Lake Ontario	19 Organic Particle	20 Study	21 Arrive CCIW 1515 hrs	22 CCIW
	23 CCIW	24 Depart CCIW 1040 hrs	25 Lake Ontario	26 Organic	27 Particle	28 Study	29 Arrive CCIW 0630 hrs
	30 CCIW	31 Depart CCIW 0940 hrs	1 Lake Erie	2 Monitor	3 Lake Erie	4 Monitor	5 Arrive Sarnia 2240 hrs
AUG	6 Sarnia	7 Sarnia	8 Depart Sarnia 1545 hrs	9 Lake Huron	10 Monitor	11 and	12 Moorings
	13 L a k e	14 H u r o n	15 M o n i t o r	16 and	17 Moorings	18 Arrive Sarnia 1645 hrs	19 In transit
	20 Arrive CCIW	21 CCIW	22 CCIW	23 CCIW	24 CCIW	25 CCIW	26 CCIW
	27 CCIW	28 Depart CCIW 0830 hrs	29 Lake Ontario DECCA Chain	30 Arrive CCIW 0400 hrs	31 CCIW	1 CCIW	2 CCIW
SEP	3 CCIW	4 CCIW	5 Depart CCIW 1113 hrs	6 Lake Ontario	7 Organic Particle	8 Study	9 Arrive CCIW 1455 hrs
	10 CCIW	11 Depart CCIW 1035 hrs	12 Lake Ontario	13 Organic	14 Particle	15 Study	16 Arrive CCIW 0540 hrs
	17 CCIW	18 Depart CCIW 0000 hrs	19 Lake Ontario	20 Intercomparison	21 Study and	22 Monitor	23 Arrive CCIW 2040 hrs
	24 CCIW	25 CCIW	26 CCIW	27 Depart CCIW 0915 hrs	28 Lake Erie	29 Monitor	30 Lake Erie
OCT	1 Monitor	2 Arrive CCIW 2350 hrs	3 Depart CCIW 1213 hrs	4 Lake Ontario	5 Heat Content Survey Eutrophication Study	6 Arrive CCIW 1630 hrs	7 CCIW
	8 CCIW	9 CCIW	10 CCIW	11 Depart CCIW 1035 hrs	12 Lake Ontario	13 Moorings	14 Lake Ontario
	15 Moorings	16 Arrive CCIW 1655 hrs	17 Depart CCIW 1315 hrs	18 Lake Ontario	19 Organic Particle	20 Study	21 Arrive CCIW 1545 hrs
	22 CCIW	23 Depart CCIW 1135 hrs	24 Lake Ontario	25 Organic	26 Particle	27 Study	28 Arrive CCIW 1020 hrs
NOV	29 CCIW	30 Depart CCIW 1455 hrs	31 Lake Huron	1 and Lake Michigan	2 Monitor	3 and	4 Moorings
	5 Lake Huron and	6 Lake Michigan	7 Monitor	8 and	9 Moorings	10 Arrive Sarnia 0845 Depart Sarnia 0930	11 Lake Erie
	12 Monitor	13 Lake Erie	14 Monitor	15 Arrive CCIW 1340 hrs	16 CCIW	17 CCIW	18 CCIW
	19 CCIW	20 Depart CCIW 1105 hrs	21 Lake Ontario	22 Organic Particle	23 Study	24 Arrive CCIW 1050 hrs	25 CCIW
	26 CCIW	27 Depart CCIW 1225 hrs	28 Lake Ontario	29 Organic	30 Particle	1 Study	2 Arrive CCIW 0345 hrs
DEC	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30

Table 5. Great Lakes studies, IFYGL, 1972. MV MARTIN KARLSEN.

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
	30	31	1	2	3	4	5
FEB	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
	27	28	29	1	2	3	4
MAR	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
	26	27 Dep. CCIW 0846 Lake Ontario	28 Met. Buoys Arr. CCIW 1445	29 CCIW	30 CCIW	31 CCIW	1 CCIW
APR	2 CCIW	3 CCIW	4 Dep. CCIW 1154 hrs.	5 Lake Ontario	6 Heat Content Survey	7 Arr. CCIW 1005 hrs.	8 CCIW
	9 CCIW	10 Dep. CCIW 1215 hrs.	11 Lake Ontario	12 Heat Content Survey	13 Arr. CCIW 1035 hrs.	14 CCIW	15 CCIW
	16 CCIW	17 Dep. CCIW 1151 hrs.	18 Lake Ontario	19 Heat Content Survey	20 Arr. CCIW 1212 hrs.	21 CCIW	22 CCIW
	23 CCIW	24 Dep. CCIW 1150 hrs.	25 Lake Ont. Heat Content Survey	26 Arr. CCIW 2215 hrs.	27 CCIW	28 CCIW	29 CCIW
MAY	30 CCIW	1 Dep. CCIW 1152 hrs.	2 Lake Ontario	3 Heat Content Survey	4 Arr. CCIW 0612 hrs.	5 CCIW	6 CCIW
	7 CCIW	8 Dep. CCIW 1153 hrs.	9 Lake Ontario	10 Heat Content Survey	11 Arr. CCIW 1145 hrs.	12 CCIW	13 CCIW
	14 CCIW	15 Dep. CCIW 0920 hrs.	16 Lake Ontario	17 Moorings	18 Moorings	19 Arr. CCIW 1544 hrs.	20 CCIW
	21 CCIW	22 CCIW	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW
	28 CCIW	29 Dep. CCIW 1019 hrs.	30 Lake Ont. Diffusion Study	31 Arr. CCIW 2050 hrs.	1 CCIW	2 CCIW	3 CCIW
JUNE	4 CCIW	5 Dep. CCIW 0853 hrs.	6 Lake Ontario	7 Energy Budget Study	8 Heat Content Survey	9 Arr. CCIW 1842 hrs.	10 CCIW
	11 CCIW	12 Dep. CCIW 0915 hrs.	13 Lake Ontario	14 Bathymetric	15 Survey	16 Bathymetric	17 Survey
	18 Bathymetric	19 Survey	20 Bathymetric	21 Survey	22 Arr. CCIW 2230 hrs.	23 CCIW	24 CCIW
	25 CCIW	26 Dep. CCIW 0851 hrs.	27 Lake Ontario	28 Inter-comparison	29 & Diffusion Study	30 Arr. CCIW 1511 hrs.	1 CCIW
JULY	2 CCIW	3 CCIW	4 Dep. CCIW 1020 hrs.	5 Lake Ontario	6 Moorings	7 Moorings	8 Arr. CCIW 0236 hrs.
	9 CCIW	10 Dep. CCIW 1033 hrs.	11 Lake Ontario	12 Temperature	13 Transects	14 Arr. CCIW 1525 hrs.	15 CCIW
	16 CCIW	17 Dep. CCIW 0915 hrs.	18 Lake Ontario	19 Diffusion Study	20 Arr. CCIW 2250 hrs.	21 CCIW	22 CCIW
	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW
AUG	30 CCIW	31 CCIW	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW
	6 CCIW	7 CCIW	8 Dep. CCIW 0930 hrs.	9 Lake Ontario	10 Temperature	11 Transects	12 Arr. CCIW 1615 hrs.
	13 CCIW	14 Dep. CCIW 1150 hrs.	15 Lake Ontario	16 Diffusion Study	17 Diffusion Study	18 Diffusion Study	19 Arr. CCIW 1024 hrs.
	20 CCIW	21 Dep. CCIW 1020 hrs.	22 Lake Ontario	23 Moorings	24 Arr. CCIW 1610 hrs.	25 CCIW	26 CCIW
	27 CCIW	28 Dep. CCIW 0905 hrs.	29 Lake Ontario	30 Diffusion Study	31 Diffusion Study	1 Diffusion Study	2 Arr. CCIW 1402 hrs.
SEPT	3 CCIW	4 CCIW	5 Dep. CCIW 0915 hrs.	6 Lake Ontario	7 Diffusion Study	8 Diffusion Study	9 Arr. CCIW 0805 hrs.
	10 CCIW	11 Dep. CCIW 0915 hrs.	12 Lake Ontario	13 Bathymetric	14 Survey	15 Bathymetric	16 Survey
	17 Bathymetric	18 Survey	19 Bathymetric	20 Survey	21 Bathymetric Survey	22 Arr. CCIW 1345 hrs.	23 CCIW
	24 CCIW	25 Dep. CCIW 0958 hrs.	26 Lake Ontario	27 Diffusion Study	28 Diffusion Study	29 Diffusion Study	30 Arr. CCIW 1415 hrs.
OCT	1 CCIW	2 Dep. CCIW 0940 hrs.	3 Lake Ontario	4 Temperature	5 Transects	6 Arr. CCIW 1515 hrs.	7 CCIW
	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW	14 CCIW
	15 CCIW	16 Dep. CCIW 1000 hrs.	17 Lake Ontario	18 Diffusion	19 Study	20 Arr. CCIW 1430 hrs.	21 CCIW
	22 CCIW	23 Dep. CCIW 0900 hrs.	24 Lake Ontario	25 Bathymetric	26 Survey	27 Arr. CCIW 1600 hrs.	28 CCIW
NOV	29 CCIW	30 Dep. CCIW 0900 hrs.	31 Lake Ontario	1 Bathymetric	2 Survey	3 Arr. CCIW 1330 hrs.	4 CCIW
	5 CCIW	6 Dep. CCIW 0900 hrs.	7 Lake Ontario	8 Bathymetric	9 Survey	10 Arr. CCIW 1220 hrs.	11 CCIW
	12 CCIW	13 CCIW	14 CCIW	15 Dep. CCIW 0903 Lake Ontario	16 Met. Buoys Arr. CCIW 1845	17 CCIW	18 CCIW
	19 CCIW	20 Dep. CCIW 0903 hrs.	21 Lake Ontario	22 Moorings	23 Lake Ontario	24 Moorings	25 Arr. CCIW 1448 hrs.
DEC	26 CCIW	27 Dep. CCIW 1100 hrs.	28 Lake Ontario	29 Bathymetric Survey	30 and	1 Decca Calibration	2 Arr. CCIW 1225 hrs.
	3 CCIW	4 CCIW	5 Dep. CCIW 1354 hrs.	6 Lake Ontario	7 Heat Content Survey	8 and	9 Met. Buoy Recovery
	10 Arr. CCIW 0145 hrs.	11 Dep. CCIW 1204 hrs.	12 Lake Ontario	13 Heat Surveys and	14 Met. Buoy Recovery	15 Arr. Toronto 1112 hrs.	16 CCIW
	17 CCIW	18 Dep. CCIW 1306 hrs.	19 Lake Ont. Heat Content Survey	20 Arr. CCIW 2055 hrs.	21	22	23
	24	25	26	27	28	29	30

Table 6. Great Lakes studies, IFYGL, 1972. CSS LIMNOS.

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
FEB	30	31	1	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
MAR	27	28	29	1	2	3	4
	5	6	7	8	9	10	11
	12	13	14	15	16 Dep. CCIW 0800 Arr. CCIW 1700	17 CCIW	18 CCIW
	19 CCIW	20 Dep. CCIW 0800 Lake Ontario	21 MOSES Arr. CCIW 1700	22 CCIW	23 CCIW	24 CCIW	25 CCIW
	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW	31 CCIW	1 CCIW
APR	2 CCIW	3 CCIW	4 CCIW	5 Dep. CCIW 0845 hrs.	6 Lake Ontario	7 Met. Buoys	8 Lake Ontario
	9 Met. Buoys	10 Lake Ontario	11 Arr. CCIW 1930 hrs.	12 CCIW	13 CCIW	14 CCIW	15 CCIW
	16 CCIW	17 In Transit	18 Dep. Cobourg 0600 hrs.	19 Lake Ontario	20 Met. Buoys	21 Lake Ontario	22 Met. Buoys
	23 Lake Ontario	24 Met. Buoys	25 Arr. CCIW 1600 hrs.	26 CCIW	27 CCIW	28 CCIW	29 CCIW
MAY	30 Dep. CCIW 0700 hrs.	1 Lake Ontario	2 Met. Buoys	3 and F.T.P.	4 Arr. CCIW 1700 hrs.	5 CCIW	6 CCIW
	7 CCIW	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW
	14 CCIW	15 Dep. CCIW 0915 hrs.	16 Lake Ontario	17 Met. Buoys	18 and F.T.P.	19 Arr. CCIW 1600 hrs.	20 CCIW
	21 CCIW	22 CCIW	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW
	28 CCIW	29 Dep. CCIW 0845 hrs.	30 Lake Ontario	31 Met. Buoys	1 Lake Ontario	2 Arr. CCIW 2045 hrs.	3 CCIW
JUNE	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 Dep. CCIW 0905 hrs.	13 Lake Ontario	14 Met. Buoys	15 Lake Ontario	16 Arr. CCIW 2045 hrs.	17 CCIW
	18 CCIW	19 CCIW	20 Dep. CCIW 1020 Lake Ontario	21 Pesticide Monitor	22 Arr. CCIW 1830 hrs.	23 CCIW	24 CCIW
	25 CCIW	26 Dep. CCIW 1015 Arr. CCIW 1930	27 Dep. CCIW 1015 hrs.	28 Lake Ontario	29 Met. Buoys	30 Lake Ontario	1 Arr. CCIW 0100 hrs.
JULY	2 CCIW	3 CCIW	4 CCIW	5 Dep. CCIW 0810 Lake Ontario	6 Pesticide Monitor	7 Arr. CCIW 1845 hrs.	8 CCIW
	9 CCIW	10 Dep. CCIW 0855 hrs.	11 Lake Ontario	12 Pesticide	13 Monitor	14 Arr. CCIW 1615 hrs.	15 CCIW
	16 CCIW	17 Dep. CCIW 0900 Lake Ontario	18 NTA Monitor Arr. CCIW 1030	19 CCIW	20 CCIW	21 CCIW	22 CCIW
	23 CCIW	24 Dep. CCIW 0840 hrs.	25 Lake Ontario	26 Met. Buoys	27 and F.T.P.	28 Arr. CCIW 1530 hrs.	29 CCIW
AUG	30 CCIW	31 CCIW	1 Dep. CCIW 0945 hrs.	2 Lake Ontario	3 F.T.P. and IRLS	4 Arr. CCIW 0300 hrs.	5 CCIW
	6 CCIW	7 CCIW	8 Dep. CCIW 1050 hrs.	9 Lake Ontario	10 Met. Buoys	11 and F.T.P.	12 Arr. CCIW 1815 hrs.
	13 CCIW	14 CCIW	15 CCIW	16 CCIW	17 CCIW	18 Dep. CCIW 0915 Lake Ontario	19 NTA Monitor Arr. CCIW 1920
	20 CCIW	21 Dep. CCIW 0905 hrs.	22 Lake Ontario	23 Met. Buoys and F.T.P.	24 Arr. CCIW 1730 hrs.	25 CCIW	26 CCIW
	27 In Transit	28 Dep. Kingsville 0735	29 Lake Erie	30 Iron-Manganese Study	31 Arr. Port Colborne 1935	1 In Transit	2 CCIW
SEPT	3 CCIW	4 CCIW	5 Dep. CCIW 0900 hrs.	6 Lake Ontario	7 Met. Buoys	8 Lake Ontario	9 Met. Buoys
	10 Arr. CCIW 0130 hrs.	11 CCIW	12 Dep. CCIW 0945 hrs.	13 Lake Ontario	14 F.T.P.	15 Arr. Oshawa 1215 Dep. Oshawa 1230	16 NTA Monitor Arr. CCIW 1230
	17 CCIW	18 Dep. CCIW 1010 hrs.	19 Lake Ontario	20 Met. Buoys	21 and F.T.P.	22 Lake	23 Ontario
	24 Arr. CCIW 1520 hrs.	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW
OCT	1 CCIW	2 Dep. CCIW 0910 hrs.	3 Lake Ontario	4 Met. Buoys	5 Lake Ontario	6 Arr. Kingston 0900 hrs.	7 Kingston
	8 Kingston	9 Kingston	10 Dep. Kingston 1315 hrs.	11 Lake Ontario Met. Buoys	12 Arr. CCIW 1700 hrs.	13 CCIW	14 CCIW
	15 CCIW	16 CCIW	17 CCIW	18 CCIW	19 Dep. CCIW 0935 hrs.	20 Lake Ontario	21 Met. Buoys
	22 Lake Ontario	23 Met. Buoys	24 Arr. CCIW 1630 hrs.	25 Dep. CCIW 0900 Lake Ontario	26 NTA Monitor Arr. CCIW 1130	27 CCIW	28 CCIW
NOV	29 CCIW	30 Dep. CCIW 0945 hrs.	31 Lake Ontario	1 Met. Buoys	2 Lake Ontario	3 Arr. Kingston 1000 hrs.	4 Kingston
	5 Kingston	6 Dep. Kingston 0700 hrs.	7 Lake Ontario Met. Buoys	8 Arr. CCIW 1430 hrs.	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 Dep. CCIW 0930 Lake Ontario	22 NTA Monitor Arr. CCIW 1920	23 CCIW	24 CCIW	25 CCIW
	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW	1 CCIW	2 CCIW
DEC	3 Dep. CCIW 0800 hrs.	4 Lake Ontario	5 Kingston	6 Kingston	7 Met. Buoys	8 Arr. CCIW 2400 hrs.	9 CCIW
	10 CCIW	11 Dep. CCIW 0900 Arr. Niagara 1500	12 Dep. Port Dalhousie 1030	13 Lake Ontario NTA	14 Arr. CCIW 1535 hrs.	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30

Table 7. Great Lakes studies, IFYGL, 1972. MV LAC ERIE.

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
FEB	30	31 Dep. Toronto 1055 hrs.	1 Lake Ontario	2 Monitor	3 Lake Ontario	4 Monitor	5 Lake Ontario
	6 Monitor	7 Lake Ontario	8 Monitor	9 Lake Ontario Monitor	10 Arr. Toronto 1955 hrs.	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
MAR	27	28	29	1	2	3	4
	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
	26	27	28	29	30	31	1
APR	2	3	4 Dep. Toronto 0936 hrs.	5 Lake Ontario	6 Heat Content	7 Survey	8 Arr. Toronto 0010 hrs.
	9	10 Dep. Toronto 0938 hrs.	11 Heat Content Survey, L.Ont.	12 Arr. Toronto 1450 hrs.	13	14	15
	16	17 Dep. Hamilton 0620 hrs.	18 Heat Content Survey L.Ont.	19 Arr. Toronto 1610 hrs.	20	21	22
	23	24 Dep. Toronto 0927 hrs.	25 Heat Content Survey L.Ont.	26 Arr. Toronto 1517 hrs.	27	28	29
MAY	30	1 Dep. Toronto 0945 hrs.	2 Heat Content Survey L.Ont.	3 Arr. Toronto 1617 hrs.	4	5	6
	7	8 Dep. Toronto 0955 hrs.	9 Heat Content Survey L.Ont.	10 Arr. Toronto 1625 hrs.	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	29	30	31	1	2	3
JUNE	4	5 Weigh Anchor, Oshawa, 1705	6 Lake Ontario	7 Heat Content Survey	8 Arr. Toronto 0010 hrs.	9	10
	11	12	13	14	15	16	17
	18	19	20	21	22	23	24
	25	26 Dep. Port Colborne, 2255	27 Lake Erie	28 Monitor	29 Lake Erie Monitor	30 Arr. Windsor 0725 hrs.	1
JULY	2	3	4	5	6	7	8
	9	10	11	12	13	14	15
	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
AUG	30	31	1	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
SEPT	27	28 Dep. Port Colborne, 0323	29 Lake Erie	30 Monitor	31 Lake Erie Monitor	1 Arr. Port Colborne 0555	2
	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
OCT	1	2	3 Dep. Toronto 1145 hrs.	4 Lake Ontario Monitor	5 Arr. Toronto 2150 hrs.	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
NOV	29	30	31	1	2	3	4
	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
DEC	26	27	28	29	30	1	2
	3	4 Dep. Toronto 0755 hrs.	5 Heat Content	6 Survey	7 Lake Ontario	8 Arr. Toronto 0905 hrs.	9
	10	11 Dep. Toronto 1400 hrs.	12 Heat Content Survey	13 Lake Ontario	14 Arr. Toronto 0510 hrs.	15	16
	17	18 Dep. Toronto 0930 hrs.	19 Heat Content Survey L.Ont.	20 Lake Ontario	21 Arr. Toronto 1450 hrs.	22	23
	24	25	26	27	28	29	30

Table 8. Great Lakes studies, IFYGL, 1972. CCGS PORTE DAUPHINE.

from the mechanical installation and recovery of towers and moorings to the selective sampling and description of the sediment/water interface. In preparation for the field season, a diving course (arranged and instructed by the Senior Diving Officer) was held at CCIW in February and March. The eight successful candidates represented the Technical Operations, Engineering and Scientific Divisions of the Centre.

A commercial diving team was also contracted to help meet the ever-increasing demands for diving assistance with CCIW projects.

Personnel

Personnel from the subdivision were assigned to the major and minor ships on a continuing basis throughout the season, and to small craft on shore-based scientific survey parties. In most cases, field operations were mainly undertaken by the Technical Operations staff. They had the responsibility for the multidisciplinary field measurements for Lakes Research Division, including all technical deck operations entailing sampling procedures, rigging, launching and recovery of moorings, and meteorological observations. In those cases where more specialized analyses were required, members of the staff formed the backup group to assist the appropriate scientists.

Projects based at Oshawa (Dye Diffusion Program) and Niagara-on-the-Lake (Niagara Bar Project) were supported and coordinated by Technical Operations staff. One staff member was seconded to the Descriptive Limnology Section for the duration of the OOPS Program and another continued to support the Lake Erie Shore Erosion program at Point Pelee.

During February, six staff members attended a 2-week course in basic RADAR at George Brown College in Toronto. Another six staff members completed the exam for their Radio/Telephone Operator Certificates.

Seven student assistants were employed by the Subdivision during the height of the field season in the summer months. Most of these were assigned to the major ships to participate in the cruise work.

Miscellaneous

Technical Operations took over the responsibility for maintaining the Lake Ontario Shore Sensor program during the year. They also provided support for the Laser experiments off Scarborough Bluffs, carried out by the University of Toronto who were testing the use of this technique for oil slick detection.

The ships and launches (in cooperation with the Coast Guard) participated in several rescue searches and managed to rescue several small craft from Lake Ontario.

During August, six winners of the Hamilton Regional Science Fair were given a week cruise on the M.V. MARTIN KARLSEN for a first-hand look at sampling and observational procedures.

SOCIAL SCIENCE RESEARCH SECTION

The Social Science Research Section is responsible for assessing, the sociological, geographical, legal, institutional and economic aspects of human activities related to water quality and water quantity management. During 1972 the section further contributed to the clarification of the different aspects of the problem of heavy metals and other environmentally hazardous materials, generated basic geographical and economic data of the Great Lakes Basins and major tributaries, continued the survey of public attitudes and degree of public concern towards the environmental problems of water quality and evaluated the legal and institutional framework which governs some of the socio-economic activities affecting the water resources.

Table 9. Total use of Selected Metals or Metallic Compounds for All Sectors of Ontario Economy*

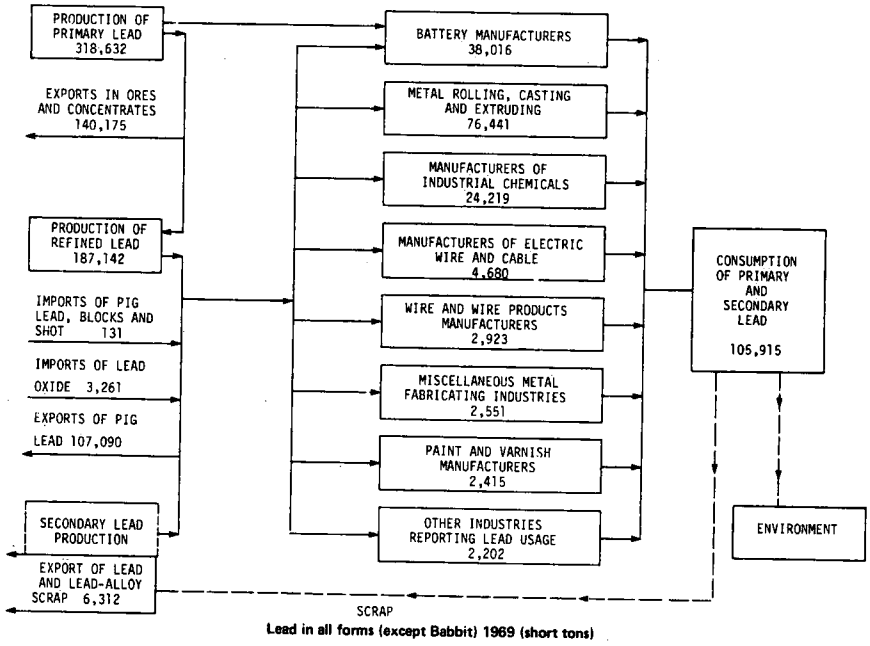
Metal or Metallic Compound	Total Direct Use	Total Direct Indirect Use	Total Direct-Indirect –Induced Use
	Pounds per $1,000 of total output (All Sectors)		
Cadmium	0.004019	0.009570	0.014755
Chrome metal	0.383215	0.507821	0.839507
Chrome colors	0.230520	0.318316	0.435165
Land metal all forms	5.077714	15.532466	24.629584
Mercury	0.004937	0.022937	0.037236
Zinc metal all forms	1.643346	4.978228	8.486322

*Forty-nine sectors as indicated by the Inter-Industry flow table of the Ontario Department of Treasury and Economics.

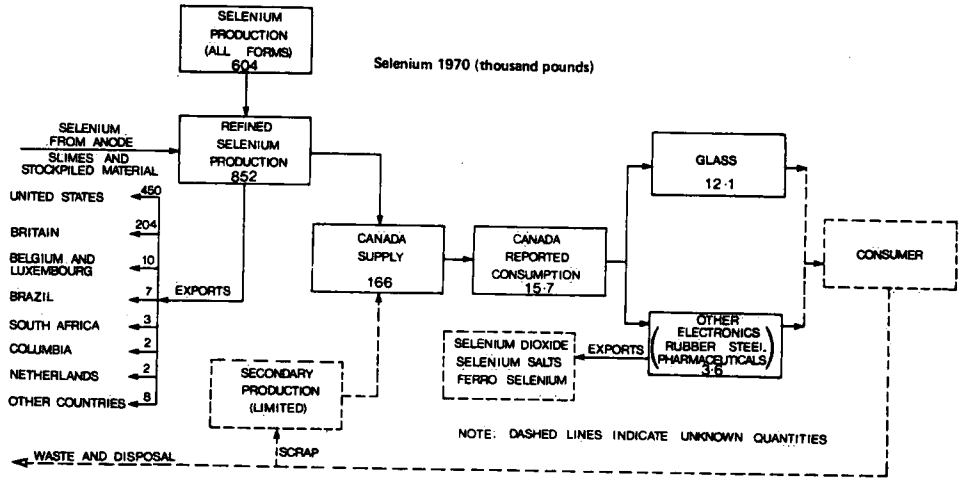
The Section participated in the Task Force on the National Water Needs Study and participated in a number of joint studies with other units of CCIW. Members of the staff represented CCIW and the Department of the Environment at the OECD Working Group in detergents, Great Lakes Basin Commission, Cross Mission group on the Environmental Contaminants Bill and some other international and national meetings.

Economics of Environmental Quality

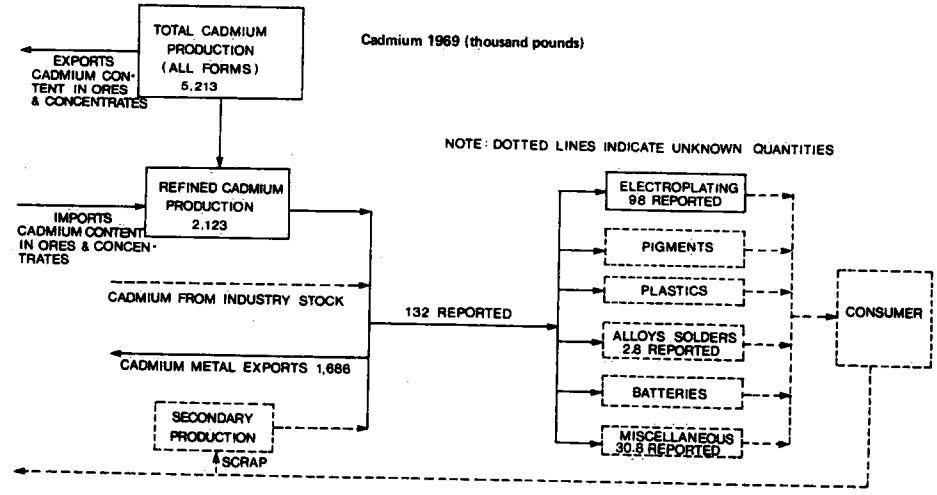
Papers on the usage, inventory of sources, consumption and fate in Canada of lead, cadmium, and selenium



Lead in all forms (except Babbit) 1969 (short tons)



Selenium 1970 (thousand pounds)



Cadmium 1969 (thousand pounds)

Figure 26. Reported materials flow charts.

Table 10. Preliminary Animal Phosphorus Accumulations – 1971.
(Kilograms)

Drainage Basin	Cattle	Pigs	Sheep	Horses	Poultry	Total
Lake Ontario	4,484,453	2,074,041	70,826	241,760	422,244	7,293,324
Lake Erie	6,423,254	6,147,313	66,029	231,887	479,761	13,348,244
Lake Huron	8,219,726	4,240,183	120,498	209,623	389,712	13,179,742
Lake Superior	86,215	13,512	640	3,306	7,132	110,805

(Fig. 26) were completed during 1972. The report on the Use of Pest Control products in Canada was also completed. These papers are part of the project on the use of substances which are potentially harmful to the environment, and they represent fundamental information for the second phase of the project which will deal with the analysis of the economics of residuals, cost-benefit analysis of the internalizing procedure and the analysis of the economics of replacing in the production process the heavy metals by less harmful substances. A preliminary step in that direction was achieved with the completion of an input-output table on the use of heavy metals and compounds in the Ontario economy. This table is a matrix of the direct, indirect and induced use of 26 selected metals and metallic compounds by 49 industries representing the Ontario economy (Table 9).

Great Lakes Studies

The task of providing background statistics on the Great Lakes basin was continued during 1972. A report on Population Estimates for the Great Lakes basins and their Major Tributaries for the period 1901-71 was completed.

The Section prepared during 1972 an evaluation of the amount of phosphorus of animal origin accumulated in the river basins of the Great Lakes areas. This information will form part of a report in which statistics on phosphorus loads by river basins and by sources will be shown for the period 1931-71 (Table 10). Analysis of trends, charts and density maps will also be included in the report.

An interesting contribution of the Section to the problem of obtaining data on a drainage basis rather than on a political or administrative basis was the preparation of the map entitled "Great Lakes Basin, Drainage and Political Divisions" (Fig. 27).

Social and Institutional Studies

A survey on the attitudes of municipal officials, both elected and appointed towards the use of renovated waste water and future alternatives of waste treatment was conducted in 11 cities and 3 provinces during the summer of 1972. The results in general show official reluctance to consider innovative waste treatment methods and rather deep reliance on traditional secondary treatment methods and nutrient removal. Although the idea of renovated waste water was often favourably received, it was considered by the municipal officials as inapplicable to "their city". A report of the results, analysis, interpretation and regional differences will be published in the near future.

A study on Administration of Provincial Water Anti-Pollution legislation was completed during 1972.

Research on jurisdictional disputes in shoreline planning and development and theoretical frameworks of the decision-making systems in resources management continued very actively in the Section during 1972.

Miscellaneous

Staff members monitored American public meetings on shoreline developments and their effects on the Great Lakes waters.

An analysis of the profile and motivations of the visitors to the Open House of the Centre was conducted by the Section. It was found that while 50.4 percent of the visitors had heard of the CCIW through news media, 37.6 percent knew of its existence because they saw the building under construction. 65.5 per cent of those interviewed thought that the main function of CCIW was on Water Research in general while 22.3 percent thought it was pollution research.

The Section participated in planning the NTA National Monitoring Program and on the Task Force on National Water Needs.

The organization of the CCIW seminar series is still the responsibility of the Section. A number of prospective speakers were contacted during 1972 in order to ensure a diversified and timely program throughout the year.

WATER QUALITY BRANCH RESEARCH

The role of the Water Quality Branch is to collect, interpret and disseminate data and information on water quality for water resource and pollution control studies; to operate and maintain analytical service laboratories for these studies in Canada; and to carry out research on analytical methodology on the characteristics and behavor

GREAT LAKES BASIN
DRAINAGE AND POLITICAL DIVISIONS

SCALE 1:3,168,000

1 INCH EQUALS 50 MILES OR 80 KILOMETRES

50 0 50 100 MILES

80 0 80 160 KILOMETRES

PREPARED BY THE SOCIAL SCIENCE RESEARCH SECTION, (C.C.I.W.), INLAND WATERS DIRECTORATE, DEPARTMENT OF THE ENVIRONMENT 1972.

ONTARIO RIVER BASINS

- NIPIGON RIVER BASIN
- WHITE RIVER BASIN
- MAGPIE RIVER BASIN
- MICHIPICOTEN RIVER BASIN
- MONTREAL RIVER BASIN
- MISSISSAGI RIVER BASIN
- SERPENT RIVER BASIN
- SPANISH RIVER BASIN
- FRENCH RIVER BASIN
- MUSKOKA RIVER BASIN
- SEVERN RIVER BASIN
- TRENT RIVER BASIN
- MOIRA RIVER BASIN
- SAUGEEN RIVER BASIN
- MAITLAND RIVER BASIN
- GRAND RIVER BASIN
- THAMES RIVER BASIN
- KAMINISTIKWIA R. BASIN

LEGEND

COUNTY BOUNDARIES

TOWNSHIP BOUNDARIES

DRAINAGE BOUNDARIES

AS SHOWN ON MAP "GREAT LAKES WATER USE" PUBLISHED BY THE POLICY RESEARCH AND COORDINATION BRANCH

U.S.A. — COUNTIES BY STATES

MINNESOTA

1. COOK
2. LAKE
3. SAINT LOUIS
4. ITASCA
5. AITKIN
6. CARLTON
7. PINE

WISCONSIN

1. DOUGLAS
2. BAYFIELD
3. ASHLAND
4. IRON
5. VILAS
6. FOREST
7. FLORENCE
8. MARINETTE
9. OCONTO
10. LANGLADE
11. MENOMINEE
12. SHAWANO
13. MARATHON
14. DOOR
15. KEWAUNEE
16. BROWN
17. OUTAGAMIE
18. WAUPACA
19. PORTAGE
20. WAUSHARA
21. WINNEBAGO
22. CALUMET
23. MANITOWOC
24. SHEBOYGAN
25. FOND DU LAC
26. GREEN LAKE
27. MARQUETTE
28. ADAMS
29. COLUMBIA
30. ONEIDA
31. WASHINGTON
32. OZAUKEE
33. MILWAUKEE
34. WAUKESHA
35. RACINE
36. KENOSHA
37. DODGE

MICHIGAN

1. GOGEBIC
2. ONTONAGON
3. HOUGTON
4. BARAGA
5. KEWENAW
6. IRON
7. MARQUETTE
8. DICKINSON
9. MENOMINEE
10. DELTA
11. ALGER
12. SCHOOLCRAFT
13. LUCE
14. MACKINAC
15. CHIPPEWA
16. EMMET
17. CHEBOYGAN
18. PRESQUE ISLE
19. ALPENA
20. MONTMORENCY
21. OTSEGO
22. CHARLEVOIX
23. ANTRIM
24. LEELANAU
25. BENZIE
26. GRAND TRAVERSE
27. KALKASKA
28. CRAWFORD
29. OSCODA
30. ALCONA
31. IOSCO
32. OGEMAW
33. ROSCOMMON
34. MISSAUKEE
35. WEXFORD
36. MANISTEE
37. MASON
38. LAKE
39. OSCEOLA
40. CLARE
41. GLADWIN
42. ARENAC
43. HURON
44. BAY
45. MIDLAND
46. ISABELLA
47. MECOSTA
48. NEWAYGO
49. OCEANA
50. MUSKEGON
51. MONTCALM
52. GRATIOT
53. SAGINAW
54. TUSCOLA
55. SANILAC
56. ST. CLAIR
57. LA PEER
58. GENESEE
59. SHIAWASSEE
60. CLINTON
61. IONIA
62. KENT
63. OTTAWA
64. ALLEGAN
65. BARRY
66. EATON
67. INGHAM
68. LIVINGSTON
69. OAKLAND
70. MACOMB
71. WAYNE
72. WASHTENAW
73. JACKSON
74. CALHOUN
75. KALAMAZOO
76. VAN BUREN
77. BERRIEN
78. CASS
79. ST. JOSEPH
80. BRANCH
81. HILLSDALE
82. LENAWEE
83. MONROE

ILLINOIS

1. LAKE
2. COOK
3. WILL

INDIANA

1. LAKE
2. PORTER
3. LAPORTE
4. ST. JOSEPH
5. ELKHART
6. LAGRANGE
7. STEUBEN
8. DE KALB
9. NOBLE
10. KOSCIUSKO
11. ALLEN
12. ADAMS
13. WELLS

OHIO

1. WILLIAMS
2. FULTON
3. LUCAS
4. OTTAWA
5. DEFIANCE
6. HENRY
7. WOOD
8. SANDUSKY
9. ERIE
10. LORAIN
11. CUYAHOGA
12. LAKE
13. GEAUGA
14. ASHTABULA
15. TRUMBULL
16. PORTAGE
17. SUMMIT
18. MEDINA
19. ASHLAND
20. HURON
21. SENECA
22. HANCOCK
23. PUTNAM
24. PAULDING
25. VAN WERT
26. ALLEN
27. HARDIN
28. WYANDOT
29. CRAWFORD
30. RICHLAND
31. AUGLAIZE
32. MERCER
33. MARION

PENNSYLVANIA

1. ERIE
2. CRAWFORD
3. POTTER

NEW YORK

1. JEFFERSON
2. LEWIS
3. HERKIMER
4. HAMILTON
5. ONEIDA
6. OSWEGO
7. MADISON
8. ONONDAGA
9. CAYUGA
10. WAYNE
11. MONROE
12. ORLEANS
13. NIAGARA
14. ERIE
15. GENESEE
16. WYOMING
17. LIVINGSTON
18. ONTARIO
19. SENECA
20. YATES
21. SCHUYLER
22. TOMPKINS
23. CORTLAND
24. ALLEGANY
25. STEUBEN
26. CATTARAUGUS
27. CHAUTAUQUA
28. CHEMUNG

CANADA — ONTARIO COUNTIES AND TOWNSHIPS

1. ALGOMA
1. DAY & BRIGHT ADDITIONAL
2. ELLIOT LAKE
3. HILTON
4. JOCELYN
5. JOHNSON
6. LAird
7. MACDONALD, MEREDITH & ABERDEEN ADDITIONAL
8. MICHIPICOTEN
9. PLUMMER ADDITIONAL
10. PRINCE
11. ST. JOSEPH
12. TARBUTT & TARBUTT ADDITIONAL
13. THESSALON
14. THOMPSON
15. WHITE RIVER
19. UNORGANIZED
20. SAULT STE-MARIE

2. BRANT
1. BRANTFORD
2. BURFORD
3. DUMFRIES, S.
4. OAKLAND
5. ONONDAGA
6. TUSCARORA

3. BRUCE
1. ALBEMARLE
2. AMABEL
3. ARRAN
4. BRANT
5. BRUCE
6. CARRICK
7. CULROSS
8. EASTNOR
9. ELDERSLIE
10. GREENOCK
11. HURON
12. KINCARDINE
13. KINLOSS
14. LINDSAY
15. ST. EDMUNDS
16. SAUGEEN

4. DUFFERIN
1. AMARANTH
2. GARAFRAXA, E.
3. LUTHER, E.
4. MELANCTHON
5. MONO
6. MULMUR

5. DURHAM
1. CARTWRIGHT
2. CAVAN
3. CLARKE
4. DARLINGTON
5. HOPE
6. MARKHAM

6. ELGIN
1. ALDBOROUGH
2. BAYHAM
3. DORCHESTER, S.
4. DUNWICH
5. MALAHIDE
6. SOUTHWOLD
7. YARMOUTH

7. ESSEX
1. ANDERDON
2. COLCHESTER N.
3. COLCHESTER S.
4. GOSFIELD N.
5. GOSFIELD S.
6. MAIDSTONE
7. MALDEN
8. MERSEA
9. PELEE
10. ROCHESTER
11. SANDWICH S.
12. SANDWICH W.
13. TILBURY N.
14. TILBURY W.
15. WINDSOR CITY

8. FRONTENAC
1. BARRIE
2. BEDFORD
4. HINCHINBROOKE
5. HOWE ISLAND
6. KENNEBEC
7. KINGSTON
8. LOUGHBOROUGH
9. OLDEN
12. PITTSBURGH
13. PORTLAND
14. STORRINGTON
15. WOLFE ISLAND

9. GREY
1. ARTEMESIA
2. BENTINCK
3. COLLINGWOOD
4. DERBY
5. EGREMONT
6. EUPHRASIA
7. GLENELG
8. HOLLAND
9. KEPPEL
10. NORMANBY
11. OSPREY
12. PROTON
13. ST. VINCENT
14. SARAWAK
15. SULLIVAN
16. SYDENHAM

10. HALDIMAND
1. CANBOROUGH
2. CAYUGA, N.
3. CAYUGA, S.
4. DUNN
5. MOULTON
6. ONEIDA
7. RAINHAM
8. SENECA
9. SHERBROOKE
10. WALPOLE

11. HALIBURTON
1. ANSON, HINDON & MINDEN
2. BICROFT
3. CARDIFF
4. DYSART, ETC
5. GLAMORGAN
6. LUTTERWORTH
7. MONMOUTH
8. SHERBORNE, ETC
9. SNOWDON
10. STANHOPE

12. HALTON
1. ESQUESING
2. NASSAGAWEYA
3. BURLINGTON
4. OAKVILLE

13. HASTINGS
4. ELZEVIR & GRIMSTHORPE
5. FARADAY
6. HERSCHEL
7. HUNGERFORD
8. HUNTINGDON
9. LIMERICK
10. MADOC
11. MARMORA & LAKE
14. RAWDON
15. SIDNEY
16. THURLOW
17. TUDOR & CASHEL
18. TYENDINAGA
19. WOLLASTON

14. HURON
1. ASHFIELD
2. COLBORNE
3. GODERICH
4. GREY
5. HAY
6. HOWICK
7. HULLETT
8. McKILLOP
9. MORRIS
10. STANLEY
11. STEPHEN
12. TUCKERSMITH
13. TURNBERRY
14. USBORNE
15. WAWANOSH, E.
16. WAWANOSH, W.

15. KENT
1. CAMDEN
2. CHATHAM
3. DOVER
4. HARWICH
5. HOWARD
6. ORFORD
7. RALEIGH
8. ROMNEY
9. TILBURY E.
10. ZONE

16. LAMBTON
1. BOSANQUET
2. BROOKE
3. DAWN
4. ENNISKILLEN
5. EUPHEMIA
6. MOORE
7. PLYMPTON
8. SARNIA
9. SOMBRA
10. WARWICK
11. IND. RES. - RES. IND.

17. LEEDS
1. BASTARD
3. CROSBY, S.
5. LEEDS & LANSDOWNE, FRONT
9. LEEDS & LANSDOWNE, REAR
11. YONGE & ESCOTT, REAR

18. LENNOX & ADDINGTON
1. ADOLPHUSTOWN
2. AMHERST ISLAND
3. CAMDEN, E.
5. ERNESTOWN
6. FREDERICKSBURGH, N.
7. FREDERICKSBURGH, S.
8. KALADAR, ANGLESEA & EFFINGHAM
9. RICHMOND
10. SHEFFIELD

19. LINCOLN
1. CAISTOR
2. CLINTON
3. GAINSBOROUGH
4. GRIMSBY, N.
5. GRIMSBY, S.
6. LOUTH
7. NIAGARA
8. ST. CATHARINES CITY

20. MANITOULIN
1. ASSIGINACK
2. BARRIE ISLAND
3. BILLINGS
4. BURPEE
5. CARNARVON
6. COCKBURN ISLAND
7. GORDON
8. HOWLAND
9. RUTHERFORD & GEORGE ISLAND
10. SANDFIELD
11. TEHKUMMAH
13. UNORGANIZED
14. INDIAN RESERVES

21. MIDDLESEX
1. ADELAIDE
2. BIDDULPH
3. CARADOC
4. DELAWARE
5. DORCHESTER, N.
6. EKFRID
7. LOBO
8. LONDON
9. McGILLIVRAY
10. METCALFE
11. MOSA
12. NISSOURI, W.
13. WESTMINSTER
14. WILLIAMS, E.
15. WILLIAMS, W.

22. MUSKOKA
1. BRUNEL
2. CARDWELL
3. CHAFFEY
4. DRAPER
5. FRANKLIN
6. FREEMAN
7. MACAULAY
8. McLEAN
9. MEDORA & WOOD
10. MONCK
11. MORRISON
12. MUSKOKA
13. OAKLEY
14. RIDOUT
15. RYDE
18. STEPHENSON
17. STISTED
18. WATT
20. UNORGANIZED

23. NIPISSING
3. CALDWELL
6. CHISHOLM
7. FERRIS, E.
8. FERRIS, W.
9. FIELD
12. SPRINGER
13. WIDDIFIELD
15. UNORGANIZED

24. NORFOLK
1. CHARLOTTEVILLE
2. HOUGHTON
3. MIDDLETON
4. TOWNSEND
5. WALSINGHAM, N.
6. WALSINGHAM, S.
7. WINDHAM
8. WOODHOUSE

25. NORTHUMBERLAND
1. ALNWICK
2. BRIGHTON
3. CRAMAHE
4. HALDIMAND
5. HAMILTON
6. MONAGHAN, S.
7. MURRAY
8. PERCY
9. SEYMOUR

26. ONTARIO
1. BROCK
2. MARA
3. PICKERING
4. RAMA
5. REACH
6. SCOTT
7. SCUGOG
8. THORAH
9. UXBRIDGE
10. WHITBY
11. WHITBY, E.

27. OXFORD
1. BLANDFORD
2. BLENHEIM
3. DEREHAM
4. MISSOURI, E.
5. NORWICH, N.
6. NORWICH, S.
7. OXFORD, E.
8. OXFORD, N.
9. OXFORD, W.
10. ZORRA, E.
11. ZORRA, W.

28. PARRY SOUND
1. ARMOUR
2. CARLING
3. CHAPMAN
4. CHRISTIE
5. FOLEY
6. HAGERMAN
7. HIMSWORTH, N.
8. HIMSWORTH, S.
9. HUMPHRY
10. JOLY
11. MACHAR
12. McDOUGALL
13. McKELLAR
14. McMURRICH
15. NIPISSING
16. PERRY
17. RYERSON
18. STRONG
20. UNORGANIZED

29. PEEL
1. ALBION
2. CALEDON
3. CHINGUACOUSY
4. TORONTO
5. TORONTO GORE

30. PERTH
1. BLANSHARD
2. DOWNIE
3. EASTHOPE, N.
4. EASTHOPE, S.
5. ELLICE
6. ELMA
7. FULLARTON
8. HIBBERT
9. LOGAN
10. MORNINGTON
11. WALLACE

31. PETERBOROUGH
1. ASPHODEL
2. BELMONT & METHUEN
3. BURLEIGH & ANSTRUTHER
4. CHANDOS
5. DOURO
6. DUMMER
7. EMMISMORE
8. GALWAY & CAVENDISH
9. HARVEY
10. MONAGHAN, N.
11. OTONABEE
12. SMITH

32. PRINCE EDWARD
1. AMELIASBURGH
2. ATHOL
3. HALLOWELL
4. HILLIER
5. MARYSBURGH, N.
6. MARYSBURGH, S.
7. SOPHIASBURGH

33. SIMCOE
1. ADJALA
2. ESSA
3. FLOS
4. GWILLIMBURY, W.
5. INNISFIL
6. MATCHEDASH
7. MEDONTE
8. NOTTAWASAGA
9. ORILLIA
10. ORO
11. SUNNIDALE
12. TAY
13. TECUMSETH
14. TINY
15. TOSORONTIO
16. VESPRA

34. SUDBURY
1. BALDWIN
2. BALFOUR
3. BLEZARD
4. CAPREOL
5. CASIMIR, JENNINGS & APPLEBY
7. COSBY, MASON & MARTLAND
8. DOWLING
9. DRURY, DENISON & GRAHAM
10. FALCONBRIDGE
11. HAGAR
12. HALLAM
13. HANMER
14. MAIRN
15. NEELON & GARSON
16. ONAPING
17. RATTER & DUNNET
18. RAYSIDE
19. REMABIE
20. SALTER, MAY & HARROW
21. WATERS
23. UNORGANIZED
24. SUDBURY

35. THUNDER BAY
1. BEARDMORE
2. COMMEE
3. DORION
4. GILLIES
5. LONGLAC
6. MANITOUWADGE
7. MARATHON
9. NEEBING
10. NIPIGON
11. O'CONNOR
12. OLIVER
13. PAIPOONGE
14. REDROCK
15. SCHREIBER
16. SHUNIAH
17. TERRACE BAY
19. UNORGANIZED
20. THUNDER BAY

36. TIMISKAMING
22. UNORGANIZED

37. VICTORIA
1. BEXLEY
2. CARDEN
3. DALTON
4. ELDON
5. EMILY
6. FENELON
7. LAXTON, DIGBY & LANSFORD
8. MARIPOSA
9. OPS
10. SOMERVILLE
11. VERULAM

38. WATERLOO
1. DUMFRIES, N.
2. WATERLOO
3. WELLESLEY
4. WILMOT
5. WOOLWICH

39. WELLAND
1. BERTIE
2. CROWLAND
3. HUMBERSTONE
4. PELHAM
5. THOROLD
6. WAINFLEET
7. WILLOUGHBY
8. NIAGARA FALLS

40. WELLINGTON
1. ARTHUR
2. ERAMOSA
3. ERIN
4. GARAFRAXA, W.
5. GUELPH
6. LUTHER, W.
7. MARYBOROUGH
8. MINTO
9. NICHOL
10. PEEL
11. PILKINGTON
12. PUSLINCH

41. WENTWORTH
1. ANCASTER
2. BEVERLY
3. BINBROOK
4. FLAMBOROUGH, E.
5. FLAMBOROUGH, W.
6. GLANFORD
7. SALTFLEET
8. HAMILTON CITY

42. YORK
1. GEORGINA
2. GWILLIMBURY, E.
3. GWILLIMBURY, N.
4. KING
5. MARKHAM
6. VAUGHAN
7. WHITCHURCH
16. ETOBICOKE
17. SCARBOROUGH
18. YORK
19. YORK, E.
20. YORK, N.
21. TORONTO CITY

of substances in water and on water and wastewater treatment.

The elements of the Water Quality Branch at CCIW are partly operational and partly research oriented. Firstly, the Ontario Region operational element, comprising the central analytical service laboratory and a field survey unit, participates in investigations and research studies on the Great Lakes and at other locations in the region. Secondly, the research role at CCIW is carried out by two unitsç one devoted to the development of new and improved analytical methods and the other to new technology for water and wastewater treatment.

ANALYTICAL METHODS RESEARCH SUBDIVISION

The objective of the Analytical Methods Research Subdivision (AMR) is to develop methods of detection and measurement of pollutants in surface waters.

Such methods are then turned over to the WQB analytical service laboratories for routine use. The methods developed are also published in scientific journals to make them available to anyone concerned with the control of water quality.

The AMR Subdivision presently employs 12 research scientists and supporting technicians. The first nucleus of this group moved to the Centre from Ottawa in March, 1972.

During the year analytical research was carried out on some 15 projects. In spite of the disruption caused by the move from one city to another, the research staff managed to publish 6 scientific papers and give a number of conference presentations.

A brief description of the analytical research projects completed or still in progress is given below:

Cyanide Analysis

An automated method was developed for the analysis of cyanides in water. It has a limit of detection of 1 ug/1 CN. Irradiation with ultraviolet light, which decomposes complex cyanides, is used to distinguish between simple and complex cyanides.

Automated Solvent Extraction – Atomic Absorption

A method has been developed for the determination of heavy metals in water by automated solvent extraction – Atomic absorption. This enables such metals as copper and zinc to be measured at a sample rate of 40 per hour with a limit of detection of 0.5 ug/ml.

Colorimetric Determination of Iron

A study was made of the interferences when iron is determined colorimetrically in natural waters by tri-pyridy1-S-triazine. A means was found to overcome these interferences.

Phenol Analysis

Two automated colorimetric methods for the determination of phenolic substances in water have been developed. Both use automated steam distillation followed by colour formation and solvent extraction. One method uses 4-amino-antipyrine, the other 3-methy1-2-benzothiazolinone hydrazone. The limit of detection at a rate of 10 samples per hour is 0.2 ug/1 phenol.

Potentiometric Titrations Using Silver-Sulfide Selective Electrode

The potentiometric titration curves of sulfide, iodide, bromide, chloride, thiocyanide, cyanide, xanthate, mercaptan, thiophosphate, thiosulphate, dithionate, thiocarbonate, thiocarbamate, thioamide and thiourea with Ag, Pb, Cd, Cu and Hg standard solutions using solid state ion-selective electrodes were established. All possible combinations of simultaneous titrations of two compounds were studied. The details on these titrations and the values of Δ E at the equivalence points were provided.

Potentiometric Titrations Using Ammoniumpyrrolidindithiocarbamate Solution

The course of the potentiometric titrations of Ag^{+}, Hg^{2+}, Cu^{2+}, Pb^{2+}, Cd^{2+}, Ni^{2+}, Co^{3+}, Zn^{2+}, Fe^{3+}, Bi^{3+}, and Tl^{3+} ions with ammoniumpyrrolidindithiocarbamate standard solution, using the sulfide-ion selective electrode, was estimated. In addition, simultaneous titrations of possible combinations of tested ions were evaluated.

Automation of Direct Potentiometry

Commonly used methods of direct potentiometry were

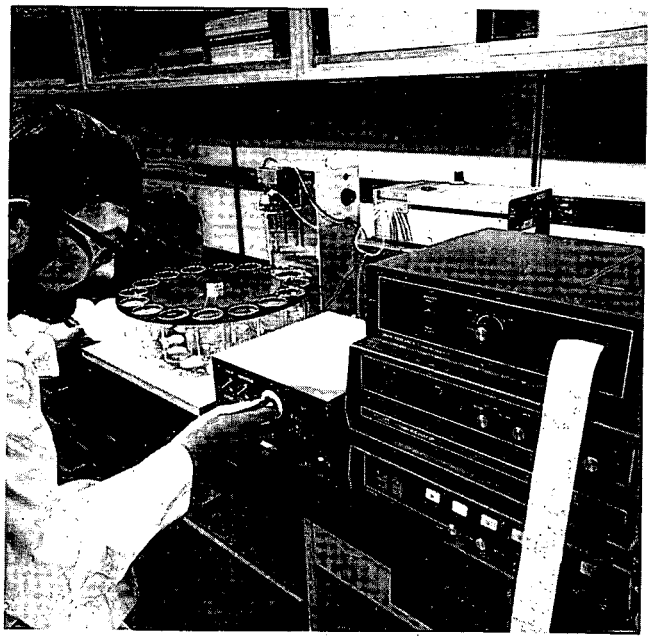


Figure 28. Joe Lechner sets the control for automated potentiometric analysis of ammonia and fluorides.

automated. The automated apparatus consists of a turn-table sampler connected to an automatic switch, pH/mV meter and printer system via a control module. The optimum sampling rate is 20 samples/hr. The operation of the apparatus was verified by the determination of fluoride and ammonia in water samples using commercially available ion-selective electrodes.

Automated Determination of Fluoride Ion in Parts per Billion

Fluoride ion, down to 2 ppb, has been determined by automated direct potentiometry using a fluoride ion-selective electrode. The method reduces the dilution and contamination effects of TISAB and takes the electrode time response into consideration. The relative standard deviation in water samples is 1.5 to 1.8% and the recovery varied from 97.5 – 102.0%.

Twin-Cell Voltammetric and Related Techniques for the Analysis of Trace Contaminants

A systematic study is under way to evaluate voltammetric and related techniques, in a twin-cell mode, to device improved methods for analysis of pollutants, and also to obtain information concerning various forms and oxidation states of individual species.

Methods were developed to determine the total content of heavy metals down to 1 ug/litre without preconcentration. Information has also been obtained concerning the forms or oxidation states of these metals.

Methods have also been developed to analyze synthetic chelating agents, such as SHIM, NTA, EDTA, Citric Acid and Polyphosphate, in detergents and natural waters. By automating such methods, these sequestering agents can be determined simultaneously at the rate of 20-30 samples per hour.

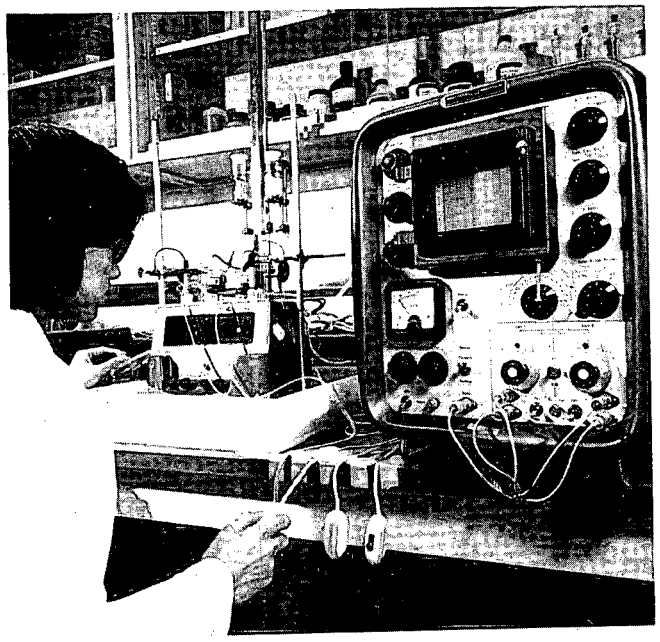


Figure 29. Rickey Leung analyzes synthetic chelating agents in detergents by twin-cell voltammetry.

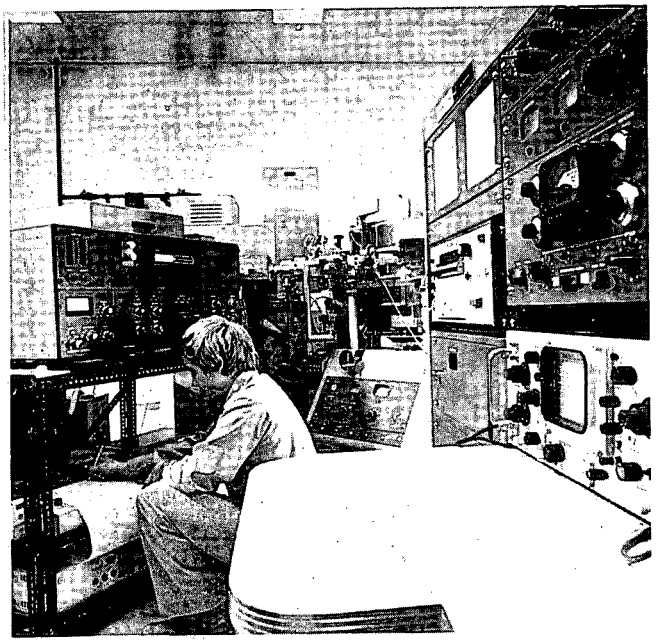


Figure 30. Mike Comba identifies GC-MS peaks for PCB's and other pesticide residues.

Molecular Fluorescent Spectroscopy for the Analysis of Water Pollutants

New reagents were developed to determine trace metals, such as Ag, B, Be, Cd, Pb, Cr, V, in natural waters, sewage effluents and sediments. These reagents can also be used to obtain information concerning the oxidation states of the metals. Automated methods were developed for boron and other metals down to 0.5 ug/litre in water and sediment without preconcentration. The maximum sample size needed for the analysis is approximately 1 ml. An analysis rate of 20-40 samples per hour can easily be achieved.

High Speed Liquid Chromatography for Pesticides and Other Organic Compounds

Work is continuing towards developing a new qualitative and quantitative methods for the analysis of organic contaminants using High Speed Liquid Chromatography.

Methods have been developed to separate, identify and measure individual phenolic-type compounds in natural waters and sediments. It is possible to detect and determine individual phenols down to 1 ug/litre.

Work is also continuing to interface various detectors, such as electrochemical, flame/atomic and fluorescence, to

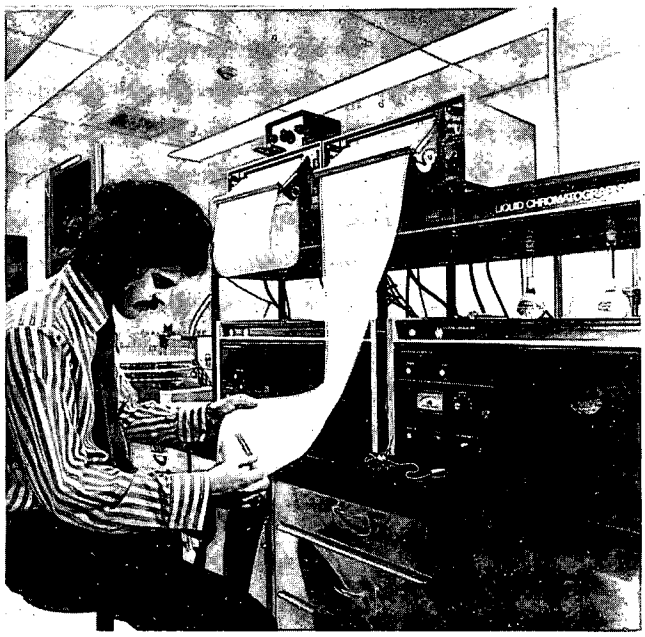


Figure 31. Richard Larose measures the peaks of a variety of separated phenols by High-Speed Liquid Chromatography.

extend the potential of the technique to pesticides and other organic compounds.

Stability of Organochlorine Pesticides in Water

Gas Chromatographic methods were employed to determine the rates of degradation of aqueous solutions of various organo-chlorine pesticides. Identification of the product(s) was made, where possible, and rate constants calculated where applicable.

Gas Chromatography of Polychlorobiphenyls

High efficiency gas chromatography employing S.C.O.T. columns was used to resolve complex mixtures of polychlorobiphenyl (PCB) isomers. The relative concentrations of all resolvable isomers in a number of commercially available PCB mixtures are being calculated. Aqueous solutions of these same mixtures will later be examined for possible alteration or degradation of some of the isomers.

GC – Mass Spectrometer (Mat Data System)

A mass spectral library of PCB's and pesticide residues was compiled during the year providing analytical support for the Division's laboratories in Moncton, Burlington and Calgary.

Project support was extended to Eldorado Mining and Uniroyal in Guelph with the successful identification of toxic by-products that were being discharged in their wastewater effluents.

WATER AND WASTEWATER TREATMENT RESEARCH SUBDIVISION

It is the responsibility of the Water and Wastewater Research Subdivision to generate new knowledge and evaluate existing knowledge, that can be used to effectively manage the quality of Canada's water resources. This responsibility is met by:

(a) studying chemical and physical methods of quality control by unit processes,

(b) application of scientific information to specific problems,

(c) arranging and administering scientific investigative contracts, and

(d) consulting with industrial environmental personnel, consulting engineers, university staff members and others who are involved with the generation and practical application of scientific information which is aimed at improving or safeguarding water quality.

Some of the studies are conducted in government laboratories; others will be undertaken at problem sites. Some of these studies are conducted under contract.

Effluents from both primary and secondary treatment plants have been analyzed for; BOD, COD, phosphorous and nitrogen, toxic material, heavy metals, radio active material and other exotic and potentially harmfully chemical complexes. Based upon the analysis, potentially successful treatment processes are studied in the laboratory, and then depending upon the laboratory studies, some of these studies are extended and applied to specific wastes.

Six man-years have been assigned to the subdivision. Staffing commenced in October 1972, and by the end of calendar year 1972, four of these positions were either occupied by research scientists or were committed. In addition to the research scientists several technicians and other support personnel were recruited to the subdivision staff during 1972.

Studies that are either in the planning stage or active are in the area of: (a) absorption, (b) ozonation, (c) reverse osmosis, (d) fate and removal of heavy metal, (e) laser application to sewage treatment.

Environmental Protection Service

The Environmental Protection Service was formed to ensure that the Federal Government's legislation, regulations and guidelines concerned with the quality of the environment are approached in a fashion consistent with national policy and enforced under appropriate circumstances. The Environmental Protection Service is involved in the development of guidelines and regulations in the identification and solution of pollution problems, problem surveillance and monitoring, and the development and demonstration of waste control technology. It draws on expertise from the Resource Missions of the Department for the criteria necessary to develop meaningful regulations, guidelines, and codes of good practice and for the conduct of research required to support E.P.S. responsibilities.

TECHNOLOGY DEVELOPMENT AND DEMONSTRATION DIVISION

The Technology Development and Demonstration Division, Technology Development Branch, Water Pollution Control Directorate, is charged with the conception, development, and implementation of technical development programs as related to water pollution control for industrial and municipal wastewaters across Canada. The Division not only undertakes bench and pilot scale studies in their laboratories but also participates in field demonstration projects at industrial sites.

To fulfill the mandate of the Technology Development Branch, EPS established a program at the Wastewater Technology Centre at the Canada Centre for Inland Waters (CCIW). The Wastewater Technology Centre is located in a two-storey building at the North end of the CCIW site. The building houses laboratories, and provides 15,000 sq. ft. of working area for a wide variety of modular wastewater and sludge treatment process equipment.

The staff of the Wastewater Technology Centre is organized into four main sections. These are the Process Development Section, Demonstration Section, Laboratory Services Section and Facilities Services Section, all supported by administrative personnel.

PROCESS DEVELOPMENT SECTION

The Process Development Section comprises five units organized along process lines: (1) biological processes, (2) physical processes, (3) chemical processes, (4) soil processes, and (5) process control.

Biological Processes Unit

This group is responsible for examining the biological and microbiological aspects of water pollution control systems, e.g. nitrificationdenitrification, activated sludge systems, anaerobic and aerobic digestion processes, and for toxicity and biodegradability studies.

Pulp and Paper Mill Effluent Treatment

Environment Canada in November 1971, published the Pulp and Paper Effluent Regulations to control BOD, suspended solids and toxicity of pulp mill effluents. Biological treatment by activated sludge is known to be effective in reducing BOD and suspended solids and to partially reduce the acute toxicity of Bleached Kraft Mill effluents (BKME). A study to determine in Kraft Bleachery waste could be successfully treated in a high rate, two stage, biological reactor system was initiated. Comparisons were made between the efficiency of a two-stage and a single-stage process.

Weekly samples of Kraft Bleachery waste were shipped from a pulp mill in Northern Ontario. The waste was fed to the two biological processes and the treated effluent used for acute toxicity studies on Rainbow trout.

At organic loadings up to 1.2 kg BOD_5/kg MLSS, 90% BOD_5 reduction was achieved. Under these conditions the total aeration time for the single and two-stage systems were 1.7 hours. The overall system detention times in both cases were 3.9 hours. Biological treatment of bleachery waste was only partially successful in reducing acute toxicity. Generally, the bench scale project indicated that biologically treated effluent was from 3 to 4 times less toxic than raw effluent.

Continuous Biological Denitrification of Wastewater

A nitrification/denitrification pilot plant program (5 gpm) was carried out in conjunction with McMaster University in 1972 to investigate the feasibility of using continuous microbial denitrification for nitrate removal from municipal wastewater under cold temperatures. Upflow packed column reactors and column reactors and a stirred tank reactor provided denitrification using methanol as an external carbon source. The denitrification units were designed to allow calculation of a nitrogen balance.

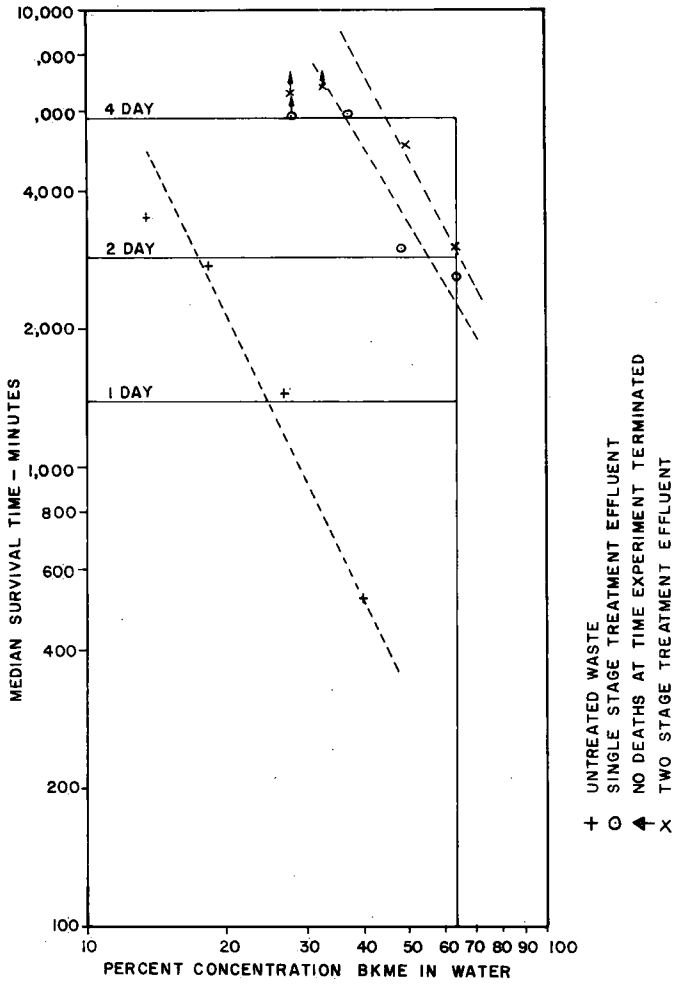


Figure 32. A toxicity curve comparing the survival time of 50% of the exposed population to concentrations of: (a) untreated Bleached Kraft Mill effluent (BKME); (b) treated BKME in a single-stage AS plant; (c) treated BKME in a two-stage AS plant.

The experimental temperature range was 5–25° C. Comparisons were made between the quality of the effluent from the upflow column reactors and the stirred tank reactor in terms of nitrate plus nitrite concentration and suspended solids concentration. Predictions of the stirred tank effluent from resulting batch unit rate data were made. The unit rate data were derived from batch runs carried out in the pilot plant stirred reactor. These results and the continuous operational data indicate the definite dependency of nitrate plus nitrite removal on temperature. The importance of proper addition of the external carbon source in order to ensure minimal effluent organic carbon was demonstrated. Nitrogen balances were obtained on the column units and the stirred tank under the various operational conditions.

Aircraft De-Icer Studies

An experimental program is being conducted to determine the biodegradability of aircraft de-icers used at Canadian airports. Continuous bench scale biological reactor studies and pilot plant studies are being conducted at low temperatures using mixtures of de-icer and sanitary sewage that might be encountered at any Canadian airport. Various concentrations of de-icer and treatment plant effluents are being subjected to bioassay tests to determine their toxicity.

Soil Processes Unit

The chief area of responsibility of this group is in investigating methods suitable for the disposal of effluents and chemical sludges using soil systems. Areas of concern consist of characterizing the leachate from the sludge-oil system and the role different soil systems play in removing various constituents.

Environmental Effects of Chemical Sludge Disposal on Land – Lysimeter Studies

This project was initiated and supported under the Canada/Ontario Agreement in 1972. An environmentally-controlled facility, accommodating sixty-six fibreglass lysimeters, six feet high and one foot in diameter has been erected at the Wastewater Technology Centre. Fifty-four treatment lysimeters and twelve control units have been filled and packed with sandy loam soils collected from the Hespeler and Guelph-Flora Research Station. The lysimeters have been packed to the natural field density and each soil system has been set with three horizontal materials. An extensive program is underway to study: the biochemical degradation of sludges in different soil systems for nutrients and trace metals with their residual effects on physico-chemical properties of soils and leachate systems; the transport and complexing of organic and inorganic constituents of chemical sludges in soil and leachate; the performance and efficiency of two soil systems; and the survival, longevity and transmittal of pathogens and viruses in soils and leachate.

Biochemical Characterization of Chemical Sewage Sludges

With the mandatory removal of phosphorus from sewage and the increasing use of alum, ferric chloride and lime to precipitate phosphorus, large quantities of organo-chemical sludges will be produced in Ontario each year, with a wide variation in characteristics, due to different chemicals, different treatment processes, different sludge handling practices and different seasonal operations.

To establish disposal criteria, environmental contamination standards and waste management practices, studies are underway to assess the chemical variability of sludges due to the use of the three principal precipitation chemicals; to evaluate the microbial characteristics and variations; and to establish the value of different sludges as fertilizers.

Recycling and Utilization of Digested Sewage Sludge and Effluents on Land – Iona Island, Vancouver

A three year study program is underway to investigate the disposal of digested sewage sludge and effluent on land

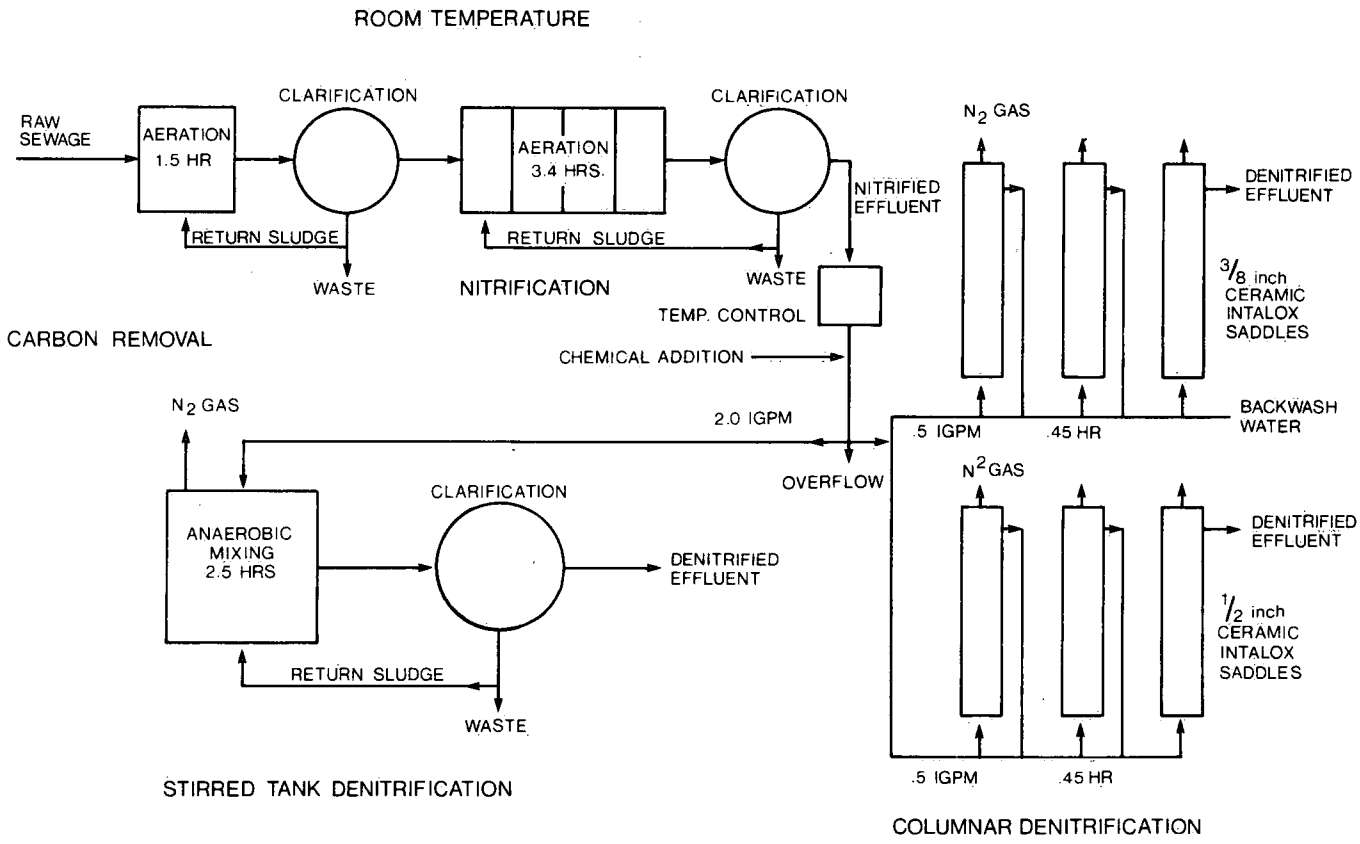


Figure 33. Flow diagram of 4300 IGPD Nitrification – Denitrification Pilot Plant.

to obtain a comprehensive understanding of environmental effects on soil, plant, groundwater and public health.

The experiments are being conducted in sands piped from the Fraser River on which Reed canary grass, oats and a forage crop will be grown on a three year rotational cycle.

Chemical Processes Unit

This group carries out developmental work in chemical processes for the removal of undesirable and potentially harmful constituents from effluent waste streams. Of emmediate concern and involvement is the removal of phosphates by chemical means.

The Detergent Substitution Study at C.F.S. Gloucester

Canadian Forces Station (CFS) Gloucester was the site of full-scale detergent substitution studies. Wastewater characteristics and sewage treatment plant performance were monitored under baseline (consumers using existing detergent formulations), NTA, carbonate, high-phosphate and citrate detergent substitution conditions. Specific objectives of the program included: (1) to determine the degradability of NTA and citrate when subjected to biological treatment, (2) to determine the relationships between detergent formulations and phosphorus removal with calcium, iron and aluminum salts, and (3) to assess consumer attitudes towards the various detergent formulations.

It was found that the substitution of non-phosphate detergents for existing detergents (phosphate content less than 20% as P_2O_5) resulted in an average reduction of 24% in the total phosphorus loading of the domestic wastewater. Figure 35 shows the effect of the various formulations on

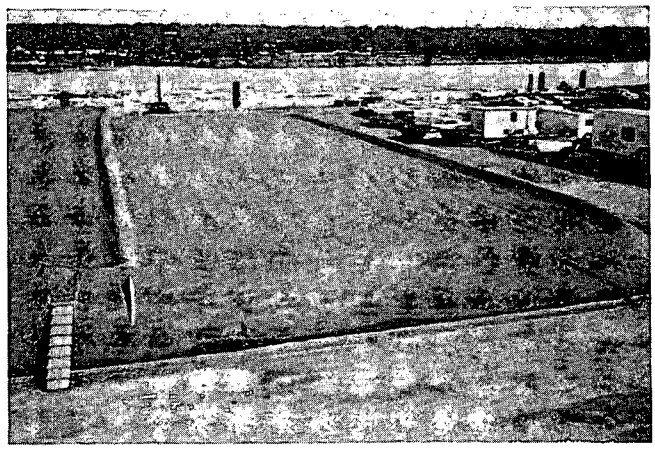


Figure 34. Sludge disposal experiment, Iona Island, Vancouver.

total phosphorus levels in the sewage from the married quarters area.

NTA was significantly degraded (60-75% removal), whereas citrate was essentially completely degraded (> 95% removal) by the activated sludge treatment process. Detergent induced increases in NTA and citrate did not have any quantifiable effect on phosphorus removal with alum, ferric chloride or lime. In fact, the reduction in wastewater phosphorus levels resulted in a corresponding reduction in the dosage of alum and ferric chloride required to achieve a residual phosphorus level of 1 mg/1. It was estimated that complete substitution of phosphate-based detergents may result in a 25-30% reduction in coagulant requirements.

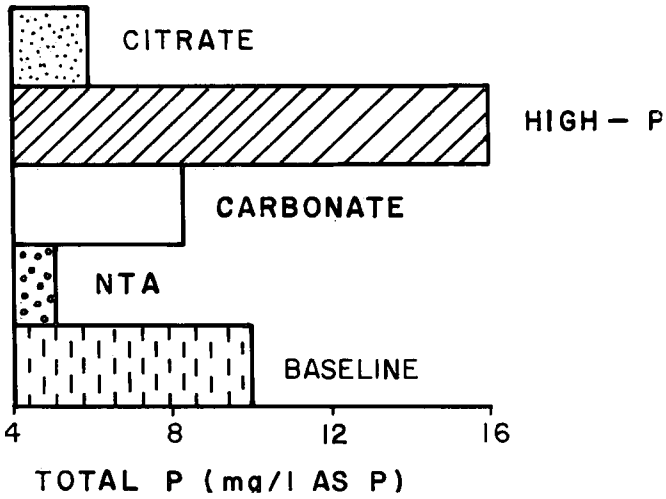


Figure 35. Comparison of total phosphorous concentrations in married quarters' wastewater for five detergent conditions.

Water Quality Control Experiments on the Welland Canal

The existing (fourth) Welland Canal will be replaced by the new (fifth) Welland Canal in the Spring of 1973. In order to evaluate water quality control alternatives for the abandoned canal, the St. Lawrence Seaway Authority and the Environmental Protection Service initiated a demonstration study in May, 1972, on four basins located in a stretch of the third Welland Canal. One basin was treated with aluminum sulphate (alum) at a dosage of 5 mg/1 as Al; another basin was maintained as a controlled flowthrough situation (4-day retention time); a third basin was treated with copper sulphate at a dosage of 1 mg/1 and the fourth basin was used as a control.

The biological, chemical and physical characteristics of the basins were monitored on a weekly basis from May to August, 1972. Specific water quality comparisons between basins were made with respect to total phosphorus, chlorophyll *a*, primary production, turbidity, sediment characteristics and heavy metals. Although nuisance conditions (algal blooms) did not develop in any of the

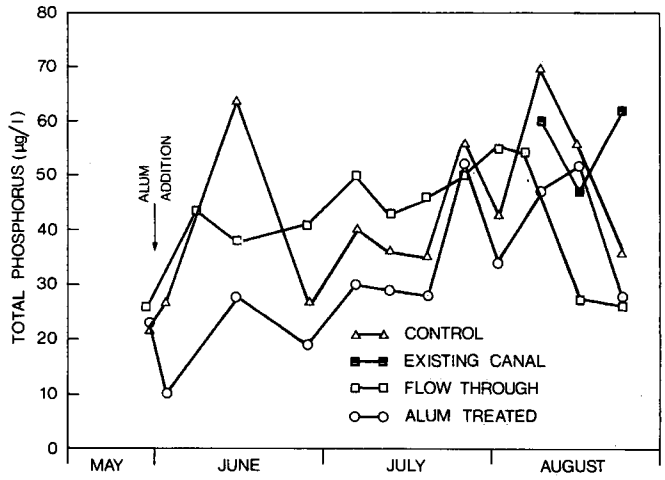


Figure 36. Total phosphorus variations in Welland Canal test basins (May-August 1972).

experimental basins, there were significant inter-basin water quality differences – for example, note total phosphorus variations in the basins for the period May to August, 1972, in Figure 36.

Availability and Quality of Chemical Precipitants for Phosphorus Removal

This project, funded under the Canada-Ontario Agreement on the Lower Great Lakes, was initiated to assess the location and quality of industrial wastes or by-products (pickle liquors, mill-scales, carbide limes, etc.) which have potential usefulness for phosphorus removal. An inventory of such waste sources in Ontario and Quebec has been prepared and preliminary testing has identified several wastes that are capable of efficient phosphorus removal (either in an as-is condition or, in some cases, a reprocessed state). Specific studies of the effects of pickle liquor additions on (i) the activated sludge process and (ii) sewage plant effluent heavy metal (e.g., chromium and zinc) are also being conducted.

Physical Processes Unit

The responsibilities of this group consist of process development in the domain of physical processes such as settling, filtration, aeration, flotation and mixing, and sludge dewatering and handling.

Unslake Lime – Its Direct Use in Phosphate Removal Processes

A study of the use of dry unslake lime (quicklime) in the primary treatment of sewage was carried out to demonstrate the feasibility of using the chemical for phosphorus removal. The 30,000 IGPD pilot plant which was constructed in the Wastewater Technology Centre was operated for a year to establish design criteria for quicklime systems and compare the phosphorus removal efficiency and economics of this process with conventional processes using slurried hydrated lime.

Comparisons between quicklime and hydrated lime for the low lime system (pH 9.5-10), low lime system with sludge recycle, high lime system (pH > 11) and the high lime system with sludge recycle, have shown that removals of phosphate using quicklime was equal to hydrated lime when equivalent amounts of chemicals were used (on a CaO content basis). A process for adding the quicklime to the rapid mix tank of a waste treatment plant was developed and operated without failure during the project. The unit consists of a storage hopper, a continuous slaking reactor and slurry storage and pumping unit. The system includes process control to establish the dry quicklime feed rate, water to quicklime ratio and reaction temperature to ensure a uniform supply of lime of the desired quality and the complete reaction ofthe quicklime with the water. The use of such a quicklime system should reduce the operating cost for lime-phosphate treatment by approximately 30% and the capital cost by approximately 10%.

New Brunswick Acid Mine Drainage Treatment Program

In 1972, a joint Federal/Provincial/Industrial study was initiated for the development of mine wastewater treatment

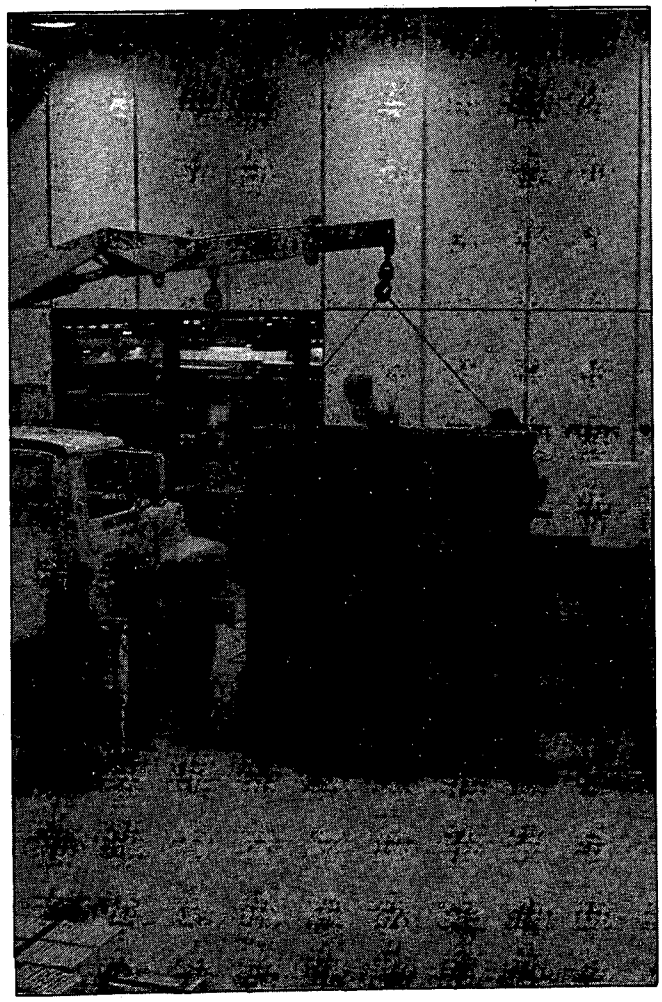


Figure 37. Installation of clarifier in the Quicklime Pilot Plant.

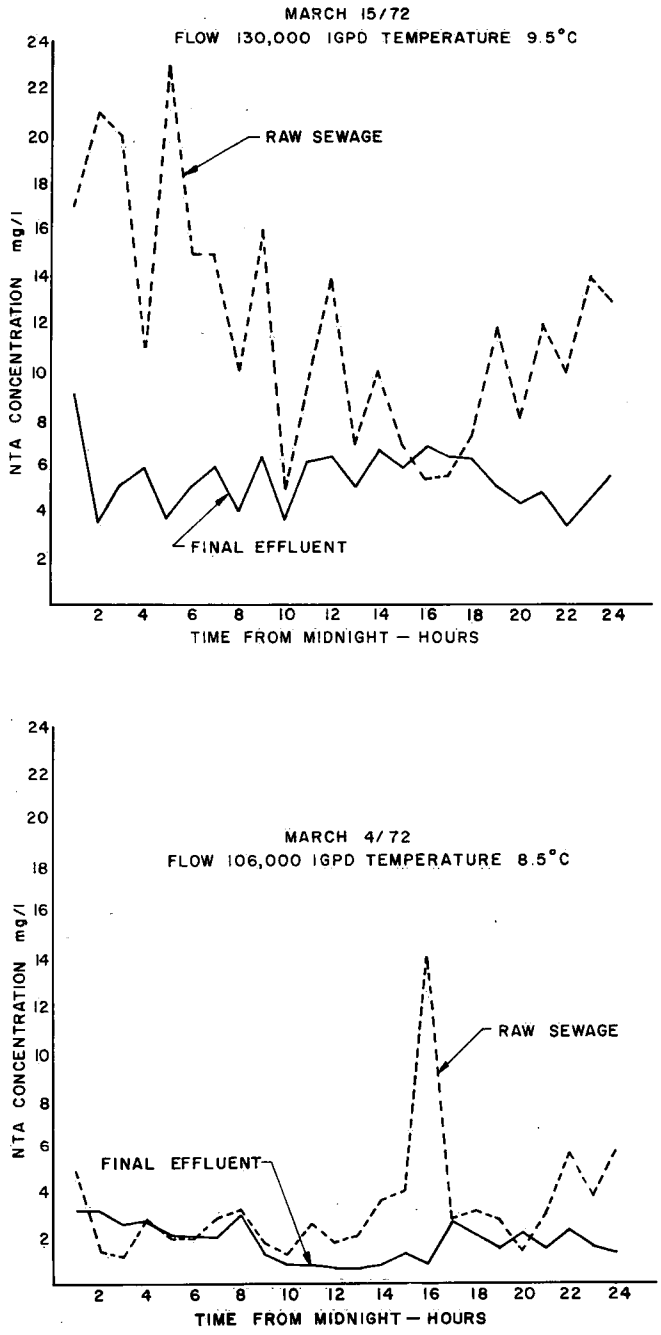


Figure 38. NTA in influent and effluent waters of the Waterdown Wastewater Treatment Plant.

technology in the base metal mining industry. As a result, a waste treatment pilot demonstration plant is being established at the Brunswick Mining Company site in northeastern New Brunswick. The plant data obtained will be a cornerstone in the development of national pollution abatement guidelines for the mining industry and should provide a treatment process to enable the mining of copper, lead and zinc to co-exist with salmon fishing of northeastern New Brunswick.

The unit has developed a flexible and versatile pilot plant system which incorporates state-of-the-art technology for treatment of such acidic wastewaters. Unit processes included are thiosulfate stabilization, neutralization and precipitation, sedimentation, sludge handling and effluent polishing.

In support of the field program, bench scale studies have been carried out to assess the feasibility of various processes and to narrow the experimental range of the studies to be undertaken in the field with the pilot plant. Bench scale studies on a high-density sludge process have shown that the maximum effluent quality obtainable with lime or limestone lime precipitation systems is approximately Img Zn/1 and 0.2 mg Cu/1. These levels do not meet the proposed guidelines. Thus, studies have been undertaken to assess various effluent polishing processes such as sand filtration, ion exchange, cementation on aluminum and magnesium metals, and ion exchange with silicon alloys to provide better removals. Excellent results have been obtained for several of the processes and trials at the pilot scale are under consideration for the field installation.

Sludge Dewatering and Reduction Processes

An extensive program is underway to investigate sludge dewatering processes with respect to he characterization of sludges and the effect of type of sludge and chemical treatment on physical properties; the determination of parameters and properties governing dewatering processes; and the prediction of plant operation from laboratory determined physical properties and pilot plant operation.

Extensive experimental work has been carried out on the development and assessment of sludge characterization parameters. They include: bulk properties — settling, rheology, compressibility, filterability, specific resistance, compressibility, and capillary suction time; continuous phase properties — viscosity surface tension, TDS and density; and dispersed phase properties — particle sizes and distribution, zeta potential, nature of particulate material (granumetric property), surface charge and bound water.

DEMONSTRATION SECTION

The Demonstration Section implements and monitors experimental programs in the field.

Maritime Fish Processing Study

The Section participated in a study of fish processing plants located in Nova Scotia, New Brunswick and Newfoundland. The effluents from these plants were studied to determine waste characteristics and water usage in the ground fish filleting, whale slaughtering and sardine canning processes. Effluent loadings per 1000 pounds of ground fish and final product were determined from experimental data, flow measurements and production figures. The results will form part of the data base for writing the effluent guidelines for the fish processing industry.

Waterdown Wastewater Treatment Plant NTA Study

A field study was carried out during the winter of 1971-72 and 72-73 at the Waterdown Wastewater Treatment Plant to assess the impact of NTA on chemical treatment phosphorus removal facilities and treatment plant operation. The studies also investigated NTA degradation and the effect of NTA loading on heavy metal transport through the treatment plant.

The biological, chemical and physical characteristics of the plant were monitored on a daily basis for 12 months. It was found that NTA loading had no effect on the chemical dosages required for phosphorus removal. NTA was significantly degraded on passage through the treatment plant; however, the removal was influenced significantly by wastewater temperature and NTA influent concentration to the treatment plant (see Figure 38). Heavy metal transport through the treatment plant increased with increased NTA loading to the plant.

Combined Sewers

Over the past ten months, in conjunction with the Hydraulics Division, IWD, an extensive survey of the literature was carried out to assess combined sewer overflows to outline a research strategy and to develop technology for the problem and the approach to be taken. Recommendations were put forth on strategy to be followed within the Canada/Ontario Agreement in addressing the problem of combined sewer overflows in Canada.

LABORATORY SERVICES SECTION

Early in the year, the section moved to a permanent location in the Wastewater Technology Centre where increased space permitted the installation of new automated analyzers and atomic absorption spectophotometric facilities. This new equipment was immediately placed to

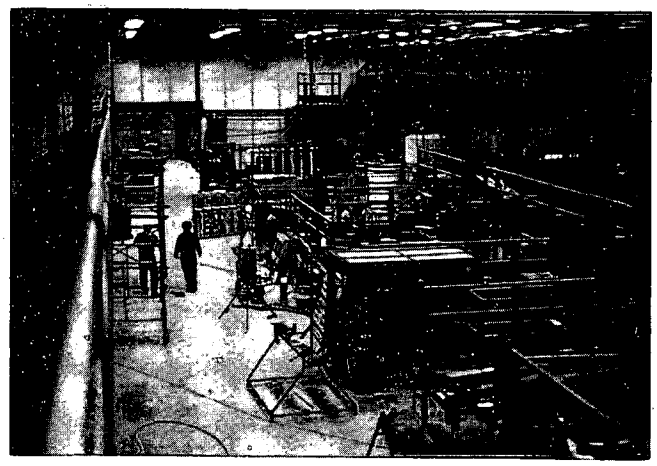


Figure 39. Fixed process mechanical and electrical systems for waste treatment pilot plants.

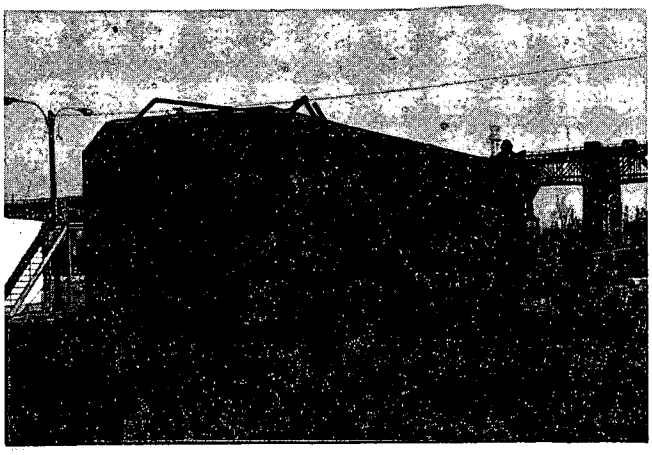


Figure 40. Extended Aeration Pilot Plant.

provide analytical support to the bench scale, pilot plant and field projects in which the Division is engaged.

Throughout the year, heavy demands were placed on all available facilities and manpower to meet analytical requests. Analyses performed were largely confined to the various forms of the C, N, P nutrients and heavy metals, mainly in samples of a domestic sewage type. However, there was increasing demand for analyses (for similar parameters) on samples of the biological and chemical sludges produced by various treatment processes and soils. More than 16,000 samples were processed during the year for a total of more than 50,000 parameters.

FACILITIES SERVICES SECTION

The Facilities Services Section operates and maintains the various pollution control process units in the Wastewater Technology Centre and ensures that new pollution control process hardware is assembled according to designs generated by the Process Development Section.

Construction and installation of the fixed process piping, waste storage, electrical and control systems was accomplished in 1972. An observation deck was added to the second floor, opposite the working mezzanine, to permit scientists to make immediate contact with operations in the plant and to provide an area for the general public to see the facilities.

Fish culture and bioassay capacity was increased by an extension to the environmental room facilities.

Numerous pilot plant unit processes, such as reverse osmosis, vacuum filters, clarifiers, centrifuges, a calcinator and a multiplehearth furnace were procured and assembled in the Wastewater Technology Centre.

Significant construction and installation was carried out on the north side of the Wastewater Technology Centre to provide electrical, air, water, sewage and drainage services. A twenty-gallon-per-minute extended package plant has been installed on the prepared site, along with an air-conditioned moveable test building that accommodates soil lysimeters for experiments on land disposal of chemical sludges.

ENVIRONMENTAL EMERGENCY BRANCH

The Environmental Emergency Branch (EEB) which is part of the Environmental Protection Service, is responsible for protective and preventative activities where an environmental threat results from an accident in which a hazardous chemical is released into the environment. EEB is represented at CCIW by the Hazardous Material Spill Countermeasures Unit and the Environmental Emergency Coordination Unit.

Hazardous Material Spill Countermeasures Unit

The Hazardous Material Spill Countermeasures Unit is the national centre for evaluation and development of countermeasures systems for dealing with spills of oil and other hazardous and toxic materials. The primary functions of this unit are the testing and evaluation of current countermeasures equipment, materials and techniques, and the subsequent design and development of a number of effective, economical and ecologically safe, multicomponent control systems to combat spills occurring under various conditions throughout Canada. The unit is further responsible for the development of Federal guidelines for the acceptability and use of oil spill treating agents and techniques.

Since July, 1972, when the unit began operations at CCIW, several projects have been undertaken in liaison with other groups and scientists at the Centre, with industrial companies, with university consultants and with other governmental agencies. Two major projects were completed

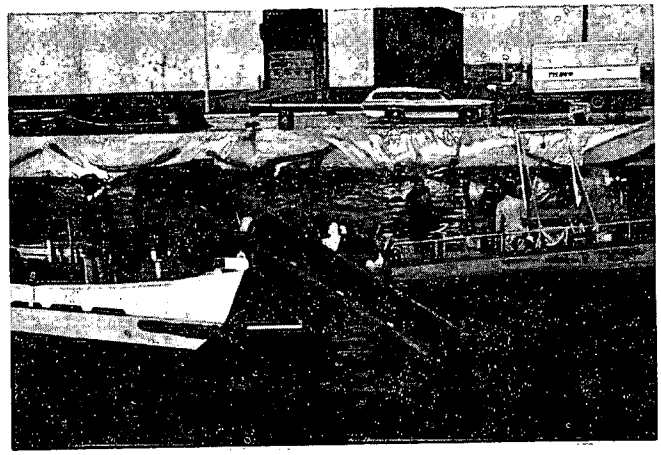


Figure 41. Field testing at CCIW of oil spill collection system.

in 1972. These were (1) the testing and evaluation of an oil spill collection system developed (under contract) by Canadair Ltd., and (2) the development of Federal guidelines for the acceptability and use of oil spill dispersants. Current work includes (1) testing and evaluation of several dispersants, (2) feasibility studies of a passive microwave radiometer system for the detection and measurement of oil spills and (3) field testing of chemical oil herders. Planning is underway for extensive testing and evaluation of (1) several absorbent boom products, (2) Lockheed's Clean Sweep oil spill remover and (3) JBF's Dynamic Inclined Plane oil spill removal system.

Great Lakes International Contingency Plan

The Great Lakes International Contingency Plan was officially implemented on the 15th. of April, 1972, with the signing of the Canada-U.S. Agreement by the Prime Minister and the President. The plan was invoked in June as a result of the Parker Evans and Sidney E. Smith collision in the St. Clair at Sarnia. During subsequent recovery operations, the Parker Evans' fuel oil was successfully removed with minimal spillage from the wreck. The event provided experience in operational procedures and communications and resulted in recommendations for improvements to streamline operations. These improvements will be incorporated in a revised plan in 1973.

In late September, an Environmental Emergency Co-ordinator joined the staff to assist the Director of the Centre as the Great Lakes Regional Co-ordinator. An Operations Centre was established to provide a focal point of major spill reports on the Great Lakes and will aslo act as the contact point for the United States Regulatory Agencies related to matters under the Great Lakes Contingency Plan.

Oil Spill Countermeasures equipment, such as 2000 ft. of oil spill boom and 2 Slicklickers have been located at the Centre. Additional equipment, such as sorbents, generators, floodlights, radios, clothing, small hardware, etc., will be in place before the end of this fiscal year. Similar equipment is also stored at the Ministry of Transport Marine Agencies in Prescott, Amherstburg, Sarnia, Parry Sound and Thunder Bay. The countermeasures equipment will assist the staff to enable them to improve the operational response to future spill incidents.

Fisheries Research Board

The year 1972 was a year of change for the FRB Detachment. This unit, formerly administered by the Freshwater Institute at Winnipeg, was established as a separate responsibility centre with the name, Great Lakes Biolimnology Laboratory. Dr. Arnold Nauwerck, Head, left the group to return to Sweden at the end of January. Dr. Walter A. Glooschenko assumed duties as Acting Head on February 1, and held the position until November 30, 1972. Dr. Murray G. Johnson was appointed as Program Head on December 1st.

The programme of the unit focuses on three main areas. The first of these is Descriptive Biolimnology, led by Dr. Nelson Watson, which includes surveys, surveillance and work on taxonomy and developmental cycles of phytoplankton, zooplankton and bottom fauna in the Great Lakes. Dr. Walter Glooschenko is leading the second area, Environmental Toxicology, with emphasis on the effects of toxic substances such as pesticides and trace metals and of waste heat on aquatic life. The third area, Ecosystem Metabolism, emphasizes primary and secondary production in lakes and effects of environmental stresses on production dynamics. A leader will be appointed in early 1973.

During 1972, the major effort of the unit was the IFYGL programme on Lake Ontario with emphasis upon diel, seasonal and spatial distribution of phytoplankton and zooplankton. Primary production studies were a major part of this effort. Surveillance of other lakes was continued and data interpretation from previous years completed, especially upon Lake Huron. Since moving into the new building, considerable effort has been made upon isolation and culturing of phytoplankton and zooplankton for life history toxicological and other studies.

Surface Chlorophyll and Primary Production

In 1972, during the International Field Year for the Great Lakes, primary production was measured *in situ* in Lake Ontario on nine cruises at two fixed stations. The daily production was measured on short-time intervals over the whole day at various depths to 20 meters. Photosynthetic rates were compared with biomass present using chemical parameters and with measurements of solar irradiance and the attenuation in the water column of the part of the spectrum which can be utilized in photosynthesis. There was a strong difference between the inshore and the offshore stations in spring and early summer. The inshore station showed consistantly higher photosynthesis rates reaching a peak in June ($1.9gC\ m^{-2}\ day^{-1}$. From April to June at the offshore station the rates were constantly low ($0.4gC\ m^{-2}\ day^{-1}$), while in July and September the rates were high ($1.4gC\ m^{-2}\ day^{-1}$).

During the 48-hour investigation period on the two stations the daily radiation energy differed sometimes by a factor of 3, while at the same time the daily production rates per unit square meter varied by a factor of at most 1.7. At the offshore station the daily efficiency of algae (% of energy at 400-700nm fixed) varied by a factor of as much as 2.4 on two consecutive days and ranged from 0.2 – 0.17, and at the inshore station from 0.10 – 0.15. This means that in the euphotic zone (0-20m) 10 – 17% of the biomass present was renewed daily.

Chlorophyll and primary production measurements (^{14}C method) were analyzed in 1972 from 13 cruises on Lake Ontario and 10 on Lake Erie made in 1970 and additional cruises on Lake Huron in 1971.

In general, Lake Ontario chlorophyll *a* values were highest in inshore waters (<20m depth) and in the eastern portion of the lake. Lake Erie chlorophyll *a* levels were related to basin and season of sampling. In Lake Huron values were generally low except for Saginaw Bay where the highest mean chlorophyll *a* values were found for the three lakes (Fig. 42). Seasonal cycles of chlorophyll *a* varied in the three lakes, but the bimodal pattern was most prevalent.

Primary production was directly correlated with chlorophyll *a*. Highest values of production occurred in Saginaw Bay and the Western Basin of Lake Erie, with lowest values in eastern Lake Erie and Lake Ontario (Fig. 43). Assimilation ratios, mgC/mg chlorophyll *a*/hour, were generally related to nutrient distribution in the three lakes.

Monitor cruise data for chlorophyll *a* in Lake Superior collected in 1970 and 1971 were compiled (Fig. 44). Values were extremely low, roughly half of those found in Lake Huron, which indicates that Lake Superior is an extremely oligotrophic environment. No definite trends were found in the pattern of chlorophyll in Lake Superior. Inshore areas did not appear higher than offshore regions as in the other lakes, indicating that no pronounced effects of nutrient inputs occur along the shore.

Phytoplankton

Integrated phytoplankton samples (0–10m) had been collected from Lake Huron in 1971 on eight monitoring

cruises between mid-April and early December at 48 stations distributed over the entire lake. A preliminary analysis of two inshore stations and one mid-lake station indicated that diatoms and flagellates (Chrysomonadinae, Cryptomonadinae and Dinophycinae) contributed significantly to the phytoplankton biomass. The abundance of flagellates was striking and its species composition was more or less similar to that found earlier in Lake Ontario and Erie. The spring maximum in Lake Huron was dominated by diatoms and flagellates. During the summer season the phytoplankton was composed mainly of greens, blue-greens and flagellates, whereas blue-greens, flagellates and diatoms occurred in the fall. The inshore station in Saginaw Bay showed the maximum phytoplankton biomass.

The lakewide study dealing with the seasonal abundance and composition of Lake Erie phytoplankton communities was completed. A mean spring value of 6.7 x 10^6 μ^3/ml was observed in the Western Basin which was higher than in the other two basins. The monitor station off Colchester in the Western Basin showed the highest total biomass value of 21.0 x 10^6 μ^3/ml. On a yearly basis the Eastern Basin had the lowest levels of phytoplankton biomass. A ratio of 1 : 1.4 : 2 was calculated for the Eastern, Central and Western Basins respectively. Diatoms were dominant, followed in importance by flagellates which were abundant in the Central and Eastern Basins. Microflagellates contributed up to 60% of the total phytoplankton biomass. The significance of microflagellates has been neglected in the past but this study demonstrated their importance. Seasonal abundance of total phytoplankton biomass and the contributions of various taxonomic groups in central Lake Erie were examined (Fig. 45). Four maxima were observed, one in spring, two in summer and one during the fall.

Zooplankton of Lakes Huron, Erie and Ontario

The numbers of crustacean zooplankton were compared from cruises at 30 stations on Lake Erie in 1970 and 12 stations on Lake Huron in 1971. Differences were

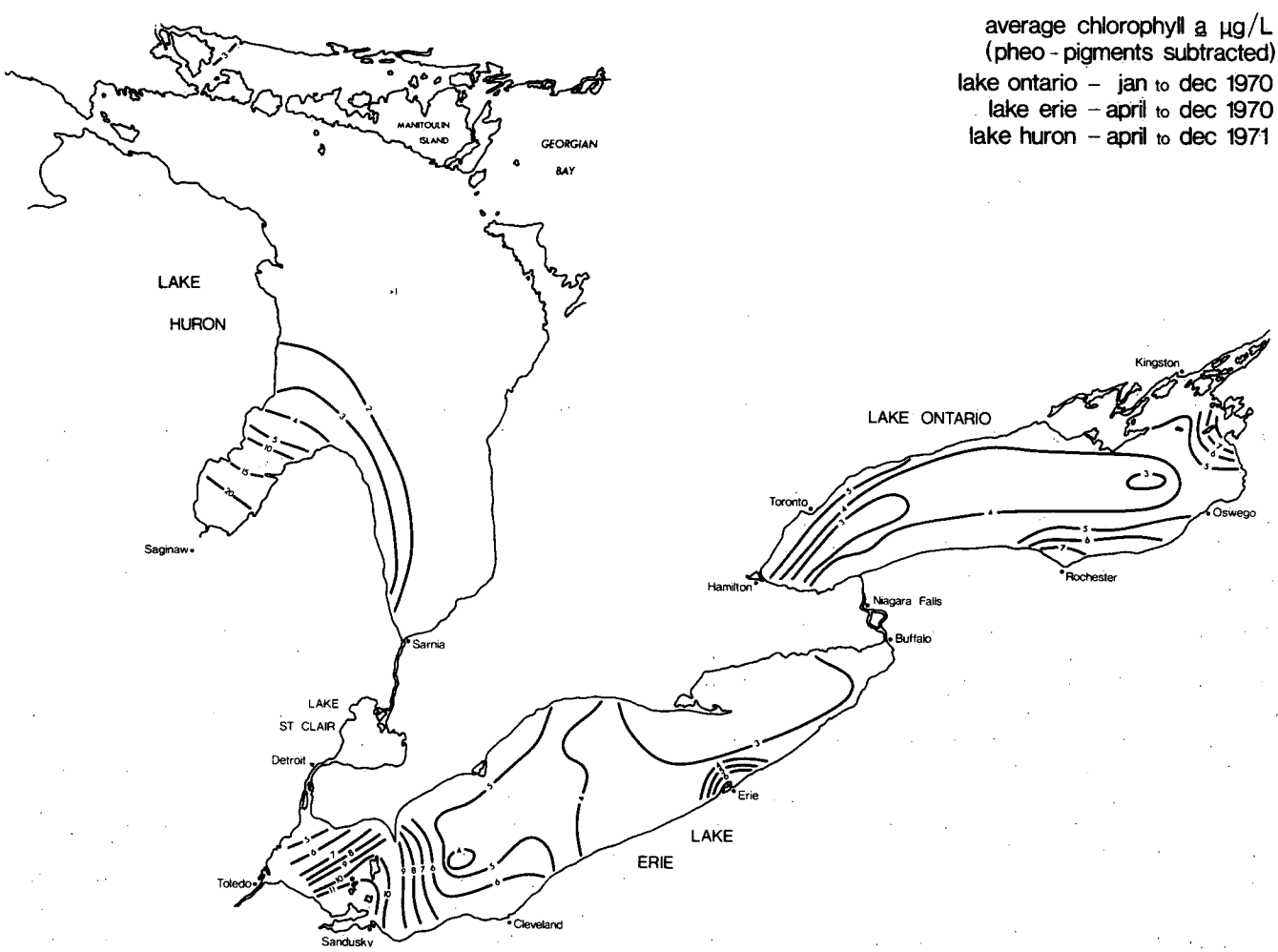


Figure 42. Average chlorophyll *a*, µg/l, in Lake Ontario (January to December, 1970), Lake Erie (April to December, 1970), and Lake Huron (April to December, 1971).

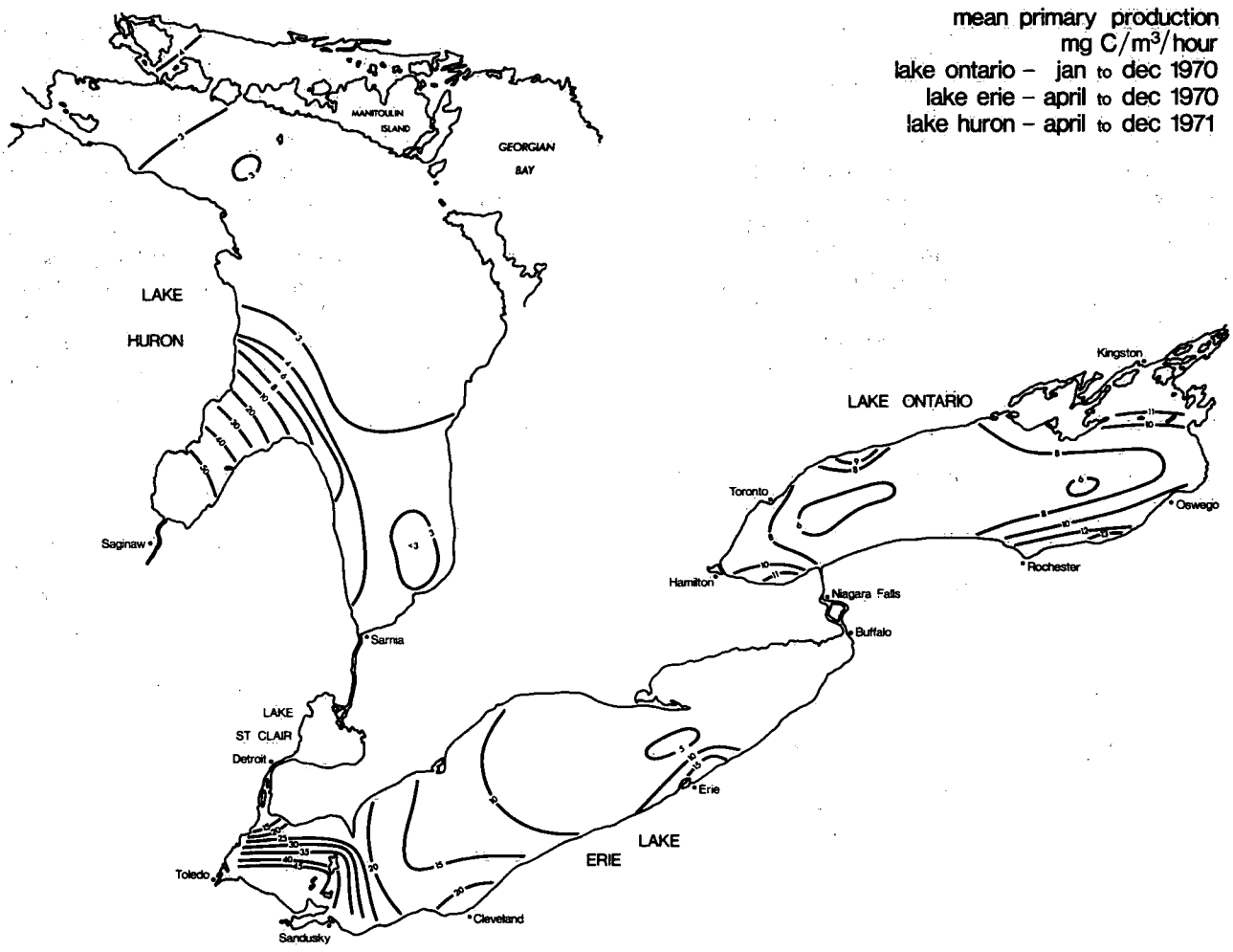


Figure 43. Mean primary production, mgC/m^3 /hour in Lake Ontario (January to December, 1970), Lake Erie (April to December, 1970), and Lake Huron (April to December, 1971).

recorded in the abundance and species composition of plankton with season in each lake and between lakes.

The species of zooplankton Crustacea are similar among lakes although the time of seasonal maxima and relative abundance is different for each (Fig. 46). Calanoid copepods are more numerous and diverse in Lake Huron and western Lake Erie. Cyclopoids and Cladocera are most abundant in Lake Erie and Ontario and in the Saginaw Bay region. The most prevalent species over the whole year in all three lakes is *Cyclops bicuspidatus thomasi* which becomes most numerous in Lake Erie. *Tropocyclops* is relatively important in Lake Ontario and *Acanthocyclops* in Lake Erie. Among the Cladocera, Daphniids are most numerous in Lake Erie, including *Daphnia, Bosmina, Diaphanosoma, Chydorus* and *Leptodora. Bosmina* is most numerous in Lake Ontario. *Holopedium* is most important in Lake Huron.

First order estimates of standing crop biomass have been calculated from estimates of zooplankton abundance in the three lakes. Populations of the relatively large calanoids present in Lake Huron produce biomass values which are relatively underestimated by numbers while in Lakes Erie and Ontario numerical values overestimate biomass.

Effect of PCBs on Phytoplankton

Recent studies have shown that PCB (polychlorinated biphenyl) compounds inhibit the growth and photosynthesis of marine phytoplankton at concentrations in the low ppb range. At CCIW *Synedra acus* and *Scenedesmus quadricauda* were isolated into pure culture and grown at 15C at a light intensity of approximately 10 klux. Additions of the commonly used PCB compound Arochlor 1242 dissolved in methanol were made to obtain concentrations of 1, 5, 10, 20 and 50 ppb in culture flasks. In *Scenedesmus*, inhibition of cell division was observed at all concentrations as early as 1 day after application. However, after 9 days, cell division rates approximated those in control cultures of Arochlor 1242 levels up to 10 ppb. At 20 and 50 ppb, cell numbers after 5 days were approximately 20% of those in controls and did not recover. Cultures of *Synedra* showed similar effects. However,

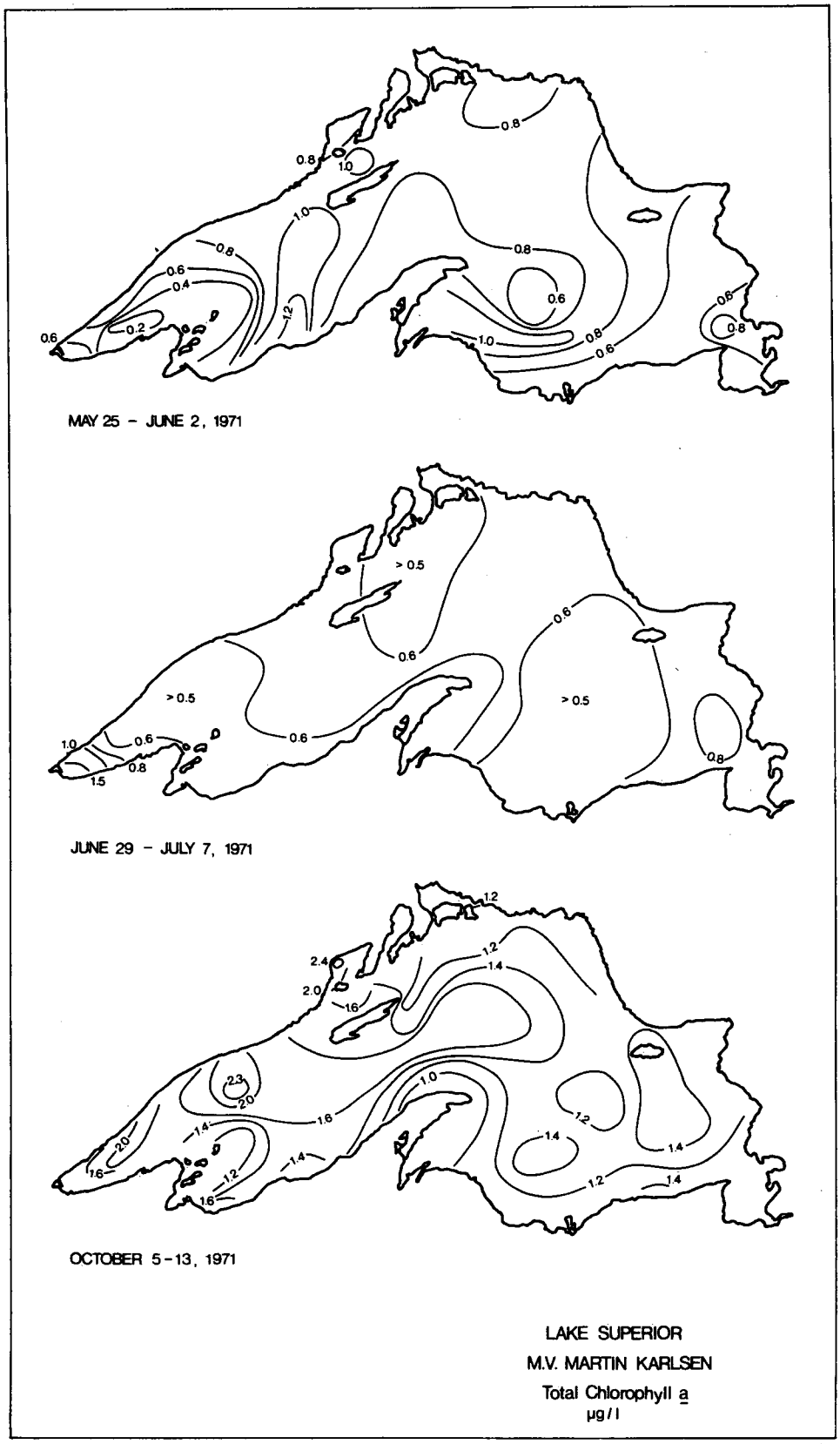


Figure 44. Chlorophyll *a* distribution in Lake Superior, 1971.

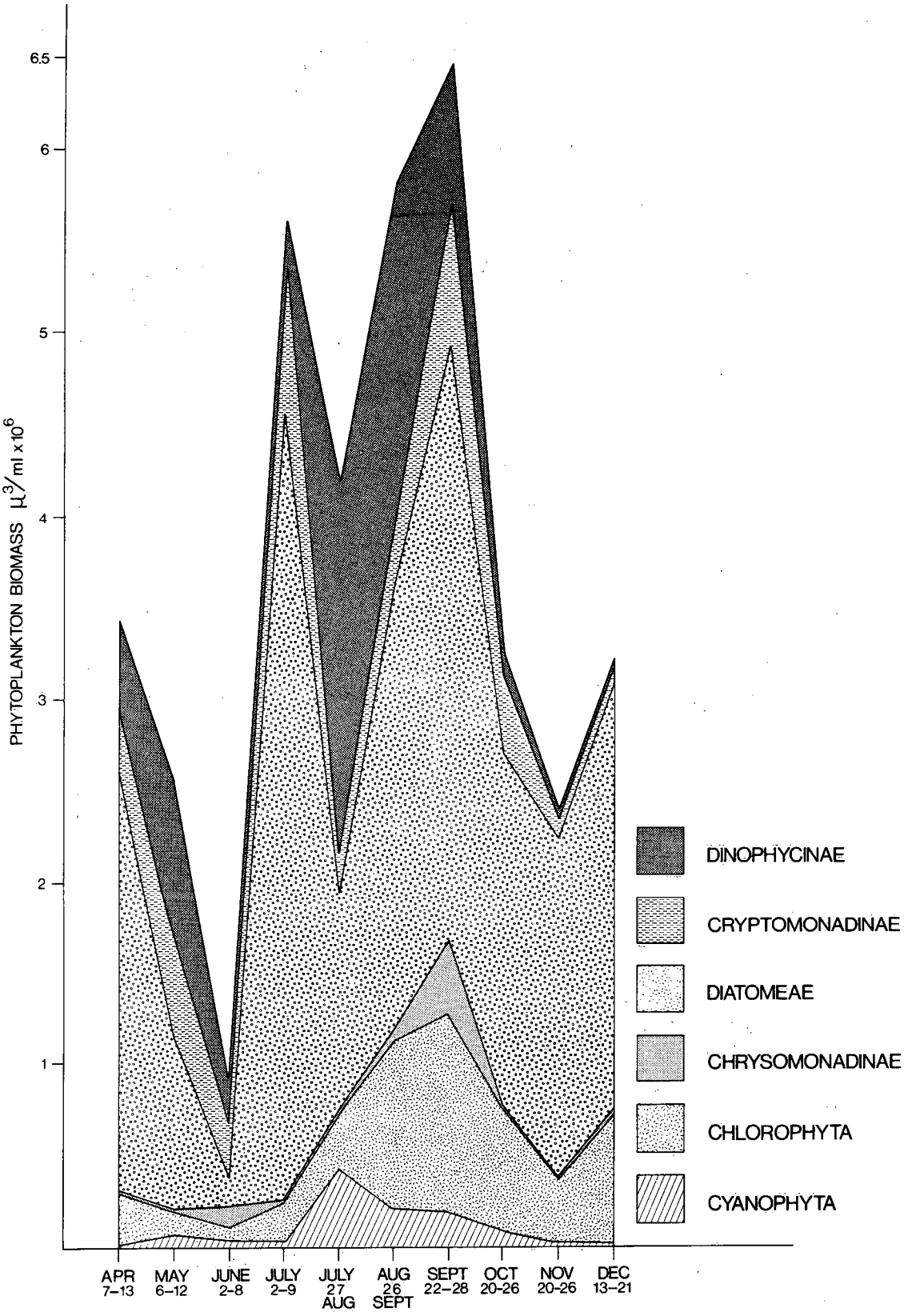


Figure 45. Seasonal cycle of phytoplankton biomass by major taxonomic groups in Lake Erie.

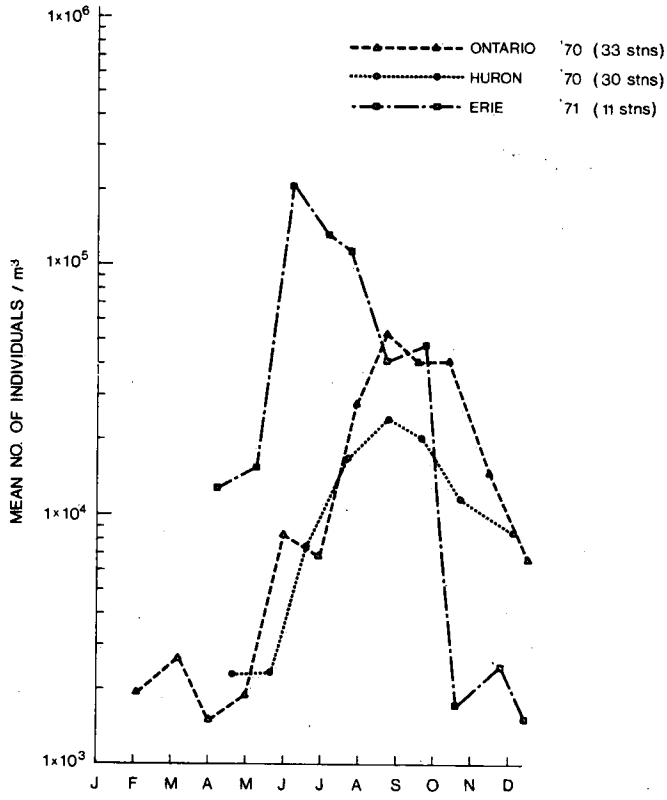


Figure 46. Comparative zooplankton numbers, individuals/m^3, in Lakes Ontario, Erie and Huron.

beyond day 7 all concentrations inhibited cell division over controls by 35% at least, while 50 ppb reduced cell numbers by 75%. The reduction of cell division rates in both species may have been related to inhibition of photosynthesis observed in carbon -14 uptake studies. Chloroplast morphology was altered at all PCB concentrations.

Automated Particle Counting System

Two electronic particle counters: The Millipore Corpn. "π MC" Particle Measurement Computer System, and the Coulter Counter Model "B" were compared with the inverted microscope technique in counting and sizing a variety of algal species in culture, as well as Lake Ontario phytoplankton samples. There was generally good correlation between electronic and microscope counts of unicellular species, but the reverse was the case for field samples of phytoplankton. Quantitative measurements of phytoplankton were erratic, if not erroneous, and of questionable value. Evidence strongly suggests that the electronic instruments are best suited to specific investigations, especially those concerning area or volume determinations.

Mysis relicta Studies

The study of *Mysis relicta* was extended for a second year to gain information on the life history of this species. On the basis of further sampling it is strongly felt that the

Figure 47. Controlled environment room for culturing of algae and invertebrates for research programmes in toxicology and physiological research.

earlier reporting of *Mysis* as a monocyclic population is incorrect. Data collected from Lakes Huron and Ontario strongly suggest that there are two major breeding periods per year. Breeding females appear throughout the year, with two definite breeding peaks occurring during the spring and fall periods. However, according to available data the heaviest breeding period occurs in the fall. The brood size remains relatively constant, with each breeding female carrying approximately twenty young.

Project Quinte

Primary production and phytoplankton communities were examined weekly at seven stations in the Bay of Quinte and zooplankton were collected monthly as part of a co-operative study among Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, University of Guelph, Queen's University and Environment Canada. This study will lead into an assessment of the effects of phosphorus removal on the limnology of the Bay of Quinte, involving almost all ramifications of improvements expected in water quality.

Marine Sciences Directorate (Central Region)

CANADIAN HYDROGRAPHIC SERVICE

The objectives of the Hydrographic Division (Canadian Hydrographic Service) of Central Region, Marine Sciences Directorate, are the gathering, processing and compilation of bathymetric data and marine information on the navigable waters contained within the boundaries of the region, that are essential to the safe, orderly and efficient conduct of commercial, recreational and defence shipping together with the survey requirements associated with the management of water resources and the protection of the marine environment.

In support of the foregoing, a hydrographic development group investigated and developed hydrographic survey systems, techniques and methodology, the Tides and Water Levels Section provided hydrodynamic data, the Electronics Maintenance Section operated and maintained survey, navigation and communication systems, the Marine Information Centre and a Cartographic Unit. During 1972, additional responsibilities, related to IFYGL, included the management of a contract for the rental of a Decca Survey System and associated services as well as the calibration of the system and the production of lattices for special IFYGL plotting sheets.

In carrying out the prime responsibility of the Canadian Hydrographic Service, a great deal of data is gathered and made available for other purposes; some of these data are almost by-products of our primary program. The output is valuable to such functions as transport and communications, limnological studies, culture, recreation and economic development.

The 1972 Field Programme was carried out by 50 hydrographic surveyors, 8 electronics technicians, and some 130 ships' crew. During the season, use was made of 3 ships, 26 survey launches, and 23 major survey craft as well as one floating electro-mechanical workshop. Six office trailers and 13 boat trailers were used. Two helicopters and three fixed-wing aircraft were used periodically. The total helicopter flying time was 1342 hours and the total fixed wing flying time amounted to 277 hours. The shore-based survey operations also required the use of 18 motor vehicles.

The Field Projects were carried out in Nares Strait, Norwegian Bay, Jones Sound, and Amundsen Gulf in the Arctic; in James Bay and Hudson Bay; in Playgreen Lake in Northern Manitoba; in Lake of the Woods in Western Ontario; in Georgian Bay; in Lake Ontario, Lake Erie; St. Lawrence River between Montreal and Kingston as well as in the lower St. Lawrence River below Quebec. In addition to this program, a co-operative program was carried out with the Province of Quebec to obtain hydrographic data required for the development of a mathematical model of a section of the Richelieu River between the US border and St. John. In co-operation with the Ontario Government, a small program was carried out in south-eastern Georgian Bay to assist with pollution studies. This field program involved the use of electronic positioning and distance-measuring systems in addition to the usual optical systems and included the use of tellurometers, hydrodist, Mini-fix, Decca 6f survey system, RPS, automatic data acquisition systems and automatic data processing systems as well as a number of tide gauges, water level gauges, and current meters.

As an on-going program to develop systems and techniques which will allow maximum return from our investment in human and material resources the Development Group continued research into the use of electronic positioning systems particularly Loran C and the use of a variety of side-looking sonars and, as a new program, monitored the first full hydrographic survey to be contracted to a commercial firm. This program was carried out in Georgian Bay.

The resurvey of Navigation Ranges Program which was commenced in 1969 was continued in 1972 and by the end of the field season a total of 99 navigation ranges and associated channels in the area between Quebec and Kingston had been resurveyed. Also in this area a total of 48 fixed navigation lights had been re-positioned. A large number of ranges and fixed lights have also been resurveyed as a normal part of other hydrographic projects. However, some 82 ranges and associated channels as well as 342 fixed lights remain to be resurveyed in the Great Lakes.

The systematic Revisory Survey required to maintain existing charts up-to-date was continued and all charts of Lake Erie and Lake Ontario were field examined during 1972. Data for the Shore Properties was collected as part of the ongoing survey project.

During the year the Tides and Water Levels Section was strengthened in preparation for 1973 Field Programmes. In addition to its normal functions related to navigational matters the Section undertook the co-ordination of an Oceanographic Program in James Bay which was carried out

by the Hydrographic Survey team operating from CCGS NARWHAL in co-operation with the Atlantic Oceanographic Laboratory.

1972 saw the initiation of a technical exchange program with the Lakes Survey Center of the US National Oceanic and Atmospheric Administration of Detroit. Mr. Peter Richards of Central Region's Canadian Hydrographic Service component was exchanged for a three-month period with Mr. W. Bergen of NOAA. This exchange demonstrated beyond a doubt the value of such a program and we look forward to a continuation of exchanges. Meetings were also held between the Canadian Hydrographic Service, the Director of Central Region and the Director of the US Lake Survey Centre at Detroit with regard to future co-operative program and a decision was reached to attempt a co-operative Revisory Survey Program on the St. Lawrence River during 1973.

Also on the International scene a joint Canadian-Danish team worked in the Nares Strait area and determined geographic co-ordinates for Hans Island. This joint program was carried out because of the close proximity of the island to the limits of Canadian and Danish territorial seas.

Hydrographic participation in the limnogeological programs of the Centre continued, with provision of survey and survey system expertise to man the systems and to check for positioning and depth record quality.

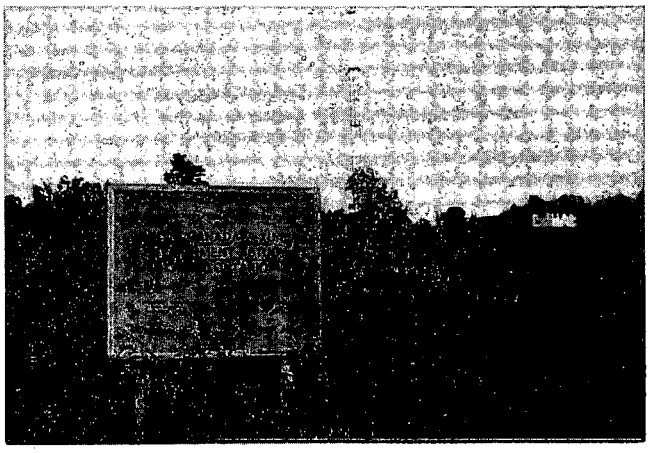
The 1972 season was carried out without serious accident and all objectives were achieved.

IFYGL AND LIMNOGEOLOGY PROJECTS

Perhaps the major project undertaken by the Marine Sciences Directorate, as an integral part of the Canada Centre for Inland Waters, during 1972 was participation in the International Field Year for the Great Lakes (IFYGL) study of Lake Ontario and Basin.

The primary objective of the IFYGL program which will continue into 1973 is to develop a sound scientific basis for water resource management on the Great Lakes as an aid in solving problems of water quality and quantity. Lake Ontario and the Ontario Basin were selected as representative of physical characteristics typical of the Great Lakes and other fresh water bodies throughout the world.

Specifically, personnel from the Canadian Hydrographic Service, Central Region, have to date effectively carried out a comprehensive phasing-in and calibration/evaluation exercise of the DECCA (6f) positioning system — navigation on the lake and over its basin being one of the more important responsibilities of the Directorate. This programme was headed up by F. L. De Grasse, under the direction of Mr. T.D.W. McCulloch, Director.



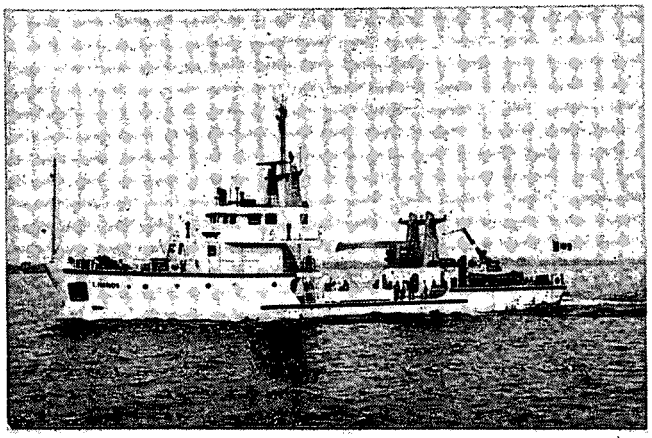
Decca Lambda 6f, Red Slave, Grimsby

In addition to being accountable for logistics, i.e. land rental, frequency licensing, etc. for the positioning system, a major bathymetric survey of the offshore areas beyond the 30 meter contour has been completed which will result in the publication of a new or revised edition of a bathymetric chart — our first contribution towards metrication in the Great Lakes utilizing the automated Hydrographic Acquisition And Processing System (HAAPS) aboard the research vessel 'LIMNOS'

Limnogeology Project Lake Erie

This is a continuing nearshore survey in which C.H.S. has participated for the past two summer field seasons. For this particular exercise our involvement consisted of a navigational survey system to provide high accuracy positioning and expertise to check positioning and depth record quality. Positioning and depth data are to C.H.S. standards and are used not only by the Limnogeological Project but also by ourselves for charting purposes. Mr. P. Davies, sub-party chief, assisted (part-time) by one hydrographer and one crew, was in charge of field operations.

Two similar short term limnogeology surveys were



Research Vessel LIMNOS

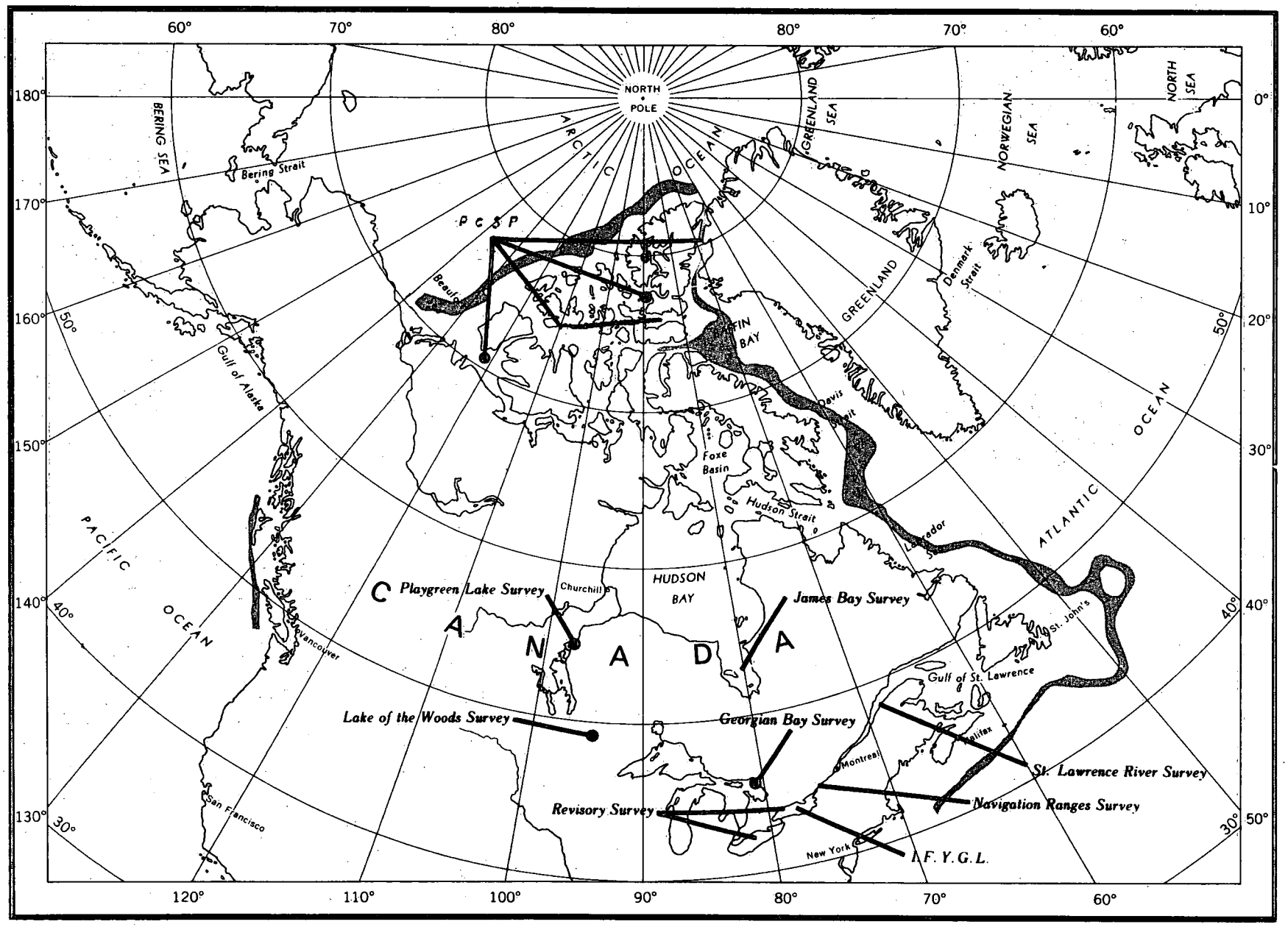


Figure 48. 1972 Surveys.

carried out to completion off the Burlington-Centennial Park area, western Lake Ontario.

In response to a request originated by headquarters of the International Boundary Commission, a marker buoy designated 'Y' was moored and positioned on the Canada-United States boundary approximately 13.5 nautical miles from Southeast Shoal Lighthouse at Point Peter on Lake Erie. Hydrodist MRB-201 and Wild T2 theodolites in the range-bearing mode were used for this exercise. The 9th Division of the U.S. Coast Guard is the agency responsible for aids to navigation in the area.

The MV MARTIN KARLSEN, a major vessel working out of CCIW was assigned to the establishment for this exercise.

To facilitate acceptance trials of the recently completed research vessel CSS ADVENT, two spar-type buoys were moored just south of the Burlington Canal to approximate a range distance of one nautical mile. The markers were subsequently fixed by Hydrodist and Wild T2 theodolites and the exact distance and bearing obtained by Inverse Solution.

JAMES BAY SURVEY

Jutting south from Hudson Bay is the relatively unknown body of water, James Bay. Equal in water area to Lakes Ontario and Erie combined, a basin for waters gushing seaward from many rivers draining the Canadian Shield, it has long been a bane to both explorer and hydrographer. Its rich but brief history extends from 1610 when Henry Hudson made his ill-fated plunge into these waters. The bay was named after Thomas James who, in 1631, sailed his ship, the HENRIETTA MARIA, deep into the bay, and after a scurvy-ridden winter hold-over at Charlton Island, escaped the following year for England.

Hydrographic interest in the bay has been sporadic at best. Limited navigation demands in the bay precluded extensive charting, and thus, except for a few harbour surveys and some charting of the extreme southern end of the bay, the major waters lay fallow of bathymetry.

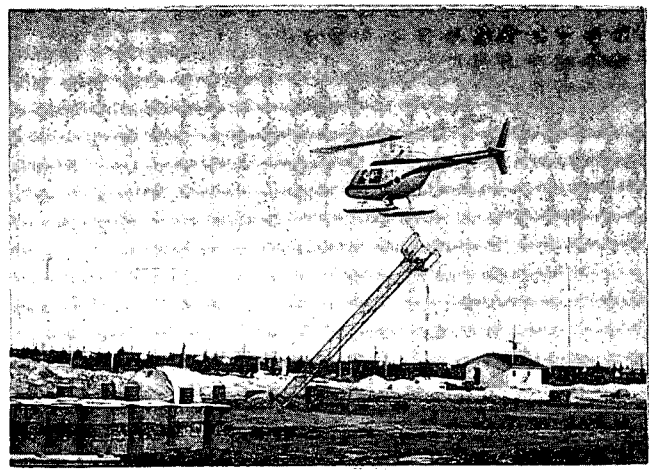
The James Bay Development Corporation, and more specifically, the proposed hydro-electric projects, brought the area into sharp focus from a development point of view. Projects of a magnitude contemplated on La Grande Rivière required supplies on a scale that could only be supplied through commercial navigation. Thus, it was necessary to provide safe access routes for freighters and oil tankers traversing from Hudson Bay into the staging area at Fort George. At this time, 1971, Central Region, with an expertise for big term projects on short notice, became the dominant character in this narrative. In December 1971, it was decided to proceed with a control survey along the east coast of James Bay. This was a basic requirement in order to provide electrical centres for proposed positioning systems.

The 1972 work in James Bay was divided into three stages. The initial stage – the winter control program which ran from March 15, to April 30; secondly the shore survey, which was located at Fort George from June 15, to October 15; and finally the ship program, which employed the CCGS NARWHAL from August 7, until October 13 in the offshore survey area.

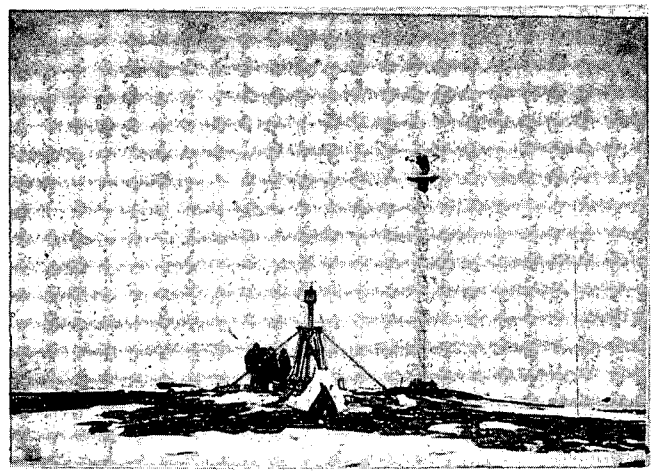
The results of the three surveys provided horizontal control extending seaward to all islands in the north half of the bay; standard hydrographic bathymetry on the approaches to Fort George, La Grande Rivière, an access corridor; reconnaissance surveys south to Eastmain and Paint Hills; and physical oceanographic data on a grid pattern in the northern half of the bay. A summary of each survey is as follows:

Winter Control Survey

The winter program embraced the efforts of five hydrographers, plus two helicopter crews. The hydrographers arrived in Fort George on May 20, and were followed closely by the two MSD Bell 206A helicopters. In



MOT Jetranger slinging a Millard tower to work site.



Millard Tower erected foreground shows old MOT radar reflector.

the following month control was extended from established geodetic points at Fort George, both north and south along the east coast of James Bay. In total, the traverse extended over 100 miles and closed on terminal geodetic points. The islands in the bay were controlled by trilateration, using Millard towers as necessary. Distances up to 60,000 metres were effected across the ice, in order to bridge and verify control to these islands. In addition, a number of solar observations were taken in order to confirm or establish azimuth values. Thirty-one permanent hydrographic positions were established during the survey, many on islands heretofore inaccessible.

The survey generated adequate control to satisfy Mini-fix and Hydrodist requirements on the summer surveys. Temperatures during the survey hovered between 0° and 30° Fahrenheit. Visibility conditions generally precluded observations beyond 6 miles. The helicopters logged 200 hours of flying, and provided an indispensible service.

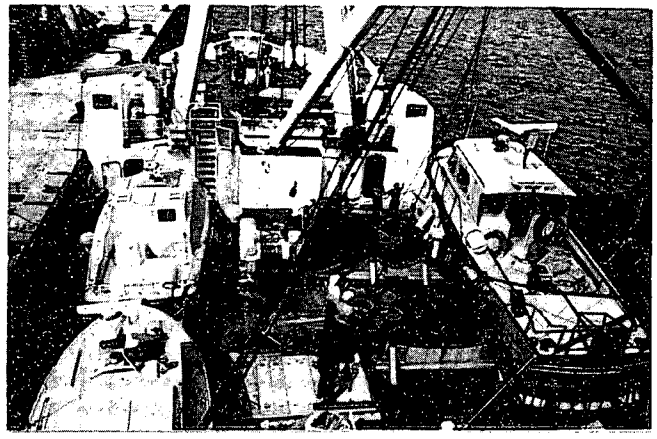
Shore Survey — Fort George

Once it became apparent that a large-scale survey would be required of the estuarine areas of La Grande Rivière, and of the three initial miles of the river itself, it was decided to operate a shore-based survey. In addition to the above tasks, the unit would be committed to the installation and maintenance of a water-level gauging program, the monitoring and maintenance of the Mini-fix system, plus the extension of local control to the numerous delta islands. Hydrodist was the system selected for positioning of the sounding platforms. Both the new MRB 201 and the vintage MRB 2 were used successfully. Two freighter canoes were obtained locally, and converted into sounding launches. Charting was conducted at a 1:10,000 scale over 100 square miles of coastal waters. A proposed harbour location, south of La Grande Rivière was charted as an alternate to the hastily erected discharge depot 3 miles up river. In general, all objectives set for the shore party were achieved. A Bell 206A helicopter permanently attached to the party, was in continuous use either supporting the sounding programs or the maintenance requirements. The continuous dust-bowl conditions of Fort George did not discourage the shore-based unit, and their four month siege in this settlement can be summed up as a profitable campaign.

Ship-Based Survey, CCGS NARWHAL

On July 26, the NARWHAL, a 250 ft. M.O.T. ice strengthened vessel primarily designed as an arctic personnel carrier, departed Quebec City, and sailed for James Bay. On August 7, after a quiet passage up the Labrador Sea, through Hudson Strait, and down Hudson Bay, the ship entered James Bay and commenced the designated charting and oceanographic programs.

The 10,000 mile cruise of the NARWHAL combined physical oceanography with contemporary hydrography. While the basic program involved charting using a horizontal control system, much reconnaissance work was



CCGS NARWHAL at Quebec City.

completed, including tracks into, and surveys of, the settlements of Paint Hills and Eastmain.

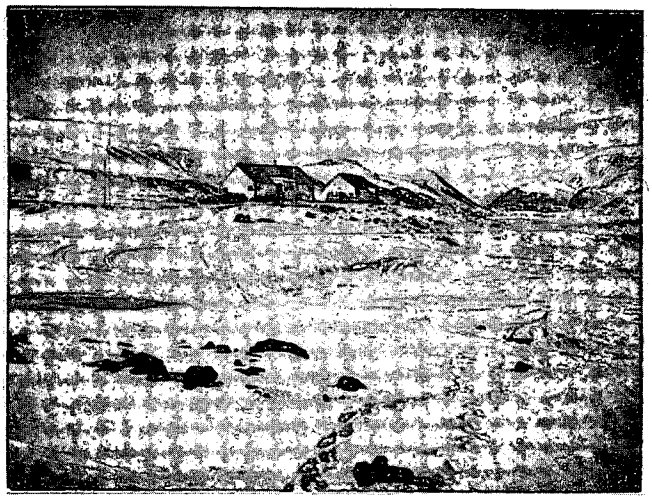
Salinity and temperature profiles, *in situ* water and temperature samples, dissolved oxygen analysis, plankton casts, bottom cores, and light penetration measurements were taken as part of the oceanographic program. 65 stations were occupied. The controlled charting program evolved within a 3000 square mile lobe extending seaward from Fort George. Three survey launches plus the ship were employed to establish bathymetry along a preselected corridor. In total, over 5000 miles of sounding was completed. A beefed-up Mini-fix system (50 watts possible output as opposed to a standard 16 watt output), with baselines in excess of 30 miles, was used to provide horizontal control for sea-borne platforms. In addition, a receiver was mounted into a helicopter.

The ship spent a total of 56 days in James Bay. The total cruise embraced 99 days. A bunkering trip to Churchill, Manitoba, an emergency fuel lift to Whale Cove on the west coast of Hudson Bay, and time consumed steaming to and from terminal agency points, consumed the remainder of the cruise.

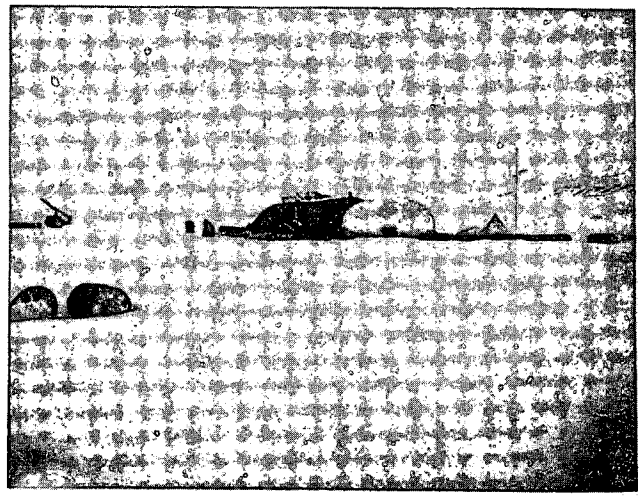
The information obtained during this cruise established a viable route for commercial shipping, from Cape Louis XIV into an anchorage area at La Grande Rivière estuary. It also proved the feasibility of operating close to the east coast along north-south tracks. The hazardous, unpredictable, bottom topography was alarmingly evident on all operations, and required the full deployment of resources to insure a safe passage across previously unknown water. Much was accomplished. Much more remains if safe navigable channels are to be established.

POLAR CONTINENTAL SHELF PROJECT

The Hydrographic Section of Polar Continental Shelf Project departed for the 1972 survey operation on May 1st via Resolute Bay to Alert, N.W.T. to commence the first of four assignments.



Base camp, Alexandra Fiord.



Base camp, Surprise Fiord.

l. to r. M. Thamsborg, J. Ekholm (Danish representatives), M. Haycock (National Archives representative).

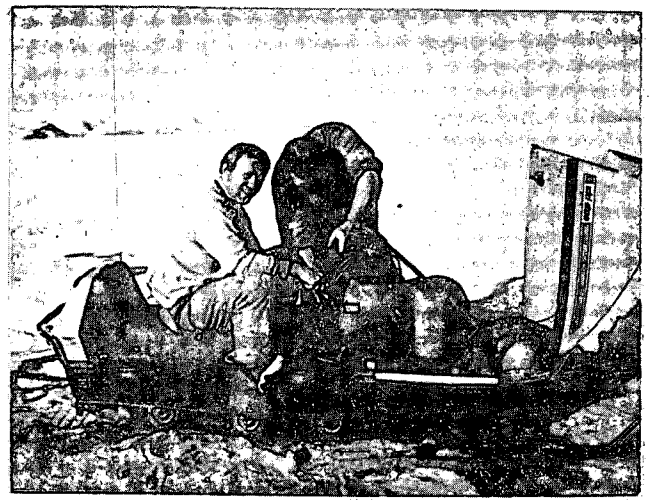
From the Alert base, a network of horizontal control was extended in the Nares Strait area from Robeson Channel southward to Franklin Island. The base of operations was then moved to the R.C.M.P. Camp at Alexandra Fiord, where the control system was completed to the northern end of Smith Sound. We were joined in this assignment by two Danish representatives whose efforts were much appreciated and who worked very hard to make the combined Canadian-Danish survey a success. Closure for the system was in the order of twenty parts per million over a distance of five hundred miles of traverse. A total of sixty monumented horizontal control stations was established, mainly on the Greenland coast.

Included in the assignment was the positioning of a small island, Hans Island, whose exact position was in some doubt. In the process of locating the island some discrepancies in the shoreline of Greenland were adjusted by as much as two and one half to six kilometers.

Second on the list was a brief sounding survey in Eureka Sound for the safe passage of ships bringing construction and drilling equipment in to sites located at Mokka Fiord and Depot Bay. A total of seventy through-the-ice soundings was required to cover the designated area.

From Eureka the establishment set up camp at Surprise Fiord where a second control survey was conducted covering the whole of Norwegian Bay. The purpose of this part of the field operation was the selection and location of suitable sites for an RPS controlled survey presently planned for the coming winter sounding program in March 1973. Most of the time was used in the recovery of existing control, which is, for the most part, suitable to our purposes. Only four new points were required to provide adequate coverage.

Last on the list of operations was the establishing of electrical centres for a Hi-Fix controlled survey in the Jones



Mechanical repairs to skidoo.

Sound area. A base of operations was established at Grise Fiord from which the required sites were obtained in four days. A total of twelve stations was required to give suitable coverage for this survey to be conducted by personnel from the Atlantic Oceanographic Laboratory.

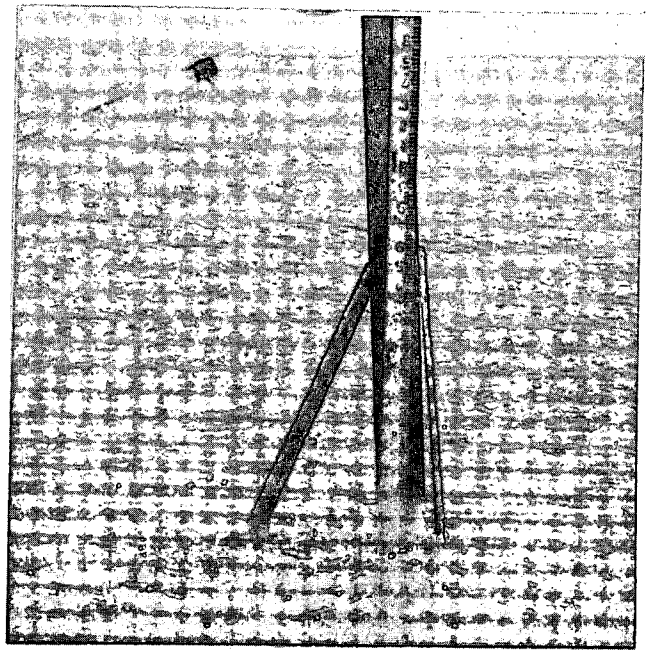
On completion of the Jones Sound project the members (staff and support group) of the Hydrographic Section, P.C.S.P. returned to headquarters on July 7th where computations, field notes, etc. were submitted to Nautical Geodesy for checking and adjustment.

Throughout the operation no difficulties were encountered with electronic instrumentation. Elevations of traverse stations were checked by use of altimeter on the helicopter (a Bell 205A) and barometric observations. All control points established throughout the field season were targeted and photographed from the air using hand-held cameras (Polaroid and/or 35 mm)

In addition to the above, logistic support was provided to members of the Earth Physics Branch, Dept. of E.M.R. who were carrying out further investigations of the Alert "Magnetic Anomaly" about 75 miles offshore on Lincoln Sea. Support was also provided to an official who was conducting assignments for the National Archives, Department of National Defence and the R.C.M.P.

LOWER ST. LAWRENCE SURVEY

The 1972 hydrographic survey on the Lower St. Lawrence River was a continuation of the project begun in 1969; namely, the resurvey of the river from Pointe au Père to Quebec City, a distance of 133 miles.



Staff gauge crib at Goose Cape, Lower St. Lawrence Survey, 1972.

Work was concentrated, during 1972, in the areas east and southwest of Ile aux Coudres.

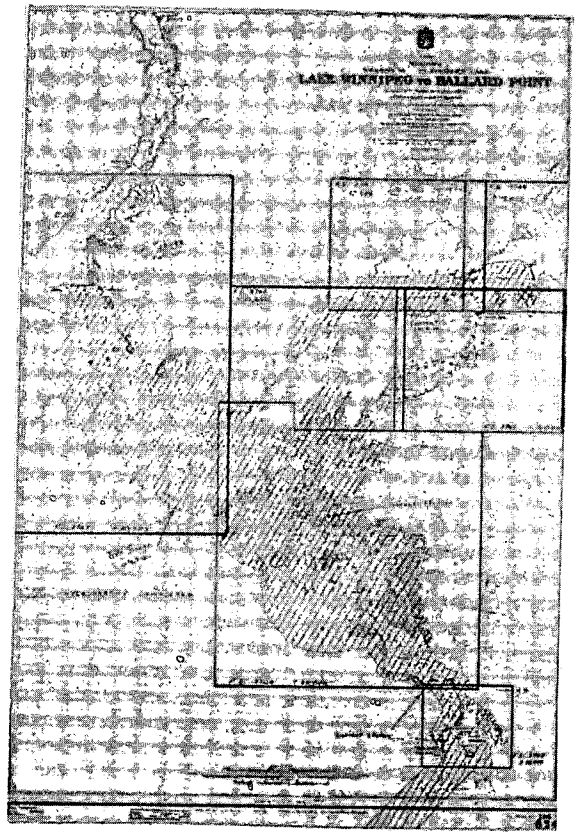
Soundings were taken in metres and all field sheets were inked in metric units.

Hydrodist and Motorola R.P.S. positioning systems were used to control 4 sounding launches.

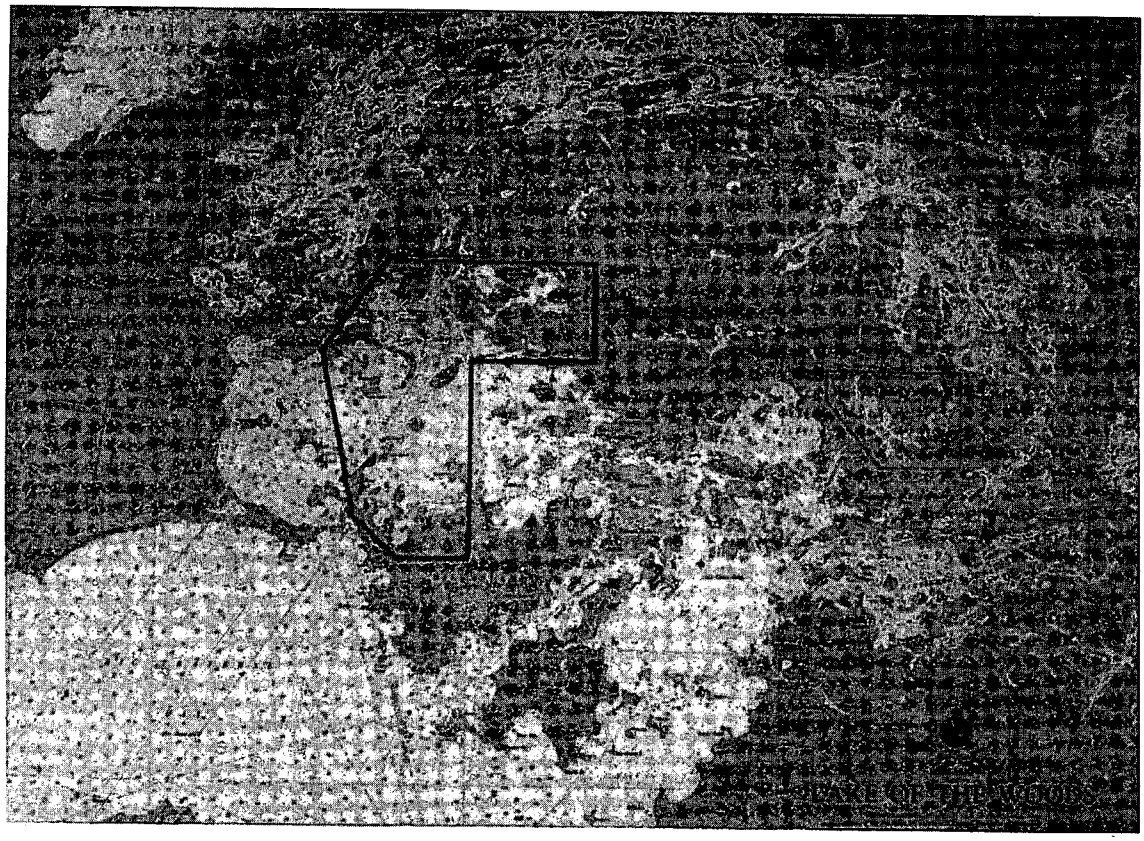
The main deep draft shipping channel has now been completely surveyed from Ile du Bic to Cape Maillard, a distance of 94 miles. Future operations upstream from Cape Maillard will depend on the completion of a large scale dredging programme presently being carried out, southwest of Cape Brûlé.

PLAYGREEN LAKE SURVEY

This was a continuation of the 1971 hydrographic survey. The demand for a modern hydrographic survey came as a result of the Nelson River Power Project whereby diversion channels from Lake Winnipeg to Playgreen Lake and Playgreen Lake to Kiskattogisu Lake are to be built for the purpose of regulating the water level in Lake Winnipeg. Therefore, a requirement for modern hydrographic charts was created for monitoring siltation and its effects on navigation in the future.



Playgreen Lake Survey, 1972.



Lake of the Woods. Area completed in 1972.

The charting program was carried out from Warren Landing by a party of ten staff and thirteen crew from May 24 to Sept. 28.

The new "21 ft. MON-ARK" launches carried out the major part of the sounding program. Hydrodist in the range-bearing mode was used for positioning in open areas and visual positioning in congested areas.

This survey went exceptionally well, considering the turbid, shallow and shoal infested waters, however, the area between Sandy Bar Point and Whiskey Jack Landing remains to be done. The area completed this year extended from the outside entrance to Warren Landing to Sandy Bar Point on Playgreen Lake, both branches of the East Nelson River and approximately 50% of Little Playgreen Lake.

LAKE OF THE WOODS SURVEY

For the sixth consecutive season, Central Region fielded a hydrographic survey party in Lake of the Woods. The party this year was divided into two sections with the main group staying at a trailer camp in Morson, Ontario, which it had occupied since 1970, while a sub-party, comprising 8 to 14 men operated out of commercial tourist camps in the 3770 field sheet work area.

The party undertook to survey Obabikon Lake (a large bay of Lake of the Woods located in the Aulneau Peninsula), and field sheets 3769 and 3770 on the western side of Lake of the Woods bordering on Minnesota, U.S.A. A revisory survey of field sheet 3653, between Miles Bay and Morson, was also completed.

Most of the sounding was done by three-man crews using 21 foot Botved launches and EDO 9040 echo sounders. The conventional sextant resection technique was used for position fixing.

In late September, launches and equipment were stored at Winnipeg and at the Hydrographic Depot in Selkirk in anticipation of proposed activities in Lake Winnipeg.

A small sub-party will be required in 1973 to complete some field sheets initiated in 1972. This will provide bathymetry across Lake of the Woods in total except for Shoal Lake which has been dropped from the original survey proposals.

Remaining Navigation Ranges work along the St. Lawrence Seaway can be handled by a revisory team.

Among some of the work remaining is the continuation of the control network in Ile Delaurier area and the

sounding of that range. Nicolet and Pointe-du-Lac sounding lines have yet to be run. Future work in this area will be required if there are any relocation projects for ranges and lights.

Lights through the tourist regions of the Thousand Islands were not positioned this season. It was felt that as a result of the shortened field season, the seaway lights and ranges should be of prime importance so our efforts were directed along those lines.

During the period, July 17 to July 29, the senior hydrographer and Mr. Gorski conducted a reconnaissance survey of the Richelieu River between St. Jean and U.S. border. The survey was conducted at the request of the Quebec Department of Natural Resources for the purposes of flood control on the river.

NAVIGATIONAL RANGES SURVEY

The 1972 Navigational Ranges Survey began May 1 with the establishment of the Base Camp in Cornwall, Ontario. While there, three (3) channel lights, three (3) sector lights, and one (1) range (Cornwall Island range) were positioned. No soundings were obtained. However, sounding marks were established and channel buoys positioned along the range lines and sector lines.

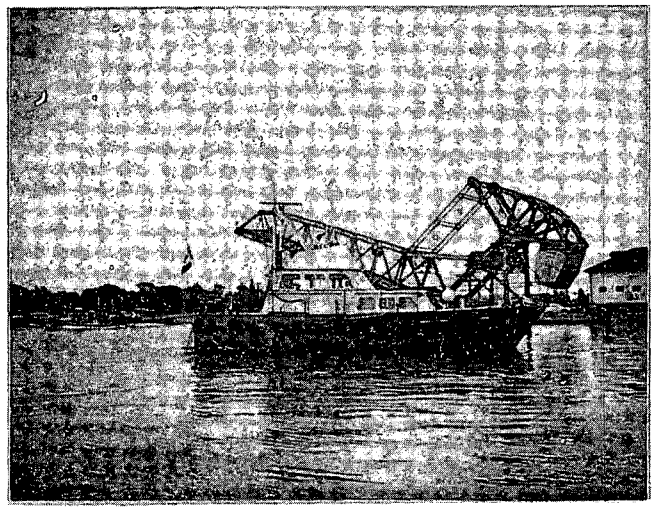
The Base Camp then moved to Morrisburg on May 29. Four (4) lights and three (3) sets of ranges were positioned in the area adjacent to Chrysler Park and Morrisburg. Two (2) lights and two (2) ranges were positioned in the area adjacent to Mariatown and two (2) sets of ranges were positioned in the Iroquois area.

"CADET" was inoperative throughout this period. As a result the sounding program had still not begun. However, as was done in Cornwall, sounding marks were established and the channel buoys along the range lines were positioned.

While in Morrisburg, Mr. Eidsforth travelled to the Montreal area to establish horizontal control required for the positioning of the Ile Delaurier range.

The survey party moved up river to Brockville on June 16. From here, ten (10) Channel lights in the Brockville Narrows were positioned. By this time, our sounding program had seriously fallen behind. It now became obvious that "CADET" would probably not be operational for the remainder of the season and no boats were available to replace her. It was decided to outfit one of our whalers for sounding and hopefully we would get enough good weather to enable us to sound the range lines. Luck was with us and our sounding program was up to date by August 11.

August 12 saw the party move to Kingston, Ontario where three (3) lights, a sector light and Irving point range were positioned and sounding lines completed by the 25th of August.



CSL VEDETTE in Kingston Harbour.

Mr. Eidsforth then returned to Montreal to complete the control work for the Ile Delaurier range. The senior hydrographer and one crew member began preparation for the return trip to Burlington for August 31.

Sounder check by cone.

As a result of this year's efforts, 28 channel lights and 10 sets of ranges were positioned and 14 sets of ranges were sounded. Solar Azimuths were taken at all ranges except Cornwall Island range and Ile Delaurier range. These two ranges were checked using the Gyro theodolite.

REVISORY SURVEY

During 1972, 22 charts were revised on Lake Ontario and Lake Erie. It was the first time a revisory survey had been conducted on Lake Erie; Lake Ontario charts had been revised in 1968. Shore Properties inventory strip maps were updated in conjunction with the revisory survey.

In addition, reported dangers to navigation in Lake Ontario near Whitby Harbour, and in Lake Erie near Amherstburg, were examined.

HAMILTON HARBOUR SURVEY

Hamilton Harbour Survey began in early April and will continue until completed. The harbour is 90% complete, however a considerable number of wharves have not been started.

Due to the number of wharves to be sounded in Hamilton Harbour, and Toronto Harbour, consideration was given to the possibility of improving the stretchline method of sounding the wharf areas.

The most efficient method to date is the use of a subtense-bar with predetermined sextant angle for distance off by sighting through a transit or sextant. With radio communication to con the boat onto line, continuous sounding lines can be run in lieu of lead line soundings.

The Code-Lite is a sector light, showing a green light when on one side and red when on the other side of center, with the green and red alternating flashing lights being seen when on the center line.

With the subtense method, two men are usually required to move the subtense bar and other equipment with two in the boat. Predetermined angles are required to obtain the distance off and must be reset on the sextant when approaching shore. Continuous voice communication with the boat must be maintained.

The Code-Lite can be mounted on a transit, with a pulse system and a small 12 volt battery, attached to the legs. One man can move this setup to previously established points when surveying the wharf. A radio can be used if required to supplement the control of the boat which can be held on line by the coxswain.

A single sextant angle between the transit and one control point, or between two base line control points suffices to position the boat off the wharf.

Besides the harbour, about 1/3 of the approach area to the canal has been sounded. It is planned to extend the coverage to overlap the Decca controlled sounding of the IFYGL programme carried out by the LIMNOS.

Code Lite Advantages and Disadvantages

Advantages:

1. eliminate one man ashore – by presetting the light two men in a boat can run lines – awkward when having to move the light, but possible.
2. reduces and/or eliminates voice control.
3. boat can get on line faster.
4. light being on a transit, fan lines can be turned off quickly.
5. transit can be used to do stadia work, if necessary.
6. light can be used to run lines across a river or fan lines in confined areas.

Disadvantages:

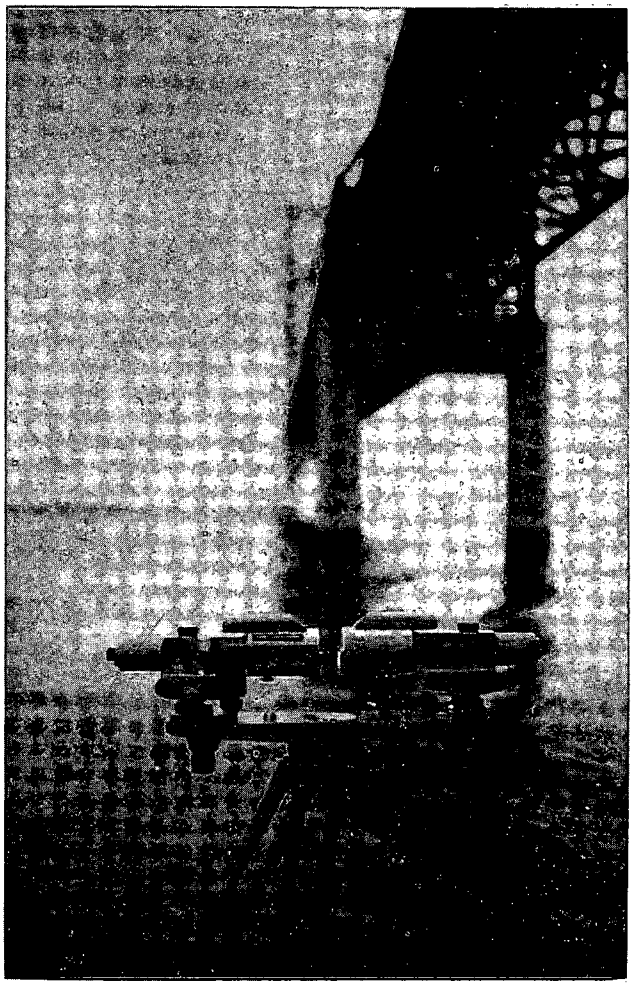
1. battery failure.
2. light breakdown.
3. plot may be required in boat, but not essential.

U.S. LAKE SURVEY CENTRE EXCHANGE PROGRAM

During the past field season, a four month staff exchange was undertaken between United States Lake Survey Centre and Central Region, Canadian Hydrographic Service.

The Canadian exchange consisted of a two week orientation period at the LSC Detroit offices followed by field work with the Vertical Control, Revisory, and Horizontal Control Sections for the remainder of the period. The work areas were along the shores of Lakes Superior, Huron and Ontario.

Zeiss level with micrometer attachment.



Zeiss water crossing equipment.

Office

The LSC comprises two main Divisions – Limnology (Research) and Marine Mapping and Charting. The area of responsibility for both is the Great Lakes and the Waterways as far west as Lake of the Woods. All the Sections were visited including the Compilation and Chart Production Branches.

Vertical Control Section

Field work consisted of running a precise level line and making a water crossing in the Straits of Mackinac area. Work included selection and placement of markers, use of 'KERN' rods and Zeiss level with micrometer attachment, and recording by computer. The water crossing involved special equipment and techniques.

Revisory Section

Lakes Superior and Huron were covered as part of a recurring three year schedule for the Great Lakes. The unit is a mobile land-based operation with an office trailer. A 54' revisory craft is used for chart work. A traverse of the Duluth-Superior Harbour area was done as well during the summer.

Horizontal Control Section

The field project was a first order traverse along the northwestern shore of New York State. Work included reconnaissance through to instrumental observations with Wild T-3's and a laser Geodimeter. Data will be used by other agencies as well as by LSC for future hydrographic control.

HYDROGRAPHIC DEVELOPMENT GROUP

During 1972, many diverse and interesting projects were undertaken by this Group with good progress being made in such important areas as automated data processing, automated data collection, evaluation of positioning systems, sonar development and an evaluation of private industries' capabilities in conducting hydrographic surveys.

Contract Hydrographic Survey

In June 1972, the Canadian Hydrographic Service, Central Region, awarded a contract valued at $89,500 to Computing Devices of Canada to complete field work necessary for the production of new charts for small boats and deep-draft ships in north-western Georgian Bay. The location of the 60-square mile area from Cape Smith on Manitoulin Island to Killarney Harbour, is as shown on Figure 1.

This area is representative of many areas of Canada, as the limits include open, relatively deep unrestricted areas as well as narrow shoal-infested channels.

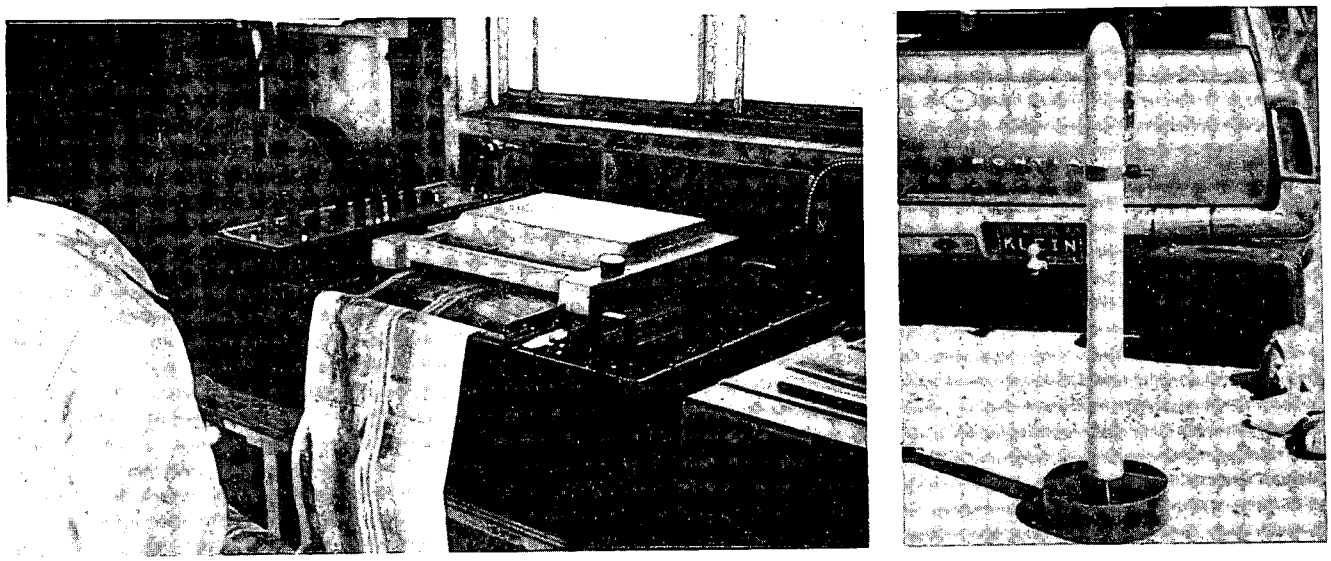
The survey contract was the first to be let by the Canadian Hydrographic Service following a recommendation by the Science Council of Canada that, where possible, government and university laboratories contract work to develop technical expertise in industry. It is coincidental that the area chosen for this first contract is in the same area as the first survey undertaken by the Canadian Hydrographic Service in 1883.

The Development Group responsibilities for the survey included the preparation of detailed survey specifications, review of the submitted tenders, and during the field operations to ensure that accuracy standards and attention to details as outlined in the specifications were being adhered to. As this was the first contract survey, responsibilities also included the development of effective monitoring systems for future surveys of this nature.

A detailed report on this survey is available from Central Region.

Sonar Development

As part of the Development Group's field program this year, considerable effort was directed toward the evaluation of side scan and omni-directional scanning sonar with potential for launch use on hydrographic surveys.



Klein Mk. 400 recorder and transducer units.

Four sonars, EG&G, MK 1A, KLEIN MK400, C-TECH LSS-30 and C-TECH LSS-30 (PT) were used during the program which was cunducted in the Killarney area of Georgian Bay.

All sonars were installed, at various times, on the modified barge "SORA" and an area of approximately 1.5 square miles was traversed with closely spaced and overlapping lines. A modern survey at a scale of 1:12,000 was available for this area, and numerous additional standard sounding lines were run in order to prepare an accurate contoured plot of the area. All shoal indications as detected by the sonar records were examined by conventional methods in order to fully develop the shoal contours.

The analysis of bottom coverage, comparison of sonars, descriptions of the equipment, the evaluation procedures and potential application techniques will be described in a paper to be presented at the 1973 Hydrographic Conference and copies will be available at that time.

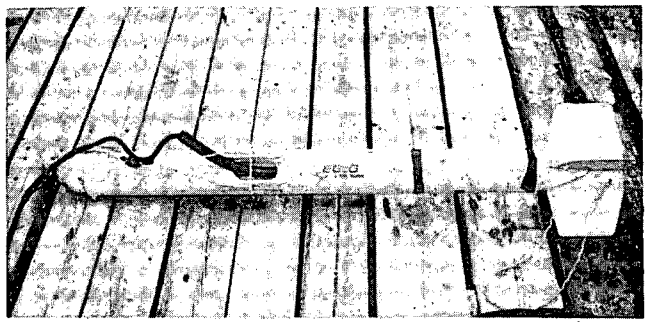
HAAPS Systems

Central Region presently owns the following equipment associated with HAAPS:

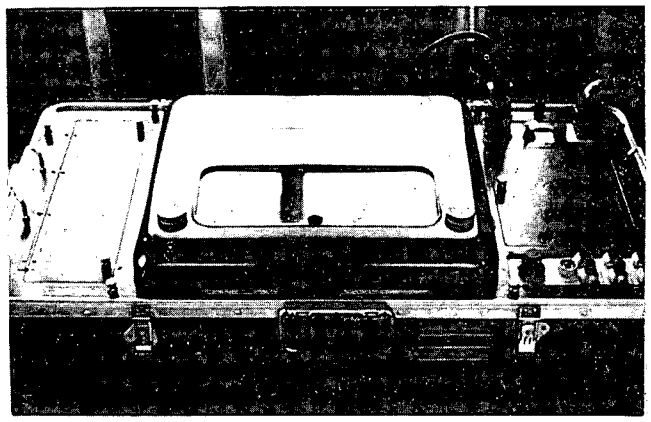
2 – C-Tech Depth Digitizers
2 – Digital Couplers
2 – Tape Recorders
1 – Atlas Depth Digitizer
1 – Decca Digital Display Unit
1 – PDP-8/E Computer with Peripherals
1 – Calcomp Plotter

During the year, two HAAPS acquisition systems were deployed in the field along with the one processing system.

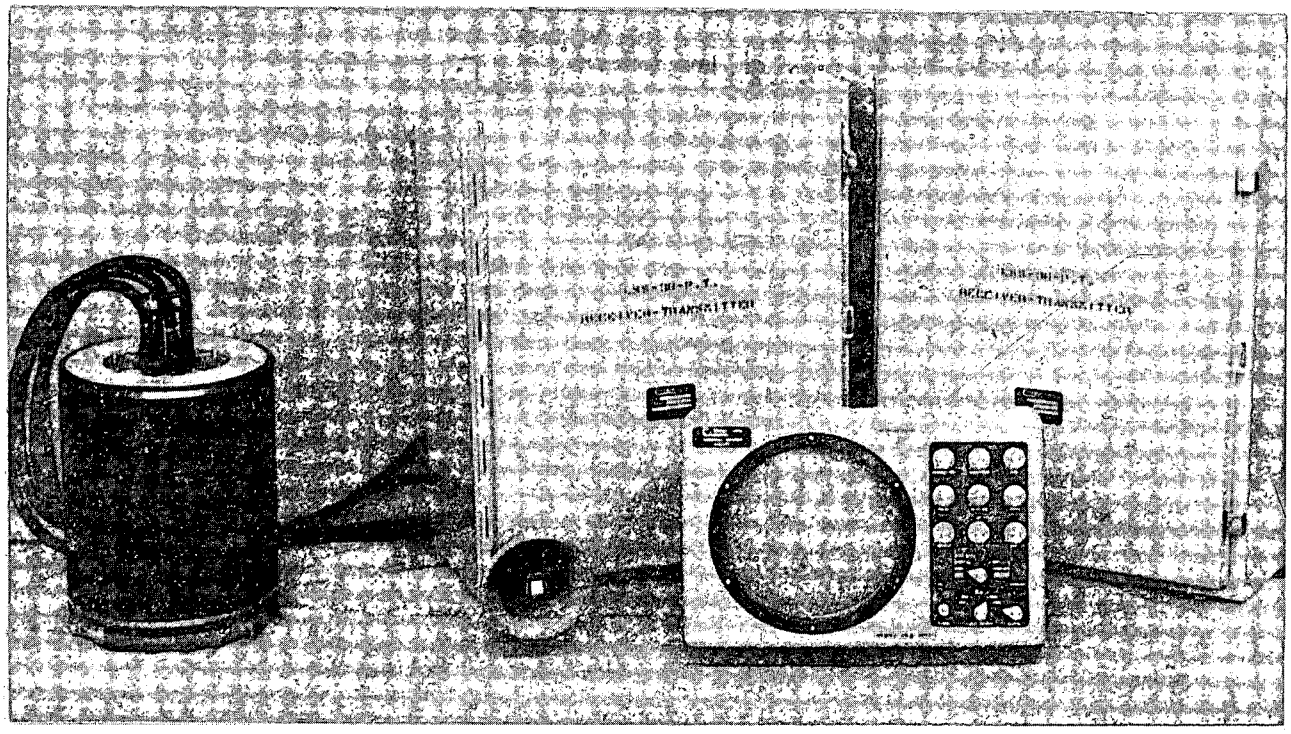
The acquisition system using the Decca Digital Display Unit and Atlas Depth Digitizer was used exclusively on LIMNOS for the bathymetric Survey of Lake Ontario.



EG&G transducer unit.



EG&G recorder unit.



C-TECH LSS-30 PT transducer, transmitter and display units.

Early in the year the equipment was installed in "VERITY" and used on western Lake Ontario to ensure that all systems were operational and that staff were adequately trained prior to the installation on LIMNOS.

The system was used for the entire Lake Ontario Survey with excellent results being achieved.

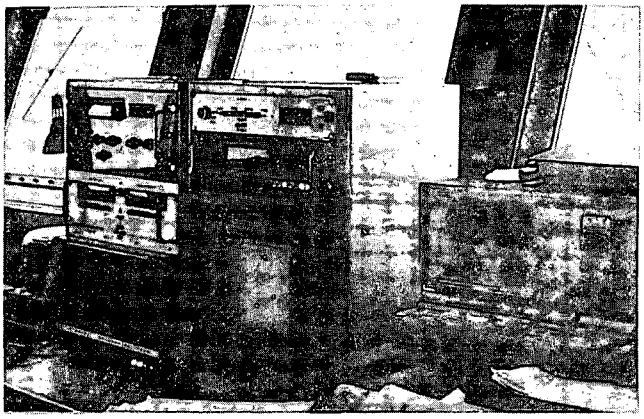
The second HAAPS system was deployed on a survey of approximately 45 square miles in northwestern Georgian Bay. (The area surveyed is shown in Figure 48).

Loran C Evaluation

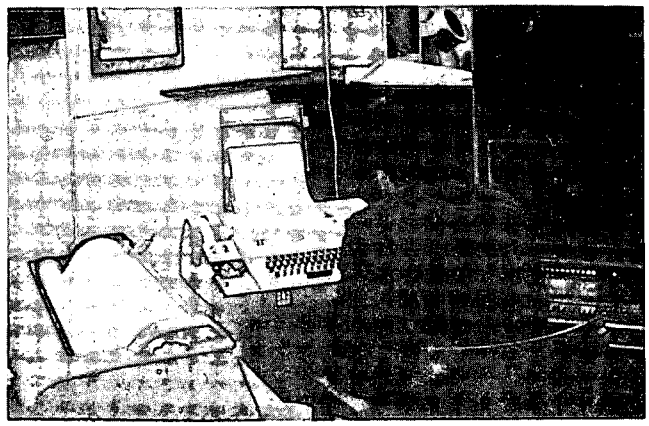
As a possible positioning aid for survey and research vessels operating in the Upper Great Lakes a detailed evaluation of Loran C, in both Hyperbolic and RHO-RHO mode, was undertaken this year.

To assist in this study a DECCA ADL-21 receiving system, complete with Hewlet Packard calculator and plotter, was obtained on loan from the U.S. Coast Guard. In addition, an Internar 101 receiver was rented from HPL Engineering and the AUSTRON RHO-RHO system was borrowed from the Navigation Group at Bedford Institute.

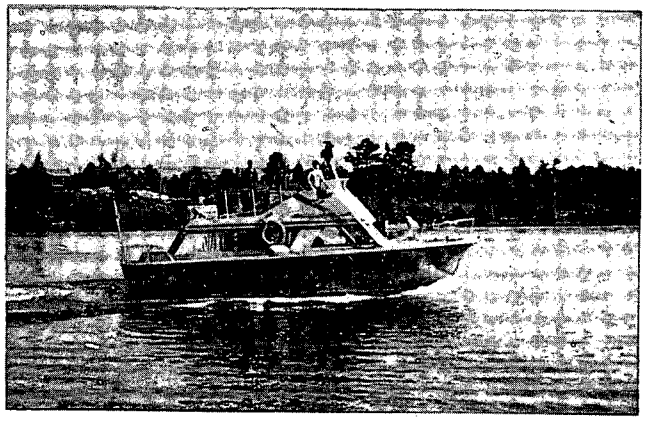
The Decca ADL-21 receiver was used essentially as a monitor unit during the period that the Internar 101 was operated in the Northwestern area of Georgian Bay. This



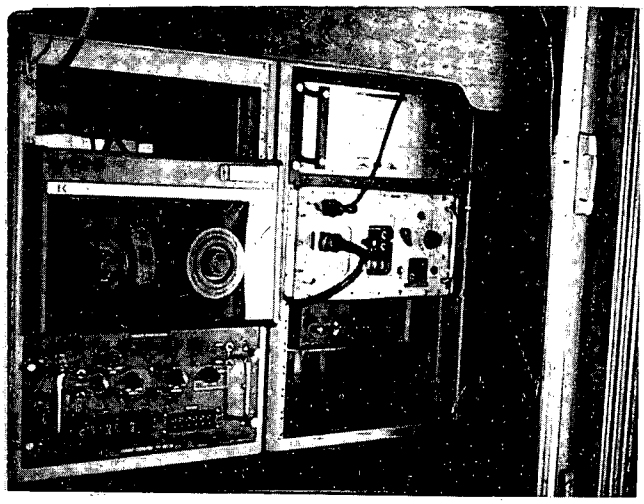
HAAPS – Hydrographic Acquisition System as installed on LIMNOS.



HAAPS – Processing System as installed on LIMNOS.

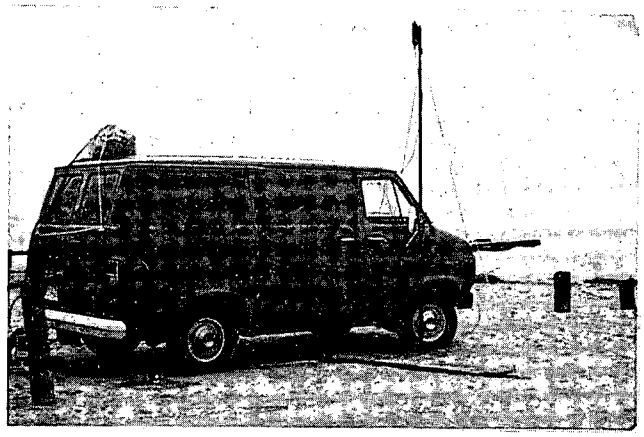


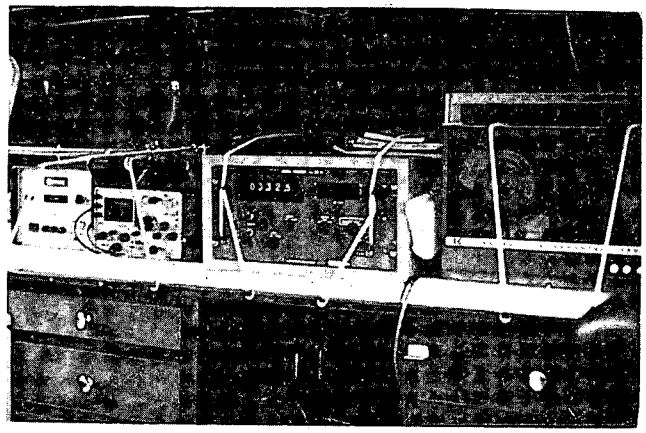
VERITY – used for HAAPS survey in Georgian Bay.



Equipment installation in VERITY.

Decca ADL-21 receiving and plotting system.





Electronics van with Loran C equipment installation.

phase of the trials involved the continuous logging (on magnetic tape) of both Loran C and Mini-fix signals for a comparison of accuracies.

For the second phase of the Loran C evaluation, the Internar receiver along with magnetic tape logging equipment was installed in our Electronics van and recordings were made at known points along the shore of Lake Superior and Lake Huron. Recordings of 48 hours duration were made at five stations along Lake Superior and two stations along Lake Huron.

The next phase of the evaluation involved the use of the RHO-RHO system which again was installed in the Electronics van. Recordings with this installation were made at known points along the four Canadian Great Lakes and Georgian Bay.

The Loran C evaluation will be discussed in detail in a paper to be presented at the next Canadian Institute of Surveying annual meeting.

Harbour & River Positioning System

The need for a more efficient method of positioning survey vessels in confined areas such as harbours and rivers has long been apparent. To assist in this area the Region

purchased a CODE-LITE, which emits a visible fan-shaped beam using high intensity Xenon lamps. The beam is made up of three sectors with each beam encoded for visual identification. The central beam can be adjusted from approximately 20 seconds to one minute of arc which makes it ideal for running ranges on short-range work.

To further assist in positioning vessels within short range, an acoustic measurement system is being developed from existing digital echo sounders. Preliminary tests of this system in 1972 have been successful in providing encouragement for continued effort in 1973.

Data Processing & Development

Much of the data processing activity of this Group is now in a production status, however, it remains within the responsibility of the Development Group.

As of the end of 1972, the Region owns three mini-computer systems, a PDP-8/I which is dedicated to the Gerber 22 plotting system, a PDP-8/E which is a desk-top model to be used for surveys where a good deal of general computations are necessary.

The Gerber 22 plotting system has had a very busy year on both production and development projects as can be seen on Figure 49.

The usage as shown on Figure 49 has been mainly on the preparation of field sheet basis, for all of Central Region field parties, and the production of Hyperbolic lattices, for all three Regions as well as Range/Bearing lattices for those surveys using that mode of operation.

Development work for the plotter has been mainly in the area of automatic drawing of soundings for both the Hypos and HAAPS methods of collection. Excellent progress has been made in these areas.

MARINE INFORMATION CENTRE

Nautical Chart Sales

During the past, M.I.C. handled a volume of about 1500 charts. Most of these were free issues supplied to field parties and other sections working in the Centre. Chart sales totalled about 300 for the year which is an increase from last year. Also during the year charts covering the East and West Coasts of Canada were acquired and are stored in the sales office for reference use only. Arctic charts are carried in limited numbers and are available to the public. Topographical maps of Canada are carried also but at present are for reference only, as only one or two prints of each map are in stock.

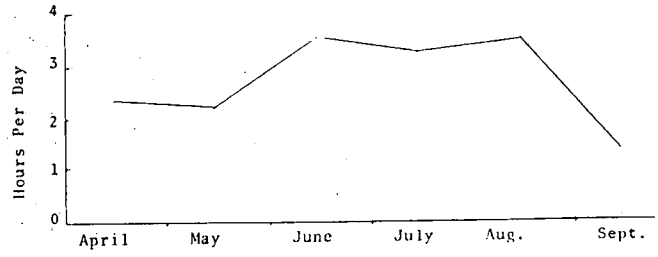


Figure 49. Total Gerber 22 usage.

Marine Information Centre also has a wide selection of publications useful to the mariner and the weekend sailor as well. These list as follows: Pilots of all Canadian waters, List of Lights, Radio Aids, Notices to Mariners, chart catalogues, Water Level information (yearly and monthly), Rules of the Road, and Boating Safety, to mention a few. During the past year, limited use was made of this information and there again mainly by people involved in projects here at the Centre.

Technical Records

The indexing and storage of field data collected during the field season has been continued as established the previous year. Most of this data is stored in the Centre and is readily available to anyone who might require it.

CARTOGRAPHY

During 1972, the Cartographic Section increased its capability of giving cartographic support to the Marine Sciences Directorate, Central Region with the purchase of reprographic equipment in late 1971.

The Morisawa Photo-typesetter has enabled us to supply the various printing needs of the Directorate with a significant improvement in quality and a saving in time and cost. One advantage has been the printing of field sheet titles which previously had to be done by the slower Leroy method. A variety of type styles in a size range of 5.5 to 60 points are available.

The Kodak Ektamatic Processor is used to process the exposed photographic papers used in the photo-typesetter. It is a compact machine which requires very little maintenance.

The Blu-Ray diazo whiteprinter produces ozalid prints of field documents to a maximum width of 42". This machine takes up very little office space, needs only a periodical change of ammonia and has proven to be very economical as many hundreds of ozalid prints are required each year. Diazo transparencies used with overhead projectors are also a capability of this machine.

The Nu-Arc plate maker is used to make film negatives required for the slide-screen printing process. Field sheet titles, publication covers, crests, certificates and display

signs are a few examples of the type of work done by the screen printing method.

In addition to the reprographic services, drafting support was given to the Geo-technology Section in the preparation of hydrodynamic and shoreline study drawings.

A responsibility of the Cartographic Section is the originating of supply requisitions for the drafting materials and instruments used by Central Region, both in the office and the field.

In December 1972, Mr. J. Elliott of the Canadian Hydrographic Service, MSD, Ottawa assumed duties as head of the Cartographic Section, Central Region, MSD, in Burlington.

SHIP DIVISION

Launch support was provided so shore based hydrographic parties scattered over a distance of some two thousand miles east to west from the Lower St. Lawrence to Lake Winnipeg, and north to James Bay via Dartmouth, Nova Scotia.

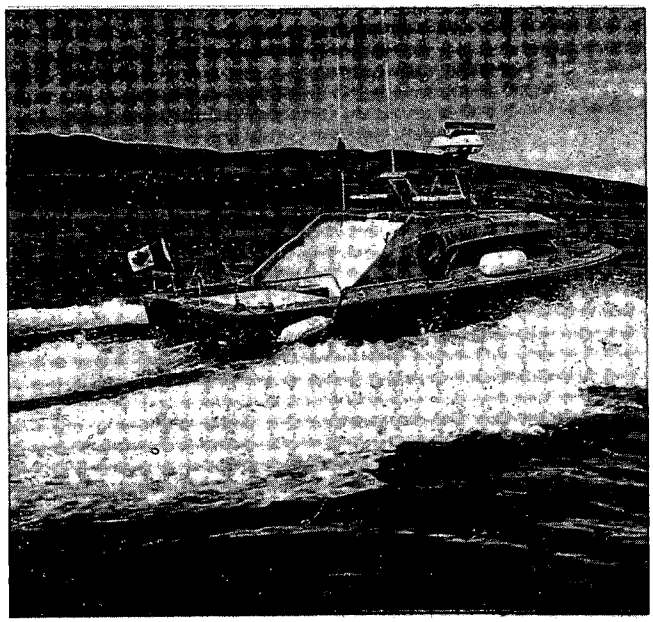
The variety of craft in the regional fleet was increased even further with the introduction of a new type for use initially in Playgreen Lake, a shallow, turbid, shoal-strewn hydrographer's nightmare. This was a Mon Ark "Little Giant", a 21-foot welded aluminum cathedral hull boat, almost devoid of beauty but with good practical features, such as good initial stability, shallow draft and maximum deck space by virtue of a box-like shape. Four of these units were purchased and in anticipation of numerous groundings, in preferance to inboard or Z-drive (boat-biz term for inboard-outboard), twin 65 h.p. outboards were selected, with a goodly number of spares provided for quick turnaround. In spite of a few holes, cracks and splits, these craft got the job done in what must be considered a national proving ground and it is most probable that more of these units, with some strengthening modifications, will be purchased.

The James Bay Project proved to be something of a challenge. Originally, it was proposed to use four Bertram launches operating from CCGS NARWHAL, a fairly suitable ship borrowed, after delicate negotiations, from MOT. Two of these were gasoline engined and two just recently converted to diesel power. A rather sudden embargo on ship-borne gasoline storage cancelled out the use of the gasoline launches and the only available substitute was a 36-foot steel launch which happily proved to be the most suitable for James Bay sea conditions. In addition to preparation of the launches for a somewhat complex survey, cradles had to be built, welded to the deck of NARWHAL and lifting gear assembled for hoisting by NARWHAL's great-boom – a hazardous operation even in sea state 0. All in all, the launches performed fairly well but following a post mortem it would appear that for James Bay, and all points north, an efficient displacement hull of some 30 feet in length would perform more efficiently than a 25 foot semi-planing hull.

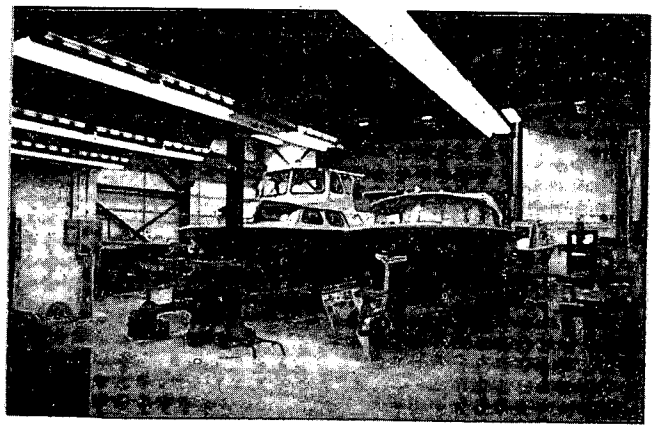
One other innovation, a tunnel-drive launch, conceived as a new weapon in the launch-rock war, did not really get off the ground, as in the first few hours of operation, blocking of the cooling water intake caused major damage to the engine block.

The lion's share of fleet support to limnological programs was devoted to IFYGL. With the exception of five excursions by MARTIN KARLSEN into Lake Erie and the Upper Lakes, principally for monitoring purposes, all major vessel time was devoted to Lake Ontario, extending from March 1972, until April 1973. In this concerted assault on Lake Ontario, LIMNOS completed 73 separate cruises, MARTIN KARLSEN 68 and the chartered tug LAC ERIE, 73.

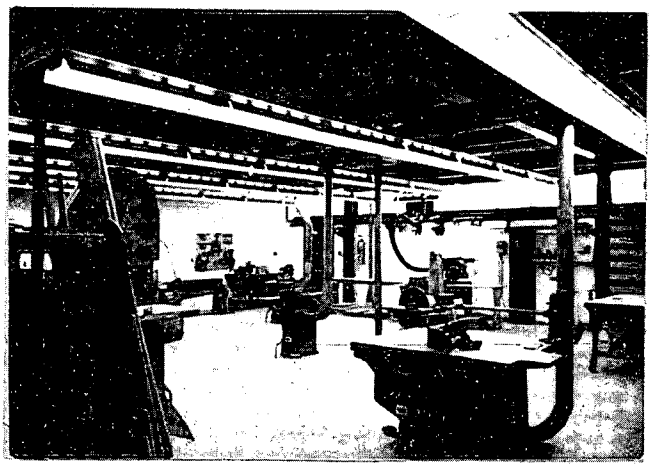
In addition to the larger vessels, the launches AQUA, AGILE, LEMOYNE, STURDY and SHARK were assigned to IFYGL support. A dumb barge, HANDY BOY, was chartered in support of three scientific observation towers on the Niagara Bar. The barge was outfitted with shelter for



CSL BITTERN (Bertram Launch).



Launch repair shop at CCIW.



Ships Division workshop at CCIW.

instruments, recorders and personnel and with a generator for power supply before being strategically moored adjacent to the towers for a six month period.

For the second year a converted landing craft with recessed propellers was chartered for nearshore sediment sampling on Lake Erie, again with considerable success.

The major acquisition was the 77-foot all aluminum vessel ADVENT. Basically a day boat with limited sleeping accommodation, her high speed will enable her to reach the work area from a convenient port with a minimum loss of operational time. A speed of 22 knots has already been achieved and this may be improved upon with the installation of finer pitched propellers.

RADEL II was finally retired and placed for disposal. When last heard of, she was in Midland, being fitted out as a pleasure craft.

Two oil recovery vessels, fitted with "slick-licker" units purchased by MOT were assigned to the Centre. These have been operated and maintained by MSD personnel as required.

The launch repair shop experienced its busiest year to date. Most hydrographic survey craft were recalled for inspection and overhaul and although repairs to engines and outdrives were contracted out every minor hull in the fleet was completely refitted. In addition to general overhauls and refits five new launches were modified and outfitted and two launches completely rebuilt.

The ship engineering section continues to be kept fully occupied throughout the year in the repair and maintenance area, both preventive and emergency, to various vessels and related equipment. A good deal of this work which is beyond the capability of shop resources or outside the home port, is contracted out.

The major vessels enjoyed a relatively trouble-free year. LIMNOS experienced one major breakdown, resulting in a loss of 4 days. The cause of the breakdowns, both breakages in a Harbourmaster drive gear, has since been investigated and the cause determined and corrected.

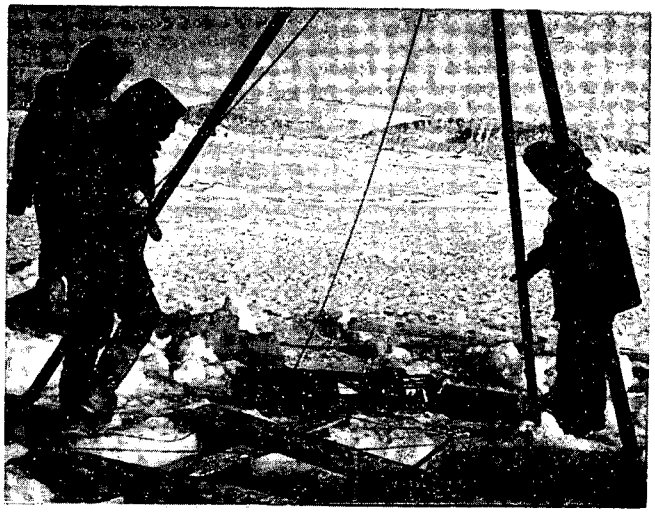
MARTIN KARLSEN continued to suffer a shortage of AC power with the constantly increasing demand. Balancing of loads on the various supplies has relieved the situation to some degree and it is hoped that the addition of an additional 20 KVA motor generator will eliminate the problem for the foreseeable future.

The Centre accommodated a number of participating U.S. and provincial IFYGL craft, while perhaps the highlight of the season was the successful and enjoyable multi-fleet get together and Ship Open House in June.

GEOTECHNOLOGY SECTION

HYDRODYNAMICS

Even though the Section's title, for the sake of brevity and increased generality of functions has been significantly reduced, its overall responsibilities over the past year have grown. In addition to its prime functions of tidal, current, and water level support for hydrographic surveys, and independent hydrographic surveys in the interest of safe navigation, it now has the responsibility for planning and organizing the oceanographic programs to be included in regular hydrographic surveys. Early in the year, an extensive outline of the functions and organization of the Section was developed, including a number of position descriptions.



Current meter installation, Nares Strait in the Eastern Arctic.

In April, N. Freeman assisted personnel of Defence Research Establishment, Ottawa, in the installation of current meters and thermographs through the ice in Nares Strait, to study the mass movement of Polar-deep water from the Arctic Ocean to Baffin Bay. In conjunction with the hydrographic field parties, tidal and inland water level records were obtained at all of the 1972 field survey locations with the northeast section of James Bay providing up to four months of tidal data from some of its eight temporary stations. In James Bay it was found that, due to large storm seas, island-based tide gauges were difficult to establish and maintain and coastal locations finally had to be selected. A sloping sounding datum was determined for Playgreen Lake using past records of Water Survey of Canada and a gauging program was developed to verify the calculations. The tidal reduction program obtained from Tides and Water Levels, Ottawa was adapted to a time-sharing system and real-time sounding reductions were transmitted daily to the Lower St. Lawrence hydrographic survey party.

Numerous requests from the general public for Great Lakes water level information were readily answered because of our terminal connection to the real-time data bank established and maintained by Tides and Water Levels, Ottawa. A "Water Levels Brochure", explaining the cause and effect relationship of water level variations on the Great Lakes was also produced by the Section, in consultation with the Shore Property Studies Section, to facilitate handling of public queries.

A pressure calibration facility for pneumatic gauges was developed in the Region and five Ottboro gauges were assembled, ten procured from Ottawa, and all fifteen calibrated prior to the 1972 field season. A telemetry tide gauge acquired from Tides and Water Levels, Ottawa was tested locally and field evaluated in James Bay. Even though difficulties were experienced during its operation, the gauge performed well near the end of the survey. Using portions of the Water Survey of Canada strip chart digitizing program, a more expansive digitizing system was developed for the D-Mac pencil-follower so as to include a five-minute digitizing interval and a variable scale.

Oceanographic measurements, consisting of depth profiles of salinity, temperature, and oxygen, as well as plankton hauls and bottom cores, repeated three times during the survey, were taken on James Bay and a Data Report is in preparation.

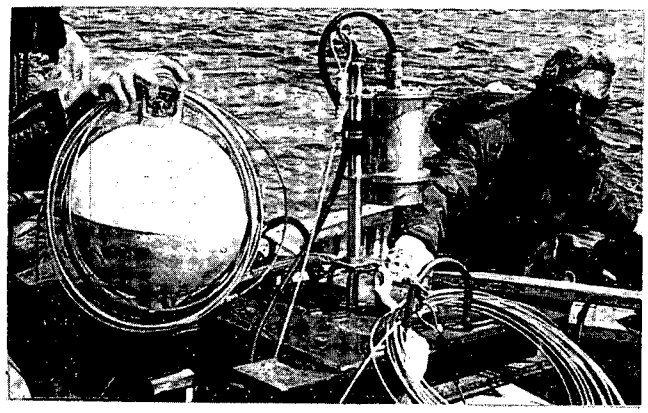
Applied research into storm surges, including numerical modelling and spectral analyses, were undertaken jointly with Shore Properties Studies, and Oceanographic Research Division, MSD to ascertain the spatial and temporal scales of the water level fluctuations, and their effect on hydrographic reductions and shoreline erosion.

Within the next few years, tidal-current surveys are proposed in three areas – the St. Lawrence River from Quebec City to Les Escoumins, the Eastern Arctic and James Bay. In the meantime, various *in situ* tide gauges and current meters are being evaluated and tested along with appropriate mooring systems for multiple environment application (marine, fresh, and Arctic waters). Further oceanographic measurements are planned for James Bay. "Available Potential Energy" calculations will be carried out this winter for Lake Ontario in conjunction with the Energy Budget estimates being made by Dr. J. Blanton for IFYGL. A two-dimensional numerical tidal model is being developed for James Bay to assist in co-tidal chart productions.

Two lectures on Tidal Theory and two on Hydrodynamic Instrumentation were presented to students in Hydrography II course, held this year at CCIW. Also during the year, two papers were accepted for publication.

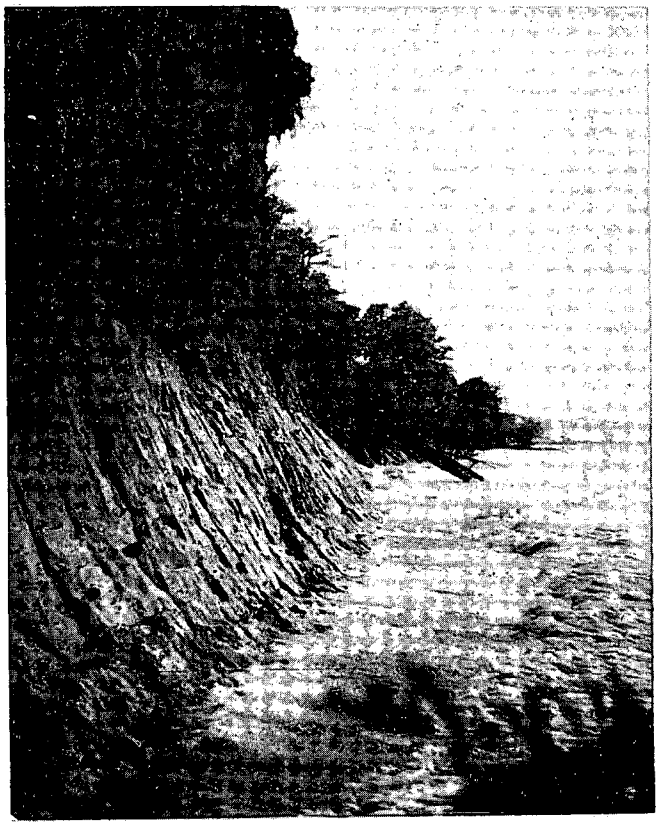
SHORELINE PROPERTIES STUDIES AND INVENTORY

The concern of the Shore Property Studies Section is the establishment of the data bank for the coastal zone



Remote sensor for telemetry tide gauge.

along some 6000 miles of Canadian shoreline of the Great Lakes and St. Lawrence River and its numerous islands. The basic inventory has existed since 1968 when it was so hastily prepared by the Task Force of the International Joint Commission for the evaluation of the effects of lake level regulation on shore property. Our main role today is to update, expand and adapt it to an ever changing application of its uses. To meet the minimum requirements the section should have staff of 3 full time members and, during concentrated field activities, two part time student assistants, plus continuous support from the cartography section. So far this has been difficult to achieve and since man-years are hard to come by, we must do the best with the resources on hand. Aided for a period of nine months by a graduate geographer who happened to have a commercial pilot's licence, this section embarked on a program of updating shoreline development from the air. During an early part of this year the westerly end of Lake Ontario and the total length of Lakes Erie and St. Clair including Detroit and St. Clair Rivers' shorelines were photographed from an altitude of 1000 feet, thus extending the existing sequential library of colour slides from Kingston to Burlington by the additional 470-mile pictorial record from Burlington westward to Sarnia. This type of inventory is not only practical and vital – especially in an age of long-term planning – but economical costing one dollar and a half per mile of shoreline.



Shoreline erosion.

We have been aware for many years of fluctuations of lake level. That these fluctuations were closely related to erosion and accretion was fully appreciated but seldom measured, and since both land and the water are moving it is by no means a simple problem to distinguish their effects. Moreover, how does one measure, relative to the present level of the lake, the height of a raised beach or the extent of erosion? What part of the beach or bluff do you select for this purpose? There is not one mile of shoreline that has identical characteristics with the next. Not only are precise measurements difficult to make, but also almost every locality has far too few of them. Previously we had to be content with qualitative assessments, and however inadequate our measurements are presently, some quantitative answers are emerging from the study of storm surges, the most devastating villain on the waterfront. To date, two of these storm surges were analyzed – one on Lake Huron in September of 1971 and a fairly recent one, on Lake Ontario, the tail end of the tropical storm 'AGNES' in June of 1972. The findings for each will be presented in a report jointly prepared by Shore Property and Hydrodynamic Sections.

It will be apparent that the study of the shoreline zone is not only of great interest from a scientific and historical point of view, but that it is also of vital importance from the economic point of view. It is not easy to find solutions, but reasonable ones are much more likely to be obtained by those who can see the shore zone as a whole, and can give time and thought to the problems in question from an early stage, because more and more care is needed in preservation and proper development. We must observe and collect as many facts as possible and try to interpret them in the light of experience – our own and that of others. Then we may begin to understand how and why change takes place on our Great Lakes shoreline and design methods of control where desirable.

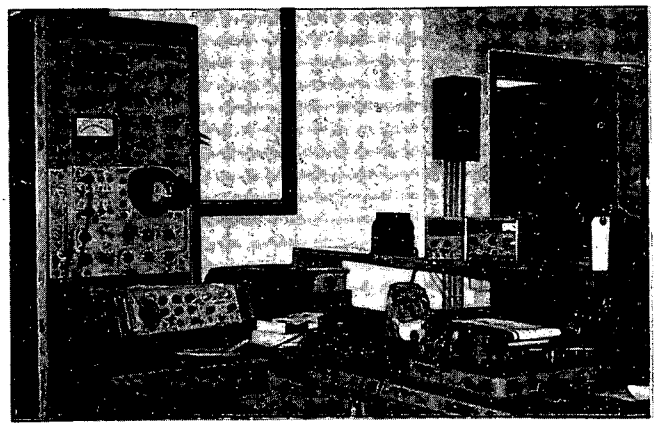
SURVEY ELECTRONICS

This year as always, the Electronics Shop was extremely busy. The Electronic Technicians' strike started the year off badly, but the late departure of most field parties tended to offset the time lost due to the strike.

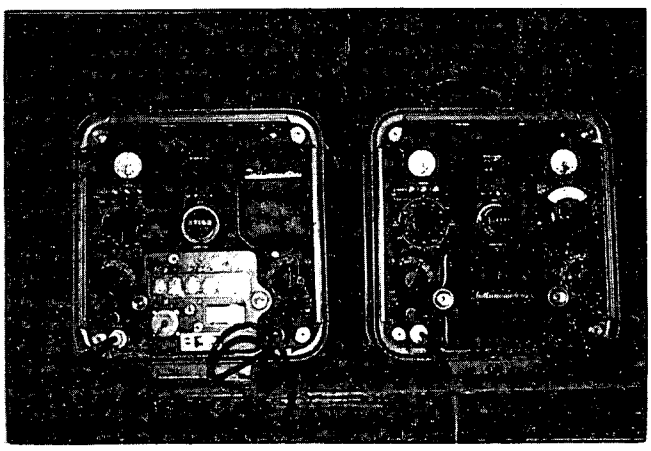
Technicians were in the field with survey parties based at: Playgreen Lake, Lake of the Woods, Lower St. Lawrence, and James Bay. In addition, Revisory Survey, Navigational Ranges, Dr. Rukavina's Near Shore Survey and IFYGL were supported by technicians based at Burlington.

The James Bay Survey was probably the most demanding so far as the Electronic Shop was concerned. In addition to the technician stationed with the party, an additional technician sailed with the NARWHAL to and from the operations area.

The James Bay Survey utilized the first fifty watt Mini-fix chain to be used in Canada. As a result of the



Electronic shop at CCIW.



MRB 201 Digital Hydrodist.

increased power, ranges over 100 miles were regularly achieved. In association with Hydrodynamics a telemetering tide gauge was also employed, however, with limited success. The James Bay Survey also used the Mufax weather receiver that formerly was aboard the CSS LIMNOS.

The IFYGL project also heavily taxed the resources of the Electronics Shop. In addition to the early outfitting of launches, we provided seven CH25 radio-telephones channelled to special IFYGL frequencies. Ground to air radio telephones and a CH25 were supplied for the Lac Erie, and a radar was supplied and installed aboard the Ontario Ministry of Natural Resources vessel COTTUS. In anticipation of possible future use of a Decca system, two of our technicians spent two weeks at the Decca stations. As usual, a considerable amount of time was spent supporting the scientific launches, working with IFYGL and separate from IFYGL.

The Hydrodist readouts that were designed by a technician from the Electronics Shop and built by C-Tech were used in the field for the first time, and from all reports worked very well and eased the strain of using Hydrodist. The new Hydrodist 201's were also used for the first time. New VHF radio telephones were evaluated, purchased and supplied to the Playgreen Lake Survey.

During the year the electronics shop acquired an additional room thus facilitating the physical and structural breaking of the shop into three areas: sonar, systems and communications.

Other areas of present involvement, in addition to the yearly overhaul, include: modifications to the Sea Fix Buoys, rebuilding of the Gifft Sounder, remote readouts and left/right indicators for the RPS, and assembling of a data recording system for Dr. Rukavina's Near Shore Program.

ADMINISTRATION

PERSONNEL

The personnel office is responsible for the orderly processing of 152 man-years complicated by the seasonal status of 101 ships crew positions. At seasonal peak 207 employees were held on strength – 1972.

Although delegation of staffing authority does not rest with the Regional Director; recruitment, documentation and most processes are handled at the Regional level with the MSD personnel Advisors office responsible for ensuring that the principles of the merit system are met.

Effective January 1, 1973, Central Region will be served by a DOE Regional Personnel Organization presumably with offices located at CCIW Burlington, thus severing personnel administrative relations with the Director General's office in Ottawa.

During the first nine months of the current fiscal year 15 full time continuing personnel were staffed and administered through this office and 127 seasonal and casual employees processed.

Services provided at the local level as follows will continue:

1) employment and discipline
2) leave and compensation
3) training and education
4) staff relations
5) security
6) staff benefits

7) health and safety
8) pay and benefits
9) man-year utilization control etc.

Close to 50 Position Analysis Schedules have been written with the aid of private consultants over the period and processed to Ottawa for classification action.

ACCOUNTS

Of a total regional budget of 4M annually, 2.4M is processed through the Accounts Office representing $500,000 in 12 field account activities, 1.5M general O&M purchases and ships charter and $300,000 in capital expenditures.

The remaining 1.6M represent salaries and other personnel costs.

Payment of accounts formerly handled through MSD headquarters is now processed direct through the Regional Services Office of DSS Toronto.

The preparation of field accounts, pre-audit for payment etc., occupy much of the staff's time during the summer field season.

Increased costs of services and supplies over the past year have forced some cutback in operational programs placing the accounts section on the alert for possible savings and tighter control of proposed spending.

The work is accomplished by three Accounts Clerks.

SUPPLY SERVICES

Organization

Supply Services are centralized under the Regional Administrative Officer and consist of a Hydrographic Stores located within an enclosure in the main CCIW warehouse, and a ships stores located some 100 yards distant in a stockroom adjacent to the boatshop. A small office in this same area houses procurement and stock control. Bulk warehousing is provided by the IWD (Scientific Support Division).

A study is currently underway to determine the feasibility of amalgamating all general purpose stores at CCIW.

Scope

Approximately 6000 accountable line items are held on MSD – Central Region charge, having a value of $12M. In the first three quarters of 1972-73 over 1000 requisitions were processed covering supplies and services for which $1.5M was committed. The controlled mobility of this inventory in support of both ship and shore based field parties operating from the high Arctic through James Bay, and the Great Lakes to the Gulf of St. Lawrence is a major concern of the Supply Services staff.

A heavy vehicle commitment to mobile field operations is demanding considerable attention under the departments vehicle fleet management system.

Inland Waters Directorate (Ontario Region Operations)

WATER PLANNING & MANAGEMENT BRANCH (ONTARIO REGION)

On September 5, 1972, the Burlington Office of the Water Planning and Management Branch (Ontario Region) commenced operation as part of the Regional Office, following the transfer from Ottawa of the positions and staff of the former Central Region, Engineering Division of the Branch. A second Office of the Ontario Region of the Branch is located at Cornwall, Ontario (Great Lakes–St. Lawrence Study Office). Mr. N. P. Persoage has served as Acting Head of the Ontario Region since September, 1972.

The two offices of the Branch carry out extensive studies related to water management problems in the Ontario Region and members of its staff serve on a number of Engineering Boards and Boards of Control on the Great Lakes established by the International Joint Commission and several joint Canada-U.S. International Committees. Emphasis during the past year has been on that aspect of the Region's work dealing with regulation and control of the Great Lakes–St. Lawrence System. In recent months, extreme high lake levels on the Lower Great Lakes have been of particular concern and have required extensive studies of possible methods of alleviating high water on Lakes Huron, Erie and Ontario.

At the Cornwall office preparations were made and methods developed to begin issuing to the public six-month forecasts of Great Lakes levels, beginning early in 1973.

A more detailed review of these activities will be contained in the annual report of the Water Planning and Management Branch for fiscal year 1972-3.

WATER QUALITY LABORATORY & NETWORK (ONTARIO REGION)

In March, 1972, the analytical services laboratories of the Water Quality Branch moved from Ottawa to the Laboratory and Administration Building at CCIW. The unit's detachment that had been located in the Pilot Plant at the Centre also moved into the Building at about the same time. The Water Quality Laboratory consists of three Sections: Analytical Services, Special Services, and Great Lakes and Ships Support. Recruitment is underway to staff the Monitoring and Surveillance (field) Section that will be responsible for planning water quality monitoring and surveys to assess the quality of the water resources in the region.

ANALYTICAL SERVICES SECTION

This Section consists of an Inorganic Analysis Laboratory, which determines major ions, trace metals, and other inorganic constituents of water, and an Organic Analysis Laboratory which determines nutrients such as phosphates and nitrates and trace organic contaminants such as pesticides herbicides, oils and polychlorinated biphenyls. Two of the major projects for which the Analytical Services Section provided support in 1972 were:

1) National Water Quality Monitoring and Surveillance–The Water Quality Branch collects water samples at selected locations throughout Canada for analysis and reporting of water quality on major lakes and rivers. The objectives are to obtain baseline data to identify and predict trends, to act as a pollution warning system and to assist in the enforcement of pollution control legislation. The laboratory at CCIW analyzes samples collected from stations in Ontario and Quebec. At present, there are eighty two stations in Ontario including ten stations on Lake Ontario, eleven on Lake Erie, twenty on Lake Superior and thirteen on Lake Huron. There are thirty-four stations in Quebec.

2) Pesticide Survey of the Lower Great Lakes–This is a special survey to determine the presence and quantity of hydrocarbon pesticides (such as DDT and its derivatives, and including polychlorinated biphenyls) in samples of water, plankton, sediments, and fish collected from the lakes.

A total of 72 projects were supported by the Analytical Services Section.

Other Work: Pesticide Method Development. The Organic Analysis Laboratory developed methods for analysis of herbicides and organophosphorus pesticides and also published a manual on methods of analyses for chlorinated hydrocarbon pesticides. In addition, this laboratory developed a method for the confirmation of pesticides using a solid matrix technique which is simpler and more sensitive than the customary solution derivation technique.

Determining trace amounts of organic constituents in water by gas-liquid chromatography.

This method, which has been adapted for routine use, has been the subject of four papers published in 1972.

In the course of the year the Analytical Services Section conducted about 70,000 analyses on 4,300 samples.

Special Services Section

This Section consists of two groups: a Special Analysis and Quality Control Laboratory, and a new Methods Development Laboratory for which staff is currently being recruited. The Special Analysis and Quality Control Laboratory has been engaged primarily in the following two projects:

1) Quality Control. The Laboratory conducts a National Interlaboratory Quality Control Program in which there are currently 25 participants including federal and provincial government laboratories, universities and industrial laboratories as well as the regional laboratories of the Water Quality Branch. Samples are sent to participants for analysis and the results are reviewed and reports written with the objective of evaluating test methods and evaluating the performance of the participating laboratories. During the past year two studies were conducted; one on metals (chromium, iron, molybdenum and vanadium), and one on physical properties (pH, specific conductance, color and dissolved solids).

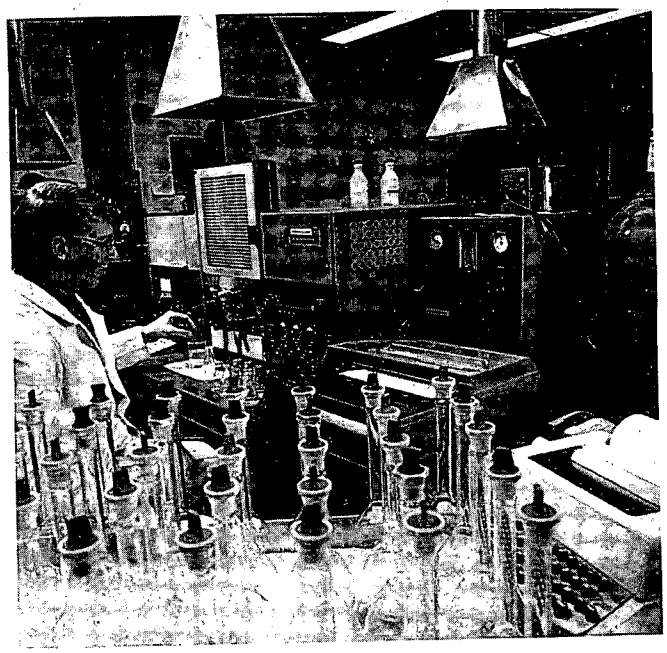
2) NTA Monitoring. A major effort of the Special Analysis and Quality Control Laboratory this year was in the determination of NTA (nitrilotriacetic acid), in support of a number of programs. Some 400 samples of river, lake, ocean and groundwater were analyzed as part of a program which had as its objective the determination of background levels of NTA in the environment. In addition, more than 3,000 sewage samples were analyzed for the Environmental Protection Service at CCIW in connection with studies on various aspects of the degradation of NTA in sewage treatment plants. A good start was made on the National Monitor Program for NTA on analysis of samples from Great Lakes, ground, surface and marine waters and finished waters from municipal water treatment plants at selected sites across Canada.

GREAT LAKES AND SHIPS SUPPORT LABORATORY

This Unit operates laboratories aboard research vessels operating out of the Centre to determine those constituents which must be determined immediately after collection. The Unit is also responsible for some of the further testing on samples returned from the ships to the main laboratory and on other projects. During the past year approximately 7,000 samples were analyzed aboard ship for soluble reactive phosphorus, silica, ammonia, nitrate plus nitrite, total soluble nitrogen, total alkalinity and chloride. The Unit conducted about 130,000 tests during the year including 53,000 aboard ship and 77,000 in the shore laboratory.

Some of the projects which this Unit supported during the past year were:

IFYGL—The laboratory participated in seven 2-week Organic Particle Study cruises on Lake Ontario



Atomic absorption spectrophotometer being used to determine parts per billion levels of metals in water.

as part of the IFYGL Program.

Great Lakes Monitoring—In addition to the IFYGL cruises, the laboratory participated in one biochemical monitor cruise on Lake Ontario, three on Lake Erie, and three on Lake Huron, one of which included Georgian Bay and northern Lake Michigan.

Precipitation Chemistry—A total of about 260 precipitation samples were analyzed for pH, total alkalinity, soluble and total nutrients, major ions and some trace metals.

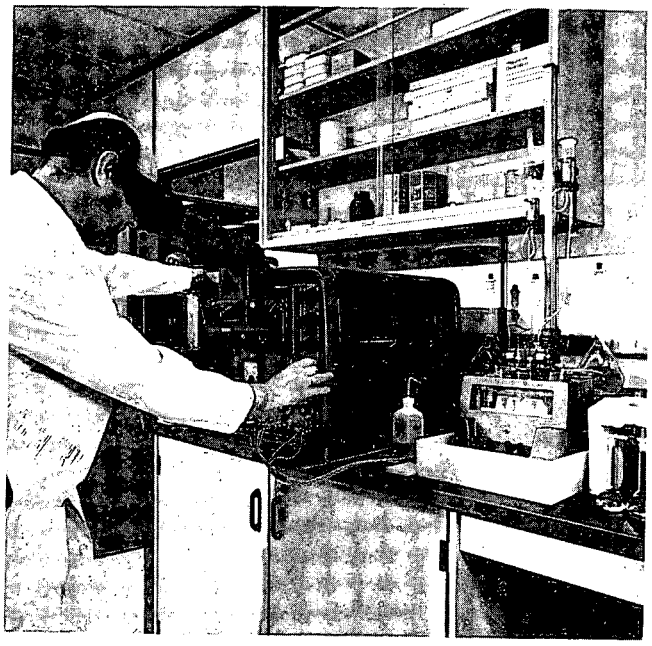
Interlaboratory Comparisons—The laboratory was involved in a number of comparisons among the laboratories involved in the IFYGL Program to ensure that the data produced by the laboratories are comparable. The laboratory was given the responsibility of collecting and distributing "split" samples of Great Lakes water to the other laboratories as part of the intercomparison program.

In addition to the above programs the laboratory has provided support to a number of smaller projects and conducted some investigations into methods of analysis and preservation of samples, particularly with reference to shipboard analysis and preservation.

Special Studies

1) Investigations into the effect of freezing of lake water samples prior to analysis.

2) Development work was conducted to ensure that the new AutoAnalyser II systems were producing data comparable to the older AutoAnalyser I systems, the latter which are gradually being replaced.



The twin cell polarograph is used to determine NTA (nitrilotriacetic acid), a replacement for phosphates in detergents.

Contracts 1972

The following private sector-branch contract from headquarters funds was monitored by W.J. Traversy:

Environmental Distribution of Agricultural Chemicals (Canadian Canners Limited Research Centre).

Central Services (Provided by Inland Waters Directorate)

CANADIAN CENTRE FOR THE INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES

The year of field work commenced on 1 April, 1972. The final details of this field operations phase were hammered out, and coordinated internationally, during January. Complete program details were assembled and published in a four-volume Technical Plan.

An IFYGL Bulletin was established to give a running account of Canadian and United States participation. The Canadian section of the IFYGL Bulletin was edited by the Coordinator. A summary of the Canadian field operations was published in Bulletin 2, further details on instrumentation systems were in Bulletin 3, in Bulletin 4 (September 1972) there were some preliminary results available on the heat content of the lake, and in Bulletin 5 some results of the Canadian fish survey (Ontario Ministry of Natural Resources) were included.

PROGRESS DURING 1972

As an essential preliminary to the field work, a Decca 6F position fixing system was set up and its cost shared between Canada (Central Region, Marine Sciences Directorate) and the United States (National Oceanographic and Atmospheric Administration).

The three major Canadian vessels (Limnos, Martin Karlsen and Porte Dauphine) commenced work in April, 1972, and were joined by two major United States ships as soon as ice conditions in the St. Lawrence allowed them to enter the lake. A field comparison between the various ship-borne measurement systems was held on 26 June, and 18 September, 1972.

By the end of December 1972, 82 Canadian ship cruise reports were filed. The cruises monitored the lake-wide network of buoy-borne instruments, surveyed the state of the lake and supported the special investigations of universities and other agencies.

The Canadian half of the 21 buoy, lake-wide meteorological and limnological observing system was regularly maintained, and six towers were installed and manned for studies of the interaction between the atmosphere and the lake. Frequent cruises were undertaken to examine lake thermal structure, heat budget and primary production in surface layers. Preliminary lake heat budgets were computed using data from both Canadian and United States vessels.

In the biological-chemical program, seven 1972 research cruises were carried out staffed by CCIW (FRB & IWD), McMaster, and Guelph University investigators. The objective was to study the interaction between chemical and biological processes. The two-week duration cruises included a period of 48 hours at two fixed locations in order to describe and understand the daily changes in the biological and chemical activity. Synchronized fish surveys were carried out by the Ontario Ministry of Natural Resources working in direct cooperation with United States federal and state agencies. Nine such cruises comprised this program.

Sophisticated techniques were used on the towers for directly measuring the transfer of heat, vapour, and wind stress between the atmosphere and the lake. Investigators from the Atlantic Oceanographic Laboratory, Dartmouth, Nova Scotia, the Atmospheric Environment Service, Toronto, or the Canada Centre for Inland Waters, Burlington, were working during the pre-arranged two week duration alert periods in May, June, August and October. The many-agency interest is due to the fact that these experiments have application to the improvement of prediction of lake and ocean currents, long period weather forecasting, waste heat dissipation, waves, limnological productivity and atmospheric pollution.

The hourly results of the six Canadian Lake level gauges were published. These showed that the level of Lake Ontario, rose rapidly to a peak in July at 246.68 feet above mean sea level at Father Point, Quebec. This level was the highest since 1952 and has only been exceeded eleven times in the last 100 years. In other respects too the year has not been a normal one. When the program started the average lake temperature was 2.9°C, 0.9°C colder than normal for early April. April 1972 was one of the coldest Aprils on record with temperatures 2 to 4°C below normal. There was an early summer storm (fringe of Hurricane "Agnes"), and an outbreak of cold air on 8/9 October, in the middle of the October alert period. These circumstances were considered to augur well for the success of the IFYGL, since a more than usually large range of parameter variations was encountered. Several well marked wind stress impulses occurred which will be helpful in understanding the dynamic response of the lake.

Six stations were set up around Lake Ontario (Canadian stations by Atmospheric Environment Service,

Environment Canada) to conduct upper air soundings during the fall and to measure the atmospheric flux of water vapour across the lake when evaporation was at a maximum. The stations were operational as planned on 16 September, and continued operations until 7 December, 1972, by which time the three Canadian stations made about 1500 radio soundings of atmospheric winds, temperature and humidity from the surface up to a height of over five miles above the surface.

Three weather radars have maintained an almost continuous watch on the rain in the basin, working together with networks of conventional rain gauges. The Canadian radar was located at Woodbridge, Ontario, and designed to prepare quantitative estimates of precipitation over the northwestern portion of the Lake Ontario drainage basin. A network of 12 precipitation gauges was located near Bowmanville (72 km from Woodbridge), and 9 gauges were placed near Uxbridge (12 km from Woodbridge) to assist in calibration of radar precipitation estimates.

The international fish sampling program took 100,000 samples and noted 53 different species.

Data was acquired by the Canada Centre for Remote Sensing. Department of Energy, Mines and Resources, which proved useful for defining the extent of *cladophora* beds in the eastern half of the Ontario near-shore zone.

It is already clear that the major part of the field program has gone as planned and acquired useful data from April 1972. Some elements of the program did not start up until June or July. The impact of these delays was assessed by the IFYGL Steering Committee and not considered serious enough to warrant any major extension of the program beyond 31 March 1973.

DATA

A detailed study was made of the Canadian Data, and formats for summarization (e.g. hourly value tables, etc.) were drawn up and published in Proceedings of IHD Workshop Seminar, Quebec City, October 1971. The Canadian Data Bank is located at CCIW and is now accumulating both raw and worked-up data from Canada and the United States.

SCIENTIFIC ANALYSIS

Preliminary studies have commenced in Canada. For example, CCIW investigators made a preliminary analysis of the lake water temperature data obtained by both Canadian and United States vessels, and Ontario Ministry of Natural Resources biologists have compiled preliminary fish distribution data.

Wind stress on the lake has been computed by CCIW from the results of the meteorological buoy measurements. The results of the CCIW lake-wide current measurements are available.

Dr. G. T. Csanady, University of Waterloo, has commenced the analysis of the IFYGL Coastal Chain project. This work seems to indicate that the circulation of the lake is episodic, rather than continuous. For each occasion of major wind stress the lake has a characteristic response which then dies away in two or three days. Marked reductions in the anticipated effect of a given wind were noted in spring due to the great stability of the air when moving over cold water. The work also appears to be useful in illuminating certain oceanographic problems. In Lake Ontario these can be studied without interference from significant tidal or salinity factors.

PUBLICATIONS

The IFYGL Coordinator, Mr. J. MacDowall, edited the Canadian part of the International IFYGL Technical Plan and Bulletings, the IFYGL Technical Manuals and compiled the proceedings of the IFYGL Biology-Chemistry Panel Meeting.

REMOTE SENSING AND DATA RETRANSMISSION BY SATELLITES

Mr. J. MacDowall assisted the Canadian Advisory Committee on Remote Sensing by serving as Vice-Chairman of their Working Group on Sensors, and as a member of the Working Group on Data Retransmission by Satellites. The second year's results from the Sensor Program was edited by Mr. J. MacDowall for publication by the Canadian Aeronautics and Space Institute Journal.

SCIENTIFIC SUPPORT DIVISION

The Scientific Support Division provides the major portion of the technical and professional support for the scientific programs at the Centre, as well as undertakes some applied research and development in such areas as Radio-chemistry and Instrumentation. It consists of five components, the activities of which are described below.

SCIENTIFIC SERVICES

Two types of laboratory activity, radiochemistry and electron microscopy, are the concern of this Section. These activities support the scientific program of CCIW through joint research projects with scientists from other CCIW components. The radiochemistry laboratory is equipped to handle medium radiation levels safely and has instrumentation for γ-ray spectrometry and low-level β counting. The electron microscope laboratory uses a Siemen's transmission electron microscope for morphological studies of bacteria and sediments and for crystal structure determination by electron diffraction.

Radiochemistry

At the present time, radionuclide levels in the Great Lakes are still due to fallout from weapons testing in the atmosphere as the nuclear power industry is still in its infancy. As a preliminary to making a baseline assessment of the radionuclide loading of the Lakes it was necessary to determine the counting efficiency of the lithium drifted germanium γ-ray detector for the more usually encountered radionuclides. After this was completed an intercomparison of methods for analyzing water samples for γ-ray emitting radionuclides was entered into with several U.S. laboratories under the auspices of the United States Atomic Energy Commission (U.S.A.E.C.). A sample of Lake Michigan water, spiked with low levels of ^{60}Co, ^{144}Ce, ^{65}Zn, ^{54}Mn, ^{134}Cs, and ^{137}Cs, by the National Bureau of Standards, was circulated to each laboratory along with an unspiked sample for analysis. Our results for the spiked sample were in very good agreement with the mean values from all the reporting laboratories while our result for Lake Michigan water at 0.085 ± 0.015 pico-Curies (pCi) per litre was close to the mean value also.

The quantities of radionuclides in lake sediments are of interest as they constitute a substantial fraction of the lakes' loading of radionuclides while the vertical distribution of the radionuclides in the sediments can provide information on sedimentation rates. A large sample of the top layer of Lake Ontario sediment was analyzed by wet chemical methods for radionuclides other than those occurring naturally and ^{144}Ce, ^{137}Cs, and ^{90}Sr, were found. The γ-ray emitting radionuclides were then analyzed for in sections of cores taken from various locations in Lake Erie by direct counting of the freeze-dried sections with a low-background Ge(Li) detector. The levels of ^{90}Sr in the 1 cm. core sections were not distinguishable from background with the present counting system which corresponds to about 0.2 pCi per gram of dried sediment. The distributions of ^{144}Ce and ^{137}Cs in the cores from the western end of Lake Erie were quite different from elsewhere in the lake. The level of ^{137}Cs in the western cores was reasonably constant down to 13 cm. then below this depth it dropped off sharply to zero. In the central basin, however, its level was higher in the first few centimetres but it tailed off at a depth of 6 cm. The behaviour of ^{144}Ce was similar but the levels were lower and the penetration somewhat less. These radionuclides most likely precipitate from the lake water as complexes with organic material, therefore, as nuclear weapons fallout only started to become appreciable from 1959, the 6 cm. in the central basin represents an average sedimentation rate of about 5 mm. per year. It is unlikely that the sedimentation rate in the western part of the lake is twice as high as this, as the two-fold deeper penetration of ^{137}Cs would suggest. It is more probable that the high turbulence in this shallow basin caused by frequent seiches, stirs up the sediment to an appreciable depth.

Neutron activation analysis for oil for trace elements as a means of identifying the source of an oil spill produced results which suggest that trace element "finger-printing" may not be as meaningful as was first thought. A can of Western Canadian crude from a local refinery storage tank was analyzed several times using different sampling methods. It was sampled directly from the container and also after heating the container to 40°C and stirring vigorously. The samples were sealed in quartz vials and irradiated in the McMaster University Nuclear Reactor along with known quantities of the elements being analyzed for. After irradiation the oil samples were transferred from the quartz vials to glass counting tubes and the counting rates of the specific γ-rays from element standard and sample compared to obtain the concentration of the element in the oil. The results in the table show that the concentrations of these elements are very dependent on sampling technique and could cause loss of correlation between spill and source.

Element Concentration (ppm)

Treatment	Co	Fe	Zn	Ni	Cr
Heated & Stirred	0.021	15.6	0.37	6.3	0.16
No Stirring	0.012	<1	0.05	3.9	0.01

This was borne out by analysis of a slick of light fuel oil and a sample from the hold of the tanker which produced the spill at a local loading dock. Preliminary results showed the copper content of the tanker sample to be much higher than that of the slick. Experiments are continuing to determine the effect of water contact on the trace element concentration.

Neutron activation analysis has also been used to trace nearshore sediment movement in the western end of Lake Ontario in cooperation with the Geolimnology Section. Glass containing about 4% antimony was made in 50 Kg batches at the School of Design, Sheridan College, then ground and sieved to produce a product with a similar size distribution to the sediment. About 15 Kg of this material was embedded in the lake bottom about a quarter of a mile offshore where the depth of water was about 7 metres. Periodic core sampling of the sediment on a grid pattern around the spiked glass was done by divers and dried sections of the cores were analyzed for Sb by neutron activation analysis. About 100 mg samples were sealed in quartz vials and irradiated seven at a time along with an Sb standard in the pneumatic carrier facility of the reactor for 5 minutes. The vials were counted unopened for ^{122}Sb after a period of 5 days to allow the preponderant ^{24}Na activity to decay. The limit of detection of Sb using this technique was about 1 ppm which was well above the background level of Sb in the sediment. This was determined initially using a much longer irradiation period and found to be less than 0.1 ppm. About 420 samples were analyzed with the results giving a clear indication of the direction and rate of sediment transport.

Electron Microscopy

Several techniques have been developed to study the external and internal ultra-structure of bacteria isolated

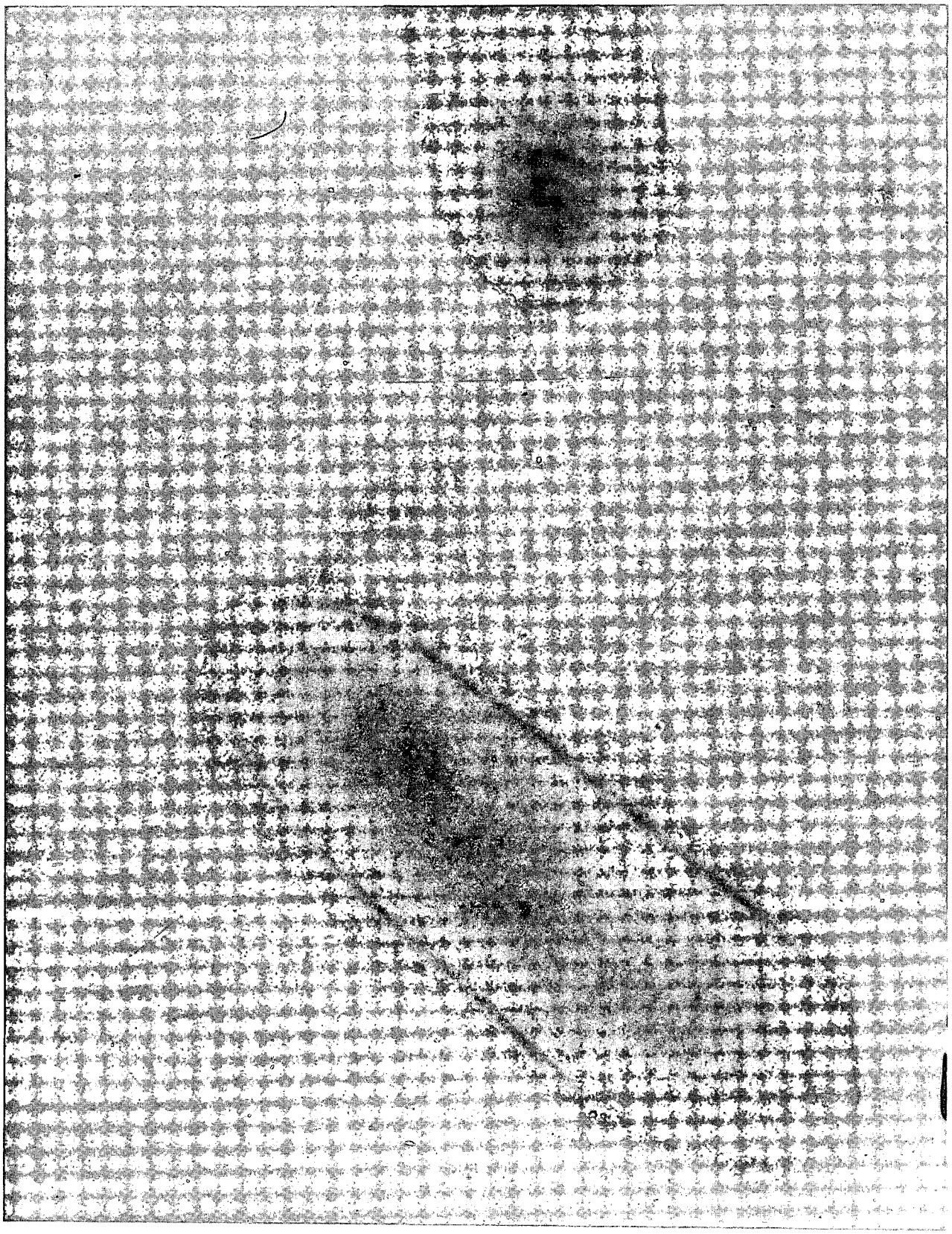


Figure 50. NTA degrading bacteria, negatively stained by ammonium molybdate.

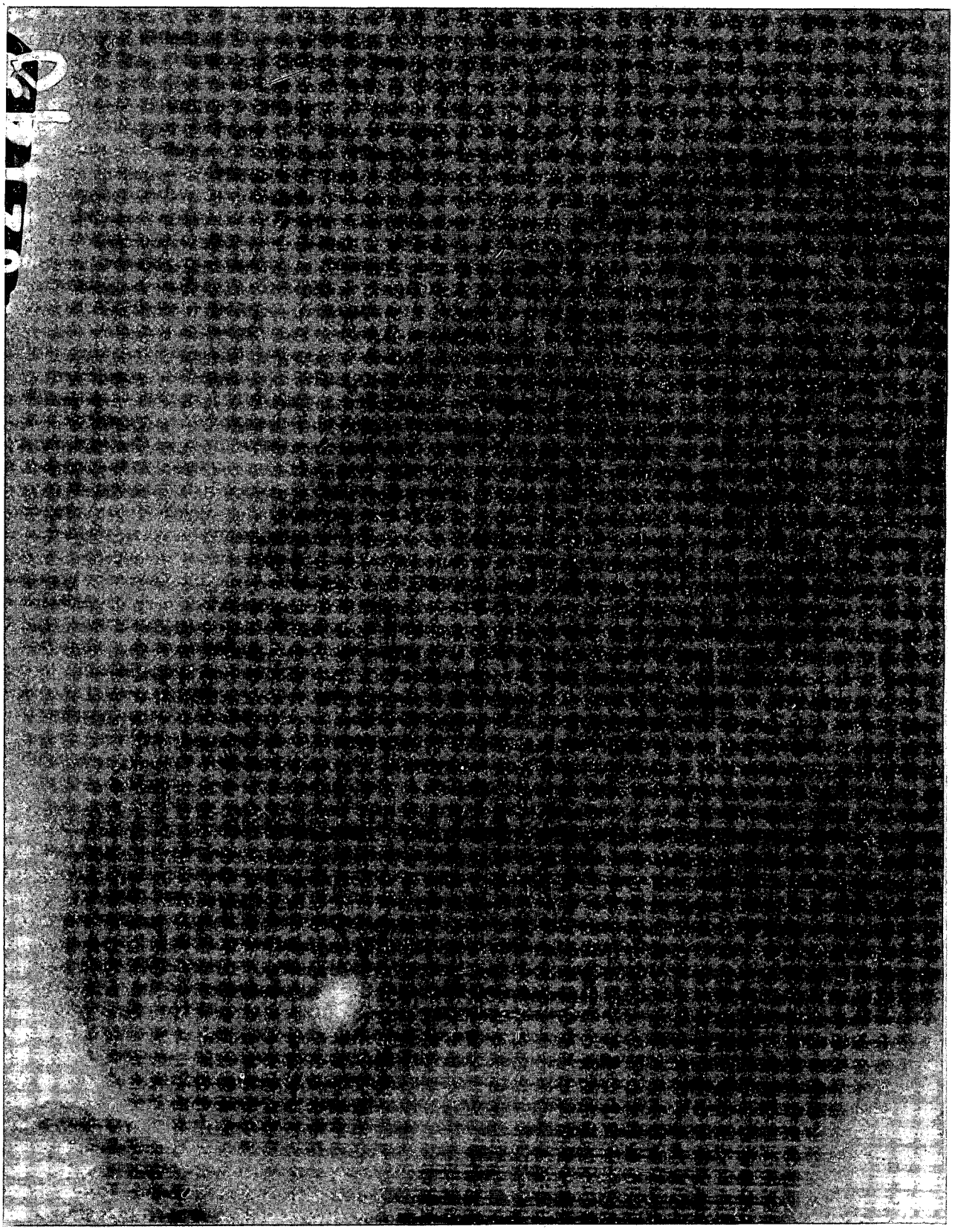


Figure 51. Thin section of NTA degrading bacteria.

from lake water, sediments and soil, and also the crystal morphology and structure of the lake sediments.

Bacteriological Specimens

Negative staining makes use of the principle of surrounding the bacteria with an electron dense material of high atomic number. This procedure preserves the three dimensional structure and the stained bacteria appear as electron-transparent objects against a relatively opaque background. Phosphotungstic acid and ammonium molybdate at 2% concentration and pH 6.0 have been applied quite successfully in the determination of the external features of the NTA degrading mutant (Fig. 50). Other similar bacteria isolates prepared by the Microbiology Section such as those which degrade PCB's have been examined using this procedure.

A thin sectioning technique has been developed to examine the microbial cell wall, internal membranes and the macromolecular aggregates within the cell. It involves sectioning bacteria with an ultramicrotome after fixation, dehydration, staining and embedding in Epon 812 resin. The two aims are to preserve the structure of the cell and to obtain thin sections of the cell between 50 and 100 nm in thickness. This is the optimum thickness for observing this type of specimen with the transmission electron microscope. The technique has been used in the examination of the internal structure of NTA degrading bacteria (Fig. 51).

Sediment Specimens

Particles which are insoluble in water are dispersed ultrasonically in water to form a dilute suspension and a small drop of the suspension transferred to a carbon coated grid. The excess water is removed with filter paper whereupon the particles settle onto the carbon film. With this technique, calcium carbonate precipitates from Kalamalka Lake, British Columbia, have been examined. Figure 52 shows the two main constituents of the sediment which are skeletons of diatoms and calcium carbonate crystals in the size range 0.5 to 5 um. From micro-electron diffraction analysis of individual particles, they were identified as calcite with a hexagonal crystal structure. Their morphological features, which were examined with a scanning electron microscope at the University of Toronto suggested that the calcite crystals at an original crystal surface and by dentritic growth by nucleation of new crystals at an original crystal surface and by dentritic growth with preferred orientations. Aggregation of small crystals into larger units was also observed.

Particles which are soluble in water are dispersed in butylphthalate and embedded in a thin film of formvar. The film is scored and a small section is transferred to a carbon coated grid. The formvar is then dissolved in chloroform and the particles settle on to the carbon film. This method has been developed to examine powdered samples from manganese-iron nodules of Lake Ontario.

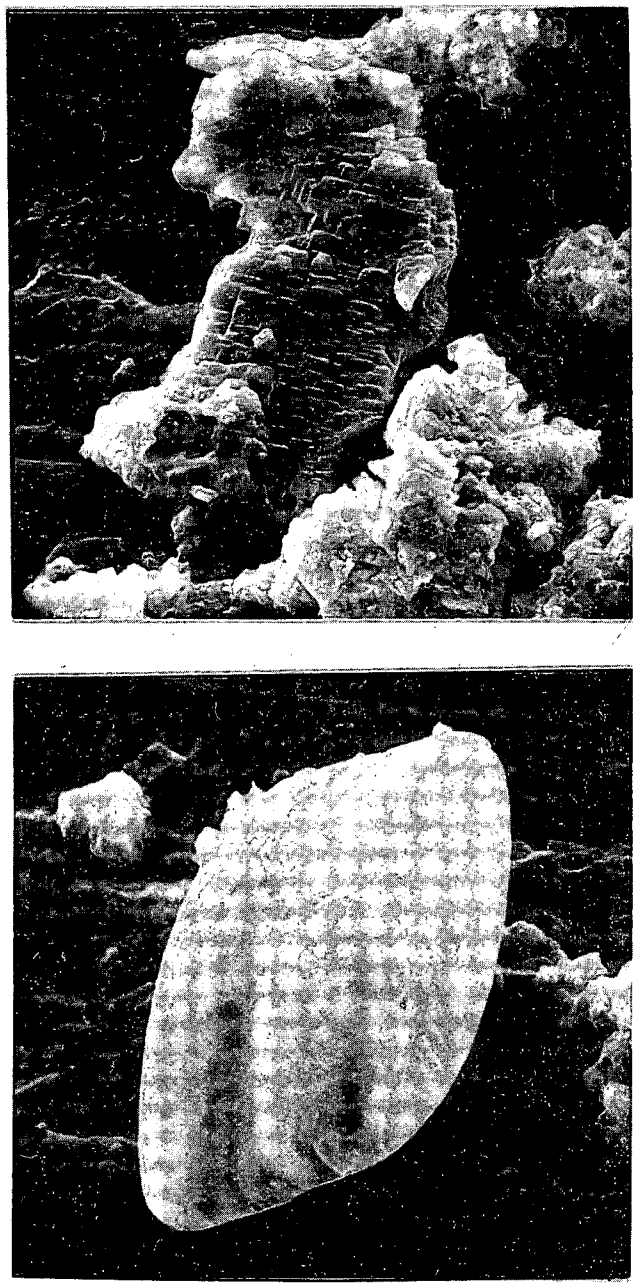
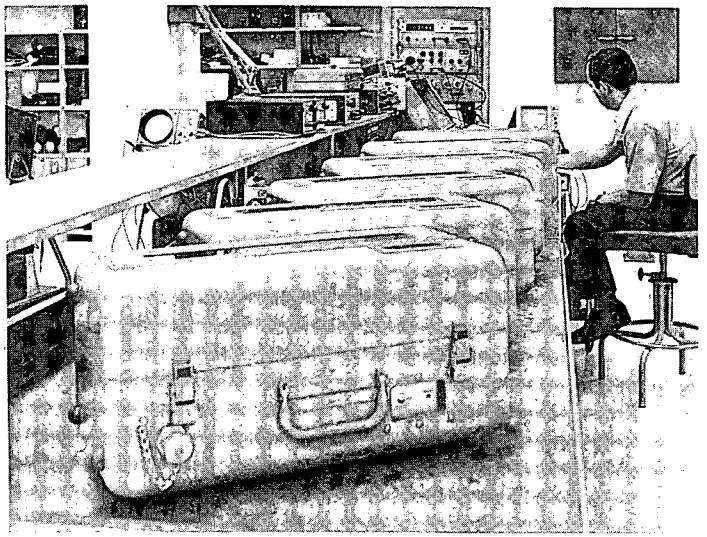


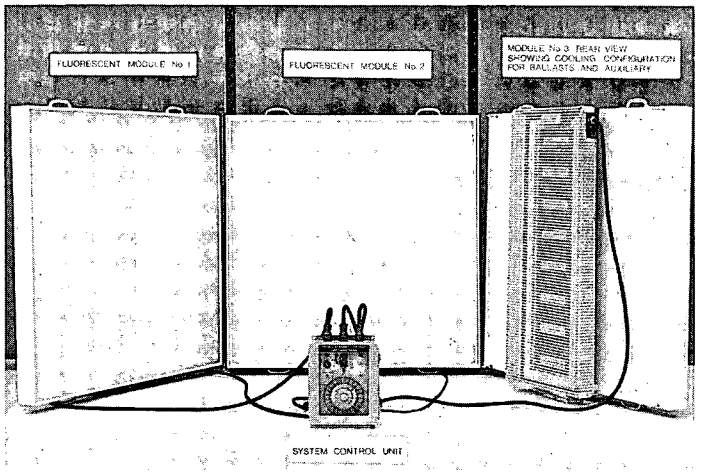
Figure 52. Calcite crystals and a diatom skeleton from sediment of Kalamalka Lake, British Columbia.

ENGINEERING SERVICES

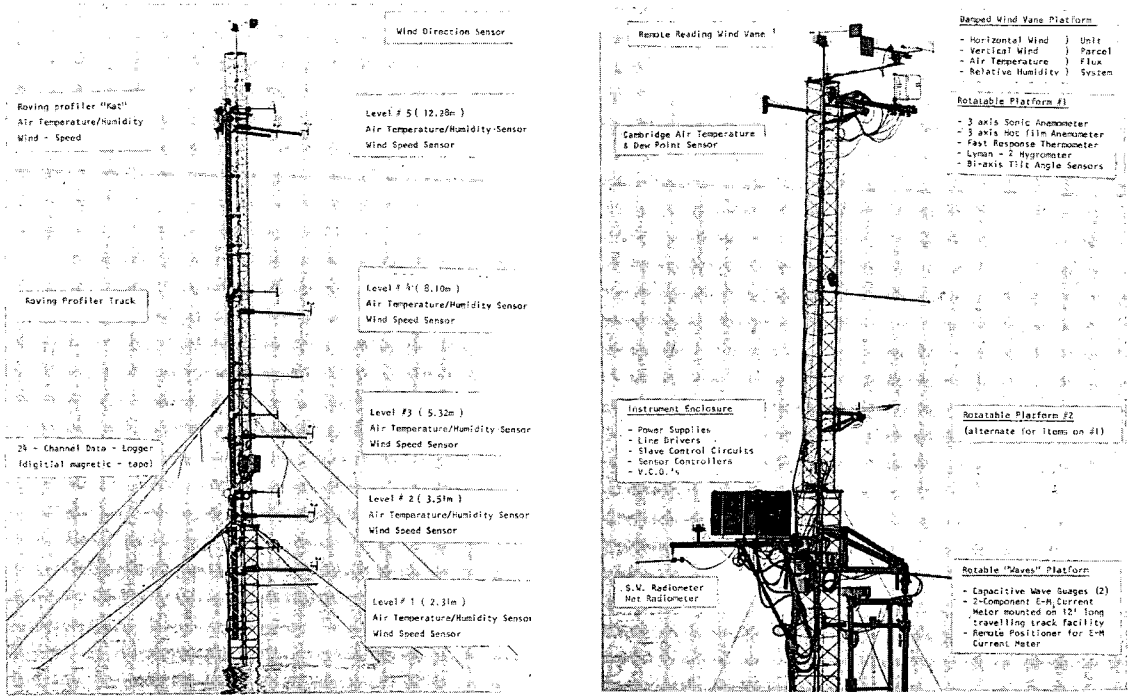
The Engineering Services Subdivision provides engineering support services upon request to all other sections, groups, and divisions at CCIW. These services range from innovative design and development, through various equipment upgrade and improvement programs, to preventive and corrective-maintenance performed on the substantial CCIW instrument inventory. This support includes both electronic and mechanical engineering, technical drafting, and provision of workshop facilities. In 1972, by far the



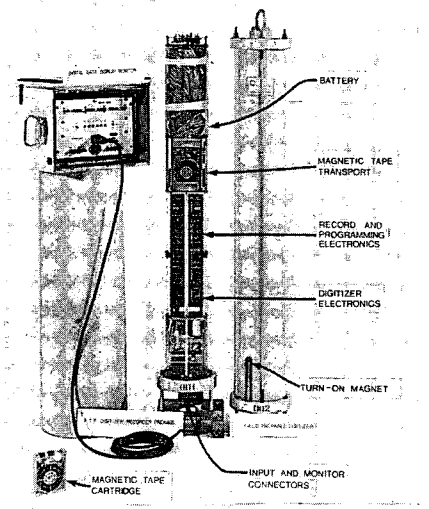
INCOMING INSPECTION ON DIGITAL MONITOR PRINTOUT UNITS MANUFACTURED FOR C.C.I.W. BY CANADIAN ELECTRONICS INDUSTRY



PROTOTYPE AUTO-PROGRAMMED LIGHT-CONTROL SYSTEM DEVELOPED FOR USE IN FISH AND PLANT-LIFE POLLUTION STUDIES



TOWER - MOUNTED ENVIRONMENTAL - SENSOR ARRAYS USED IN LAKE ONTARIO FOR INVESTIGATION OF AIR/WATER ENERGY - INTERCHANGE PROCESSES



ELECTRONIC DIGITIZER FROM THE C.C.I.W. MOORED TEMPERATURE - PROFILING SYSTEM USED FOR LAKE HEAT - BUDGET AND INTERNAL - WAVE STUDIES

Some typical equipments readied for CCIW programs by Engineering Services in 1972.

major portion of these engineering activities were in direct support of the International Field Year for the Great Lakes (IFYGL).

Described below is a summary listing of the major engineering projects, systems, or equipments requiring significant engineering participation during the year, together with a brief description of the support given to each.

Moored Meteorological Buoy Systems

A major IFYGL project was supported by providing some 20 buoys, 20 digital data-loggers, and 120 air and water sensors to maintain 11 buoy-stations in Lake Ontario. Data-logging equipment maintenance and improvements were sub-contracted to Canadian General Electric, digital timers and digital test monitors to EDA Electronics, and much of the sensor calibration to the Atmospheric Environmental Service of our Department in Toronto. Data translated from the metbuoy field tapes totalled over 1 million, with a data-recovery factor of over 90%.

Moored Current-Measuring Buoy Systems

About 80 current meters were provided and calibrated to equip 15 buoy stations in Lake Ontario, with up to 4 current meters per station. Again this work was contracted to Canadian industry, with separate sub-contracts for digital clocks, CMOS modules, low friction swivels, etc. Current meter refurbishments, including those for winter under-ice moorings and subsidiary programs, totalled about 140. With the bulk of the 1972 data tapes translated, a mean data-recovery of 80% on about 1.5 million data points has been obtained.

Shoreline Temperature Stations

Complete instrumentation systems for seven shore stations were engineered and extensive field support was provided during 1972. This equipment included spar buoys, cables, surface and bottom temperature sensors, analog chart displays, and some phoneline telemetry facilities. Notwithstanding problems from dredging, radio frequency interference, lightning, and major shoreline erosion during storms, a satisfactory degree of data-recovery was achieved for the IFYGL.

Micrometeorological System

This extensive barge and tower mounted instrumentation system, used as a component of the IFYGL Boundary-Layer Program, received major engineering support in 1972. Design, development, fabrication, assembly, test, and calibration services were provided to each of its three major sybsystems: the Integrated-Flux, Air/Water Turbulence, and the Wind-Profiling subsystems. A total of about 50 environmental sensors were involved, with three main data-acquisition systems storing meteorological data on magnetic or punched-paper tape, and all mounted on a barge and two towers. The towers required extensive modifications to accommodate the instrumentation and a roving probe was developed for the Profiling Subsystem. This probe consisted of an anemometer, an air temperature sensor, and a relative-humidity sensor, all of which were identical to those located at five fixed levels in the subsystem. The carriage for the probe was an automated welding carriage, modified to accommodate the instruments and suitably weatherproofed. The probe stopped automatically at each sensor level long enough to record two or three sets of data. In this way, data from all sensors were compared to a common set and the subsystem thus was self-calibrating.

Rotatable supports were built to hold direction-sensitive instruments for the Turbulence Subsystem, such as the sonic anemometer and hot wire anemometers. These platforms on the towers were rotated by T.V. antenna rotors controlled remotely from the nearby barge, where a readout enabled the sensors to be pointed in any desired direction.

A rotatable support was also built to hold two wave probes and an electromagnetic current meter. This support was rotated by a heavy duty T.V. antenna rotor which was remotely controlled so that the support could face into, or away from the waves. The frame that held the current meter was vertically operable from the barge, so that the current meter could be set at any depth in the water between zero and ten feet. Other work included remotely operable rain shields for two hot wire anemometers and one Lyman α humidity sensor.

The Flux Subsystem required that two wind vanes and one self-aligning Thornethwaite Flux Meter have heavy damping, but also be capable of reacting to low wind velocities. This was resolved by attaching each wind vane to a dashpot filled with silicone oil; inside each dashpot were two modified model aeroplane engines at 90° to each other. An eccentric bearing attached to the wind vane shaft actuated each piston, which pumped the oil through a controlled orifice. For low turning speeds the wind vane had negligible torque resistence, but as the speed increased the pressure inside the engine cylinder increased giving progressively greater damping.

Moored Temperature-Profiling Buoy System

Again significant design engineering was provided to these 18 channel, automatic, temperature-data-acquisition systems, four of which were maintained on station during the Field Year. Performance of the 120 system sensors, the five electronic digitizers, and the buoy moorings was most satisfactory during the year. Cable flexing problems was the major contributing factor to the 70% data-recovery for this system, however, extensive new time-series scientific data were obtained with this equipment.

Electrobathythermograph (EBT) Systems

A total of 14 systems were procured, installed, calibrated, and maintained during 1972 for a variety of the IFYGL programs. Platforms used were major ships,

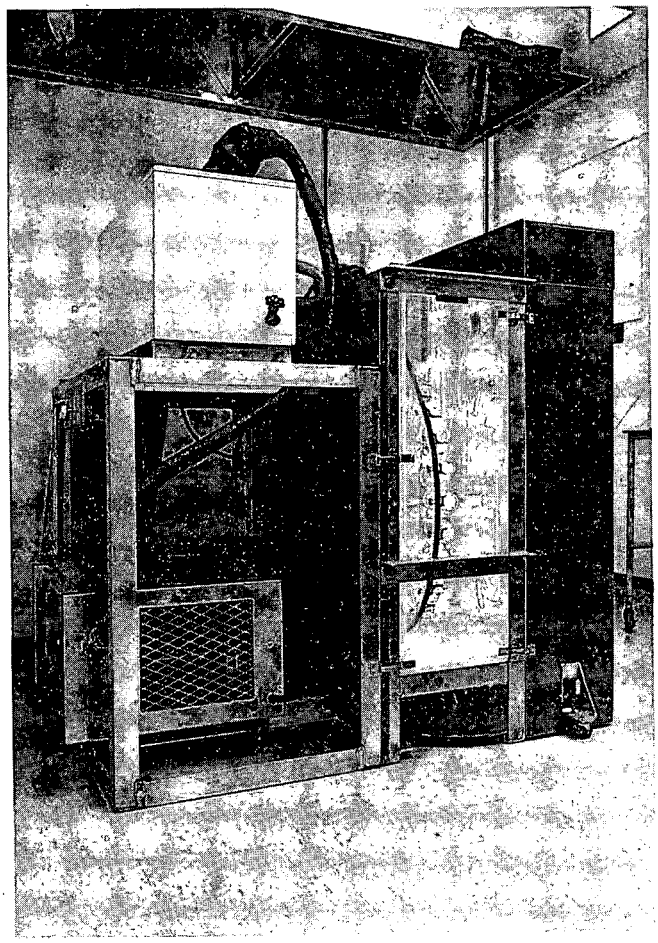


Figure 53. C-14 Incubator.

launches, the "Batfish" towed body, and a pumped sampler. System engineering responsibility embraced the temperature/depth probes, armoured cables, winches, winch control units, sliprings, probe calibration units, and X-Y displays. Several thousand detailed and valid lake-temperature profiles were generated with these equipments.

Towed Temperature-Profiling System (Thermistor Chain)

Engineering support provided for this important data-gathering system included the specifying and procuring of the special 13-channel, multi-conductor, two-cable assemblies, specifying and manufacturing a large, hydraulically-operated "A" frame with special shock absorption, and a special towing winch, as well as providing the sensor calibration services.

Fishtank Light-Control System

In support of CCIW biological studies, a transportable, autoprogrammed fluorescent light-dimming system was developed and tested successfully. This unit simulates the natural light cycles, required for certain biological studies. Similar units are being manufactured by a Canadian industry now for some of our other light sensitive environmental projects.

Sediment Settling-Tube Pressure-Recording Facility

Two such systems for monitoring sediment settling characteristics were investigated, designed, installed and calibrated for geolimnology work during 1972. These systems are unique in that the extremely small (submillimetre) differential pressure-heads involved require an unusually sensitive and stable transducing system.

C-14 Incubator

Following a successful year with a C-14 incubator aboard the Martin Karlsen, a revised version has now been completed for laboratory use; see Figure 53. This new apparatus will be used to determine the effects of nutrients and toxic materials upon different algal cultures or upon the biota in lake water. The samples are first innoculated with carbon 14-labelled sodium carbonate and then exposed to high intensity fluorescent light for several hours, filtered, and the collected residue is measured for take up of carbon 14 by means of a liquid scintillation counter.

The new C-14 incubator consists of a slowly rotating disc to which are attached the sealed sample bottles. The disc stands in a bath of continuously re-circulating freshwater which is temperature controlled to within +0.5°C, while exposed to high intensity fluorescent lights.

Support to Water Quality Branch

During 1972 engineering support was provided to Water Quality Branch, Ottawa in respect of network telemetry conversion methods; water quality network teleprinter problems; dissolved-oxygen recording systems; and auto-analyzer/printout facilities. Reviews commenced late 1972 into such aspects as sensor technology, data-acquisition and formatting, and platform selection, aimed at establishing areas where effective contributions can best be made.

Maintenance, Repair and Calibration of Instrument Inventory

As in previous years, a large portion of our support to research programs at CCIW was in the form of maintenance of the substantial amount of instruments and equipment, totalling more than 1,000 items. This inventory, which is effectively common-user in application, now comprises over $1 M in electronic test equipment, and over $1 M in conventional environmental sensing instruments.

To service, maintain, and improve these items, approximately 500 Work Order Requests were actioned, encompassing preventive maintenance, fault diagnosis, detail improvements, and calibration. Approximately $200,000 in maintenance-type contracts were placed with Canadian industry, exclusive of extensive special-spares purchase and provision of an electronic and mechanical

hardware components and stock system for general CCIW use.

Assistance to Hydraulics Division

In the areas not covered by previous contracts, Engineering has assisted the Hydraulics Division by designing and installing large baffle units for the flume header tanks, flow diverters between header tanks and volumetric tanks, and ducting, valves, diffusers, etc. for the 1 meter and 2 meter tilting Flumes. In addition, the complete design of a 104 feet long tilting re-aeration flume was done by Engineering. This flume is a recirculating type with a 60 cm wide trough and is to be used for research into the process of atmospheric re-aeration in open channel flow. It is under contract for manufacture to Canadian industry.

COMPUTER SERVICES

The Computer Services section has the responsibility for planning, implementing and operating the major electronic data processing systems and hardware at CCIW and for providing the Canadian portion of the IFYGL Data Bank. Two units comprise the section: (1) a Computer Applications Unit, which develops and maintains computer software, provides consulting services, provides data management services, and operates the Canadian IFYGL Data Bank, and (2) a Computer Systems Unit, which provides systems software services, and which schedules and operates the hardware computing and keypunch facilities at the Centre.

The Computer Systems Unit operates and maintains a variety of computer systems, the largest being the Control Data 3300, which carries the major load of computing done at CCIW. This system was delivered on January 28, 1972, switched on January 30, 1972 and, after 3 days of testing, the initial version of the Mass Storage Operating System (MSOS) was installed on February 3rd. During February, extensive system software was developed to adapt the operating system to CCIW's requirements. On March 1, the 3300 system became fully available to the user, and has been operating on a 5-day week, with the exception of June 1 - 5, when the Disk Storage Subsystem was changed.

During 1972, a total of 19,416 jobs were run on the system, which utilized 842.1 computer hours, and required the mounting of 6,686 magnetic tapes. The loading on the machine increased from 1,150 jobs requiring 46.7 hours in March, to 2,390 jobs and 110.0 hours in December.

System software development continued throughout the year and by the end of 1972, 20 successive editions of MSOS had been installed, each containing improvements and/or corrections to the previous editions. In addition, several programs and subprograms, such as a package for programming the CALCOMP plotter, have been made available to the user community.

In addition to the Control Data 3300, the section has a DEC PDP-8 system used to reformat instrumentation data tapes to "computer compatible" magnetic tape. A larger PDP-15 equipped with two magnetic tape drives, disc storage, an interactive graphics system and a CALCOMP drum plotter, is used for special applications such as analog to digital conversion, contour and other displays, data quality control, and experimental programming and processing techniques.

Terminals to off-site computers also were utilized for numerical models and special data management processing. The high-speed and large capacity Control Data 6600 at Multiple Access Ltd., Don Mills, Ontario, was used for these purposes. During the transition period to the on-site 3300 computer system, the Control Data 6400 at McMaster University was used as the major computer, but was phased out completely by July. Teletype terminal services to COMSHARE Ltd. Sigma-7 was available for interactive programming.

For all of the computer systems, a total of 32,200 jobs were run in 1972, up from 16,000 in 1971 (or an increase of 101%). This compares with 9,100 jobs in 1970, 6,800 in 1969, and 1,300 in 1968.

The Computer Applications Unit's responsibilities in detail include: (1) the provision of consultative services to users; (2) the provision of reference facilities to users; (3) the preparation of software on request by scientific and technical staff; (4) to anticipate, and plan future software needs; and (5) to develop software systems used in analysis and large-scale data base management. In addition, the unit has the responsibility for the Canadian International Field Year for the Great Lakes Data Bank, which has a counterpart in the U.S. Federal Government (National Oceanographic and Atmospheric Administration). The latter responsibility entails data management, software development, and development of new systems, methods and procedures.

During the year, a total of 34 projects were carried out, including the IFYGL Data Bank which continued over the whole year, and will continue into 1973. The other projects ranged from a short one of two weeks duration to develop a small analytical program, to one lasting four months dealing with biological-chemical modelling.

The STAR (Storage and Retrieval) software system for handling shipboard data was updated, as was the TSAR (Time Series Storage and Retrieval); both of these systems being developed in 1971. Analytical programs for standard statistical and time series analysis were developed, or modified, and are a continuing project. The major single thrust of software systems development occurred for the Canadian IFYGL Data Bank, where programs and systems were designed and developed to convert, reformat, file, and retrieve IFYGL data, which will comprise about 400-500 million characters of information.

LIBRARY

The collection consists of 9,000 books, 900 journals and related abstracting services, and 250 report series. A computer index to these reports is available and includes all those received up to the end of this year. During the year, 51 translations were made for CCIW staff members; 2,170 Inter-Library Loans were obtained; and 470 of our items were loaned to other libraries. It is estimated that an average of 120 persons use our library daily.

Several searches were made of National Research Council's (NRC) computerized data base "Pollution Information Project" to obtain information on such subjects as trace elements, viruses in water and toxic effects of chemicals on aquatic life. In addition, several new computer profiles were submitted to the various data bases in NRC's CAN/SDI current-awareness system.

With the development this year of the WATDOC information retrieval system within Water Management Service, all of CCIW's publications are now included in this system. Likewise they were submitted to the U.S. Water Resources Scientific Information Service for inclusion in *Selected Water Resources Abstracts.*

The library staff continued to produce *Collected Reprints,* acquisition lists and the other listings mentioned in previous annual reports.

TECHNICAL SERVICES

Permanent occupancy of the remaining buildings was completed during the year as staff moved into the first and second floors of the Administration and Laboratory Building in January, the remaining portion of the building was occupied early in May, and the Hydraulics Laboratory and offices were occupied in August.

All phases of the construction program are now complete, including outside signage, landscaping, and the removal of the trailer complex; the trailers were sent to various locations in Canada, such as Vancouver, Halifax, Ottawa and Sault Ste. Marie for use by other staff of our Department.

Other support services such as drafting and illustrating, security and maintenance of the buildings and property were supplied throughout the year, and a good start has been made on setting up a common-user stores system for the Centre.

Public Relations and Information Services

Public relations may appear to some an unlikely activity to associate with government-sponsored scientific research in an institution such as the Canada Centre for Inland Waters. In fact, however, relating the Centre's work and achievements to the taxpaying public and relating that public and its concern back to the management of the Centre is as vital a process as the research and surveys conducted there.

In 1972, the general public and the news media continued to demonstrate the truth of this. Following the Centre's Open House invitation in May, a total of more than 13,400 visitors came during the year to the CCIW to hear about the problems of modern fresh water management and the Centre's contributions to the growing fund of scientific knowledge of the subject. The Centre's official opening by the Minister was widely covered by both press and broadcast media. Throughout the year, newspapers, magazines, radio and television stations willingly accepted or sought invitations to news briefings, conferences and interviews so as to expose the latest findings of our scientists, surveyors and engineers.

With an Information Officer added to the staff and further augmented by student helpers during the summer, the Public Relations Unit considerably improved its capacity to meet this demand with proper response and to generate initiatives of its own.

A major challenge was the organization of the official opening of the Centre in May. Hard work and a team spirit enabled this small group to arrange effectively the hundreds of details inherent in such an occasion and to still experience the satisfaction and excitement which made it memorable.

Another auspicious occasion in which the Unit was deeply involved was the official opening of the International Field Year for the Great Lakes. This event was one which nearly turned out to be too memorable as a playfully gusty wind from Hamilton Bay tried several times to carry a symbolic weather balloon together with its hard-pressed anchor man aloft, prior to the ceremonial moment.

The Okanagan Basin Study, perhaps the finest example yet of democratic public involvement in water management decision-making, was also a project in which CCIW scientists made significant contributions. The Centre's Public Relations Officer was asked to assist and spent several weeks in Vancouver and the Okanagan helping with the public involvement aspects.

The year 1972 also saw the inauguration of the annual CCIW Science Cruise Awards. Arranged in conjunction with the Hamilton Spectator and McMaster University, this award consisting of a cruise of several days duration aboard one of the major research vessels based at CCIW were presented to six students from the Burlington/Hamilton area who had made prize-winning contributions to the annual Hamilton Science Fair.

A permanent exhibit was designed, built and installed at the Centre to become the focal point for visiting members of the public. To this was added a demonstration laboratory which by year's end was well on the way to completion.

Another innovation was the creation of CCIW News-Notes - brief, informative descriptions of new scientific undertakings at the Centre - sent to a list of nearly 100 scientific and technical publications in North America and Europe.

Finally, the Centre's public relations programme included a series of over 50 outside speaking engagements. Scientists, engineers and staff of the Public Relations Unit spoke to average audiences of 30 - 40 people reaching a year-end total of more than 2,300 interested listeners whose invitations to us had been prompted by their interest in, and concern for water.

Environmental Quality Coordination Unit

The Environmental Quality Coordination Unit (EQCU) coordinates the results of research from two or more components of CCIW with research results produced by groups elsewhere, in a form designed to assist in the establishment of policies and action programs of the Department of the Environment and other water management agencies in Canada. EQCU assists in the dissemination of research results to water management agencies in Canada in a form which may be readily converted to action programs and public policies by these agencies. In addition, EQCU provided technical input to a national contingency plan for fresh water regions; contributed to the development of the Canada-U.S. Agreement on Great Lakes Water Quality, and to the subsequent International Joint Commission activities called for under the Agreement.

EQCU continued its active role on contingency plans for combatting oil and other toxic material spills, both in the Great Lakes region and internationally. The Unit provided liaison for the Ontario Contingency Plan Coordinating Committee, provided the Chairman for the Technical Working Group of the Federal Contingency Plan, the Chairman for the CCIW Task Force on Spills of Oil and other Toxic Materials, and represented CCIW as a member of the local Hamilton Harbour Spill Control Group. These activities were assumed by the Environmental Protection Service in the latter part of the year.

The problem of nutrient control, and particularly the substitution of phosphates in laundry detergents continued to be an active topic for much of the year. Continuing coordination was provided by EQCU for the research program associated with these substitutes. In March a major meeting was called to review the results at that time of the various governmental and private sector research programs including the Canadian monitoring program for NTA in the environment. This meeting included representatives from the detergent manufacturing and related industries, and Canadian and United States government agencies. On the basis of this information which included the completion of most of the in-house programs as well as the successful completion of a monitoring program for NTA in the environment, a position paper was prepared. The decision was later taken by the Minister to decrease further the phosphorus content of detergents to 5% (as P_2O_5) beginning January 1, 1973, and to continue monitoring NTA and other detergent phosphate substitutes and their environmental effects.

As a result a plan was prepared for a national, large scale, monitoring program for detergent phosphorus substitutes and other substances, and is an extension of the previous environmental NTA program, but with the addition of samples from drinking water supplies. Input was provided to this program from industry and government personnel and implementation was initiated late in November. The operational portion of this program is now the responsibility of the Water Quality Branch; however, EQCU will continue to assist in the preparation of reports on the levels of NTA and other detergent phosphorus substitutes in the environment and their significance.

EQCU participated in working groups involved in drafting the Canada-U.S. Agreement on Water Quality in the Great Lakes in support of the Canadian negotiating team. This landmark Agreement was signed on April 15 of this year. The Unit coordinated the preparation of a major report which provided the basis for the phosphorus load reductions to Lakes Erie and Ontario required by the Agreement. In addition, a brief report was prepared assessing the adequacy of proposed U.S. programs in general and, more specifically, the adequacy of the total phosphorus control program in the Lake Erie Basin to reduce the eutrophication problem and to meet the IJC Report recommendations. Additional activities concerned the preparation of press briefings and notes about the Agreement, and also the design of a semi-permanent display for the official opening of CCIW which depicts the application of science activities to water management through this international agreement. This display traces the progress of activities which led up to the Agreement including the IJC studies and the Canada-Ontario Agreement on Great Lakes Water Quality.

EQCU was actively involved in the Canadian implementation activities associated with the Agreement, through the provision of support to the Director who was named to the Interdepartmental Committee on Water's Subcommittee concerned with implementation, and through participation in the development of submissions to Treasury Board for resources to carry out the various studies and other activities required by the Agreement.

EQCU has, for a number of years, been extensively involved in IJC activities. With the signing of the Great Lakes Water Quality Agreement additional activities were generated with a number of personnel from CCIW and Inland Waters Directorate, Ottawa, being named to the various Boards and Reference Groups which were established. EQCU is providing the technical secretariat for the

Canadian Co-Chairmen of the Great Lakes Water Quality Board, the Research Advisory Board, the Land Drainage Reference Group and the Upper Lakes Reference Group. EQCU staff serve on the Editorial Committee and other working groups of the Great Lakes Water Quality Board.

A report was prepared for the IJC Water Quality Board on Polychlorinated Biphenyls (PCB's) in the Great Lakes environment. The report consolidated information from several U.S. states, the Province of Ontario and the work carried out at CCIW. In addition, a literature survey was completed summarizing information on environmental and health effects and on analytical methodology.

EQCU continued to coordinate the pesticide surveys and organochlorine residue surveys in the Lower Great Lakes during the year. Two additional cruises, one in Lake Ontario and another in Lake Erie were made to obtain plankton samples for PCB and pesticide analysis. An interim report on the pesticide survey which included all available information on PCB's was completed.

EQCU also participated in the activities of the Technical Committee established under the Canada-Ontario Agreement on Great Lakes Water Quality. The principal activities concerned the administration of external research contracts awarded under provisions of this Agreement and the development of suitable publication policies. These policies are designed to ensure that the information produced both by the in-house (Canada and Ontario) and external research activities will be effectively put into practice both by governmental agencies and by the private sector, particularly in the design of wastewater treatment facilities required as a result of the Agreement.

EQCU continued to represent CCIW on a number of interdepartmental committees, carried out a number of international functions pertinent to the work at CCIW, and carried out extensive information programs through the giving of talks and papers at a number of conferences and symposia throughout the year.

CCIW Staff List

CCIW

Director, CCIW & Director, Ontario Region, Inland Waters Directorate – J. P. Bruce
Secretary – Mrs. C. J. McMunn

Finance and Administration

Head – J. Aris (Acting), Finance – E. Warren

Support Staff – Mrs. E. Rae, Mrs. I. Brown, Mrs. S. Ferguson, Mrs. B. Adamczak, E. Mulvaney

Personnel Administration – Miss R. M. Kelly, Mrs. M. Duggan, W. B. Christopher, M. Phillips, Mrs. C. Shepherd, Miss M. R. Warren

---

INLAND WATERS DIRECTORATE RESEARCH COMPONENTS

HYDRAULICS DIVISION (INLAND WATERS DIRECTORATE)

Chief – Dr. T. M. Dick
Secretary – Mrs. E. Gervais
Administration & Accounts Clerk – Mrs. E. Eidsforth
Dr. Y. L. Lau – fluid dynamics
J. Marsalek – waves, combined sewers
Dr. C. K. Jopys – sediment
Dr. M. G. Skafel – simulation
Dr. G. Tsang – ice and cold

Hydrometry Unit

Head – P. Engel
Technical Staff – C. Bil, B. Leaney, D. Wagner

Technical Services Unit

Head – C. DeZeeuw

Technical Staff – D. Fekyt, Miss J. Boote, J. Cameron, J. Compton-Smith, W. K. Stage, G. Voros

LAKES RESEARCH DIVISION (INLAND WATERS DIRECTORATE)

Chief – Dr. R. A. Vollenweider
Secretary – Mrs. S. M. Horne

Administration

Head – J. E. Aris
Secretary – Miss N. Taylor
Support Staff – D. Jefferson, F. Boyd

LAKES RESOURCES SUBDIVISION

Head – Dr. R. K. Lane
Secretary – Mrs. M. Stapleton

Descriptive Limnology Section

Head – F. C. Elder
Secretary – Mrs. S. Fauman
Dr. E. B. Bennett – circulation
Dr. N. M. Burns – nutrient cycles, especially particle settling in lakes
Dr. R. P. Bukata – remote sensing
C. H. Chan – chemistry in the lakes
H. H. Dobson – nutrients and water quality
H. W. MacPhail – electronics, satellite data retransmission
M. T. Shiomi – atmospheric precipitation chemistry; nutrient cycles in large lakes
Dr. B. E. St. John – trace element geochemistry
Dr. K. P. B. Thomson – remote sensing
Support Staff – G. Bengert, R. Chapil, F. Chiocchio, K. Kuntz, W. McColl, D. St. Jacques

Data Processing and Display Section

A/Heads – D. G. Robertson, D. J. Williams

Staff – J. Bond, R. Gottinger, D. Jordan, J. McAvella, W. Nagel, K. Schopf, G. Smith

Regional Laboratories (Freshwater Institute, Winnipeg)

B. C. Kenney – physical limnology
Dr. T. Jackson – geochemical limnology
Technical Staff – J. Mollison

GEOPHYSICAL LIMNOLOGY SUBDIVISION

Head – Dr. P. G. Sly – distribution and variance of lake bottom sediments
Secretary – Mrs. J. E. Cunningham

Geolimnology Section

Head – Dr. R. L. Thomas – distribution, occurrence and anthogenesis of minerals, major elements and heavy metals

in recent sediments
Dr. T. W. Anderson (GSC) – Palynology of recent sediments
J. P. Coakley – distribution, occurrence and relation to erosion, transportation and deposition of active sediments
Dr. C. I. Dell – stratigraphic correlation and mineralogy, including clay mineralogy, of recent sedimentary sequences
J. B. Henry – geophysical characteristics of unconsolidated sediments
Dr. N. A. Rukavina – interpretation of sediment distributions in the nearshore area
W. Warwick (educational leave) – palaeo ecological interpretation of chironomid fauna
Dr. C. F. M. Lewis (recalled to GSC Ottawa) – post-glacial uplift and stratigraphic correlation of recent sediments
Technical Staff – W. Booth, G. Duncan, J. Horseman (GSC), G. LaHaie, Mrs. L. Mansey, T. Morton, R. Sandilands

Physical Limnology Section

Head – F. M. Boyce – internal waves and heat content
Dr. J. O. Blanton – thermal structure and demonstration basin studies
Dr. M. A. Donelan – air/lake interaction
Dr. P. F. Hamblin – circulation and seiches
Dr. C. R. Murthy – diffusion and circulation
H. Ng – Okanagan Basin studies and retention times
Dr. T. J. Simons – hydrodynamical modelling
Technical Staff – D. Beesley, K. Miners, W. Moody

BIOGEOCHEMICAL LIMNOLOGY SUBDIVISION

A/Head – Dr. M. G. Johnson – eutrophication, nutrient budgets
Secretary – Mrs. R. E. Morrison

Geochemistry Section

Head – Dr. M. E. Thompson – specific ion electrodes, low temperature aqueous geochemistry
C. B. J. Gray – diagenesis of recent organic compounds, especially chlorophyll
Dr. A. L. W. Kemp – distribution and diagenesis of organic compounds in recent sediments and sedimentary rates in geochemical budgets
Dr. J. O. Nriagu – stable isotopes of sulfur; stabilities of authigenic minerals
Dr. R. R. Weiler – CO_2: air/lake interactions; sedimentary geochemistry
Dr. J. D. H. Williams – sediment/water interface exchange, geochemical processes in sediments
Technical Staff – R. D. Coker, Mrs. N. Harper, Mrs. A. Mudrochova, Mrs. T. Mayer

Environmental Impacts and Developmental Chemistry Section

A/Head – Dr. R. F. Platford – physical chemistry of aqueous solutions
Dr. Y. K. Chau – trace elements and natural complexation in lakes
Dr. D. R. S. Lean – phosphorus dynamics in lakes
Dr. E. Nagy – oil/water studies
Dr. W. M. J. Strachan – organic chemistry applied to lakes
Dr. P. T. S. Wong – degradation of new substances by bacteria
M. E. Fox – organic compounds in water
K. Lum-Shue-Chan – trace elements and complexation reactions in lakes
H. Saitoh – trace elements, especially mercury compounds in lakes
Technical Staff – J. Hart, Mrs. L. Luxon

MICROBIOLOGY SUBDIVISION

Head – B. J. Dutka – water quality assessment, parameter development
Secretary – Mrs. M. Jurkovic
Dr. D. L. Liu – hydrocarbon degradation, sediments, detergent degradation
Dr. P. T. Wong – sanitary microbiology, detergent degradation, PCB degradation
H. R. van Otterloo – Great Lakes studies
A. S. Menon – field bacteriologist, paper mill studies
Laboratory Supervisor – J. B. Bell
Technical Staff – A. A. Jurkovic, Miss N. C. Cameron, Mrs. D. E. Doerffer, W. K. Bedford, S. R. Kuchma

TECHNICAL OPERATIONS SUBDIVISION

Head – H. B. Macdonald
Secretary – Mrs. R. Wolkowski
Senior Operations Officer – D. J. Cooper
Senior Diving Officer – J. T. Roe
Operations Officer, M. V. "Martin Karlsen" – D. H. Hanington
Operations Officer, C.S.S. "Limnos" – D. J. Brooks
A/Standards and Development Officer – D. J. Williams
B. E. Clemmens – seconded to Lakes Research Division
Riggers – H. Greencorn, L. J. Lomas, G. M. Perigo
P. R. Youakin – IFYGL Centre, special projects
L. E. Benner, W. B. Taylor – meteorological buoy program
T. J. Carew – dye diffusion program
H. K. Cho – Lake Erie shore erosion, Hamilton Beach study
M. R. Mawhinney – Niagara Bar program
H. K. Nicholson – shore sensor program
P. M. Healey, S. B. Smith – "Limnos"
S. P. Whithers, B. H. Moore – "Martin Karlsen"
F. H. Don, J. E. Ross – "Limnos and Martin Karlsen", diving
"Limnos and Martin Karlsen" – F. J. deVree, R. D. Hore, J. R. Irwin, G. J. Koteles, M. R. Thompson

SOCIAL SCIENCE RESEARCH SECTION (INLAND WATERS DIRECTORATE)

A/Head – J. L. Pando – economics of water resources and water management
Secretary – Mrs: R. Riggs
G. Bangay – water use and environmental quality in the Great Lakes Basin
B. Lymburner – environmentally hazardous materials
R. Shimizu – institutional studies
Ms. M. Sinclair – perception and attitude studies
J. N. Thomson – economics of environmental quality

WATER QUALITY BRANCH RESEARCH (INLAND WATERS DIRECTORATE)

ANALYTICAL METHODS RESEARCH SUBDIVISION

Head – Dr. S. Barabas
Scientific and Technical Support – Dr. B. Afghan, P. Brooksbank, M. Comba, Dr. P. D. Goulden, R. Larose, J. Lechner, J. Ryan, R. C. J. Sampson, Dr. I. Sekerka

WATER AND WASTEWATER TREATMENT RESEARCH SUBDIVISION

Head – Dr. C. P. Fisher
Secretary – Mrs. S. Jones
Dr. Barry Oliver – laser use and heavy metals
Dr. A. Netzer – absorption and complexing
Dr. Kirk Johnston – reverse osmosis

ENVIRONMENTAL PROTECTION SERVICE

TECHNOLOGY DEVELOPMENT AND DEMONSTRATION DIVISION

A/Head – Wastewater Technology Centre – N. W. Schmidtke
Secretary – Mrs. V. Westaway

Process Development Section

Head – N. W. Schmidtke
Physical Processes Unit – Dr. B. P. Le Clair
Biological Processes Unit – Dr. B. Jank
Chemical Processes Unit – Dr. E. E. Shannon
Soil Processes Unit – Dr. V. K. Chawla

Demonstration Section

Head – R. E. Mills

Laboratory Services Section

Head – K. Conn

Facilities Services Section

A/Head – A. D. Stephenson

Administrative, Scientific & Professional and Technical Support Staff – G. Anthony, W. Bedford, N. Bryant, V. Cairns, H. Campbell, P. Crescuolo, J. L. Fraser, Dr. P. Guo, D. Ide, Dr. J. Kucharski, Mrs. K. Kwasniewska, E. Ladouceur, G. Lawrence, Dr. D. Liu, B. Monaghan, R. R. Nair, D. M. Niles, Miss I. I. O'Connor, Mrs. S. Perrone, J. P. Stephenson, R. Stickney, L. J. Trip, D. Vachon, Mrs. R. L. Verrdonk, Mrs. M. Wilson

ENVIRONMENTAL EMERGENCY BRANCH

Environmental Emergency Coordinator, Ontario Region – N. Vanderkooy

Hazardous Material Spill Countermeasures Unit

Head – Dr. S. L. Ross

GREAT LAKES BIOLIMNOLOGY LABORATORY (FISHERIES RESEARCH BOARD)

Head – Dr. M. G. Johnson
Secretary – Mrs. D. Moore
Dr. M. Munawar – phytoplankton taxonomy
G. F. Carpenter – zooplankton production
J. K. Leslie – zooplankton biology, automated particle counters
J. E. Moore – primary production
Dr. W. A. Glooschenko – phytoplankton ecology
E. E. Pickett – systems models
Dr. N. Watson – zooplankton
Dr. R. A. Vollenweider – seconded to Lakes Research Division
Technical Staff – H. F. Nicholson, R. H. Collins, Mrs. L. Mansey (seconded from Lakes Research Division)

MARINE SCIENCES DIRECTORATE – CENTRAL REGION

Director – T. D. W. McCulloch
Secretary – Miss L. Ram

CANADIAN HYDROGRAPHIC SERVICE

A/Regional Hydrographer – H. R. Blandford
Secretary – Mrs. R. Mikoda
Hydrographers-In-Charge – Field Surveys
R. Courtnage – navigational ranges

V. Crowley – Lake of the Woods
F. L. DeGrasse – International Field Year for the Great Lakes and Lakes Research Division
R. Lewis – Playgreen Lake
G. Macdonald – revisory survey
R. A. Marshall – Lower St. Lawrence
G. Wade – polar continental shelf project
B. Wright – James Bay
Hydrographers – R. Beri, M. Casey, R. Chapeskie, I. Charron, M. Crutchlow, K. Daechsel, P. DalBianco, P. Davies, B. Eidsforth, J. Gervais, G. Goldsteen, C. Gorski, M. Grant, K. Hipkin, D. J. Kean, D. Kimmett, R. Langford, R. Lasnier, C. Leadman, J. R. MacDougall, H. J. Marshall, J. F. McCarthy, J. Medendorp, R. L. Moulton, L. R. Muir, E. I. Norman, P. Page, H. W. Pulkkinen, T. W. Pullen, R. Rehbein, R. Robitaille, W. Silvey, R. Solvason, R. Treciokas, J. H. Weller, A. P. Welmers

Research Development

Head – E. Brown
Technical Staff – R. Tripe, R. Bryant, C. Doekes, E. Thompson, R. Preston

Tides, Currents & Water Levels

Head – N. Freeman
Technical Staff – J. Wilson, L. Barfoot

Shore Properties Studies and I.J.C. Inventory

Head – W. S. Haras
Technical Staff – J. Shaw

Marine Information Centre and Local Surveys

Head – A. R. Rogers
Technical Staff – R. Mahaffy, R. McMicking

U.S. Exchange Program

P. Richards – U.S. Lake Survey
W. Bergen – U.S. Exchange

C.S.S."Parizeau"

J. Statham

Cartography

Head – J. C. Elliott
Technical Staff – S. Holm

Electronics Maintenance

Head – E. O. Lewis
Technical Staff – R. Desilets, T. Dyas, G. Kavanagh, P. Millette, M. Moore, A. Prud'Homme, D. W. Pyatt, W. W. Smith, M. vanGendt, B. Waldock

Ships and Launches

Regional Marine Superintendent – A. Quirk
Engineering Superintendent – A. T. Hughes
Shore Boatswain – W. S. Corkum
Shop Foreman – K. D. Robertson
Shop Staff – J. Allan, J. Boyle, J. Fasullo, V. Rabelic, J. Wright, M. Thomson

C.S.S. "Limnos"

Captain – N. L. Keeping
Officers – M. C. Birchall, J. A. Butler, T. C. Kenney, G. Sproule, J. Stansfield (10 Ships Crew)

C.S.S. "Advent"

Officers – R. R. Charles (3 Ships Crew)

Launches

Scientific Support – 11 Seasonal Ships Crew
Hydrographic Surveys – 76 Seasonal Ships Crew

Regional Administration and Personnel

Administrative Officer – A. W. Appleby
A/Administrative Officer – B. J. T. O'Hagan
Office Manager – J. R. Dobson
Accounts – A. B. Mitchell
Stores – E. R. Gibbons
Support Staff – Mrs. M. Aris, C. J. Fulton, Mrs. F. M. Haaka, Mrs. F. M. Hannay, Mrs. W. J. MacDougall, Mrs. L. A. Mortimer, J. G. Rothwell, Mrs. S. Segato, Mrs. P. L. Taylor, T. H. Taylor, Miss L. Wallace

---

INLAND WATERS DIRECTORATE (ONTARIO REGION OPERATIONS)

WATER PLANNING AND MANAGEMENT BRANCH

A/Head – N. P. Persoage
Engineers – J. D. Keefe, W. M. Jones, D. W. Brown, P. P. Yee
Technical and Support Staff – C. L. Hanes, C. P. Charron

Cornwall Office

Engineer-in-Charge – D. F. Witherspoon
Secretary – Mrs. S. A. Lowe
Assistant Engineer – J. R. Robinson
Technical and Support Staff – R. J. Young, E. G. Allen, Mrs. A. L. David

WATER QUALITY LABORATORY AND NETWORK

Head – W. J. Traversy
Secretary – Mrs. V. Walker
Support Staff – W. Wakeham, Mrs. C. Furlong

Analytical Services Section

A/Head – F. J. Philbert
Chemist – D. P. Sturtevant – inorganic analysis
Support Staff – H. Alkema, P. Bothwell, J. Coburn, J. P. Emery, J. Gamble, R. Leacock, R. Luft, D. Marsh, G. M. Paquette, R. H. Plante, K. A. Terry, H. H. Tse, R. J. Wilkinson

Special Services Section

A/Head – A. S. Y. Chau
Chemist – D. McGirr – water quality
Support Staff – R. W. Wales

Great Lakes and Ships Support Laboratory

Chemist – O. ElKei
Support Staff – K. D. Austen, W. D. Blythe, J. Carron, Y. Sheikh

---

CENTRAL SERVICES (INLAND WATERS DIRECTORATE)

CANADIAN CENTRE FOR INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES

Canadian Coordinator – J. MacDowall
Secretary – Mrs. A. O'Hara

SCIENTIFIC SUPPORT DIVISION (INLAND WATERS DIRECTORATE)

Chief – A. S. Atkinson
Secretary – Miss L. Sully
Administration Unit – Mrs. J. Guenther

Scientific Services

Head – Dr. R. W. Durham
T. Pang – electron microscopy
Radiochemistry Technologists – R. J. Goble, C. Scott

Engineering Services

Head – G. A. Jones
Electronic Engineering – A. S. Watson
Electronics Engineers – K. N. Birch, A. S. Eatock, E. Harrison, J. Valdmanis
Technologists – J. A. Diaz, D. Fekyt, A. Fletcher, J. G. M. Larocque, K. Mollon, M. Pedrosa, J. A. Tyler
Mechanical Engineering – A. E. Pashley
Mechanical Engineers – B. P. Brady, P. M. Ward-White
Technologists – R. Boucher, J. Heidt, H. Savile
Tradesmen – R. V. Chumley, K. K. P. Kalter, D. H. Whyte

Computer Services

A/Head – Dr. H. S. Weiler
Computer Systems – H. C. Pulley
Support Staff – Mrs. M. Kinder, Mrs. P. Moody, Mrs. M. Phillips, Mrs. C. Taylor
Computer Application – Dr. H. S. Weiler
Programmers – G. S. Beal, Mrs. H. E. Comba, Miss J. E. Dowell, B. Hanson, Miss B. Pyde
Data Preparation and Publication – W. Nagel
Support Staff – J. W. Byron, Mrs. K. M. Schopf, Mrs. M. G. Smith

Library

Head Librarian – Mrs. E. A. C. Fosdick
Technical Services Librarian – Mrs. L. M. Brownlee
Cataloguing Assistant – Mrs. L. J. Watson
Technical Services Assistant – Miss B. J. Davis
Reference and Circulation Assistant – Mrs. A. E. Thompson

Technical Services

Building and Site Management – D. F. Stewart
Support Staff – G. Clim, J. Slaz
Stores – C. Hicks
Support Staff – F. Kushner, Mrs. B. Titley, T. A. Williams
Warehouse – A. W. Mayes
Support Staff – D. Henneberry, R. J. Haswell
Drafting and Illustrating – W. Finn
Draftsmen – J. Bodnaruk, C. Campion, A. Gris, Miss S. Longstaffe, Mrs. S. Verspagen
Stationery Engineering – G. Shortreed
Support Staff – T. Cain, H. Connors, K. Fess, E. Kennedy, A. Morley, K. Pearce, K. Platt, J. Smith, J. Thomas, R. Williams
Security – S/Sgt. R. Legg, Cpl. W. Hoy and nine members of the Canadian Corps of Commissionaires on rotation

---

PUBLIC RELATIONS AND INFORMATION SERVICES

Head – A. R. Kirby
Secretary – Mrs. I. Powell
Information Officer – D. M. Canning
Assistant – Mrs. J. Bracewell

ENVIRONMENTAL QUALITY COORDINATION UNIT

Head – Dr. A. R. LeFeuvre
Secretary – Mrs. H. Hetherington
Assistant – J. W. Schmidt
Scientific Officer – G. F. Gabriel

Publications and Presentations

PUBLISHED PAPERS

Afghan, B.K., P.D. Goulden and J.F. Ryan. Automated method for determination of nitrilotriacetic acid in natural water, detergents and sewage samples. Analytical Chemistry, *44,* 354 (1972).

Afghan, B.K., P.D. Goulden and J.F. Ryan. Automated fluorometric method for determination of boron in waters, detergents and sewage effluents. Water Research, *6,* 1475 (1972).

Afghan, B.K. and P.D. Goulden. Twin-cell oscillographic DC polarography for the analysis of trace metals. Canadian Res. & Develop., July-August, 1972.

Bell, J.B. and B.J. Dutka. Microbiological examination of Lake Ontario sediments. I. Distribution of aerobic and anaerobic heterotrophs in several Lake Ontario sediments. Proc. 15th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., pp. 1-8, 1972.

Bell, J.B. and B.J. Dutka. Microbiological examination of Lake Ontario sediments. II. Heterotroph methodology comparison. Proc. 15th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., pp 9-14, 1972.

Bell, J.B. and B.J. Dutka. Bacterial densities by fluorescent microscopy. Proc. 15th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., pp 15-20, 1972.

Boyce, F.M. 1972. The thermal structure and heat content of Lake Ontario, preliminary results. International Field Year for the Great Lakes Bulletin Number 4, p. 34.

Boyce, F.M. 1972. Temperature transects of Lake Ontario, preliminary analysis. International Field Year for the Great Lakes Bulletin Number 5.

Brewer, A.A., and *K.P.B. Thomson.* A radiometer-sonde for observing stratospheric emission due to water vapor in its rotational band, Quart. J. R. Met. Soc., *98,* pp. 187-191.

Bruce, J.P. 1972—The year of Great Lakes cooperation. Can. Res. & Development, *5,* #4, pp. 21-22.

*Based on work done before joining CCIW.
Where a paper was prepared jointly by a CCIW author and an author from another organization, the name of the CCIW author is shown in italics.

Bruce, J.P. 1972. Meteorological aspects of Great Lakes pollution. WMO Special Environmental Report No. 2, Selected Papers on Meteorology as related to the Human Environment.

Bruce, J.P. 1972. International Field Year for the Great Lakes—A Canadian Viewpoint. Proc. 15th Conf. Great Lakes Research, Int. Assoc. Great Lakes Research.

Burns, N.M. and C. Ross (eds.) Project Hypo—CCIW paper #6 (U.S. Environmental Protection Agency Tech. Bulletin TS-05-71-208-24) 182 pp.

Burns, N.M. and C. Ross. Oxygen-nutrient relationships within the central basin of Lake Erie. Nutrients in Natural Waters, eds. H. E. Allen and J. R. Kramer, Wiley-Interscience, N.Y., pp 193-249

Chau, A.S.Y. Confirmation of pesticide residue identity. Derivative formation for the conformation of photo-products of endrin: hexachloro and pentachloro-ketone pesticide residues by Gas Chromatography. J. Ass. Off. Anal. Chem. *55,* pp 519-525.

Chau, A.S.Y. and M. Lanouette. Confirmation of pesticide residue identity. II. Derivative formation in solid matrix for the conformation of DDT, DDD, methoxychlor, perthane, *CIS*—and Trans-chlordane, heptachlor, and heptachlor epoxide pesticide residues by Gas Chromatography. J. Ass. Off. Anal. Chem. *55,* pp 1058-1066.

Chau, A.S.Y. Confirmation of pesticide residue identity. III. Derivative formation in solid matrix for the confirmation of endrin by Gas Chromatography. Bull-Environ. Contam. Toxicol. *8,* pp 169-176.

Chau, A.S.Y. and K. Terry. Confirmation of pesticide residue identity. IV. Derivative formation in solid matrix for the confirmation of α- and β -endosulfan by Gas Chromatography. J. Ass. Off. Anal. Chem. *55,* pp 1228 – 1231.

Chau, A.S.Y. Confirmation of pesticide residue identity. V. Alternative procedure for derivative formation in solid matrix for the confirmation of α- and β-endosulfan by Gas Chromatography. J. Ass. Off. Anal. Chem. *55,* pp 1232 – 1238.

Chau, A.S.Y. and R.J. Wilkinson. Chromous chloride reduction. VII. Stereo-chemistry and structure of the

major product employed in the confirmation of endrin residues. Bull. Environ. Contam. Toxicol. *8,* pp 105 – 108.

Chau, A.S.Y. Analysis of chlorinated hydrocarbon pesticides in waters and wastewaters. Methods in use in water quality division laboratories. Department of the Environment, Ottawa, 1972.

Chau, Y.K. Determination of trace elements in lake water. Proc. of Int. Symposium on Identification and Measurement of Environmental Pollutants, Ottawa, June 1971, pp 354-357.

Chau, Y.K. and M.T. Shiomi. Complexing properties of NTA in the lake environment. J. Water, Air and Soil Poll. *1,* pp 149-164.

Coakley, J.P. and H.K. Cho. Shore erosion in Western Lake Erie, Canada. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res.

Coakley, J.P. Nearshore sediment studies in Western Lake Erie. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res.

Cronan, D.S. and *R.L. Thomas.* Geochemistry of ferromanganese concretions and associated deposits in Lake Ontario. Geol. Soc. Am. Bull. 83, pp 1493-1502.

Carpenter, G.F., L. Devey and A. Nauwerck. The crustacean zooplankton of Lake Ontario, 1970. Proc. 15th Conf. Gt. Lakes Res., Int. Assoc. Gt. Lakes Res.

Carpenter, G.F., L. Mansey and A. Nauwerck (N. Watson). The distribution and abundance of *Mysis* relicta (Loven) in Lakes Ontario, Erie, Huron and Superior. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res.

*Dell, C.I. An occurrence of greigite in Lake Superior sediments. Amer. Mineralogist, *57,* pp 1303-1304.

*Dell, C.I. The origin and characteristics of Lake Superior sediments. Proc. 15th Conf. Great Lakes Res., Int. Ass. Gt. Lakes Res., pp 361-370.

**Donelan, M.,* M.S. Longuet-Higgins and J.S. Turner. Periodicity in white caps. Nature, Vol. 239, N. 5373, October 1972.

Duncan, G.A. and N. A. Rukavina. 1972. The sedigraph grain-size analyser – an alternative to pipette analysis (abs.). 15th Conf. Gt. Lakes Res., Int. Assoc. Great Lakes Res. p 82. Proc. Abstracts.

*Durham, R.W. and V. Corriveau. Détermination de taux de combustion d'un train de combustibles par analyse chimique et isotopique. Atomic Energy of Canada Limited Report #4313F., Nov. 1972.

Dutka, B.J. Bacteriological study of the St. Lawrence River, 1968-71. CCIW Paper No. 8, 1972.

Elder, F.C. and B. Brady. A meteorological buoy system for Great Lakes studies. Proc. 15th Conf. on Gt. Lakes Res., Int. Assoc. Great Lakes Res., 1972 and CCIW Technical Bulletin No. 71.

Freeman, N., A.M. Hale and M.B. Danard. A sigma equations approach to the numerical modelling of Great Lakes hydrodynamics. J. of Geophysical Research, Vol. 77, No. 6., Feb. 1972.

Freeman, N. and T.S. Murty. A study of the storm surge on Lake Huron. Proc. 15th Conf. Great Lakes Res., 1972.

Gilbertson, M., H. H. Dobson and T. R. Lee. Phosphorus and hypolimnial dissolved oxygen in Lake Erie, pp 141-145 in Project Hypo report, Canada Centre for Inland Waters, CCIW Paper No. 6. 1972.

Glooschenko, W.A., H. Curl Jr. and L.F. Small. 1972. Diel periodicity of chlorophyll *a* concentration in Oregon coastal waters. J. Fisheries Res. Bd. of Canada 29: 1253-1259.

Glooschenko, W.A., J.E. Moore and R. A. Vollenweider. The seasonal cycle of pheo-pigments in Lake Ontario with particular emphasis on the role of zooplankton grazing. Limn. and Ocean. Vol. 17(4): 597-605.

Goulden, P.D., B.K. Afghan and P. Brooksbank. Determination of nanogram quantities of simple and complex cyanides in water. Analytical Chemistry, *44,* 1845 (1972).

Goulden, P.D. The chemical analysis of nutrients. Chapter IV in Nutrients in Natural Waters, edited by H.E. Allen and J. R. Kramer, John Wiley & Sons, Inc. N.Y. 1972.

IFYGL Bulletins 1972, Numbers 1, 2, 3, 4 and 5. Published by National Oceanographic and Atmospheric Administration, Rockville, Maryland, and available from IFYGL Centre, CCIW.

IFYGL Technical Plan. Vol. 1 Scientific Program, 439 pages, Vol. 2 Data Acquisition Systems, 462 pages, Vol. 3 Field Operations Plan, 604 pages, Vol. 4 Data Management, 112 pages.

*Irwin, R.W. and *G. Tsang.* Hydraulics roughness of corrugated plastic tubing. Trans. of Amer. Soc. of Agri. Engineering, Vol. 15, No. 2 pp 290, 291 and 295, 1972.

Kemp, A.L.W. Forms of distribution of nitrogen in Lake Ontario sediment. Proc. 15th Conf. Gt. Lakes Res. Int. Assoc. Gt. Lakes Res.

Kemp, A.L.W., C.B.J. Gray and A. Mudrochova. Changes in

C, N, P, & S in the last 140 years in three cores from Lakes Ontario, Erie and Huron. In: Nutrients in Natural Waters (eds. H.E. Allen and J.R. Kramer), J. Wiley & Sons, N.Y., pp 251-279. 1972.

Kemp, A.L.W. and A. Mudrochova. Distribution and forms of nitrogen in a Lake Ontario sediment core. Limno. & Oceanogr. *17,* pp 855-867. 1972.

Kenney, B.C. Circulation and diffusion in a small lake. Proc. 1st Can. Symp. Remote Sensing, Ottawa. pp 237-248. 1972.

Kramer, J.R. and *M.E. Thompson.* Geochemical studies of Canadian lakes: a review. Abstract. Int. Geo. Congress, 24th session, Montreal, Canada, pp 313. 1972.

Lane, R.K. W.D. McColl and K.P.B. Thomson. 1972. Progress report on remote sensing at Canada Centre for Inland Waters, Inland Waters Directorate Technical Series Number 13.

Lau, Y.L. A note on the prediction of BOD profile due to a source of effluent discharged in a uniformly flowing stream. Water Research, Vol. 6, pp 749-757, 1972.

Lau, Y.L. Discussion of dispersion in natural streams. ASCE, J. of Hydraulics Division, HY5, pp 963-965, 1972.

Lau, Y.L. Prediction of equation for reaeration in open-channel flow. J. San. Eng. Div., ASCE, Vol. 98, No. SA6, pp 1063-1068, 1972.

Lau, Y.L. A review of conceptual models and prediction equations for reaeration in open-channel flow. Inland Waters Directorate, Technical Bulletin No. 61, 1972.

Lee, T.R. Perception of goals in the management of water quality of the Great Lakes. In W.R.D. Sewell and I. Burton, (eds.), Perception and Attitudes in Resource Management, Dept. of Energy, Mines and Resources, Paper No. 2, Information Canada, Ottawa, 1972.

Lee, T.R. Water use, water quality and regional economic development in Ontario. Proceedings of the Oceanography International Conference.

Lerman, A. Sr-90 in the Great Lakes: Concentration-time model. J. Geophys. Res. Vol. 77, No. 18, pp 3256-3264, 1972.

Li, W.C., D.E. Armstrong, *J.D.H. Williams,* R.F. Harris and J.K. Syers. Rate and exchange of inorganic phosphate exchange in lake sediments. Soil Sci. Soc. Amer. Proc. *36*: pp 279-285, 1972.

Liu, D.L. and B. J. Dutka. Bacterial seeding techniques: novel approach to oil spill problems. Can Res. Development, *5* (4): pp 17-20, 1972.

Liu, D., P.T.S. Wong and B.J. Dutka. Determination of carbohydrates, protein and lipid in some Lake Erie sediments. Proc. 15th Conf. Gt. Lakes Res. pp 88-89, 1972.

Liu, D.L. and P.M. Townsley. Pulp mill lignin in continuous petroleum fermentation. J.W.P.C.F., *44*: pp 232-240, 1972.

*Louenberg, M.F., *C.I. Dell* and M.J.S. Johnston. Effect of a shorter day upon biotic diversity. Geol. Soc. America Bull., V. 83, pp 3529-3530, 1972.

MacDowall, J. A synoptic study for evaluating the role of the Great Lakes (in the world water balance). Proc. IAHS Reading Symposium, IAHS Publication No. 94, pp 91-103.

MacDowall, J. Proceedings of IFYGL Biology-Chemistry Panel Meeting, Niagara Falls, Ontario, November 14 – 15, 1972.

MacFarlane, R.B., W.A. Glooschenko and R.C. Harriss. 1972. The interaction of light intensity and DDT concentrations upon the marine diatom *Nitzschia delicatissima* Cleve. Hydrobiologia, Vol. 39: pp 373-382.

Marsalek, J. and T.M. Dick. Thermal wedge between Lake Ontario and Hamilton Harbour. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res. 1972.

Marsalek, J. Abatement of pollution due to combined sewer overflows. Inland Waters Directorate, Department of Environment, Technical Bulletin No. 66, 1972.

Menon, A.S., W.A. Glooschenko and N.M. Burns. Bacteria-phytoplankton relationship in Lake Erie. Proc. 15th Conf. Gt. Lakes Res., Int. Assoc. Gt. Lakes Res., pp 91-101, 1972.

Munawar, M., I.F. Munawar and A. Nauwerck. Seasonal abundance and composition of phytoplankton in Lake Erie. Proc. 15th Conf. Gt. Lakes Res., Int. Assoc. Gt. Lakes Res.

Munawar, M. 1972. Ecological studies of Euglenineae in certain polluted and unpolluted environments. Hydrobiologia Vol. 39-3, pp 307-320.

Munawar, M. 1972. Methods of taxonomic identification and enumeration of plankton. A report on a workshop held at CCIW on January 27, 1972. IFYGL Bulletin No. 3.

Munawar, M. and A. Nauwerck. The composition and horizontal distribution of phytoplankton in Lake Ontario during the year 1970. Proc. 14th Conf. Gt. Lakes Res., 1971, pp 219-223 (published 1972).

Munawar, M., J. Verduin and I. Fatima. Primary production in shallow aquatic environments of Southern Illinois. Verh. Internat. Verein. Limnol. 18: pp 113-120, Stuttgart, Nov. 1972.

Murthy, C.R. Complex diffusion processes in coastal currents of a lake. J. Phys. Ocean., Vol. 2, No. 1, pp 80-90, 1972.

Nodwell, B.H., and *J. MacDowall,* 1972. Planned data storage methods for the IFYGL. Proc. IHD Workshop Seminar on Processing of Hydrological Data, Quebec City, pp 81-92.

*Nelewajko, C. and *D.R.S. Lean.* Retention of dissolved compounds by membrane filters as an error in the ^{14}C method of primary production measurements. J. Phycol. *8*: pp 37-43, 1972.

Nalewajko, C. and *D.R.S. Lean.* Growth and excretion in planktonic algae and bacteria. J. Phycol. *8:* pp 361-366, 1972.

Nriagu, J.O. Lead orthophosphates. Part I. Solubility and hydrolysis of secondary lead orthophosphate. Inorg. Chem. II: pp 2499-2503, 1972.

Nriagu, J.O. Solubility equilibrium constant of strengite. Am. J. Sci. 272: pp 476-484, 1972.

Nriagu, J.O. Stability of vivianite and ion-pair formation in the system $Fe_3(PO_4)_2$-H_2PO_4-H_2O. Geochim. Cosmochim. Acta. *36*: pp 459-470, 1972.

Platford, R.F. Isopiestic determination of solubilities in mixed salt solutions. Two salt systems. Am. J. Sci. 272: pp 929-968, 1972.

*Richards, J.M. and *G. Tsang.* Laboratory study of line thermals. Atmospheric Environment, Vol. 6, No. 3, March 1972, pp 235-236.

Robinson, R.A., *R.F. Platford* and C.W. Childs. Thermodynamics of aqueous mixtures of sodium chloride, potassium chloride, sodium sulfate, and potassium sulfate at 25°C. J. Sol'n Chem. .Vol. 1, No. 2, pp 167-172.

Rukavina, N.A. Shallow-water sediments of Lake Ontario (abs). G.S.A. Abstracts with Programs, V. 4, No. 1, p 41, 1972.

Schindler, D.W., D.R.S. Lean, and E.J. Fee. Nutrient cycling in freshwater ecosystems. I.B.P. Summary Symp., Seattle, Washington, 1972.

Shrivastava, H. Macrobenthos of Lake Huron. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res.

Simons, T.J. Development of three-dimensional numerical models of the Great Lakes. Inland Waters Directorate, Scientific Series No. 12, 1972.

Simons, T.J. Multi-layered models of currents, temperature and water quality parameters in the Great Lakes. Proc. Int. Symp. on Modelling Techniques in Water Resources Systems, Dept. of Environment, Ottawa, pp 150-159.

Simons, T.J. On the theory of atmospheric development. Monthly Weather Review, 100, 1972.

Simons, T.J. The non-linear dynamics of cyclone waves. J. Atmos. Sci. 29(1), 1972.

Simons, T.J. and D.E. Jordan. Computer water circulation of Lake Ontario for observed winds. CCIW Paper No. 6, 1972. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res., 1972.

Simons, T.J. and D.B. Rao. Instability of rotational and gravitational modes of oscillation. J. Meteorol. Soc. of Japan, Vol. 50, pp 204-214, 1972.

Simons, T.J. and D.B. Rao. Non-linear interaction of waves and zonal currents in a two-layer baroclinic model. Tellus, 24(1), 1972.

Sinclair, M. A survey of housewives attitudes about water pollution centered around the phosphate debate. Great Lakes Basin Commission Communicator, Vol. 2, No. 8, pp 3-4, Feb. 1972.

Sly, P.G. Research and the problems of two seas. Proc. Oceans Ontario, Toronto, Ontario, pp 1-16, 1972.

Sly, P.G. and C.F.M. Lewis. The Great Lakes of Canada — quaternary geology and limnology. Excursions A43 Guidebook, 24th Int. Geological Congress, Montreal, 92 p., 1972.

Small, L.F., H. Curl Jr., and *W.A. Glooschenko.* Estimates of primary production off Oregon using an improved chlorophyll-light technique. J. of Fisheries Res. Bd. of Canada 29: pp 1261-1267, 1972.

Small, L.F., H. Curl Jr., and *W.A. Glooschenko.* Effects of solar radiation and upwelling on daily primary production off Oregon. J. Fisheries Res. Bd of Canada 29: pp 1269-1275, 1972.

Sommers, L.W., R.F. Harris, *J.D.H. Williams,* D.E. Armstrong and J.K. Syers. Fractionation of organic phosphorus in lake sediments. Soil Sci. Soc. Amer. Proc. 36: pp 51-54, 1972.

Sochasky, J.F., D.E. Aiken and *N.H.F. Watson.* Y-organ, molting gland and mandibular organ: a problem in decapod crustacea. Can. J. of Zoology 50: pp 993-997, 1972.

St. Jacques, D.A. and N.A. Rukavina. Lake Ontario nearshore sediments, Wellington to Main Duck Island, Ontario. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res..

Syers, J.K., C.W. Smillie and *J.D.H. Williams.* Calcium fluoride formation during extraction of calcareous soils with fluoride: I: Implications to inorganic P fractionation schemes. Soil Sci. Soc. Amer. Proc. 36: pp 20-25, 1972.

Thomas, R.L. The distribution of mercury in the sediments of Lake Ontario. Can. J. Earth Sci. *9*, pp 636-651.

Thomas, R.L., A.L.W. Kemp and C.F.M. Lewis. Distribution, composition and characteristics of the surficial sediments of Lake Ontario. J. Sedim. Petrol. 43, pp 66-84, 1972.

Thomson, K.P.B. Infrared scanner observations on Lake Ontario. Proc. 1st Canadian Symp. on Remote Sensing, 1972.

Thomson, K.P.B. and W.D. McColl. A remote sensing survey of the Chedabucto Bay oil spill. Canada Centre for Inland Waters, Inland Waters Directorate Technical Report No. 26, 1972.

Thomson, K.P.B. Progress report on remote sensing. International Field Year for the Great Lakes Bulletin No. 4, 1972.

Thomson, K.P.B. Limnological aspects of data retransmission. Submission to working group on data retransmission, number 21. Information Canada Data Retransmission M75-2/21.

Tovell, W.M., J.H. McAndrews, *C.F.M. Lewis, T.W. Anderson* and G.B. Hobson. Geological reconnaissance of Georgian Bay – a preliminary statement. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res.

*Tsang, G. Stack exit velocity distribution for higher effective stack height. Atmospheric Environment, Vol. 6, No. 11, Nov. 1972, pp 815-828.

*Tsang, G. and L. Szucs. Field experiments of winter flow in natural rivers. Proc. Int. Symp. on the role of snow and ice in hydrology, World Meteorological Organization, Banff, Sept., 1972.

*Tsang, G. Entrainment of ambient fluid by two-dimensional starting plumes and thermals. Atmospheric Environment, Vol. 6, No. 2, February, 1972, pp 123-132.

Vernet, J.P. and *R.L. Thomas.* The occurrence and distribution of mercury in the sediments of the Petit Lac (Western Lake Geneva). Eclogae geologicae Helvetia 65, pp 307-316, 1972.

Vernet, J.P. and *R.L. Thomas.* Levels of mercury in the sediments of some Swiss lakes including Lake Geneva and the Rhone River. Eclogae geologicae Helvetia, 65, pp 293-306.

Vollenweider, R.A. Input-output models of lakes. Proc. of Workshop Conference on Chemical-Ecological Considerations for Defining the Goal of Water Pollution Control, April 19-21, 1972.

Wales, R.W. and W.J. Traversy – Interlaboratory quality control study no. 2. Total phosphate, organic nitrogen, nitrate nitrogen, and organic carbon. Report Series No. 19, Department of the Environment, Ottawa, 1972.

Wells, P.S., *E. Nagy* and A.B. VanCleave. The mechanism of the adsorption of Alkyl Xanthate species on Galena. Can. J. Chem. Eng. *50:* pp 81-85, 1972.

Williams, J.D.H. and T. Mayer. Effects of sediment diagenesis and regeneration of phosphorus with special reference to Lakes Erie and Ontario. In: Nutrients in Natural Waters (eds. H.E. Allen and J.R. Kramer), Wiley, New York, pp 281-215, 1972.

Wong, P.T.S., D. Liu and B.J. Dutka. Rapid biodegradation of NTA by a novel bacteria mutant. Water Research *6*; pp 1577-1584, 1972.

Wong, P.T.S., D. Liu and B.J. Dutka. Effects of organic nutrients in the distribution of heterotrophic bacteria in Lake Erie sediments. Proc. 15th Conf. Gt. Lakes Res., Int. Ass. Gt. Lakes Res., pp 186-187, 1972.

PAPERS PRESENTED AND/OR ACCEPTED FOR PUBLICATION

Afghan, B.K., P.D. Goulden. Twin-Cell Oscillographic DC Polarography for the Analysis of Trace Metals in Natural Waters and Sewage Effluents. Presented at the 55th Chemical Institute of Canada Annual Conference, Montreal, June 1972.

Afghan, B.K., P.D., F.J. Ryan. Automated Fluorometric Method for Determination of Boron in Water, Detergents and Sewage Effluents. Presented at Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Cleveland, Ohio, U.S.A., March 1972.

Bangay, G. Population Estimates for the Great Lakes Basins and their Major Tributaries 1901-71, for the Social Science Series Inland Waters Directorate, Department of the Environment.

Bell, J.B., B.J. Dutka and A.A. Jurkovic. Microbiological examination of Lake Ontario sediments. III. Morphology classification and nutritional adaptations of heterotrophic bacteria isolated from a Lake Ontario

core. Submitted to the Journal of General Microbiology, November 1972.

Blanton, J.O. Vertical entrainment in the epilimnion of stratified lakes. Amer. Soc. Oceanol. & Limnol.

Blanton, J.O. Relationships between heat content and thermal structure in the mainstem lakes of the Okanagan Valley, B.C. Paper presented and published in Proceedings of "Symposium on Lakes of Western Canada", Edmonton, Alberta, November 16-17, 1972.

Boyce, F.M. and K.P.B. Thomson, 1972. Internal waves of finite amplitude in Lake Ontario. Canada Centre for Inland Waters, Technical Series 13.

Boyce, F.M. and K.P.B. Thomson. 1972. Internal waves of finite amplitude in Lake Ontario. CCIW Tech. Series.

Boyce, F.M. Internal waves of the Straits of Gibraltar. Deep Sea Research.

Bruce, J.P. The Canada-U.S. Agreement on Great Lakes Water Quality. Opening address, Hydraulics Division, American Society of Civil Engineers, Ithaca, New York, August 16.

Bruce, J.P. The Canada-U.S. Agreement on Great Lakes Water Quality. Presented at special symposium on Great Lakes Water Quality at American Institute of Biological Sciences Meeting, Minneapolis, August 30.

Bruce, J.P. Presentation on "Role of Research in Solving Pollution Problems in the Great Lakes" to Annual Dinner Dance of the Engineering Society, University of Windsor, November 10, 1972.

Bruce, J.P. Talk to Canadian Meteorological Society, Edmonton Branch, on "International Field Year for the Great Lakes", November 15, 1972.

Bruce, J.P. Keynote address at Conference on Western Lakes, University of Alberta, Edmonton, on "The Role of Research in Lake Management", November 16, 1972.

Bruce, J.P. 1972—The Year of Great Lakes Cooperation. Presented at symposium on IFYGL of International Geographical Union, Montreal, August 12.

Bruce, J.P. Water Pollution and Control. Presented at APEO Symposium on the Environment. April 1972.

Bruce, J.P. and A.R. LeFeuvre. The Laurentian Great Lakes—Environmental Problems and Solutions. Presented at the XII Convention Panamerican Union of Engineering Associates, Lima, Peru, October 1972.

Burns, N.M. The effects of potassium fluoride and potassium iodide on the expansivity of water. Submitted to Can. J. Chem.

Burns, N.M. Diver assisted sampling of the sediment-water interface. Submitted to Limnol. Oceanogr.

Chau, Y.K. Complexation capacity in natural waters. Presented at Conference on Humic Substances in Amsterdam, Holland, May 28-31.

Chau, Y.K. Determination of complexing capacity in natural waters. Presented at Recent Advances in the Analytical Chemistry of Pollutants Conference in Halifax, N.S., 1972.

Chau, A.S.Y. Solid Matrix Derivation Technique, Part I Derivative Formation in Solid Matrix for the Confirmation of Endrin by Gas Chromatography. Presented to the Western Canada Seminar on Pesticide Residue Analysis, Saskatoon, May 30-31, 1972.

Chau, A.S.Y. Solid Matrix Derivation Technique, Part II. Derivative Formation in Solid Matrix for the Confirmation of α- and β- endosulfan by Gas Chromatography. Presented to the Western Canada Seminar on Pesticide Residue Analysis, Saskatoon, May 30-31, 1972

Chau, A.S.Y. and M. Lanouette. Confirmation of Chlordanes and DDT-type Residue Identity by Solid Matrix. Presented to the 164th ACS National Meeting, New York, August 27—September 1, 1972.

Chau, A.S.Y. An Alternative Procedure for the Derivative Formation in Solid Matrix for the Confirmation of α- and β- endosulfan by Gas Chromatography. Presented to the Annual Meeting of the AOAC, Washington, D.C., October 9-12, 1972.

Chau, A.S.Y. The Use of Chemical Derivation—GLC Technique in the Confirmation of Organochlorinated Pesticide Residue Identity—Review and Comment. Presented to the Annual Meeting of the AOAC, Washington, D.C., October 9-12, 1972.

Childs, C.W., C.J. Downes and *R.F. Platford.* Thermodynamics of aqueous sodium and potassium dihydrogen orthophosphate solutions at 25°C. Australian Journal of Chemistry.

Daley, R.J., *C.B.J. Gray* and S.R. Brown. Quantitative, reverse-phase thin-layer chromatography of chlorophyll derivatives. J. Chrom.

Daley, R.J., *C.B.J. Gray* and S.R. Brown. A quantitative, semi-routine method for determining algal and sedimentary chlorophyll derivatives. J. Fish. Res. Bd. Can.

Desnoyers, J.E., R. Pagé, G. Perron, J.-L. Fortier, P.-A

Leduc and *R.F. Platford.* Thermodynamic and transport properties of sodium benzoate and hydroxy benzoates in water at 25°C. Can. J. Chem.

Donelan, M., and M. Miyake. Spectra and fluxes in the boundary layer of the trade wind zone. Journal of the Atmospheric Sciences.

Dutka, B.J. Technical and practical consideration in the microbial contamination of water. II. Coliforms; an inadequate index of water quality. Presented at 40th Meeting Canadian Public Health Association, Montreal, November 30—December 2, 1972.

Dutka, B.J. and J.B. Bell. Isolation of Salmonellae from moderately polluted waters. JWPCF.

Dutka, B.J. and J.B. Bell. Technical and practical considerations in the microbial contamination of water. I. Comparison of sampling techniques and media combinations for isolating Salmonellae from natural waters. Presented at 40th Meeting Canadian Public Health Association, Montreal, November 30—December 2, 1972.

Dutka, B.J. and D. Liu. Microbial degradation of crude oil. Presented at Workshop on Microbial Degradation of Oil Pollutants, Atlanta, December 3-6, 1972.

Fox, M.E. A rapid gas chromatographic method for the determination of residual methanol in sewage. Environ. Sci. & Tech.

Fox, M.E. The role of the Department of the Environment and its work in chemistry and chemical engineering. University of Western Ontario, March 21, 1972.

Fox, M.E. Chemistry at CCIW. Presented at CCIW for Grade 13 high school teachers receiving Shell Fellowships. July 1972.

Glooschenko, W.A. *In situ* enrichment studies upon Lake Huron phytoplankton communities. American Society of Limnology and Oceanography, August 27, 1972. Minneapolis, Minn.

Glooschenko, W.A. and C. Alvis. Changes in species composition of phytoplankton due to enrichment by N,P, and Si of water from a North Florida lake. In Press. Hydrobiologia.

Glooschenko, W.A., J.E. Moore and J.K. Leslie. The distribution of chlorophyll *a* and pheo-pigments in Lake Erie, 1970. Presented at the Annual Meeting of the American Society of Limnology and Oceanography, March 17-22, 1972, Tallahassee, Florida.

Glooschenko, W.A., H.F. Nicholson and J.E. Moore. Some problems of chlorophyll measurement in the Great Lakes with particular emphasis on fluorometry. Presented at the Third Canadian Oceanographic Symposium, CCIW, May 2-4, 1972.

Goulden, P.D., B.K. Afghan, P. Brooksbank. "Analysis of Microgram Quantities of Cyanide in Water", presented at Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Cleveland, Ohio, U.S.A., March 1972.

Johnson, M.G. Macroinvertebrate production and lake productivity. In Biology of the Benthos. R.O. Brinkhurst et al.

Johnson, M.G. and J.B. Sprague. Perspectives on water quality. In Environmental change in Canada. D. Elrick Ed. Science Research Associates (Canada) Don Mills.

Jonys, C.K. Impact of erosion on environmental quality. Presented at the Conference on Erosion—Causes, Effects, Controls, Toronto, 1972.

Kaiser, K.L.E. Determination and differentiation of ethylenediaminetetra-acetic acid (EDTA) and nitrilotriacetic acid (NTA) in the environment. Water Research.

Kemp, A.L.W. and A. Mudrochova. Nitrogen distribution in Lake Ontario sediment humic compounds. Presented at Conference on Humic Substances, Amsterdam, Holland.

Kemp, A.L.W. and A. Mudrochova. The distribution and nature of amino acids and nitrogen-containing compounds in Lake Ontario sediments. Geochimica. Cosmochimica. Acta.

Lean, D.R.S. Phosphorus dynamics in lake water. Science.

Lean, D.R.S. Radioisotope studies showing the role of phosphate in the formation of a large extracellular carbon compound. Symp. on Humic Substances (I.B.P.) Nieuwersluis, the Netherlands, June, 1972.

Lee, T.R. and P.D. Fenwick. The Environmental Matrix: Input-Output Techniques Applied to Pollution Problems in Ontario. Submitted for publication in the Water Resources Bulletin.

Lee, T.R. Approaches to Water Requirements Forecasting: A Canadian Perspective. To be published in the Social Science Series No. 9, Inland Waters Directorate.

LeFeuvre, A.R. Canadian National Policy on Nutrient Removal and Control. Presented at the Specialty Conference on "Nutrient Removal—How to Do It" of the Sanitary Engineering Division, ASCE, Rochester, N.Y., June 1972.

LeFeuvre, A.R. and J.P. Bruce. Eutrophication Research

Applied to Water Quality Management on the Great Lakes. Presented at the First Int. Conference on Transfer of Water Resources Knowledge, Fort Collins, Colorado, September 1972.

Lerman, A., Y. Chung and H. Craig. Transient events and time to steady-state in oceanic basins. Annual Meeting of the American Geophysical Union. (Abstract accepted)

Leslie, J.K., L. Devey, A. Nauwerck, M. Munawar and E. Pickett. Comparison of electronic and microscopic counting methods of phytoplankton. Presented at the Third Canadian Oceanographic Symposium, May 2-4, 1972, CCIW.

Lewis, C.F.M., A.E. Wootton, and J.B. Davis. Stratigraphic and engineering studies of unconsolidated sediments in Central Lake Erie near Erieau, Ontario. Geological Survey Report of Activities, Paper 73-1 PT.A.

Liu, D.L. and *P.T.S. Wong.* Biochemical studies on microbial degradation of Bunker 6C fuel oil. Water Research.

Liu, D.L., *P.T.S. Wong* and B.J. Dutka. Correlation between carbohydrate and some heterotrophic bacteria in lake sediment. J. Limno. and Oceanogr.

Liu, D.L., *P.T.S. Wong* and B.J. Dutka. Determination of carbohydrate in lake sediments by a modified phenol-sulfuric acid method. Water Research.

Liu, D.L., *P.T.S. Wong* and B.J. Dutka. Taxonomic and biochemical studies of a rapid NTA-utilization bacterial mutant. J. Water Poll. Cont. Fed.

Liu, D.L., *P.T.S. Wong* and B.J. Dutka. Correlation between carbohydrate and some heterotrophic bacteria in lake sediment. Submitted to Journal of Limnology and Oceanography, September 1972.

Liu, D.L., *P.T.S. Wong* and B.J. Dutka. Taxonomic and biochemical studies of a rapid NTA-utilizing bacterial mutant. JWPCF (accepted June, 1972).

Liu, D.L., *P.T.S. Wong* and B.J. Dutka. Determination of carbohydrate in lake sediment by a modified phenol-sulfuric acid method. Water Research.

Liu, D.L. and B.J. Dutka. Biological oxidation of hydrocarbons in aqueous phase. JWPCF.

MacDowall, J.A., A. Falconer and *K.P.B. Thomson.* "Simulation Studies of ERTS-A & B Data for Hydrologic Studies in the Lake Ontario Basin". Report presented to the 4th Annual Earth Resources Program Review, Manned Spacecraft Centre, Houston, Texas, January 17-21, 1972.

Munawar, M., and W.A. Glooschenko. The effects of NTA upon ^{14}C uptake by *in situ* phytoplankton in Lakes Erie and Ontario. Third Canadian Oceanographic Symposium, May 2-4, 1972, CCIW.

Munawar, M. Limnological studies on freshwater ponds of Hyderabad, India. III. The Biocenose. Accepted for publication in Hydrobiologia.

Murthy, C.R. Diffusion in coastal currents of a lake. Proc. of the Symposium on "The physical processes responsible for the dispersal of pollutants in the nearshore zone", International Council for the Exploration of the Sea. (1972) Aarlms, Denmark.

Murthy, C.R. and B.C. Kenney. Diffusion in coastal currents of a lake. Presented at Sym. Phys. Processes responsible for dispersal of pollutants in the sea with special reference to the near shore zone. July 4-7, 1972.
Aarhus, Denmark. Accepted for publication in proceedings.

Nauwerck, A., L. Devey and G. Carpenter. The crustacean zooplankton of Lake Ontario, 1970. Presented at the Third Canadian Oceanographic Symposium, May 2-4, 1972, CCIW.

Nriagu, J.O. Lead Orthophosphates. II. Stability of chloropyromorphite at 25°C. Geochim. Cosmochim. Acta.

Nriagu, J.O. Lead Orthophosphates. III. Stabilities of fluoropyromorphite and bromopyromorphite at 25°C. Geochim. Cosmochim. Acta.

Nriagu, J.O. and A.S. Menon. Distribution and diagenesis of sulfur in Lake Erie sediments and overlying water. Presented at CCO Conference, May 1972.

Nriagu, J.O. Dissolution characteristics of freshwater ferromanganese nodules under controlled Eh and pH conditions. Limnology and Oceanography.

Nriagu, J.O. Solubility equilibrium constant of α-hopeite. Geochim. Cosmochim. Acta.

Nriagu, J. and A.S. Menon. Distribution and diagenesis of sulfur in Lake Erie sediments and overlying waters. Presented at 3rd Canadian Oceanographic Symposium, CCIW, Burlington, May 2-4, 1972.

Peters, R.H. and D.R.S. Lean. The characterization of soluble phosphorus released by zooplankton. Limnol. & Oceanogr.

Platford, R.F. The osmotic coefficients of aqueous solutions of seven compounds at 0°C. J. Chem. & Eng. Data.

Platford, R.F. The role of the Department of the Environment and its work in chemistry and chemical engineering. Presented at the University of Waterloo, March, 1972.

Rukavina, N.A. Seasonal and progressive changes in sediment properties in the Lake Ontario nearshore zone. Accepted for presentation at the International Symposium on Inter-relationships of Estuarine and Continental Shelf Sedimentation. Bordeaux, France.

St. John, B.E. 1972. Trace elements in corals of the Coral Sea: Their relationship to oceanographic factors. In oceanography of the South Pacific 1972.

St. John, B.E., P.G. Sly and R.L. Thomas. 1972. The importance of sediment studies in Western Lakes as a key to basin management. In Symposium on the Lakes of Western Canada.

St. John, B.E. 1972. The limnogeology of the Okanagan mainstem lakes: Final Report of Task 121 of the Okanagan Basin Study.

Sekerka, I., J. Lechner. Some characteristics of Ion-Selective Electrodes. Tech. Bull.

Sekerka, I., J. Lechner. Influence of Container Material on the Loss of Silver, Mercuric and Cupric Ions from Water Solutions. Tech. Bull.

Sekerka, I., J. Lechner. Automation of Direct Potentiometry. Int. J. of Env. Anal. Chem.

Sekerka, I., J. Lechner. International Symposium "Recent Advances in the Analytical Chemistry of Pollutants". Dalhousie University, Halifax, N.S. Presented paper: Automation of Direct Potentiometry.

Sinclair, M. A Review of J.F. Johnson's Renovated Water. Accepted by Canadian Geographer.

Stadelmann, P. Nitrogen cycle and primary production in two Swiss lakes: mesotrophic Lake of Lucerne (Bay of Horw) and eutrophic Rotsee. American Society of Limnology & Oceanography, August 27, 1972, Minneapolis, Minn.

Strachan, W.M.J. The role of the Department of the Environment and its work in chemistry and chemical engineering. Presented at the University of Toronto, April, 1972.

Thomas, R.L. The distribution of mercury in the surficial sediments of Lake Huron. Can. J. Earth Sci. 10.

Thomas, R.L., A.L.W. Kemp, and C.F.M. Lewis. The surficial sediments of Lake Huron. Can. J. Earth Sci. 10.

Thompson, M.E. The Orion water hardness electrode: An unexpected response to magnesium ion. Presented by Y.K. Chau at Recent Advances in the Analytical Chemistry of Pollutants Conference in Halifax, N.S., 1972.

Thompson, M.E. Book Review of new journal Chemosphere. Hydrologic Sciences Bulletin.

Thompson, M.E. The Orion water hardness electrode: An unexpected response to magnesium ion. International J. of Environmental Analytical Chemistry.

Vernet, J.P., *R.L. Thomas,* J.-M. Jaquet and R. Fridli. Texture of the sediments of the Petit Lac (Western Lake Geneva). Eclogae geologicae Helvetia.

Watson, N.H.F. The laboratory fecundity of the freshwater Cyclopoid copepod Diacyclops navus Herrick. American Society of Limnology & Oceanography, August 27, 1972, Minneapolis, Minn.

Weiler, R.R. The interstitial water composition in the sediments of the Great Lakes. I. Western Lake Ontario. Limnology & Oceanography.

Williams, J.D.H. Phosphorus in the sediments of the Okanagan Mainstem Lakes. Okanagan Study Committee.

Williams, D.J. General Limnology of the Mainstem Lakes in the Okanagan Valley, British Columbia. Submitted to the Canada-British Columbia Okanagan Basin Study Committee. 1972.

Wong, P.T.S. Rapid degradation of nitrilotriacetic acid (NTA) by a bacterial mutant. Presented at American Society of Limnology and Oceanography Conference, Talahassee, Florida, Mar. 20-24, 1972.

Wong, P.T.S. Rapid degradation of nitrilotriacetic acid (NTA) by a bacterial mutant. Presented at the Amer. Soc. Limnol. Oceanogr., Tallahassee, March 18-25, 1972.

Wong, P.T.S. and D.H. MacLennan. Restoration by fatty acids of active transport in a lactose transport mutant of *Eschericia coli.* Can. J. Biochemistry.

Wong, P.T.S., D. Liu and D.J. McGirr. Mechanism of NTA degradation by a bacterial mutant. Water Research.

REPORTS

Anderson, T. W. Historical evidence of land use in a pollen profile from Osoyoos Lake, British Columbia. Geological Survey Report of Activities, Paper 73-1 PTA.

Blanton, J.O. and H.Y.F. Ng. 1972. The circulation of the

effluent from the Okanagan River as it enters Lake Skaha, Task 120. 24 p. CCIW.

Blanton, J.O. and H.Y.F. Ng. 1972. The physical limnology of the mainstem lakes in the Okanagan Basin, B.C. Vol. 1. 34 p. CCIW.

Blanton, J.O. and H.Y.F. Ng. 1972. The physical limnology of the mainstem lakes in the Okanagan Basin, B.C. Vol. 11, data. CCIW.

Clemmens, B.E. Sedimentation mooring report. 1972.

Clemmens, B.E. An Evaluation of the Conductivity Measurements used at CCIW. 1972.

Compton-Smith, J. and W. Stage. Dissolved Oxygen and Temperature in Lake Huron. 1971.

Dell, C.I. 1972. A preliminary assessment of geological research to be carried out in Lake Superior. CCIW.

Dobson, H.H. 1972. Nutrients in Lake Superior.

Dobson, H.H. 1972 Nutrients in the Great Lakes: A New Comparison.

Dolling, R.K. Thermal Regime of Lake Ontario, 1970.

Dutka, B.J. Criteria for bacteriological participation in a water quality network. Prepared for inclusion in the ICW Working Group "Guidelines for the planning and operation of water quality network and the interpretation of data".

Glooschenko, W.A., H.F. Nicholson and J.E. Moore. Surface distribution of total chlorophyll *a* in Lakes Ontario and Erie, 1970. Accepted for publication in J.F.R.B. Technical Report Series.

Hamblin, P.F. 1972. Some free oscillations of a rotating natural basin. Unpublished Ph.D. thesis, Univ. Washington, Seattle.

Hannon, S. and W. Hyatt. The Benthic Community of Hamilton Harbour. 1972.

Healey, P.M. Bottom Sediment Sampling aboard C.S.S. LIMNOS and M.V. MARTIN KARLSEN in 1971.

Hore, R.D. Relationship in categorized lakes of mean depths to mean surface temperatures in various physical combinations. 1972.

Jonys, C.K. Manual of SI Units of measurement and symbols and abbreviations for hydraulics and fluid mechanics. 1972.

Lymburner, B. The Production and Use of Cadmium in Canada. April 1972.

Lymburner, B. Beryllium Use in the Canadian Economy. June 1972.

Lymburner, B. Selenium Production and Use in the Canadian Economy. October 1972.

Magee, D.M. The Production and Use of Lead in the Canadian Economy.

Menon, A.S. A preliminary report of a bacteriological study of the Upper Rainy River. Presented to the International Rainy River Pollution Board, August 23, 1972.

Menon, A.S. The significance of coliform bacteria as indicators of potential health hazards in Rainy River. Report prepared for the International Rainy River Pollution Board.

Menon, A.S., H.R. van Otterloo and B.J. Dutka. A preliminary bacteriological investigation of a pulp and paper mill aeration lagoon, Ontario-Minnesota Pulp and Paper Company, Fort Frances, Ontario. EPS Report No. EPS-4-WP-72-5.

Moore, B.H. Techniques for mooring surface and underwater instruments on the Great Lakes. 1972.

Taylor, W.B. Buoy intercomparisons with National Oceanic and Atmospheric Administration, Rochester, N.Y. 1971.

Withers, S.P. The Otter trawl as a means of sampling Great Lakes Fish. 1972.

LIMNOLOGICAL DATA REPORTS

No. 1, Lake Erie, Cruise 69-101, Feb. 6-27; Cruise 69-103, May 29-June 4; Cruise 69-104, July 2-6; Cruise 69-105, July 28-August 2. (1969).
No. 2, Lake Erie, Cruise 69-107, Aug. 25-30; Cruise 69-108, Sept. 13-18; Cruise 69-110, Oct. 14-20; Cruise 69-111, Dec. 7-13. (1969)
No. 1, Lake Huron/Lake Superior. Lake Huron, Cruise 69-202, Sept. 22-29; Cruise 69-203, Nov. 18-Dec. 6; Lake Superior, Cruise 69-302, Nov. 12-25. (1969)
No. 1, Lake Ontario, Cruise 69-002, Apr. 12-15; Cruise 69-007, May 12-17; Cruise 69-011, June 9-14. (1969)
No. 2, Lake Ontario, Cruise 69-015, July 8-13; Cruise 69-017, Aug. 5-10, Cruise 69-025, Sept. 4-10. (1969)
No. 3, Lake Ontario, Cruise 69-030, Oct. 2-7; Cruise 69-033, Oct. 31-Nov. 5; Cruise 69-034, Dec. 1-6. (1969)

AWARDS

At the 1972 International Association for Great Lakes Research Conference in Madison, Wisconsin, a new prize called the Chandler-Misener Award was given to H. Dobson and M. Gilbertson for their 1971 paper "Oxygen depletion in the hypolimnion of the central basin of Lake Erie, 1929 to 1970". The award was given for the best paper of the 1971 Conference Proceedings.

Advisory Committee Membership

ADVISORY COMMITTEE TO THE CANADA CENTRE FOR INLAND WATERS

CONVENOR

Dr. A. T. Prince
Director-General
Inland Waters Directorate
Environmental Management Service
Department of the Environment
Ottawa, Ontario, K1A 0H3

CHAIRMAN

Dr. E. G. Pleva
Department of Geography
Middlesex College
University of Western Ontario
London, Ontario

SECRETARIAT

Mr. G. E. Bangay
Secretary, ACCC
Social Science Research Section
CCIW, Box 5050
Burlington, Ontario

MEMBERS

Mr. J. Windish
Water Pollution Hazards Division
Environmental Health Directorate
Department of National Health & Welfare
Ottawa, Ontario K1A 0L2

Professor J. H. Dales
Department of Political Economy
University of Toronto
Toronto 181, Ontario

Mr. R. K. Fraser
President
Fleet Manufacturing Limited
Box 800
Hamilton, Ontario

Mr. J. B. Hooper
City Engineer
City of Peterborough
City Hall, Peterborough, Ontario

Dr. N. E. Cooke
Principal Chemical Engineer
Canadian Industries Limited
630 Dorchester West
Montreal, Quebec

Professor W. K. Oldham
Department of Civil Engineering
University of British Columbia
Vancouver 8, B.C.

Dr. G. Shane
Director of Research
Shell Oil Canada Limited
Box 400, Terminal A
Toronto 1, Ontario

Professor K. S. Davar
Department of Civil Engineering
University of New Brunswick
Fredericton, N.B.

Mr. J. P. Gourdeau
Vice-President
Surveyor, Nenniger and Chenevert, Inc.
1500 O. Boul. de Maisonneuve
Montréal, Québec

Dr. W. E. Johnson
Director, Freshwater Institute
Fisheries Research Board of Canada
501 University Crescent
Winnipeg, Manitoba R3T 2N6

Professor J. R. Kramer
Department of Geology
McMaster University
Hamilton, Ontario

Mr. J. W. MacLaren
James F. MacLaren Limited
Environmental Engineers & Scientists
435 McNicoll Avenue
Willowdale, Ontario

Mr. M. S. Slivitzky
Directeur
Centre Québécois des Sciences de l'eau
Institut National de la Recherche Scientifique
Université du Québec
C.P. 7500
Ste. Foy, Québec (10e)

Dr. N. E. R. Campbell
Department of Microbiology
University of Manitoba
Winnipeg, Manitoba

Mr. F. A. Voege
Executive Director
Laboratory and Research Division
Ontario Ministry of Environment
135 St. Clair Avenue West
Toronto 195, Ontario

Mr. M. Mitchenson
President
Committee of a Thousand
P.O. Box 185
Niagara Falls, Ontario

Dr. A. D. Misener
Director, Great Lakes Institute
University of Toronto
Toronto 181, Ontario

Mr. T. L. Richards
Chief, Hydrometeorology and Marine Applications Division
Atmospheric Environment Service
Department of the Environment
4905 Dufferin Street
Downsview, Ontario

Dr. D. R. Stanley
President
Stanley Associates Engineering Limited
11810 Kinsway
Edmonton, Alberta

Mr. T. E. Weber
Director-General
Water Resources Branch
Department of Mines, Resources and Environment Management
693 Taylor Avenue
Winnipeg, Manitoba R3M 2K2

OBSERVERS

Mr. J. B. Bryce
Hydraulic Engineer
The Hydro Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario

Alternate:

Mr. R. A. Walker
Asst. Hydraulic Engineer (Studies)
The Hydro Electric Power Commission of Ontario
620 University Avenue
Toronto, Ontario

Mr. J. L. MacCallum
Assistant to the Chairman and Legal Adviser
International Joint Commission
151 Slater Street
Ottawa, Ontario, K1P 5H3

Mr. H. G. P. Taylor
Director, Resources Programs Division
Department of Finance
Confederation Building
Ottawa, Ontario

Dr. A. DesMarais
Principal Science Adviser
Science Secretariat
Privy Council Office, East Block
Parliament Buildings
Ottawa, Ontario K1A 0A3

Mr. H. G. Kingstone
Deputy Head, U.S.A. Division
Department of External Affairs
Ottawa, Ontario K1A 0A3

Dr. E. Y. Spencer
Director, Research Institute
Research Branch, Canada Agriculture
University Sub Post Office
London 72, Ontario

Dr. W. J. Waines
Associate Director (Domestic Programmes)
Association of Universities and Colleges of Canada
151 Slater Street
Ottawa, Ontario K1P 5N1

Alternate:

Monseigneur J. Garneau
Directeur adjoint (Programmes internationaux)
Association des Universités et Collèges du Canada
151, rue Slater
Ottawa, Ontario K1P 5N1

ACCC WORKING GROUP ON THE USE OF CCIW FACILITIES BY THE UNIVERSITIES

E. G. Pleva, Chairman
T. S. Hillis, Secretary
J. P. Bruce
J. R. Kramer
A. D. Misener

ACCC WORKING GROUP IN HYDRAULICS

Mr. Leonard Cartier
c/o Asselin, Benoit, Boucher, Ducharme, Lapointe, Consulting Engineers
4200 Dorchester Blvd. W.
Montreal 215, Quebec

Mr. D. Foulds
Ontario Hydro
620 University Avenue
Toronto 2, Ontario

Mr. N. H. James
Director, Water Planning & Management Branch
Department of the Environment
Ottawa, Ontario K1A 0H3

Prof. S. S. Lazier
Department of Civil Engineering
Queen's University
Kingston, Ontario

Mr. F. I. Lorant, P. Eng.
M. M. Dillon Ltd.
Consulting Engineers
50 Holly Avenue
Box 219, Stn. K.
Toronto, Ontario

Dr. B. Michel
Dept. of Civil Engineering
Laval University
Ste. Foy, Quebec.

Mr. Hans Neu
Atlantic Oceanographic Institute
Bedford Institute
Dartmouth, N.S.

Mr. M. W. Paul
Chief of the Marine Eng. Div.
Design Directorate
Public Works Department
Room C547, Sir Charles Tupper Bldg.
Riverside Drive
Ottawa, Ontario K1A 0M2

Mr. R. H. Smith
Director of Marine Hydraulics Branch
Ministry of Transport
Ottawa, Ontario, K1A 0N5

Mr. W. Stichling, Sediment Surveys
Water Resources Branch
Inland Waters Directorate
Department of the Environment
Ottawa, Ontario K1A 0H3

Prof. K. S. Davar
Dept. of Civil Engineering
University of New Brunswick
Fredericton, N.B.

Research and Development Contracts 1972

To provide estimates of the current use of potentially environmentally harmful substances in Ontario industry. (P. D. Fenwick–$3,990).

To conduct the analysis of mercury content of surface sediments from lakes and rivers in Canada. (Barringer Research Ltd.–$5,000).

An investigation of the forms of occurrence of toxic trace metals in river and lake bottom sediments. (Barringer Research Ltd.–$5,000).

To carry out studies of turbulent diffusion in relation to environmental conditions. (Dr. G. Kullenberg, University of Copenhagen–$9,000).

To provide continuing research on a project involving the geological study of the nearshore environment of Lake Superior. (Lakehead University–$10,000).

Advise on lakes research needed to determine water quality criteria with respect to potentially polluting substances. (Mr. D. Matheson–$8,000).

To prepare samples and measure isotopic ratios of sulphur. (McMaster University, Prof. C. E. Rees–$7,970).

To provide for services covering "Radiation Analysis" of data from IFYGL. (McMaster University–$10,750).

An investigation into the feasibility of detecting and quantitatively estimating phosphate minerals in lacustrine sediments by mineralogical methods. (New Brunswick Research and Productivity Council, Dr. D. Abbott–$4,000).

Palynological (pollen) analysis. (Royal Ontario Museum, Dr. J. McAndrews–$2,500).

To identify 1500 Coliform isolates collected from the Rainy River study. (University of Toronto, Prof. P. L. Seyfried–$4,600).

To conduct limnology study as part of IFYGL (University of Toronto, Prof. G. K. Rodgers–$14,666).

To conduct Great Lakes Monitoring program using the Port Dauphine. (University of Toronto, Dr. A. D. Misener–$40,000).

To conduct Coastal Chain studies. (Waterloo Research Institute, University of Waterloo, Dr. G. T. Csanady–$45,000).

Composition of surface sediments of Lakes Ontario, Erie and Huron. (Scintrex Ltd.–$2,500).

Develop and manufacture two prototype and nine production fixed/towed temperature profiling electrical cables. (Boston Insulated Wire, Hamilton–$26,000).

Repair, overhaul, modifications, special investigations and technical studies of existing instrumentation; e.g., current meters, met. packs, etc. (Canadian General Electric, Weston–$150,000).

Manufacture and test prototype expanded Multiple Digital Input Recorder System. (EDA Electronics, Ottawa–$4,400).

Manufacture and test ten monitor printout units (for Plessey Instruments). (EDA Electronics, Ottawa–$19,000).

Develop and manufacture four prototype, seventy-nine production, solid state timers for Plessey Instruments. (EDA Electronics, Ottawa–$23,000).

Manufacture and test 10 Dyna-Grip termination assemblies including cable for EBT systems. (Preformed Line Products, Cleveland, Ohio–$15,000).

To provide software for conversion of EROS data retrieval system from 6600 to 31000 computer. (Entropy Systems, Vancouver–$1,500).

The following contracts from headquarters funds were monitored by CCIW staff.

Efficiency and cost of dredging procedures in the removal of polluted fine-grained sediments. (H. G. Acres Consultants Ltd., Niagara Falls–$39,500).

Environmental Distribution of Agricultural Chemicals. (Canadian Canners Ltd., Burlington–$35,700).

The use of plastic-media trickling filters for waste water treatment. (Industrial Research Institute, University of Waterloo–$60,000).

To determine the effect of phosphorus limit on the washing efficiency of detergents. (Ontario Research Foundation–$30,988).

Analytical techniques and methodology for polycyclic aromatic hydrocarbons. (University of Calgary, Dr. G. W. Hodgson–$21,468).

Lake Huron–St. Clair critical coastal interface study. (University of Western Ontario, Prof. E. G. Pleva–$9,000).

Application of satellite imagery to water mass delineation of western Lake Ontario. (University of Toronto–$2,983).

Application of ERTS imagery to the study of the ice regime on Lake Erie and the reservoir areas above the Churchill Falls power development in Labrador. (ACRES–$3,500).

Application of satellite data to freeze-up, break-up and changing configuration of Lakes in Northern Quebec and Labrador. (McGill University–$9,210).

Application of satellite imagery to the study of the St. Lawrence Valley area in particular Lake St. Louis and Lake St. Pierre. (CENTREAU, Université Laval–$12,868).

Application of satellite imagery to the study of Big Quill Lake. (Sask. Research Council–$23,560).

Application of satellite imagery to the inventory of the surface and groundwater patterns in the Cooking Lake and Gull Lake Basins in Alberta, Canada. (University of Alberta–$3,209).

Design, assembly and testing of transmitter-receiver system. Conduct propagation and scattering studies at CCIW to determine feasibility of the system as a workable water lidar. (York University–$23,600).

The following contracts were let by CCIW and funded under the Canada-Ontario Agreement on Great Lakes Water Quality.

An Examination of Sewage and Sewage Sludge for Enteroviruses. (Central Public Health Lab.–$9,000).

Solidification of Phosphate Sludges using Industrial Sulfate Wastes and Thermal Power Plant Fly Ash. (Acres Consulting Services Ltd.–$7,500).

Heavy Metals in Agricultural Lands Receiving Chemical Sewage Sludges. (University of Toronto–$15,000).

Aerobic Digestion of Organic Sludges Containing Inorganic Phosphorus Precipitates. (University of Toronto–$10,000).

Wet Oxidation of Chemical Sludges. (Waterloo Research Institute, University of Waterloo–$8,000).

The Assessment of Polymers as Aids to the Removal of Phosphorus from Wastewater. (McMaster University–$13,000).

Design and Performance Criteria for Settling Tanks for the Removal of Physical-Chemical Flocs. (University of Toronto–$16,000).

The use of Lime in the Treatment of Municipal Wastewaters. (Domtar Limited–$15,000).

Integration of Physio-Chemical and Biological Wastewater Treatment Processes. (Water Research Institute, University of Waterloo–$21,450).

To Establish Viable Methods of Maintaining Waste Treatment Facility Efficiencies with Reference to Waste Variations. (James F. MacLaren Limited–$13,000).

Chemical Dosage Control for Phosphorus Removal. (Pollutech Pollution Advisory Services Ltd.–$25,000).

Nutrient Control in Sewage Lagoons. (Pollutech Pollution Advisory Services Ltd.–$10,000).

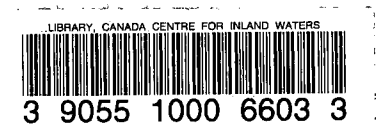
The Effect of Household Sanitary Systems on Urban Watershed Phosphate Levels. (Industrial Research Institute of the University of Windsor–$9,680).

Nitrogen Removal from Municipal Wastewaters. (Dupont of Canada Limited–$30,000).

The Removal of Nutrients by Partial Ozonation followed by Coagulation. (University of Sherbrooke–$7,000).

Land Disposal of Sewage Sludges. (University of Guelph–$50,000).

Characterization of the Behaviour of Chemically-Precipitated Sludges in Soils. (Soil Research Institute, Canada Dept. of Agriculture–$8,000).



CANADA CENTRE FOR INLAND WATERS,
BURLINGTON, ONTARIO, 1973.