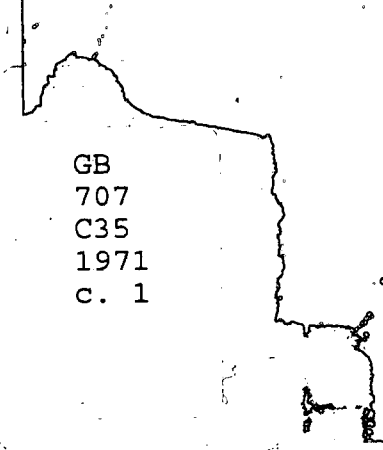
Environment Canada | Environnement Canada

CANADA CENTRE FOR INLAND WATERS



1971

CANADA CENTRE FOR INLAND WATERS – 1971

Contents

Huron, Lake of the Woods, St. Lawrence River, and Playgreen Lake, Manitoba. Central-Region staff also assumed responsibility, as part of its revisory survey program, for keeping up-to-date the shoreline land use and erosion surveys initiated by Department of Public Works for the International Joint Commission studies of the Great Lakes levels controls. These latter surveys and the shoreline charts are proving to be valuable to Ontario Conservation Authorities bordering Lake Ontario, many of which have shoreline land use studies underway.

A chart sales outlet and Marine Information Centre were established at CCIW by the Marine Sciences Branch.

Phosphate Replacement Evaluations

With continued emphasis on control of phosphate content in detergents in order to reduce eutrophication, evaluation of potential environmental impact of possible phosphate substitutes continued, in coordination with Department of National Health and Welfare's studies of potential health effects. Nitrilotriacetic acid (NTA) and citric acid were investigated in this connection and the results of studies co-ordinated by CCIW. The current NTA evaluation program with reports scheduled for spring 1972, includes: (1) a coast to coast monitoring program of present NTA levels in various water environments by a number of components of Environment Canada to permit prediction of future concentrations; (2) evaluation by Environmental Protection Service (EPS) detachment, CCIW and Hydrologic Sciences Division, Ottawa, of potential effects of NTA on nutrient removal at wastewater treatment facilities; (3) bacteriological degradation of NTA (at CCIW) and (4) detergent cleaning ability as related to detergent formulation and water hardness (by contract with Ontario Research Foundation).

Transfer of Microbiology Section

The Microbiology Section based at Kingston, and formerly with Public Health Engineering, Department of National Health and Welfare, transferred to temporary quarters at CCIW in spring 1971. An active research program has been developed to complement the survey program of this Section prior to the transfer. Important results have been obtained by isolating a bacterial mutant which uses NTA as sole carbon, nitrogen, and energy sources at temperatures as low as 4°C. Special bacteriological studies were conducted in connection with the Lake Erie organic particle study, the Lake Ontario thermal bar phenomenon, and sediments in Lake Erie and Lake Ontario.

Primary Production and Algae in Great Lakes

Surveys and analyses by the Fisheries Research Board group of primary production data (by chlorophyll *a* and C^{14} assimilation) gave evidence of relative production of Lakes Ontario, Erie, and Huron. Average C^{14} assimilation values in Ontario were 1.7μgC/1/h in winter and 12.5μgC/1/h in summer with a maximum inshore value of 43.9μgC/1/h. Lake Erie averages ranged from 5.1μgC/1/h to 32.0μgC/1/h with an absolute maximum of 228.0μgC/1/h. Production values for Lake Huron are much lower, except for Saginaw Bay. For Lake Ontario, 374 species of plankton algae were recorded of which only 70 had been reported from earlier studies of the Lake.

Wastewater Treatment – Nutrient Removal Studies

In addition to the continuing study of parameters affecting "luxury uptake" of phosphorus at the Drury Lane treatment plant, Burlington, Ontario, studies were initiated on the optimum phosphate removal process applicable at a number of Department of National Defence (DND) bases. The effects of detergent formulation on phosphate removal at treatment plants are under investigation at the DND base, Gloucester. A study of the possible use of quicklime for phosphorus removal was initiated at the pilot plant.

Mercury in Sediments

Sampling was completed for assessment of mercury distribution in surface sediments of the Okanagan Lake system (B.C.) and the Nottaway River system (Quebec) as well as in Lake Huron. In Lake Huron the average is about 0.2 ppm with anomalous high values generally less than 1 ppm, significantly lower than values reported earlier for sediments of Lake Erie and Lake Ontario. A contract with H.G. Acres was started to assess the possibilities of dredging or burying highly contaminated areas of Great Lakes sediments to prevent the mercury and other contaminants from entering the food chain.

Okanagan Study

Sampling and field data collection phases of Lakes Division's contributions to the federal-provincial Okanagan Basin Study were completed in October 1971 and reports are in progress.

Waste Heat Discharges

Studies are nearly completed of the temperature effects of projected waste heat discharges on waters of the Great Lakes. The Hydraulics Division produced an improved solution for equations governing dispersal of waste heat in rivers. At the same time a contract study by Montreal Engineering of waste heat discharges across Canada indicates that these will increase from 2.86×10^{10} BTU/h in 1970 to 76.7×10^{10} BTU/h by the year 2000.

Mathematical Modelling of Lake Systems

Significant progress was made in mathematically modelling lake systems to lead to the prediction of circulation and nearshore dispersal of conservative pollutants. Good results were obtained with a four-layer stratified model. Further verification of models through data collected in IFYGL will be of a major importance in 1972 and 1973.

Great Lakes Water Uses

A map published by the Lakes Management Research Section and the Resources Research Centre, Ottawa, on Great Lakes waste use has proven to be a most useful and popular publication. In graphic form it shows population densities, water withdrawals, waste discharges, fish catches, generation of electrical energy, shipping statistics, and irrigated crop acreage.

International Field Year for the Great Lakes (IFYGL).

Plans were nearly completed for IFYGL, the international Hydrologic Decade program on Lake Ontario. Drafts of an internationally coordinated four-volume technical plan were completed, covering the scientific program, data acquisition system, operation plans and schedules, and the data management plan. IFYGL will be the most comprehensive physical-chemical-biological study of a major lake ever attempted and major ship and scientific resources of both U.S. and Canada will be deployed during the field program from April 1972-March 1973.

Advisory Committee and Project Planning

The Advisory Committee to CCIW continued to provide advice on program development at the Centre directly through subcommittees on hydraulics, and waste treatment research, and on university and private sector use of CCIW facilities. Arrangements have been made for a number of university professors and their students to spend sabbatical years or shorter periods working at the Centre in 1972. A new project forecast form was developed and introduced for Centre's use and to provide information on project plans for comment by the Advisory Committee.

Future

The occupation of the Centre's Laboratory and Administration building and Hydraulics Laboratory will speed up the implementation of CCIW programs in 1972. Signing an agreement with the United States on pollution control of the Great Lakes will involve extensive follow-up activities by CCIW staff. The year's major field program will be conducted on Lake Ontario in the IFYGL. Major expansion of the multi-disciplinary program on environmental impact of new and toxic substances is planned and completion of equipment for the Water Quality Pilot Plant will permit full development of wastewater treatment studies and demonstration projects.

Inland Waters Branch and Fisheries Research Board Research Components

HYDRAULICS UNIT

Equipment

The Hydraulics Unit is responsible for operating a national calibration centre for hydrometric instruments and for research and tests in waves, fluid dynamics, sediment transport and problems encountered with ice and cold environment.

In April a contract was given to Westinghouse Canada Ltd. to supply a towing carriage equipped with precise control and data acquisition systems to serve the national needs in hydrometric calibration, particularly for current meters and sediment samplers. The primary performance specifications are:

Minimum steady velocity	0.5 cm s^{-1}
Maximum steady velocity	600 cm s^{-1}
Allowable variation in velocity	±1%

In the towing tank (Figure 1) – 122 m long, 3 m deep, and 5 m wide – up to four current meters may be calibrated simultaneously. It is expected that the towing carriage will be in operation by October 1972.

Considerable time was devoted to developing the design by a consultant of a 2 m wide x 27 m long tilting flume for sediment research. This rather unique flume empties into sediment traps with a normal capacity of 10 cubic meters of sand and has a maximum flow of 0.8 cubic meter per second (30 cfs). Another tilting flume 1 m wide by 26 m long was also designed for general purposes. Both these flumes will be constructed in 1972. Specifications have also been drawn up for cold rooms designed especially for hydraulic research. These cold rooms pose special problems in design because of high humidity and heat load from water surfaces in the rooms. One of the rooms is being designed to torture test instrument packages under simulated weather conditions. The other will be designed for a wide range of experiments connected with the use and control of water in a cold environment.

Design and conceptual work was also undertaken for a proposed wind wave flume which will be 4.5 m wide by 114 m long overall. Studies of the air flow, the heat budget and the mechanical generation of waves were undertaken as a preliminary to having engineering designs performed by private industry.

Research Activities

Research activities have been quite varied and successful although restricted to theoretical and office studies until the laboratory is completed in July 1972.

Studies of the discharge of waste heat into river flows resulted in an improved solution for the diffusion equation and procedures were recommended for calculating the temperature distribution downstream of a source. Much improved estimates of temperature due to warm discharges are now possible. As a result of this work, a parallel analysis was undertaken of the dispersion process and decay of the Biological Oxygen Demand of an effluent entering a river. Preliminary reviews of the present knowledge of the transfer process of oxygen into flowing water revealed that

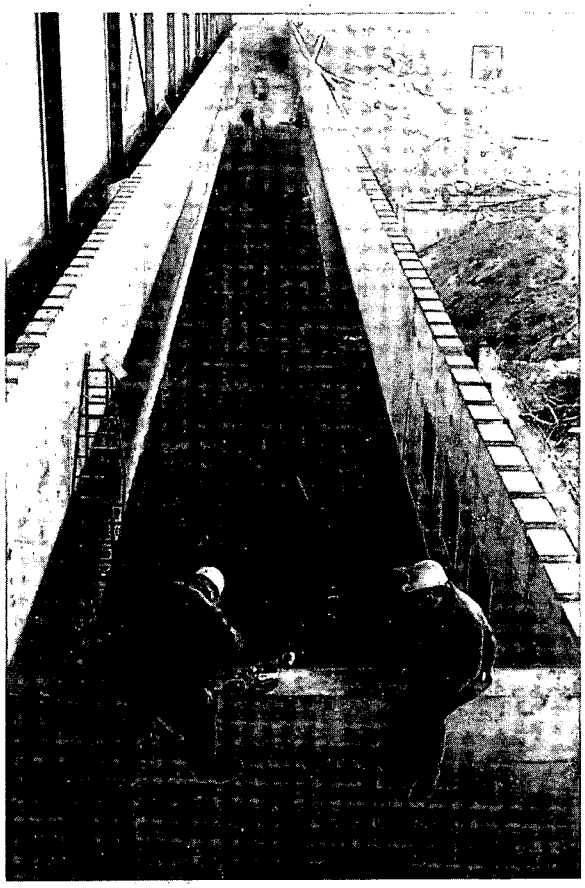


Figure 1. Towing tank under construction, February 1972

not only several theories but also that empirical relationships were inconsistent.

A rather comprehensive review of the problems caused by combined storm and sanitary sewer systems and by storm water runoff was undertaken. The study found that much could yet be done towards finding economically and technologically feasible methods of treating large flows of storm water or combined sewage.

Problems in sediment transport and erosion germane to environmental control and engineering developments were under active review. An early conclusion is that field measurements may often lack sufficient precision and that there is a great need to seek methods of improving the estimation of sediment transport in nature. Bed load measurements, for instance, are very difficult to obtain.

Advisory Working Group

During the year, a Working Group in Hydraulics was formed to provide advice and priorities on national needs for hydraulic research. Members for the Working Group are drawn from private industry, federal government groups and some universities. The Group is not primarily research oriented but composed of designers and managers concerned with water resource management. At their second meeting the Working Group prepared a list of proposed research areas in sediment, snow and ice, waves, and fluid mechanics and also indicated relative priorities.

LAKES DIVISION

The objective of Lakes Division, within the broad terms of reference of the Department of the Environment and the Water Management Service, is to provide the government with the scientific knowledge needed for managing the freshwater resources stored in lakes of Canada. Accordingly, Lakes Division has two basic functions: a) to perform basic research with a view to increase 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.

As organized in 1971, Lakes Division consists of four scientific sections; physical limnology, limnogeology, chemical limnology, and biological limnology. This latter group is being seconded to Lakes Division from the Freshwater Institute, Winnipeg, Man., of the Fisheries Research Board. In addition to these Sections a separate Technical Operations Section carries responsibilities for planning and implementation of the field operations connected with the scientific programs and gives assistance to other sections in data handling and data analysis.

In considering the multidisciplinary nature of a large portion of Lakes Division's activity a new organization plan has been developed recently. The reorganization should provide a greater flexibility to meet interdisciplinary program needs.

BIOLOGICAL LIMNOLOGY (FISHERIES RESEARCH BOARD)

Dr. A. Nauwerck, Acting Head, FRB Detachment (Biological Section) from November, 1970, has been appointed Head of the Detachment since May 1, 1971. However, Dr. A. Nauwerck returned to Sweden at the end of January, 1972, and Dr. W.A. Glooschenko took over as Acting Head.

Staff activities have been concentrated in two fields: the monitoring of the Great Lakes biological features, and the testing of substances of possible impact on lakes ecology such as nutrients, toxic and chelating compounds.

The monitoring efforts were concentrated on Lake Huron, while Lake Ontario, Lake Erie, and Lake Superior were covered by repeated research cruises. A considerable part of the time was also devoted to the interpretation of the data collected in 1970.

Phytoplankton

For Lake Ontario, 374 species of plankton algae were recorded. Only about 70 of these had been observed in earlier studies of the lake. In several taxonomical groups, particularly in the genera *Stephanodiscus Oocystis* and *Cryptomonas,* a considerable morphological variability was observed and was studied separately. The investigation indicates that morphological variability is a much more sensitive indicator of environmental conditions and changes than are species composition and species diversity, which in contrast to European experience, seem to be of limited significance in north American lakes. Another study on the phytoplankton of 8 Yukon lakes and of 5 lakes on Cornwallis Island confirmed that species known as eutrophication indicators can appear in dominating numbers in quite untouched, oligotrophic lakes, and that arctic waters may have practically the same species composition as, e.g., Lake Ontario has through winter and spring. Thus, the main difference in the phytoplankton of the Great Lakes is in

quantity rather than in quality. Nevertheless, significant differences are notable even in species composition.

Phytoplankton biomass in the epilimnion of Lake Ontario was found to have a typical inshore-offshore development and, in spring, shows a clear relationship to the development of the thermal bar. Only one pulse is established in late summer in the open lake, reaching a maximum of almost 90×10^5 μ^3/ml while repeated pulses are common throughout the year in the inshore region, and the average plankton volume there is 33×10^5 μ^3/ml compared to 26×10^5 μ^3/ml in the open lake.

The dominant groups in the phytoplankton biomass of Lake Ontario are diatoms, cryptomonads and green algae; the diatoms have a spring maximum, the others have a late summer maximum (Figure 2).

A more pronounced summer dominance of green algae and a relatively higher number of dinoflagellates and chrysomonads were found in Lake Erie. Water blooms of blue-green algae, observed frequently during summer in the western basin of the lake, did not add drastically to the total biomass, even if they sometimes dominated the samples from that part of the lake.

During the ice-free period of the year, plankton volumes in western Lake Erie were about twice as high as in the eastern lake, and almost 4 times as high as comparable values from Lake Ontario, while central Lake Erie showed values that were rather lower than the ones from Lake Ontario.

Chlorophyll

Corresponding results were obtained for the epilimnic

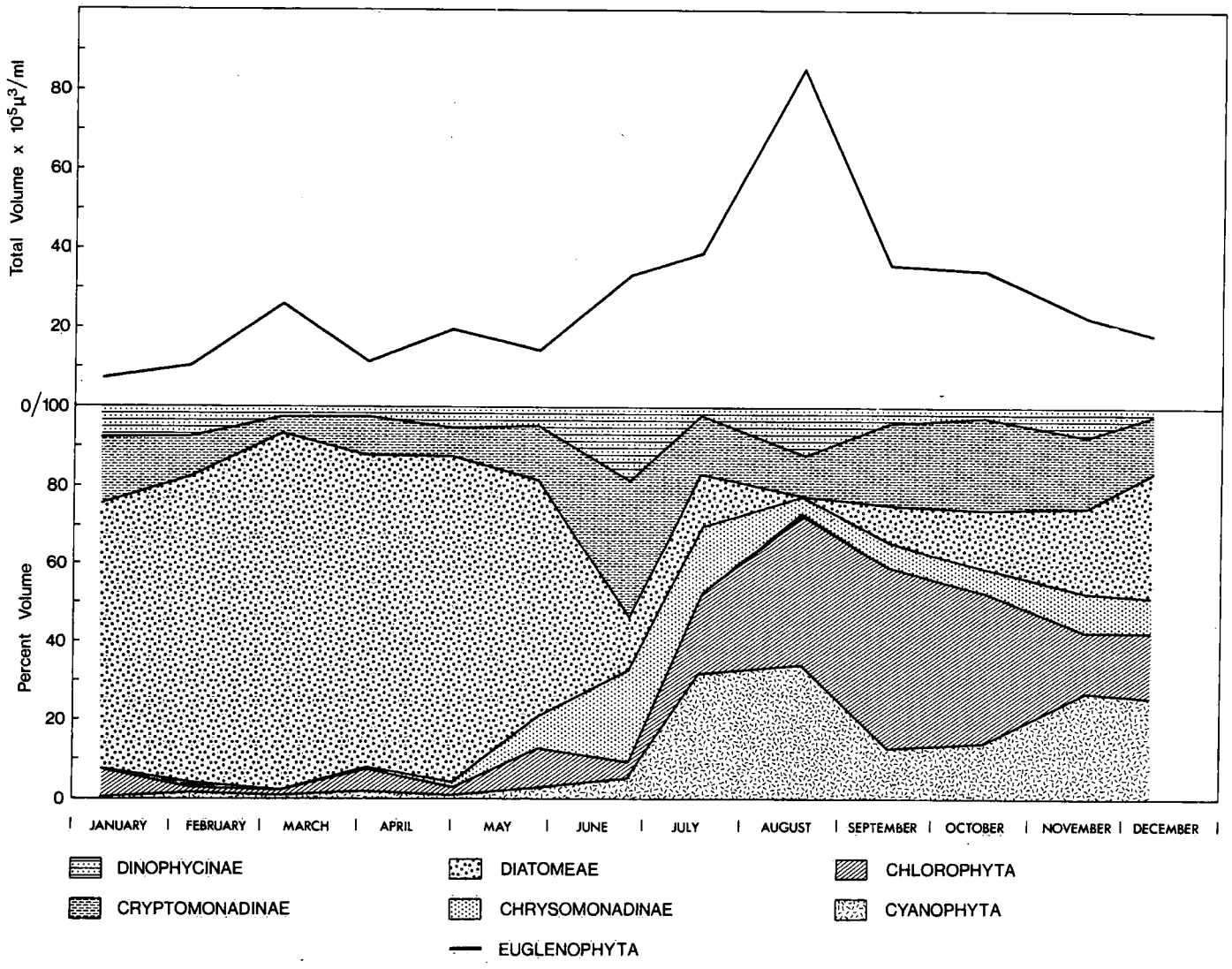


Figure 2. Annual distribution of phytoplankton biomass in Lake Ontario with species composition of major groups.

chlorophyll distribution in the lakes. The annual cycles of chlorophyll *a* and pheo-pigments of Lake Ontario were studied on 32 stations during 13 cruises between January and December, 1970.

Highest amounts of chlorophyll *a* were found in inshore waters, particularly along the southern shore from east of Rochester, N.Y. to the St. Lawrence River. In terms of the seasonal cycle of phytoplankton biomass as measured by chlorophyll *a*; three types of cycles were seen: (1) a unimodal distribution in the deeper waters which are last to warm up in the late spring; (2) a bimodal pattern with spring and fall peaks mainly along the central basin and north and south shores; and (3) a series of three pulses in nutrient-rich areas and in the warmer eastern region of the lake. Zooplankton biomass increased eastward in the direction of increasing heat content.

Low values of pheo-pigments were seen during the spring increase of phytoplankton. However, the relative amount of pheo-pigments compared with chlorophyll *a* was significantly correlated ($r = +0.896$) with zooplankton abundance (Figure 3). The highest percentage of pheo-pigments were found in the eastern basin of the lake confirming the observed sedimentary distribution of these pigments. Grazing appears to be the main mechanism by which pheo-pigments are produced in the lake. However, resuspension of bottom sediments in shallow waters may be important locally. The need to correct chlorophyll *a* values for pheo-pigments is emphasized especially during times of the year when zooplankton grazers are abundant.

Chlorophyll data for Lake Erie in 1970 have been analyzed in detail. Average values and ranges of chlorophyll *a* (μg/l) in eastern, central, and western basins of Lake Erie 3.2 (2.2-6.6), 4.4 (2.6-6.8), and 8.9 (4.2-11.1) respectively. No distinct seasonal cycle of chlorophyll could be found in the eastern basin where peaks of repeated pulses occurred at the stations studied. The central basin shows a summer peak, but a spring maximum may have been missed due to April being the earliest sampling month. The western basin has a large late summer bloom. No vertical stratification of chlorophyll has been noticed during Project LEPS cruises.

Primary Production

Primary production was measured by the C^{14}-method in a shipboard incubator. Average assimilation values for the open waters of Lake Ontario varied in 1970 between

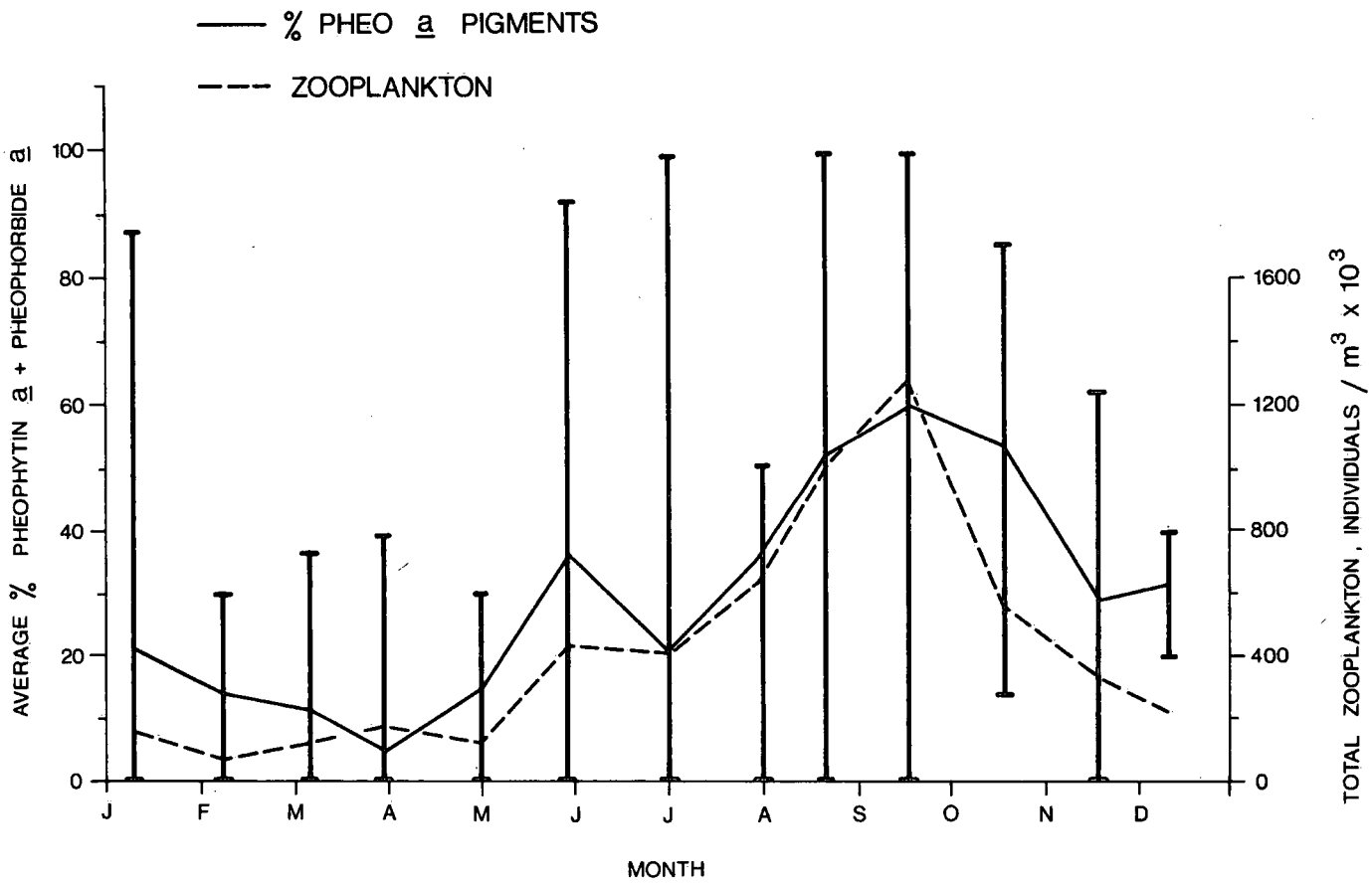


Figure 3. Relationship between pheo-pigments and zooplankton abundance in Lake Ontario.

1.7 μg C/l/h in winter and 12.5 μg C/l/h in summer. In the inshore region the highest assimilation values were found in spring and averaged to 25.0 μg C/l/h in late May. The highest single inshore value obtained was 43.9 μg C/l/h.

In 1970 the average values in Lake Erie varied between 5.1 and 32.0 μg C/l/h. The highest average values were: in the eastern basin, 13.9 μg C/l/h; in the western basin, 146.9 μg C/l/h and in the central basin 71.4 μg C/l/h. The absolute maximum 228.0 μg C/l/h, was found in the western basin in summer (Figure 4).

The assimilation of C^{14} shows a direct linear relationship with chlorophyll *a* in all the lakes. Lake Erie C^{14} assimilation per unit of chlorophyll *a* was greater than in Lake Ontario.

Zooplankton

A species study was carried out on the planktonic rotifers of Lake Ontario. Forty-five species were noted, one of which had been discovered previously in North America, and another one, considered to be extremely rare, which was found to be common.

Most important, quantitatively, were *Polyarthra vulgaris, Keratella cochlearis, Synchaeta lackowitziana* and *Keratella earlinae.* The highest numbers of rotifers appeared in July and averaged several hundred individuals per litre in the epilimnion. Thus, the biomass of the rotifers may equal occasionally that of the crustaceans, which makes rotifers an important part of the secondary producers.

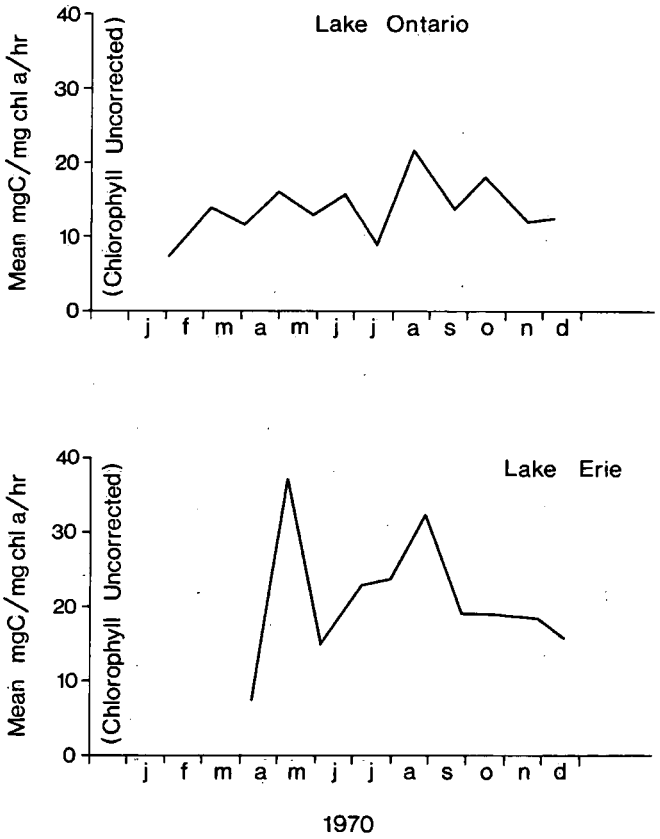


Figure 4. Comparison of seasonal cycle of carbon assimilated per unit chlorophyll *a* in Lakes Erie and Ontario.

Altogether 25 taxa of crustaceans were found in Lake Ontario, of which 3 were previously recorded from that lake. Crustacean plankton in the epilimnion of Lake Ontario was found to develop one peak in late summer, with a lake average of 50 individuals/1, the annual average being 17.4 individuals/1. Cyclopoids, with dominating *Cyclops bicuspidatus thomasi* and cladocerans, with dominating *Bosmina longirostris,* were almost equally important, quantitatively, while Calanoid copepods represented only 2% of all individuals. In winter, however, almost only copepods are found in the lake.

As an annual average, inshore regions showed approximately twice the population density of the open lake, but there is a distinct preference of offshore regions in the calanoids and in the adults of *Cyclops bicuspidatus thomasi.* The relative amount of Cladocerans, particularly of *Daphnia, Ceriodaphnia* and *Chydorus,* was highest in eastern and northeastern regions of the lake (Figure 5).

In Lake Erie, for comparison, during the ice-free period, the average number of Crustaceans was more than 5 times that of Lake Ontario. Percentage composition was 57% Cyclopoids, 38% Cladocerans and 5% Calanoids. The main difference was in the relative importance of *Bosmina longirostris,* which was almost lacking in Lake Erie but comprised 29% of all Crustaceans in Lake Ontario. Another difference was the very high amount of *Chydorus sphaericus,* particularly in the western basin of Lake Erie. In contrast to Lake Ontario, Lake Erie showed a two peak development of the zooplankton with a maximum in early summer and in a late fall. Highest concentrations were found in the western basin as early as June and amounted to over 1300 individuals/1.

In Lake Huron, in 1971, crustacean numbers varied from a few to some ten's of individuals per litre in the open lake but did not attain 100 individuals/1 in Saginaw Bay.

A strong correlation could be established between phytoplankton biomass and egg production in *Cyclops bicuspidatus thomasi* in Lake Ontario. For *Bosmina* a similar correlation existed, but the data indicate a more subtle dependence of egg production on food quality.

Preliminary results on the population dynamics of the dominant species show *Limnocalanus macrurus,* monocyclic; in most of the other copepods one long winter

generation and 2 - 3 short summer generations; and in most of the cladocerans 10 - 20 summer generations depending on temperature.

Diurnal migration was found in all species, its amplitude depending mainly on the size of the animal. The migration amplitude also was clearly dependent upon the season and was most marked during late spring, i.e., at the most light-intensive time of the year.

Bottom fauna

Another special study was devoted to *Mysis relicta*. This semi-planktonic species appears to be monocyclic, in Lake Ontario and in Lake Huron and shows a strong nocturnal migration from the bottom sediment to the uppermost layers of the lake. In winter, the animals are distributed over most parts of the lakes, but the females occur more commonly on inshore regions. In summer, there is a direct

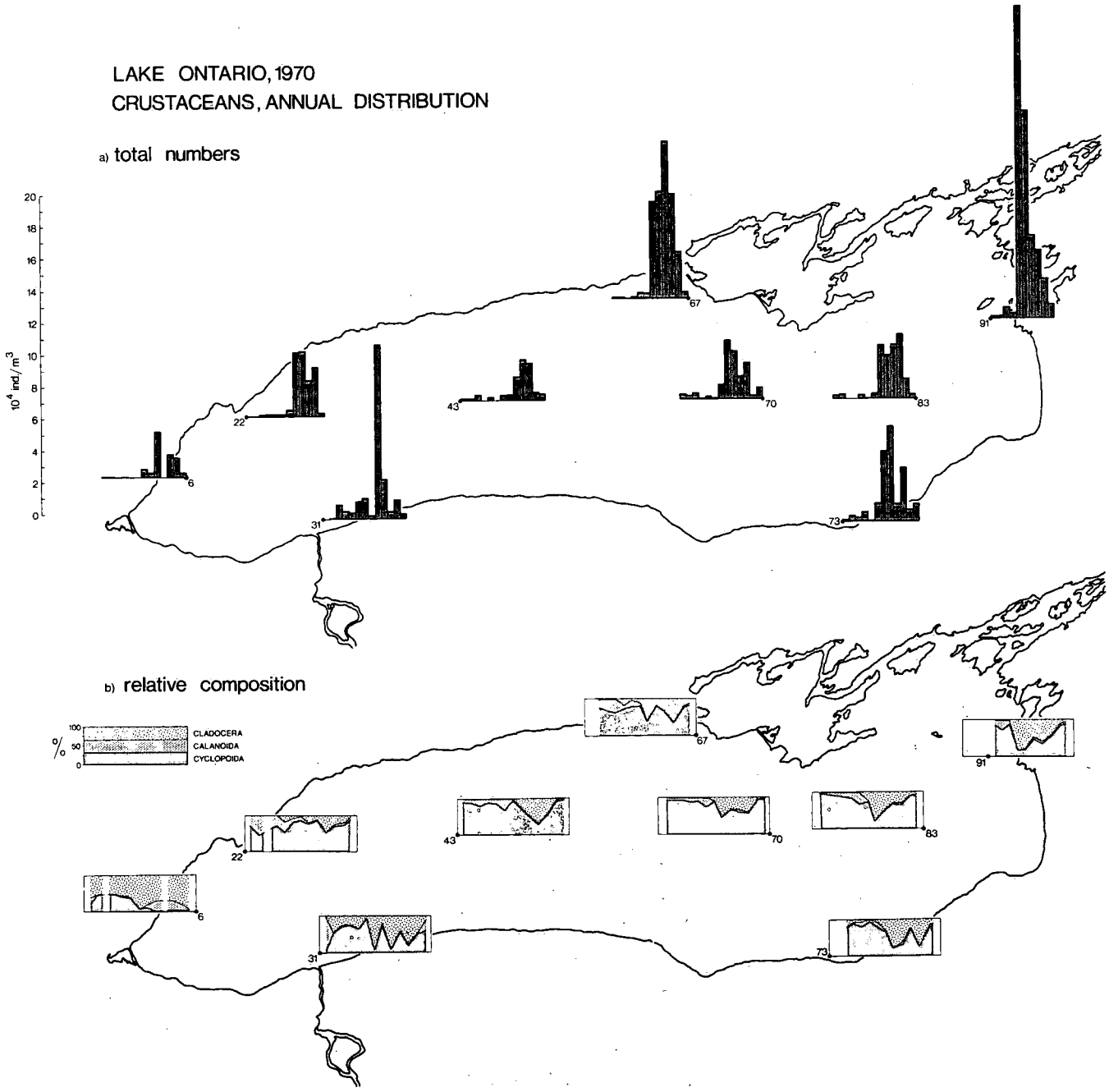


Figure 5. Annual distribution of crustacean zooplankton in Lake Ontario.

relationship between depth and numbers of animals per square unit. The average number of animals was around 30/m^2 in Lake Huron, twice as much in Lake Ontario and 5 times as much in Lake Superior. Calculated per water volumes, the numbers are 0.5, 1.0; and 1.2 individuals/m^3, respectively. In Lake Erie only a few individuals were found averaging to 0.7 individuals/m^2 or 0.03 individuals/m^3.

Bottom fauna studies also comprised a survey over Lake Huron and an investigation of Hamilton Harbour, Lake Ontario. In Lake Huron, an average of 880 organisms/m^2 was recorded from over 80 stations all over the lake. *Pontoporeia hoyi* and *Stylodrilus heringianus* with 33% and 19% of all individuals were the dominants. The average dry weight of the macrobenthos was found to be 1.36 $\mu g/m^2$, composed by Amphipoda, 0.39 $\mu g/m^2$, Oligochaeta, 0.13 $\mu g/m^2$, Chironomidae, 0.12 $\mu g/m^2$, and Mollusca 0.72 $\mu g/m^2$.

In Hamilton Harbour, *Limnodrilus hoffmeisteri* was the dominant species, representing 62% of the profundal Oligochaete community. A number of species, mainly molluscs, could be considered as new-comers to the Bay since the installation of a sewage primary treatment plant at the outlet from the City of Hamilton. Hence, the total biomass of bottom fauna is still increasing.

Bioassays

Experiments with the addition of nutrients and metal compounds to lake water and the study of algal response as assimilation rate, continued in the upper Great Lakes. It was found that significant positive and negative reactions on all added substances, (P, N, Fe, Mn), were most common in spring. In summer the number of significant reactions was low, and in fall they were mainly negative. This result indicates that (1) normally no single factor is limiting assimilation and (2) algal physiology is dependent on the season and determines the outcome of the experiment rather than the added substance *per se.*

Bioassays using mixed phytoplankton algae from Lake Ontario and Hamilton Harbour in order to evaluate the effects of sodium citrate indicated that chelation was the most probable mode of action of citrate upon algal growth. The interaction of zinc, copper, sodium citrate, and EDTA showed citrate to be a relatively weak chelating compound compared to EDTA. (Figure 6).

Lake Huron

Several conclusions may be drawn from preliminary interpretations of data from Lake Huron. With the exception of Saginaw Bay, chlorophyll *a* values are low-averages

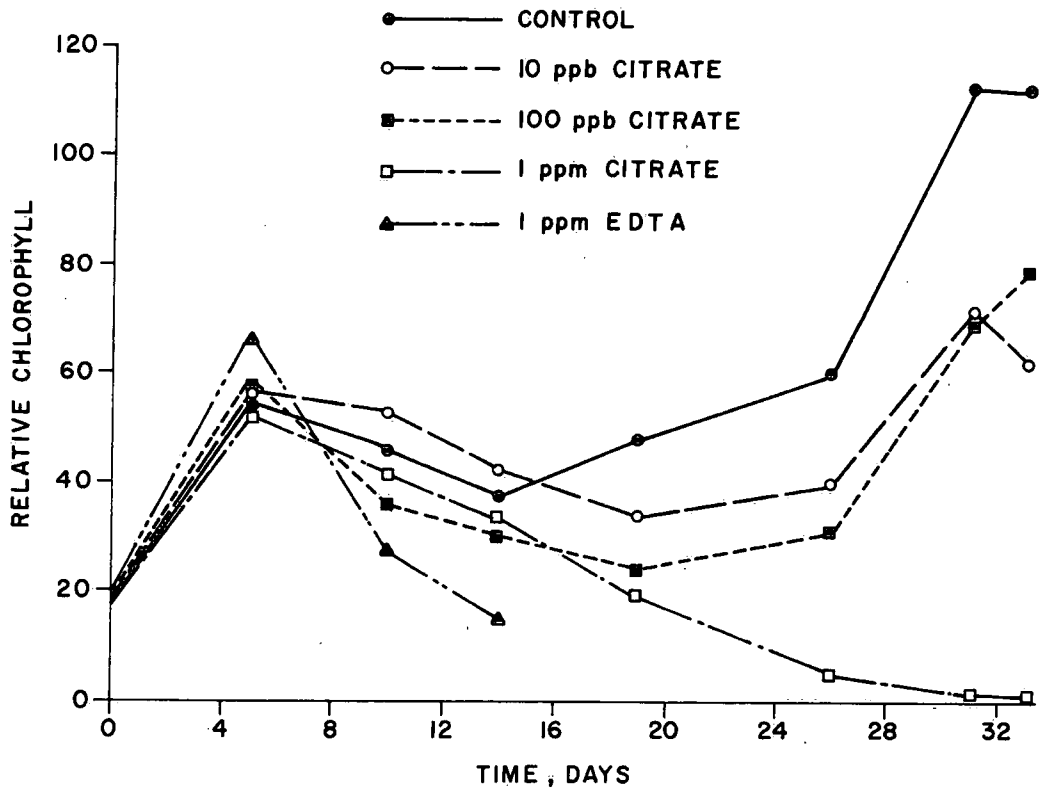


Figure 6. Effect of addition of citrate on algal growth from Hamilton Harbour.

from April to December are from 1 - 2 μg/1 over most of the lake except the western shore from the mouth of Saginaw Bay to St. Clair River where 2 - 4 μg/1 were found. In the Bay, sharp gradients from 4 μg/1 at the mouth to 24 μg/1 at the head occur indicating an extremely eutrophic environment. Neglecting the Bay, the seasonal cycle of chlorophyll *a* is mainly bimodal with vernal and autumnal peaks and a summer minimum which is less than 50% of the peak values. A slight summer maximum is found in the lower central portion of the lake. Primary production reached a maximum in late September; neglecting Saginaw Bay, maxima of about 4.5 mg C/m^3/h occurred. Primary production increased directly with temperature in a linear manner. Assimilation ratios reached a maximum of approximately 3 mg C/mg chlorophyll *a*/h comparable to the highest values found in Lake Erie. Nutrient enrichment experiments showed positive responses to nitrogen and phosphorus to occur in the spring and fall but negligible or negative responses were seen in the summer.

CHEMICAL LIMNOLOGY SECTION

During 1971 the staff was engaged in a variety of research projects: applied lake-study, a continuing study of the chemical quality of atmospheric precipitation, developmental projects on analytical methods and cycles of trace elements and soluble organic compounds (including NTA), basic laboratory research on the stabilities of authigenic phosphate minerals and the physical chemistry of aqueous solutions.

The applied lake study projects include continuing attention to the Chemical Monitor Cruise Program on the Great Lakes; a replicate sampling program to provide statistical assessments of the quality of the data; winter study of Lake Erie from the icebreaker, the CCGS N.B. McLean; monthly cruises of the CSS LIMNOS on the Central Basin of Lake Erie from May to December – the cruises being used for a variety of special projects; the chemistry of interstitial water of the bottom sediments, stable isotopes of carbon and sulfur; and bottom sampler and instrument development.

The collection of samples of rain and snow continued, and a variety of special purpose samplers were developed and evaluated.

Development continued on procedures for separating and identifying organic compounds in lake water, and a small-scale NTA monitoring program was set up. Research continued on the detection and chemical speciation of trace metals in lake water.

Specialized laboratory research projects included measurements of the stabilities of authigenic iron-phosphate minerals and the associated equilibrium water chemistry, the physical chemistry of aqueous solutions, e.g., the measurements of activity coefficients of solutes and solubilities of salts in three component systems.

Chemical Monitor Cruises

The Chemical Limnology Section was responsible for planning and evaluating results of the Chemical Monitor Cruises on the Great Lakes, although most of the work of sampling and chemical analysis is done by staff of the Technical Operations Section and of the analytical detachment of the Water Quality Division. The emphasis was on Lake Huron, eight cruises being carried out between April and December. As part of their input to the Monitor Cruise Working Group, M.T. Shiomi and K. Kuntz provided contoured charts of surface distributions of soluble nutrients for each of the Lake Huron and Lake Superior cruises.

A replicate sampling program was undertaken to obtain statistical evaluation of the quality and reproducibility of the chemical monitor cruise data. Standard deviations of the procedures were obtained from quintuplicate determinations at six stations during cruises on Lakes Huron, Erie and Ontario. The means of the five cruise standard deviations and the mean ranges over which they were determined are:

Dissolved oxygen	0.10 mg/1	10.98 – 12.12
pH	0.03 units	8.10 – 8.32 units
Specific electrical conductance	3 μmho/cm	224 – 257 μmho/cm
Total alkalinity, filtered	0.6 mg/1	74.2 – 82.6
Total nitrate, filtered	0.009 mg/1	0.162 – 0.255
Soluble reactive phosphate, filtered	0.001 mg/1	0.004 – 0.013
Soluble ammonia, filtered	0.002 mg/1	0.005 – 0.030
Nitrite, filtered	0.0005 mg/1	0.0014 – 0.0047
Reactive silica, filtered	0.093 mg/1	0.737 – 1.282
Turbidity	0.7 units	0.7 – 6.4

The large dispersions in phosphate, ammonia, and nitrite values probably stem from the fact that the levels of these components were at or near their detection limits. Silica and turbidity standard deviations are high and it is hoped efforts will be made to improve methods of sampling and analysis. The other values all represent a small fraction (less than 5%) of the determined values.

An unexpected opportunity to survey and sample Lake Erie during the winter was provided when space was made available on the CCGS icebreaker N.M. McLEAN; ice and water samples were taken. The water column was homogeneous at all stations and dissolved oxygen was at or near saturation. Soluble nutrients were near their annual highs except for silica which was low, suggesting some diatom growth, even under ice.

Analysis of the melted ice yielded inconclusive results, showing no patterns with respect to sampling location, ice thickness, or nearness to the water. However, ice formation and movement may be an important part of Lake Erie's annual cycle, as some of the ice contained large amounts of particulate matter, and assayed very high (~ 1.7 mg/l) in particulate phosphorus.

Interstitial Water

Sediment cores from three stations in the central basin of Lake Erie were collected at monthly intervals from May to October, to study the chemical properties of the interstitial water and the effects of seasonal changes in the chemistry of the overlying water.

The hypolimnion of the central basin warms over the summer from about 7°C to about 15°C, while the oxygen content of the bottom water decreases in large areas to zero. During the same period, chemical changes were seen in the interstitial water, most markedly near the sediment-water interface. The pH and Eh decreased, and Ca and Mg content and alkalinity increased. Except for sulphate, the interstitial waters were enriched in nutrients relative to lake water. Sulphate content decreased with depth and alkalinity and the amount of ammonia increased. These observations are in agreement with the interpretation that carbonate and silicate minerals in the bottom sediment are slowly being dissolved.

Stable Isotopes of Carbon and Sulfur

Samples of water, interstitial water, and plankton were collected from Lake Erie for a preliminary evaluation of the value of carbon isotope analyses in lake studies. The C^{13}/C^{12} ratio has been determined for some of the water samples on the special mass spectrometer in the laboratory of Dr. H. Schwarcz at McMaster University. The following tentative conclusions have been drawn:

1) The δC^{13}* of the surface waters in both lakes ranges from about +0.6 to about −0.5 $^0/_{00}$, suggesting that the surface waters are in equilibrium with atmospheric CO_2.
2) The δC^{13} of the water just off the bottom, i.e., below the thermocline, is more negative, indicating that CO_2 from decomposing organic matter is added to the water. In Lake Erie the δC^{13} becomes more negative as oxygen is depleted in the hypolimnion.

Information was also obtained on the isotopic sulphur composition in lake water, algae, and the sediment. The abundance of isotopic sulphur in the lake water is remarkably uniform (mean δS^{34} value of six samples is +4.7 $^0/_{00}$, with the standard deviation of 0.2 $^0/_{00}$). It is somewhat surprising that the isotopic data for the algae is essentially identical (mean value for three samples is +4.6 $^0/_{00}$) to that of the lake water. Typical of the syngenetic or diagenetic sulphides resulting from biogenic activities, the sulphur in the sediments shows widely scattered δS^{34} values ranging from −10.8 to +15.1 $^0/_{00}$. While a detailed interpretation of the data is not feasible at this stage, the preliminary results to indicate the potential importance of stable sulphur isotopic analysis in environmental studies.

Bottom Sampler and Instrument Development

A large area (0.28 m^2) diver-operated, interface sampler was developed for the purpose of observing sediment-water processes in the laboratory with the interface in its natural condition. The sample obtained is large enough to be set up as a test tank in the laboratory with controlled circulation and has been used in measuring sediment oxygen demand under conditions in which some variability of natural conditions has been removed; it can also be used for a large number of different investigations. At present the sampler cannot be used at depths greater than 100 ft. due to diver limitations, however, the experience gained in developing the instrument will be used in the subsequent development of a diver independent interface sampler.

Work has progressed on the development of an *in situ* instrument to measure settling rates and settling fluxes of algae and suspended minerals. This "sedimentation bottle" will be used in studies of nutrient cycling in lakes and in the transfer of quantities of materials from the epilimnion to the hypolimnion during stratified periods.

Rain Chemistry Project

Another station located at Sarnia Airport in the Lake Huron Basin was added to the sampling network of the Rain Chemistry Project (Figure 7). The sampling network now comprises a total of 16 sampling stations in the Laurentian Great Lakes basin – 8 in the Lake Ontario basin, 3 in the Lake Erie basin, 3 in the Lake Huron basin, and 2 in the Lake Superior basin. Bulk precipitation (rain-fall and dust-fall combined) samplers are used at all of these stations and each month's collection of bulk precipitation is analyzed. For over 2 years, chemical data have been accumulated from the Lake Ontario basin stations and for about 1 year from the rest of the stations with exception of the new Sarnia Airport station.

More detailed investigations into the chemical nature of precipitation are carried out at the site of the Canada Centre for Inland Waters. Automatic rain samplers which collect only rain-fall or snow and not dust-fall have been

* $$\delta C^{13} = \left(\frac{C^{13}/C^{12} \text{ sample} - C^{13}/C^{12} \text{ standard}}{C^{13}/C^{12} \text{ standard}} \right) \times 1000$$

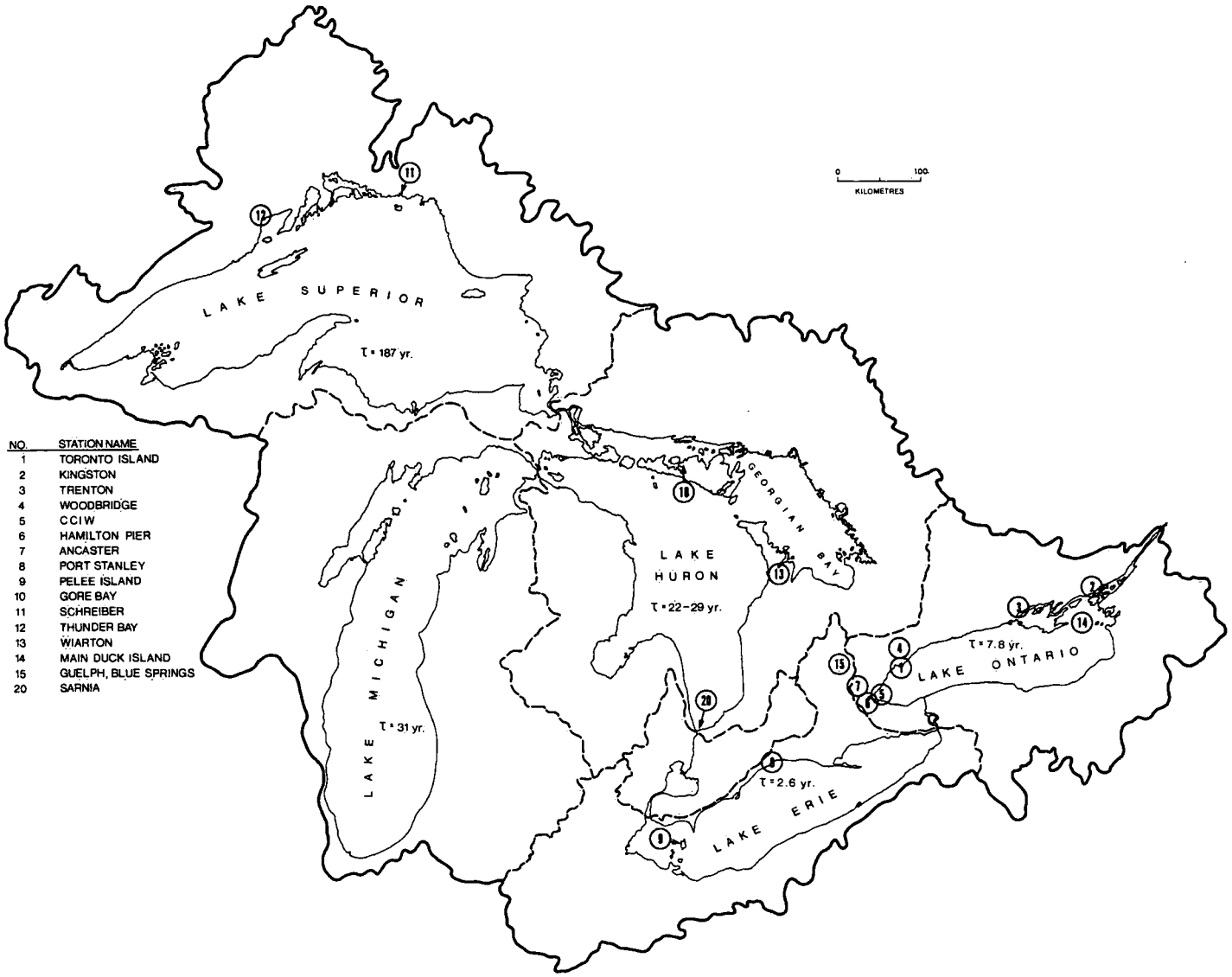


Figure 7. Rain chemistry project, station locations, Dec. 1971.

acquired. These samplers were modified before use, incorporating heating elements for winter operation and wind directional sensors. The latter modification enables us to collect the rain or snow only when the wind is blowing in a certain specified direction. It is hoped that by using a number of these samplers together, all fitted with this modification, it will be possible to determine qualitatively the effect of specific air pollution sources on the chemical composition of the rain collected. Three of these samplers have been in operation at the CCIW since late September. All special experiments into rain chemistry will be restricted to the CCIW site for the present time.

Organic Compounds in Lake Water

Work begun in 1970 on the chemical properties of NTA (nitrilotriacetate) now being used in Canada as a substitute for polyphosphates in laundry detergents, was essentially completed in 1971, and several papers were published (Chau and Fox; Childs; Lerman; Chau and Shiomi). Towards the end of 1971, the emphasis turned toward monitoring the levels of NTA, now present in near-shore waters.

Detection of low concentrations of NTA in water involves an extraction by an anion exchange resin, preparation of the propyl ester and gas chromatography. Some other organic acids in this molecular – weight range will be carried through this procedure.

Water samples from Lake Huron, Lake Erie, and Lake

Ontario were analyzed for NTA, using large enough samples to permit the detection of <1 μg NTA/1. NTA was detected only in the Lake Ontario sample, but, interestingly, different arrays of background peaks were obtained for the various samples of lake water. This procedure shows promise for "fingerprinting" different waters and for characterizing a number of soluble organic compounds.

Dissolved organic material in lake water is generally present in lower concentrations than can be isolated and identified by standard chemical methods or by most instrumental techniques, so various methods of extraction and preconcentration were investigated. A continuous extraction apparatus was designed for use with immiscible solvents of different densities than water, and capable of accommodating large (8 l) samples. An efficient preconcentration technique involves use of a Virtis Freeze Concentrator which provides approximately a ten-fold concentration of dissolved material in water, and ultra-pure ice. The preconcentration cannot be carried further due to a precipitate, presumably $CaCO_3$. The precipitate is caused chiefly by the hardness and high alkalinity of most Great Lakes water.

Trace Elements in Lake Water

A PAR Model 170 Electrochemistry system was acquired for applications in trace metal analysis and studies of chemical speciation in lake waters. Considerable time was spent in optimization of the instrumental parameters of operation in the various modes of polarography. This polarographic technique is capable of direct and simultaneous determination of several metals in lake water at the μg/l concentration level. Methods have been established to differentiate between a metal in a free ionic state and in a complexed form.

A special project on the chemical forms of Hg in lake water shows that little, if any, is present as methyl mercury.

Solubilities of Authigenic Phosphate Minerals

A knowledge of the solubilities of authigenic phosphate minerals is relevant to the question of the geochemical migration and fixation of phosphorus and the various metals in soils and sediments. The solubilities of important phosphate minerals are now being determined using a saturator which allows the aqueous solvent to percolate through a cascade of the phosphate beds. The analytical data on the leachates are computer processed to obtain the solubility product constants and the association constants for any ion-pairs.

The results obtained so far are encouraging. For example, measurements on vivianite [$Fe_3(PO_4)_2 \cdot 8H_2O$] suggest that $FeH_2PO_4^+$ and $FeHPO_4^0$ may be important species in reduced aquatic systems and the formation of this mineral may be significant in regulating the P and Fe levels in natural waters and in anaerobic digester supernatants.

Physical Chemistry of Aqueous Solutions

Measurements of the activity coefficients of brine analogs containing two salts are now essentially complete, as are measurements of solubilities in two-salt solutions using the isopiestic technique of Kirgintsev and Trushnikova[1].

The following parameters were determined:

(a) The activity coefficients, and the solubilities at the eutectic at 25° and at 0° of the systems:

H_2O–NaCl–$MgSO_4$
H_2O–NaCl–Na_2SO_4
H_2O–K_2SO_4–Na_2SO_4

(b) the activity coefficients at 25° of the systems:

H_2O–NaCl–K_2SO_4
H_2O–KCl–Na_2SO_4
H_2O–KCl–K_2SO_4
H_2O–$MgCl_2$–$Mg(NO_3)_2$
H_2O–$MgCl_2$–$Ca(NO_3)_2$
H_2O–$CaCl_2$–$Mg(NO_3)_2$
H_2O–$CaCl_2$–$Ca(NO_3)_2$
H_2O–$Mg(NO_3)_2$–$Ca(NO_3)_2$

(c) the activity coefficients at the freezing point of the binary systems:

H_2O–$Na_2B_4O_7$
H_2O–$K_2B_4O_7$
H_2O–$NaBO_2$
H_2O–$NaBF_4$
H_2O–KBF_4
H_2O–H_3BO_3

Work is now beginning on the measurement of activity coefficients and solubilities in three-salt solutions to see whether the isopiestic method can easily be extended to cover such systems or whether the solubilities should be calculated from two-salt data. The first system chosen for this study was H_2O-NaCl-Na_2SO_4-$MgSO_4$ at 25° and 0°. Experimental work is in progress.

LIMNOGEOLOGY SECTION

The Limnogeology Section has been responsible for undertaking research on the bottom sediments and suspended particulate material in major Canadian Lakes and their interconnecting waterways. Activities in 1971 fall

[1] Russ. J. Inorg. Chem., *13*, 600 (1968).

under five main headings: Regional Inventory Studies, Process Studies, Special Studies, Technological Development, and Contract Studies. A wide range of investigations was carried out mostly in the lower Great Lakes and a significant amount of the 1970-71 data has already been presented or submitted for publication.

Regional and Inventory Studies

Reconnaissance Seismic Surveys

Regional seismic reflection surveys were undertaken in Georgian Bay and the North Channel, and Lake St. Clair, to provide reconnaissance data on bedrock topography and the distribution and thickness of Quaternary deposits. The surveys were carried out jointly with the Geological Survey of Canada (GSC), CCIW staff, and the Royal Ontario Museum, using vessels provided by Great Lakes Institute, University of Toronto, and the Canada Centre for Inland Waters.

The cruise patterns consisted of east to west lines spaced 10 km apart, with north to south and diagonal tie lines. In addition to the instrument data, sediment samples were obtained at 88 stations.

The seismic data were obtained from broad-band analogue recordings with a Bolt air gun as the energy source, and a multi-element eel receiver towed at the surface. A magnetic tape recorder was interfaced with the analogue recorder.

North of latitude 44°52′ the exposed Precambrian rocks slope into the basin. The Precambrian surface beneath a cover of unconsolidated sediments is irregular and hummocky, similar to the topography of the eastern and northern nearshore areas.

The western shores of Georgian Bay expose Silurian and Ordovician strata which extend beneath the water level – the deepest parts of the Bay are found along these western shores. The Palaeozoic – Precambrian contact can be identified on some seismic records.

Chart CHS 2201 shows two valleys in the southwestern part of the Bay; one is associated with Owen Sound, the other lies to the east of it. The valleys join at latitude 45°02′ and longitude 80°45′ and then continue northward. Where the survey lines cross these valleys, the data indicate that they are underlain by bedrock valleys, and suggest that the valley to the east of Owen Sound heads into the Bighead Valley, a large re-entrant into the Niagara escarpment. The maximum bedrock relief in these valleys determined so far is 100 m. The valleys are filled with unconsolidated sediments, with maximum thicknesses of over 50 m.

The sedimentary sequences in Georgian Bay are variable. Sands and/or sand and gravel overlie glaciolacustrine red clay at many localities. These red clays have laminations of silt suggesting varves. The sands and gravels are present in waters up to 115 m in depth. At other localities, grey, silty clay overlies the red clay; the grey sediments contain black iron sulphide bands. Till has been cored in the southern and northwestern parts of the basin.

The low-level stage of Georgian Bay, Lake Hough, can be recognized from unconformities, pollen studies, and the occurrence of peats and shallow-water plant fossils in sediments presently at great water depths. Evidence, so far, is insufficient to date it or map its shorelines.

Surveys in Lake St. Clair support earlier findings, and have confirmed the existence of generally very thin veneers of recent unconsolidated sediments.

Regional Sampling Programs – Lakes Erie, Ontario and Huron

A regional sediment sampling program, during the summer of 1971, provided 287 samples located on a 10 km square grid in Lake Erie. Initial analyses support the earlier findings reported to the IJC. An early study of the distribution of mercury in the lake's sediments showed expectedly high values at the mouth of the Detroit River. High concentrations (up to 2.7 ppm) occurred over the whole of the western basin and also in areas adjacent to Erie (2.6 ppm) and Buffalo (7.5 ppm) on the U.S.A. shore.

Studies on the sediments of Lakes Ontario and Huron have also continued, and the distribution of three major sediment units (glacial till and bedrock, glaciolacustrine clay, and post-glacial mud) have been mapped. Separate physiographic sub-basins strongly affect the accumulations of post-glacial muds, and the irregular bathymetry of northern Lake Huron is particularly notable in this respect.

More detailed studies on the composition of Lake Ontario sediments show that quartz and feldspar contents are greatest in the coarser inshore sediments while clay minerals and organic carbon are greatest in the finer offshore sediments. Illite is the dominant clay mineral with lesser amounts of chlorite and kaolinite. Textural characteristics of the sediments imply a mixing of two end-member populations, sands and clays. The resulting sediment distribution is believed to be a direct function of decreasing energy with water depth.

Studies on the mercury content of Lake Huron sediments suggest that the average is about 0.2 ppm, with anomalous highs generally less than 1 ppm. In Lake Ontario the average content is significantly higher, 0.6 ppm;

extensive areas are above 1.0 ppm and highest values (as in Lake Erie) exceed 2.0 ppm. The mercury distribution strongly reflects the influence of the Niagara River, the general mass transport eastwards along the southern shore of the lake, and possible additional inputs along the south shore.

Nearshore Sediment Inventory

This sampling program was again extended eastwards to cover the area between Presqu'ile and Main Duck Island in eastern Lake Ontario. Bedrock dominates the area east of Wicked Point, but sand covers much of Wellington Bay where its maximum thickness does not appear to exceed 5 m. Sand which appears to be derived from glacial drift (in the Presqu'ile area), is transported by eastward longshore drift, and is trapped by the Owen and Wicked Point promontories. Comparison of the present sediment distribution with that of an earlier study of Wellington Bay by Kindle in 1925, suggests that both the extent and thickness of the sand bodies may have increased.

In Lake Erie, the nearshore inventory program extended sampling westwards from Mohawk Point to Peacock Point; four bottom types were identified: bedrock, till, glaciolacustrine sediments, and recent muds. Bedrock outcrops inshore and on an offshore ridge between Hoover and Peacock Points. Glaciolacustrine sediments, capped with a thin lag sand, generally occupy the intermediate and outward parts of the zone. Till and associated lag deposits comprise most of the zone east of Port Maitland and isolated exposures occur elsewhere throughout the zone. Recent muds overlie the glaciolacustrine sediments in deep water and also comprise the fluvial deposits at the mouth of the Grand River. The shoreline generally intersects a low till bluff with bedrock exposed at or near the waterline. In the vicinity of Peacock and Mohawk Points, the till bluffs exceed 10 m and are undergoing active erosion. Dunes occur at Rock House Point.

Grid Survey

The field work of this sampling survey, covering the selected areas of Niagara and Kingston (Lake Ontario), and Tobermory (Georgian Bay), was successfully completed during the year. Of prime importance has been the collection of more than 300 high quality underwater photographs for comparative analyses. Although only about 30% of the sedimentological and geochemical analyses have been completed, physiographic plots are complete and seismic interpretation is well advanced. Of particular interest has been the location, in the Kingston area, of extensive levels related to the post-Iroquois low lake Admiralty phase. Since such areas were influenced by littoral conditions they may prove to be of some interest as potential sand-source locations (probably acceptable from both the ecological and resource standpoint).

Isostatic Rebound – Lake Huron and Georgian Bay

A simple theoretical model was established which describes the effects of isostatic crustal rebound on lake level and drainage in the Huron – Georgian Bay Basin during the last 10,000 years. The model shows that the lake level, and hence water volume and shoreline positions, varied by several orders of magnitude when the basin was differentially tilted up to the north. The earliest post-glacial lake levels were extremely low (over 130 m below present level) and drained northeastward over a succession of thresholds around Manitoulin Island into Georgian Bay and ultimately into the Ottawa Valley through the Nipissing – Mattawa lowland. Lake levels then rose with rebound of the outlet area to the Nipissing Great Lakes stage about 18 m above present lake level, approximately 5,500 years ago. Renewed operation and subsequent erosion of the present St. Clair River outlet caused Lake Huron to fall gradually to its present position.

Some of the theoretical predictions concerning low lake levels were borne out by a series of piston cores, up to 21 m in length, collected from Lake Huron. Unconformities, commonly indicated by thin units of sand, gravel, shells or plant detritus, were revealed in the late glacial – post-glacial sediment sequence at nine localities distributed throughout the Huron basin. Of particular significance is an extensive bed of buried plant detritus indicating a previous marsh environment. The detritus underlies an area of at least 20 km^2, 17 km east of the Michigan shoreline on latitude 44°30′N, where the present water depth is 59 m.

Process Studies

Nearshore Processes – Western Lake Erie

An investigation into the sediment distribution and its transportation in western Lake Erie, along the Canadian shore, was completed. The area of concern extended from the Detroit River mouth, eastwards towards Wheatley. With the exception of sediment input from the Detroit River, most source material (west of Point Pelee) is derived from erosion of bluff materials (at a rate of about 1.5 m/a). On the east side of Point Pelee, the subaqueous erosion of glacial till appears to account for much of the recent sediment accumulation. Stream inputs are negligible. Sediment movement in the vicinity of Point Pelee appears to be more complex than was previously believed and indications of reversals in longshore drift on the west side of Point Pelee were found in both textural and mineralogical data. Although the causes of erosion at the tip of Point Pelee are difficult to define precisely, they appear to be related to: shoreline construction, offshore dredging, and persistence of high water levels.

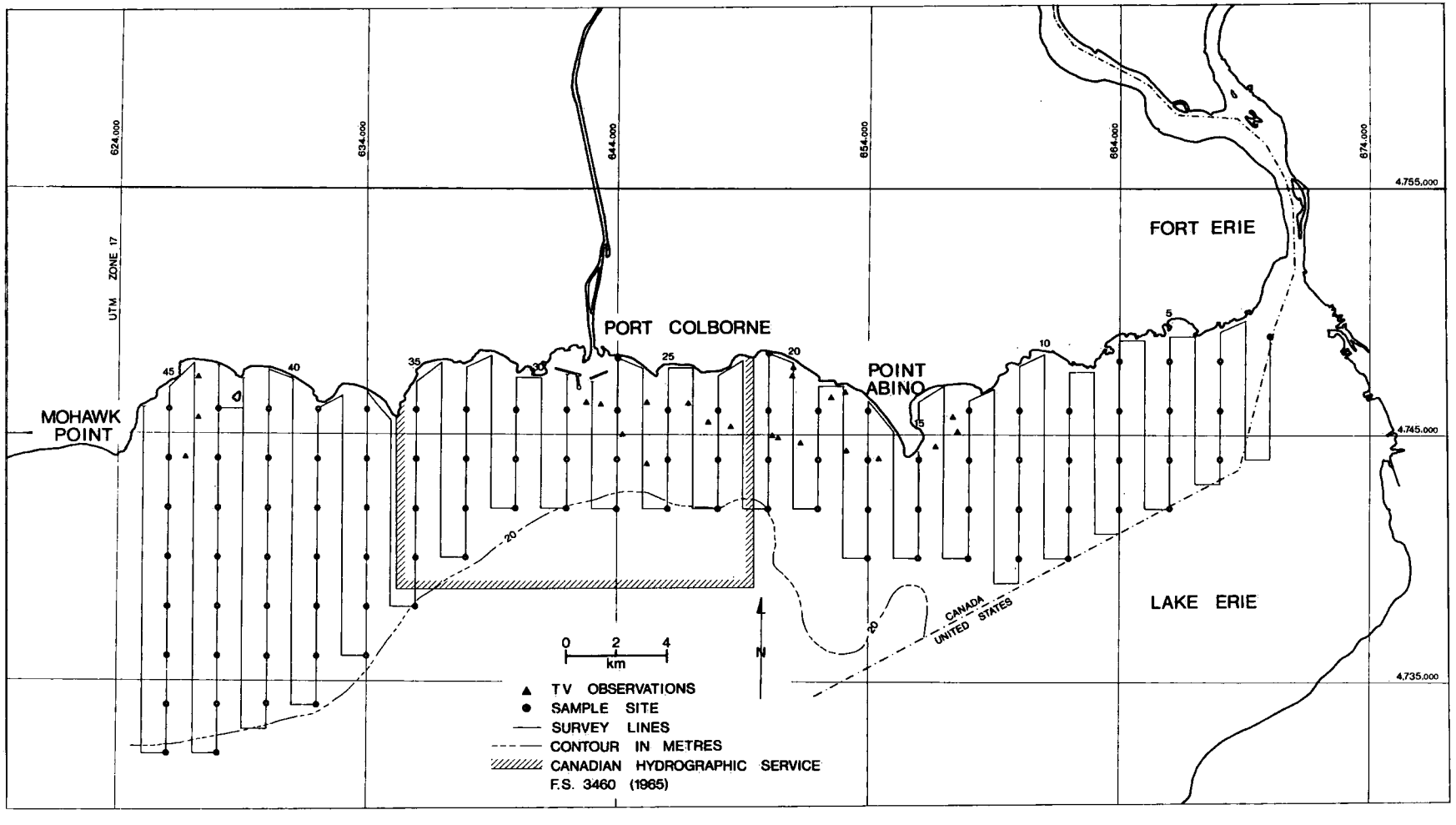


Figure 8. Survey pattern and sampling points.

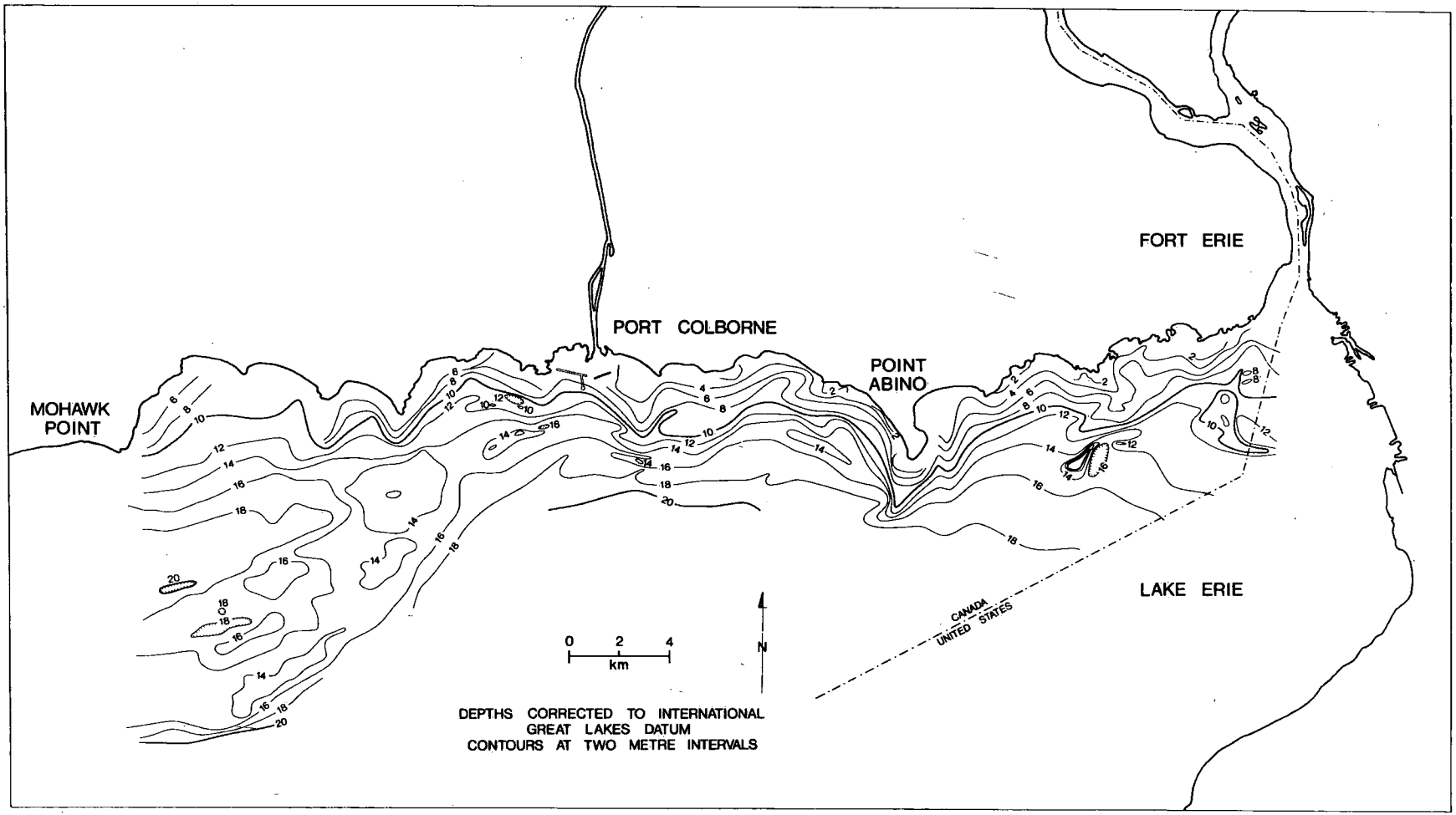


Figure 9. Nearshore bathymetry.

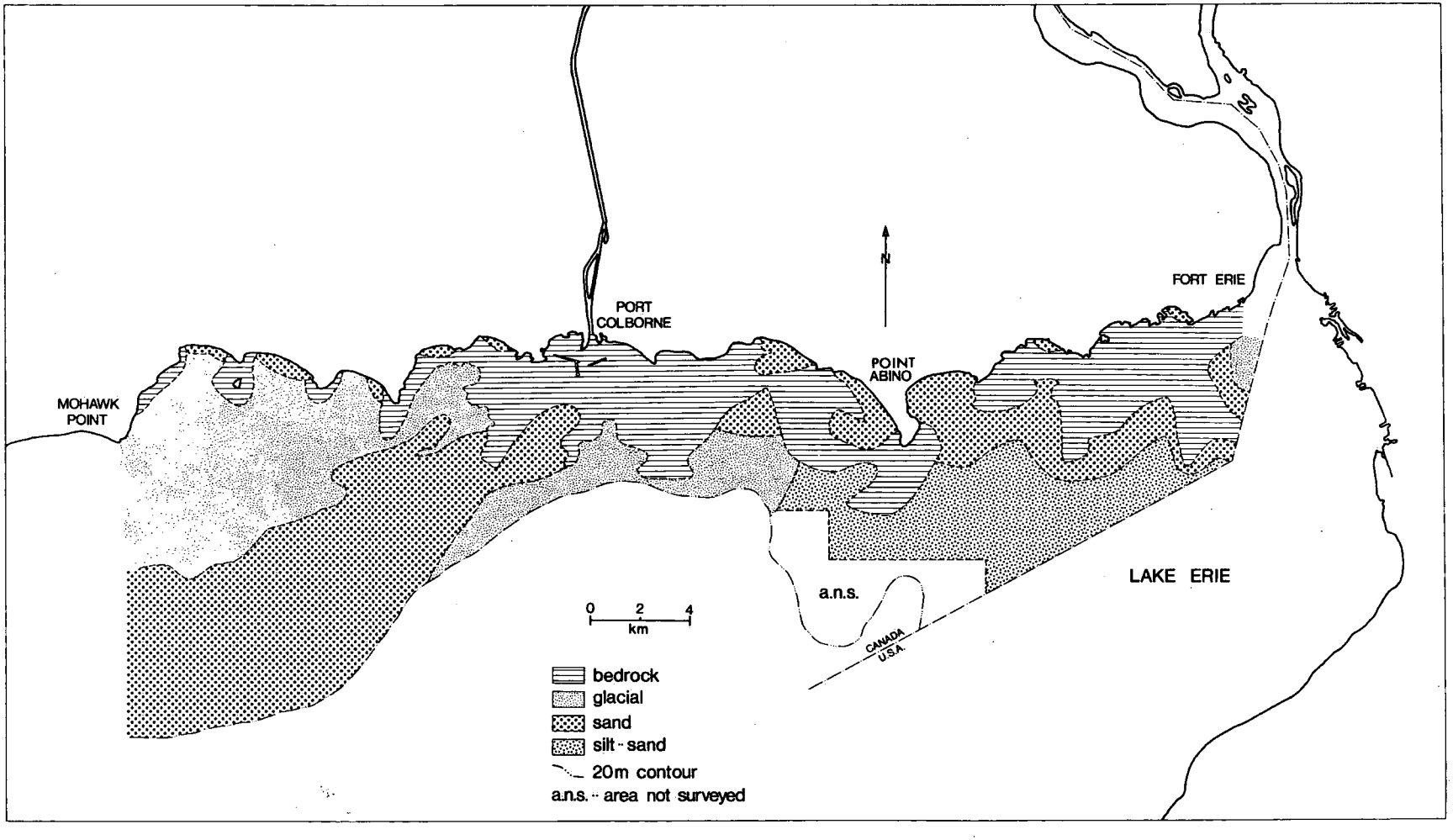


Figure 10. Bottom sediment distribution.

Related studies on sediment transport, using tracers, also reflected the variability in direction of longshore drift along the Point (frequently northerly along the southwestern part); south, east, and northward vectors were all observed. Drift rates appeared to be directly related to significant wave height and incidence, with maximum velocities of 0.3 m/s.

Monitor Sediment Survey (MOSES)

This program was initiated in March of 1971 and so far ten cruises (about one-month interval) have been completed, covering an area of some 80 km^2 at the extreme western end of Lake Ontario. Two trends in the data have been observed so far: (1) water depths appear to be deepening in the nearshore area, and shoaling offshore, and (2) major textural changes appear to be occurring at intermediate depths (12 to 24 m). These generally consist of a change in the sand/silt ratio and appear to be independent of bathymetric change. The study also involves trace element and heavy metal geochemistry, sediment bacteriology, bottom fauna, recent stratigraphy, and is supported by additional aerial reconnaissance.

Sediment Bacteriology

This study has been undertaken in conjunction with the MOSES program. The emphasis has been upon heterotrophic total counts and biotype distributions. Although total counts reduced with sediment depth (aerobes 8.2×10^7 and 2.5×10^6; anaerobes 4.9×10^5 and 8.3×10^4 – surface and 21 cm depth) the primary relationship appears to be with Eh. Sediment profiles were very similar between July and October, have less reduction in November, and very much less by December. It is not yet known if the bacterial population will increase significantly in response to the smaller reduction rate of the sediment observed in November and December.

Rates of Sedimentation

Studies have continued on the rates of modern (offshore) sedimentation in Lake Ontario estimated by determining the *Ambrosia* horizon (circa 140 years BP). From a total of 20 sediment cores located throughout the lake, the horizon appears to occur beneath 15 to 25 cm of sediment cover. The data so far suggests a uniform filling of the various sub-basins at a rate of about 2 mm/a. Because of the prevailing winds and mass transport within the lake, sedimentation is greatest in the Mexico Bay region.

Lake Sediments

(a) Carbon, Nitrogen and Phosphorus (C,N,P) Content: Mud cores from Lakes Huron, Erie, and Ontario have been measured at close intervals, for total organic matter, nitrogen and phosphorus content. The values observed from Lake Erie and Lake Ontario cores suggest an exponential increase in such content from an estimated time of deposition (1900) to the present. No significant changes were observed between the 1900 level and present day surface in the Huron core. The results clearly demonstrate a three-fold increase in organic matter, nitrogen and phosphorus input into Lakes Erie and Ontario (over the natural level), but no significant change is so far observed in northern Lake Huron.

(b) Forms of Nitrogen: Continuing studies have shown that organic nitrogen accounts for more than 95% of the total sediment nitrogen found in the Lake Ontario and Hamilton Harbour muds; the remaining nitrogen being in the fixed- and exchangeable-ammonium form. Fixed-ammonium nitrogen accounted for more than 90% of the sediment nitrogen in the Lake Ontario glacial sediments. C:N:P ratios in the surface sediments and the increase in fixed-ammonium nitrogen in cores indicate that the nitrogen released by the decay of organic matter is returned to the lake water at the sediment interface, while it is fixed by the clays at a greater depth in the sediment cover.

The nitrogen content of Great Lakes humic acids (like the oceanic environment) is double that usually found in soils, though the humic/fulvic acid ratio is similar to that reported in tundra soils (pointing to the similarity of the two environments).

(c) Forms of Phosphorus: Studies on sediment samples from Lakes Erie and Ontario have shown that organic phosphate, sorbed forms of orthophosphate, and apatite (calcium phosphate) were present at the surface. Sorbed and organic forms decreased with depth in sediment, while apatite increased. Sorbed orthophosphate is thought to be readily mobile and capable of returning to overlying water under certain conditions (e.g., during periods of hypolimnetic deoxygenation). Organic phosphate is much less available for regeneration to the overlying waters. Apatite, being rather insoluble, released phosphorus into solution only slowly. These findings suggest a mechanism whereby phosphorus becomes immobilized in lake sediments. It seems likely, also, that any excess of phosphorus which may be accumulating in Great Lakes sediments as a result of high phosphorus loading will ultimately be converted into apatite; thus permitting little if any future regeneration of phosphorus under conditions of improved water quality.

Interface cores were obtained from six locations in Lake Erie, on a monthly basis between May and November. New techniques which allow precise subsampling and progressive electrode emersion in core material are being used. The pH values averaged 7.0 to 7.3 and showed little or no variation with depth, location, or time of sampling.

Eh values of the top 0.5 cm of sediment reflected that of the overlying water. In cores where recent mixing of the surface layers appeared to extend below the 2 cm depth, the decline was more gradual. The results, which compare with visual observations, suggest that surface sediment oxidation does not extend more than about 2.0 cm unless the sediment is subject to disturbance.

(d) Chlorophyll Studies: Detailed studies were initiated on the distribution of chlorophylls in the surface sediments of the Great Lakes, together with studies on organic diagenesis. In this first year of the program, analytical techniques have been significantly improved; sensitivity to chlorophyll *a*, using thin layer fluorescence scanning in reflectance mode, is now 0.1 ng (± 10%). This is about two orders of magnitude better than the elution and spectrophotometry technique previously used. These studies form part of an MSc course at Queens University, Kingston, which has also involved a sediment-water interface sampling program in Lake Opinicon and Little Round Lake (north of Kingston).

Special Studies

IFYGL – Compilation

A map showing the distribution of surficial deposits (Pleistocene geology) in the Lake Ontario drainage basin, including the sediments beneath Lake Ontario, is being prepared for publication to a scale of 1:500,000. The glacial history and evolution of Lake Ontario will be illustrated in a series of sketch map inserts. Because further field data were required in some areas of the United States and Canadian portions of the drainage basin, the anticipated completion date for the map-draft is now late 1972 or January 1973.

Field mapping is being conducted in Canada by the Geological Survey of Canada (GSC), in the United States by Syracuse University for New York State Geological Survey. GSC-CCIW are compiling data for Lake Ontario and the GSC is preparing the sketch maps of Ontario-basin glacial history.

Okanagan Task 121

By the end of 1971 the sample and data collecting phases of the Okanagan study were almost complete, and reduction of data and compilation of results were at an advanced stage. A number of interesting characteristics have been noted with regard to the lake system. A 50-foot stand, emphasized by the presence of erosional features and remnant deposits, has confirmed the existence of a former lower lake level in both Okanagan and Skaha Lakes. Accumulations of very considerable thicknesses of unconsolidated deposits have been recorded from seismic studies, well in excess of 1,000 feet thick. A submerged drumlinoid feature has been observed off Squally Point, on the floor of Lake Okanagan.

From both the sedimentological-bathymetric and geochemical aspects, each of the major lakes can be divided into a number of sub-basins. It appears that these are frequently quite distinct, and may differ markedly even within the same lake. Particle size and trace element analyses are not yet complete; however, mercury distributions show interesting trends. Mercury values are high in Wood Lake, marginally lower in Kalamalka Lake, and in Lake Okanagan (above Vernon). Below Vernon values remain low, but in Osoyoos values again rise significantly. Ash bands have been identified in cores from both Kalamalka and Osoyoos Lakes and will be used for dating and estimating accumulation rates. Interpretation is not yet complete.

Analyses of total amounts and forms of phosphorus from lakes in the Okanagan Valley indicate no relation between phosphorus content in sediments and the degree of eutrophication of the lake. In Lake Okanagan, total phosphorus of surface sediments varied from 800 to over 3,000 ppm and tended to increase towards the centre of the lake. Values for Skaha were generally lower (200 to 1,200 ppm) although this lake is more eutrophic. These findings indicate that the gross chemical and mineralogical characteristics of the sediment, such as the amount of fine clay-sized material, may play a greater role in determining the level of phosphorus that accumulates in the surface sediments, than does the concentration of phosphorus in the overlying water.

Bell-Nottaway Study

In response to a request for assistance to study mercury levels in sediments of the Bell-Nottaway River System (N.W. Quebec), the area staff undertook sampling programs in early September and October. Sampling was undertaken from an 18-foot (trailer mounted) launch, and from a float plane. Twenty-three sampling locations were established in eight lake areas of the river system. Results, to date, indicate that total mercury content in the sampled sediments is extremely low; however, further appraisals of the data are currently being undertaken and final results are not yet available.

Hudson Bay and Mackenzie Study

GSC staff, based at CCIW, were involved in a reconnaissance survey of Hudson Bay from the end of July to the beginning of October. 2,500 line miles were covered using echo sounding, seismic, and side scanning equipment. Lakes Division staff provided limited support for a reconnaissance survey program in the lower Mackenzie delta, under the

direction of GSC staff during the period June 15 to August 7, 1971. Detailed reports are provided in the Geological Survey of Canada Report of Activities 72-1A.

St. Clair and Detroit River System Studies

As part of a co-operative federal-provincial study on mercury pollution in the interconnecting channels between Lake Huron and Lake Erie, Section staff participated in a limited sampling program in Lake St. Clair and the Detroit River during May. The object of the survey was to define 'natural' mercury background concentrations within the general trends and to differentiate pollutant mercury, its transport paths and possible quantities. Reports on this study are presently confidential, pending judicial proceedings by the Ontario Government.

Chironomid Studies

Palaeoecological studies on chironomid forms derived from sediment cores taken at selected sites in the Bay of Quinte and the Long Reach (Prince Edward County-Lake Ontario), as part of a doctoral study by a CCIW staff member at the University of Manitoba, are showing signs that the environmental conditions in the area have changed significantly under the impact of human development. Core samples in the shallower areas of the bay have yielded remains of mixed populations, indicative of input from multiple sources, and probable sediment reworking. At the deeper core sites, however, significant population changes strongly suggest a trend of increasingly eutrophic and otherwise degraded conditions. Present studies are emphasizing the statistical trends of population variations.

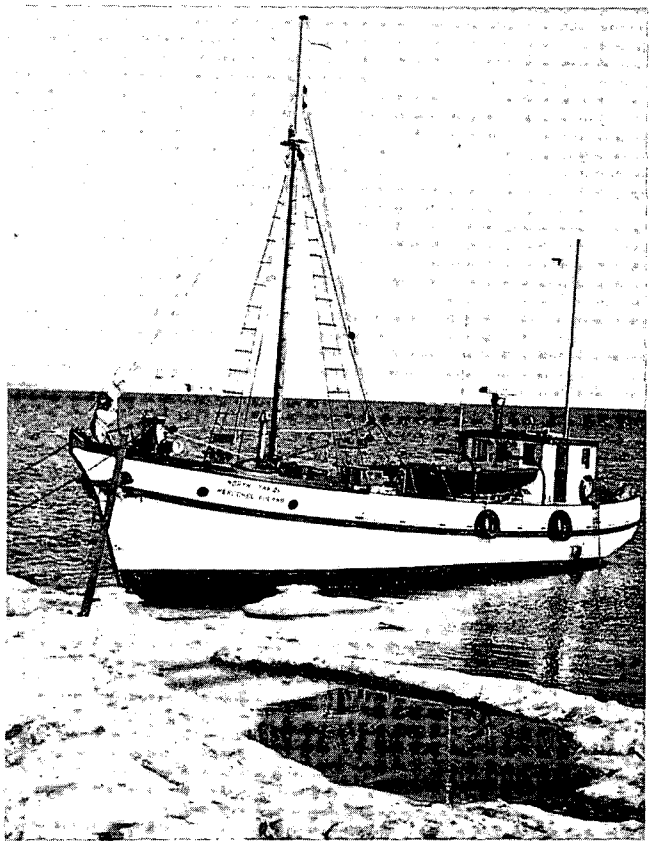


Figure 11. Survey vessel "North Star of Herschel Island", Mackenzie Delta Program.

Palynological Studies

Pollen studies of lake sediments are providing useful information about the transport and diagenesis of modern sediment. In addition, studies of fossil pollen are leading to the establishment of horizon markers and chronologic subdivisions of the complete late glacial and post-glacial sediment column. Investigations have been conducted under a GSC contract at the Royal Ontario Museum, Toronto. During the latter half of 1971, additional palynological studies have continued under the supervision of an NRC-GSC post-doctoral fellow.

Studies in Lakes Ontario, Erie, and in adjacent small lake basins have established that the highest pollen concentrations occur in the basinal, silty clay facies of Lake Ontario's surface sediments (top cm); the lowest concentrations are associated with coarser sediments in the inshore zone. Local percentage trends suggest that most pollen in the sediments is delivered to the lake by river and stream transport.

Stratigraphic pollen analyses show that the basinal muds and underlying glaciolacustrine clays of Lakes Ontario, Erie, and Georgian Bay do contain pollen although often degraded. Distinctive pollen assemblages have been divided into eight zones. The uppermost zones characterized by high ragweed, grass, and other pollen types are relatively recent, generally less than 150 years old, and provide extremely valuable chronologic horizons for determining rates of sedimentation.

Physiographic Charting

A long term program has been initiated jointly with the Inland Waters Branch Drafting Office, Ottawa, to undertake preparation of a series of physiographic charts of the Great Lakes. The first compilation, covering Lake Ontario, is nearing completion, and is to be published in time for release at the 24th International Geological Congress in Montreal (August 1972). The charts will be coloured and will carry information about general sediment distributions, and both raised and submerged shorelines.

A second chart, covering a much smaller area in Georgian Bay, north of the Bruce Peninsula, is also being compiled and hopefully will be available for use in conjunction with Ontario's first underwater provincial park,

off Tobermory.

Technological Development

Computer Stat-Store Programs

Progress was made in the development of computer and statistical techniques for the reduction of Great Lakes geologic data. Data display programs utilizing both CALCOMP and Benson-Lehnner plotters are now in operation for presenting X-Y spatial data. Work was initiated on establishing a storage and retrieval facility at CCIW for lake sediment data. The SAFRAS system, developed at the University of Western Ontario, was chosen for this purpose and with the co-operation of the Canadian Centre for Geoscience Data, three files corresponding to shipboard, physical laboratory, and analytical laboratory data, were initiated. Final testing, including the entry and selective retrieval of a test file, is scheduled for January 1972.

Sedigraph 5000 Analyser – Appraisal

The results of a continuing appraisal of the automated particle sizer, Micromeritics Corps., recently brought into use in the Sedimentology Laboratory of the Section at CCIW, indicate that it overcomes difficulties encountered in pipette analysis for grain-size analysis in the silt-clay size range and still provides acceptable values.

Continuous Seismic Profiler

As part of a continuing development of techniques and equipment to provide high resolution, continuous seismic profiling, work is being done with HUNTEC (70) Ltd. of Toronto on the replay of unfiltered signals recorded synchronously on an on-line four-channel magnetic tape recorder. Original data is recorded on a wet paper recorder and frequently, due to excessive energy levels, shallow water, or extraneous noise, resolution of early returns has been masked or lost. Later replay and selective filtering of poor quality sections of profile have been made possible by use of the mag-tape system. In most cases, improvement has been effected. These studies have shown the need to develop hydrophone arrays of improved sensitivity (but less susceptible to extraneous reflections), the need to control better the energy level of acoustic and seismic sources, and the need to be able to control the frequency of the energy spectrum in relation to sediment type.

Contract Studies

Forms of Mercury in Sediment

This study is currently being pursued under a contract with Barringer Research Ltd., Toronto. The purpose of this project is to develop a realistic method of distinguishing between, or where possible identify, the different mercury compounds which commonly occur, particularly in the Great Lake sediments.

It appears from analysis of other elements that the mercury is most probably not present as an individual compound but is far more likely to occur as a complex with iron oxide, clay minerals, or organic matter. The work should be completed by March of 1972. Fifty to sixty samples representing a variation of cross-section conditions from Lake Huron, Lake St. Clair, Lake Ontario, and Lake Erie will be run in conjunction with further known samples.

Lake Superior Survey

A contract with the Department of Geology, Lakehead University, was extended from 1970 to 1971 under similar terms, for the survey of nearshore and bottom sediment types in Lake Superior. Studies were concentrated in the nearshore region, in Black Bay, and in Nipigon Bay during the early part of the program, but later, extensive support by the MV MARTIN KARLSEN enabled samples and cores to be taken for deep water coverage (to the international boundary) between Thunder Bay and Marathon.

The sampling program has confirmed the presence of unconsolidated sediment cover over most of the lake bed surveyed; the only notable exception being in the area around the Lake Superior shoal where bedrock is exposed. Recent sediment reaches a maximum thickness of about 6 m to the south of the Black Bay Peninsula. However, the presence of exposed red-Valders varved clays over extensive areas of the lake floor in eastern and central parts of the 1971 survey area suggests non-deposition or even erosional conditions. Scour channels (apparently sub-lacustrine in origin) developed in recent sediments south of the Nipigon Bay outlets suggest that outflow from the Nipigon region may extend some distance southwards into the main lake basin. This observation is further supported by the fact that sediment Eh, and some heavy metal distributions show a degree of N-S linearity in the same general area.

There appears to be no evidence of significant industrial or urban pollution in the main lake areas, with the exception of some anomalous values noted close to Marathon. Evidence of environmental degradation appears to be most noticeable in the sediments of Thunder Bay.

Survey of Dredging, Disposal and Burial Techniques

As a follow-up to studies on the distribution of heavy metals (in particular, mercury) in lake bottom sediments, and to provide a better insight into the problems of removal or disposal of dredged materials, a contract has been established with H.G. Acres, Niagara Falls, Ontario.

In particular, the problem of removal or burial of

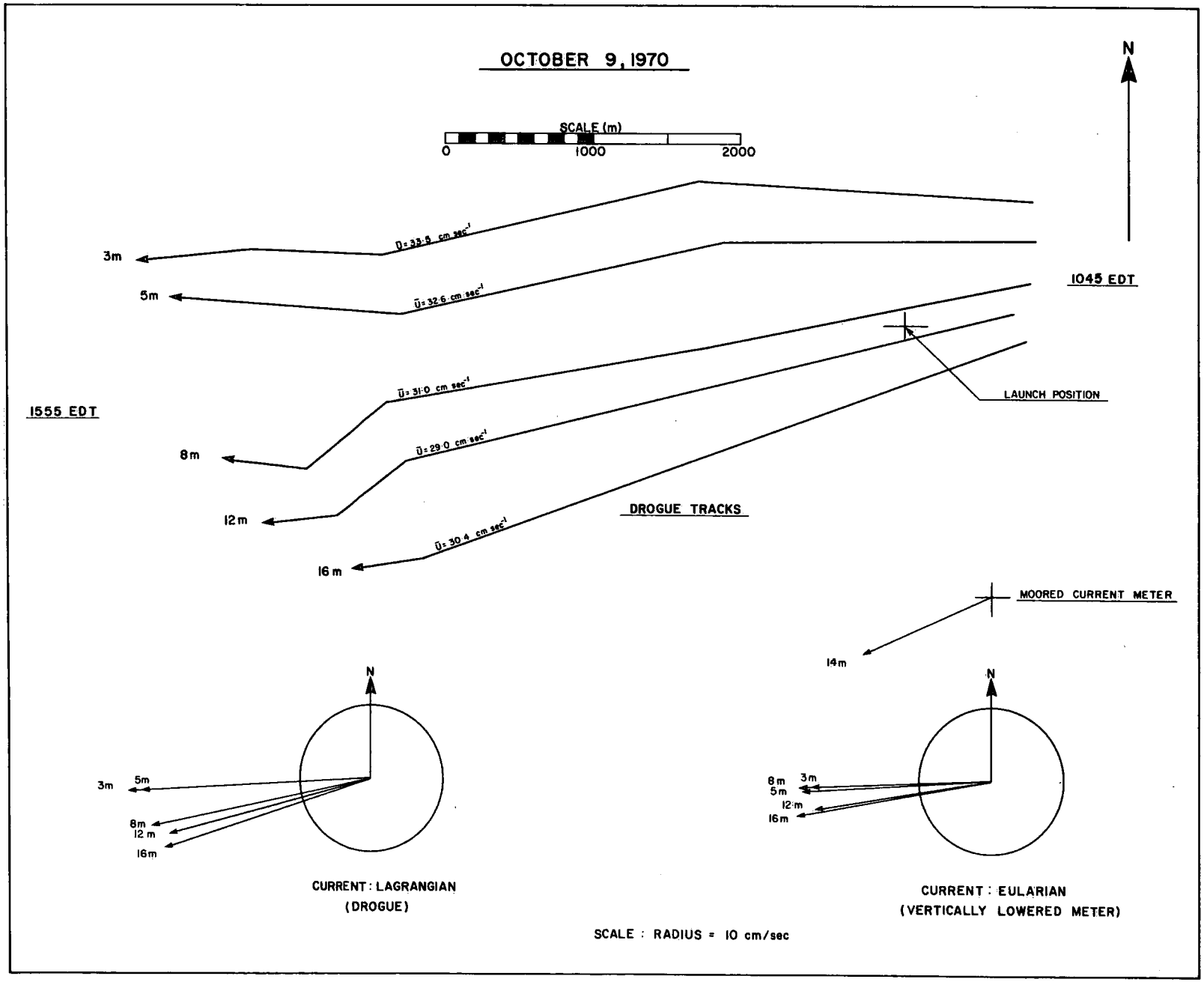


Figure 12. Lagrangian and Eulerian currents in Lake Ontario, near Oshawa.

mercury contaminated sediments in the Great Lakes is raised, and suggestions for dealing with this existing situation are requested together with an evaluation of the cost and effectiveness of various methods.

The ecological impacts of the various techniques for removal or burial are also to be considered, insofar as case history and published information is available. The contract is to be completed in June 1972.

PHYSICAL LIMNOLOGY

The Physical Limnology Section is responsible for aspects of lake behavior which are related to physics. Geographically, the major effort has been in physical and multidisciplinary projects in the lower Great Lakes, especially Lake Ontario. A substantial portion of this work has been in connection with preparations for the 1972/3 International Field Year on the Great Lakes (IFYGL). Participation in a joint federal-provincial (British Columbia) study of the Okanagan Basin was continued. An expansion of the Section's involvement in research of small lakes occurred with the permanent location of two staff at the Freshwater Institute, Winnipeg.

Progress achieved was in some of the basic physical processes, in the construction of mathematical models, and in major developmental phases of future investigations of lake processes. These are reported separately. A summary of applied and lake climatology programs follows.

Research on Physical Processes

Diffusion and transport in the nearshore zone of large lakes is of substantial importance in studies of movements of pollutants. Of particular interest is the case where a thermocline is interposed between an outfall and the free surface. Results of deep water diffusion studies in the shore zone have shown some striking peculiarities as compared to surface layer diffusion studies. Vertical diffusion appears to be quite regular, similar to molecular diffusion, and the effective diffusivity is of the order of 1 $cm^2\ s^{-1}$. Vertical diffusion is controlled by very small scale motions; horizontal diffusion, on the other hand, was very irregular and seems to be a consequence of internal wave motions. These features of diffusion may be attributed to the current structure in the shore zone, where a fairly well marked "mean motion" occurs on which large scale unsteady flow structures are superimposed.

Accurate measurements of *current velocities* are essential to studies of coastal processes. The Lagrangian and Eulerian types of measurements were compared by using drogues and both moored and deck read-out current meters. The two techniques give equivalent values of the mean flow velocity within the limits of experimental accuracy (see Figure 12). Coastal currents were generally shorebound and flowed 'up' or 'down' the shore for a few days and reversals occurred mainly in response to changes in winds. In addition to such bi-modal flow characteristics, occasional stagnation periods were observed, during which negligible current velocities persisted for a few days. These data, along with meteorological data measured simultaneously will provide the basis for establishing a climatology of coastal currents essential for site evaluation and planning effluent outlets and municipal water intakes.

Preparations have been made to use the observed coastal current data to verify currents computed by numerical-hydrodynamical models based on observed wind data. It is hoped that nearshore currents will be predictable from numerical models using observed wind field data.

In a separate study, current meter records obtained in 1971 from Main Channel, between Lake Huron and Georgian Bay, have shown strong evidence of *semi-diurnal tidal motion.* Corresponding water level changes of 5 cm, are identifiable in water level records from several places in Georgian Bay. This appears to be a near-resonance phenomenon, as the fundamental period of oscillation of the Lake Huron – Main Channel – Georgian Bay system is about 12 hours, close to those of some of the astronomical forces. The implication of tidal motion in the Main Channel is that, in the absence of net flow, the exchange of water between Lake Huron and Georgian Bay would be wholly predictable. The results of a detailed investigation of these findings will be reported in 1972.

Vertical circulations, including entrainment and upwelling, are important in connection with the interactions between stratified layers in lakes. Thermal data on several morphologically different lakes have been compiled in order to test the applicability of the one-dimensional theory of turbulent entrainment to the growth of epilimnion volumes in stratified lakes. The surface areas of the lakes varied from 0.04 km^2 (Lake 304, Western Ontario) to 31.5 $10^3 km^2$ (Lake Baikal, USSR). The test results suggest that stratified lakes achieve a balance whereby the growth of volume of the epilimnion (entrainment) is correlated with the mean stability over the period of growth. The mean depth of a lake appears to be the single most important morphological parameter governing the magnitude of entrainment (Figure 13).

The importance of entrainment has been demonstrated in Woods Lake, a small eutrophic lake in British Columbia. Major increases in chlorophyll *a* correlated well with episodes of entrainment during 1971.

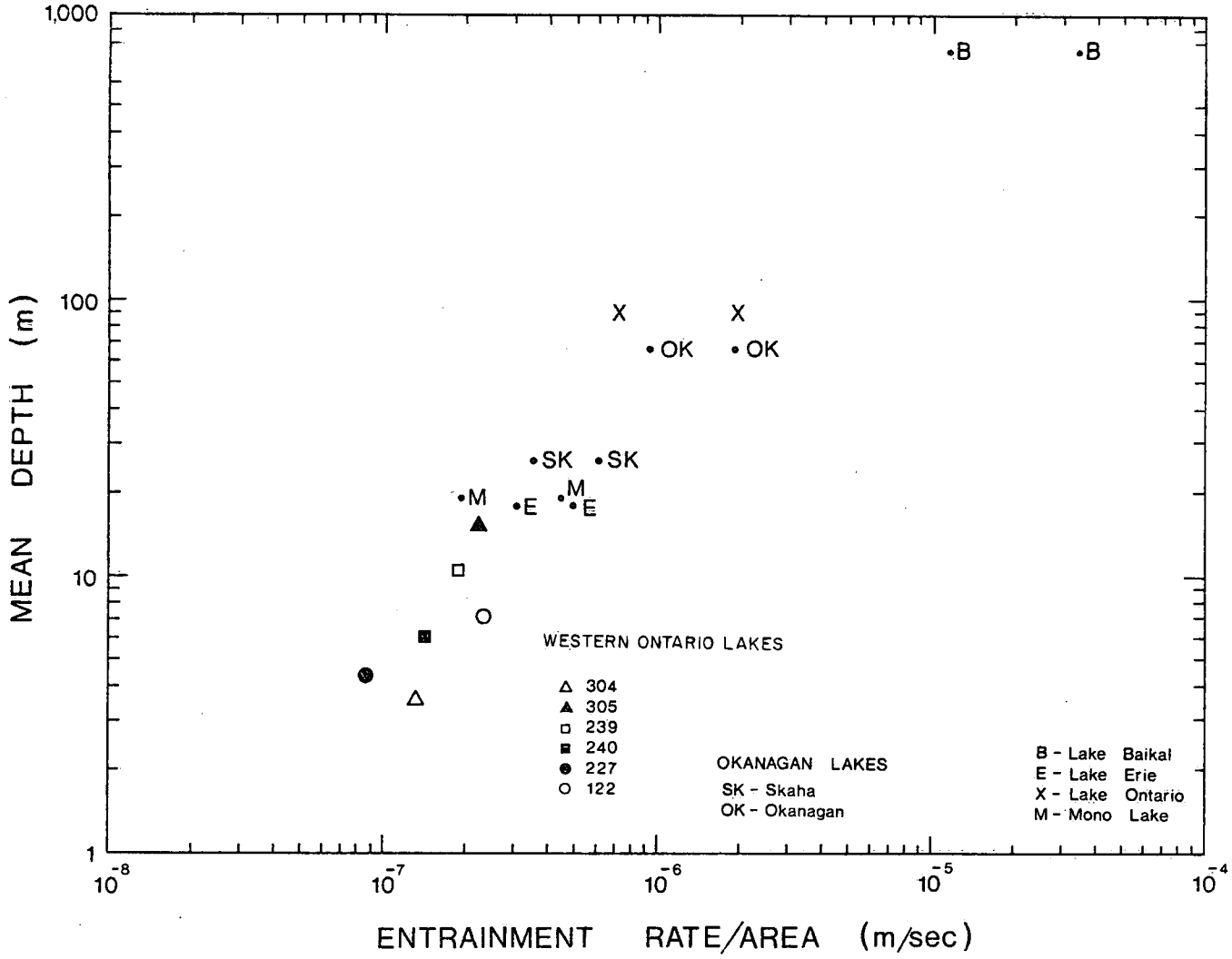


Figure 13. Relationship between entrainment rate and mean lake depth.

The study has stimulated further interest since entrainment plays a significant role in budget calculations of heat and chemicals in lakes. The circulation of hypolimnion water in Lake Erie Central Basin has been of particular interest in view of the findings of Project Hypolimnion. Analysis of current meter data from moorings established from 14 July to 3 September, 1970, showed dominant currents toward the Canadian coast (Figure 14). Upwelling along the Canadian shore appears to account for a significant portion of this net hypolimnion flow.

Other episodes of upwelling have been studied in Lake Ontario. The key result from a descriptive point of view lies in the fact that many of the upwelling regions in Lake Erie and Lake Ontario are extremely narrow, often extending no more than 3 or 4 km from shore. These regions may be missed by normal monitoring programs. Upwelling in these lakes is generally correlated with the alongshore component of the wind.

In a program devoted entirely to *processes in small lakes*, lakewide circulation was measured in a small lake (50 hectares) in the Experimental Lakes Area (ELA) of the Freshwater Institute, near Kenora, Ontario. Temperature and Eulerian velocities were recorded continually at an instrument tower near the center of the lake. Lagrangian velocities were obtained on 20 separate occasions by tracking drogues with shore based radar. Lakewide variations in diffusion characteristics were examined by time sequential, aerial photography of an array of five continuous point-source dye plumes. Dye plumes near the center of the lake show marked similarity with plumes previously photographed in the Great Lakes. Nearshore plumes show large spatial and temporal variance in both relative and absolute diffusion characteristics. Analyses of the data will continue.

The *exchanges of energy between the atmosphere and lakes* continue to receive a high level of attention at CCIW

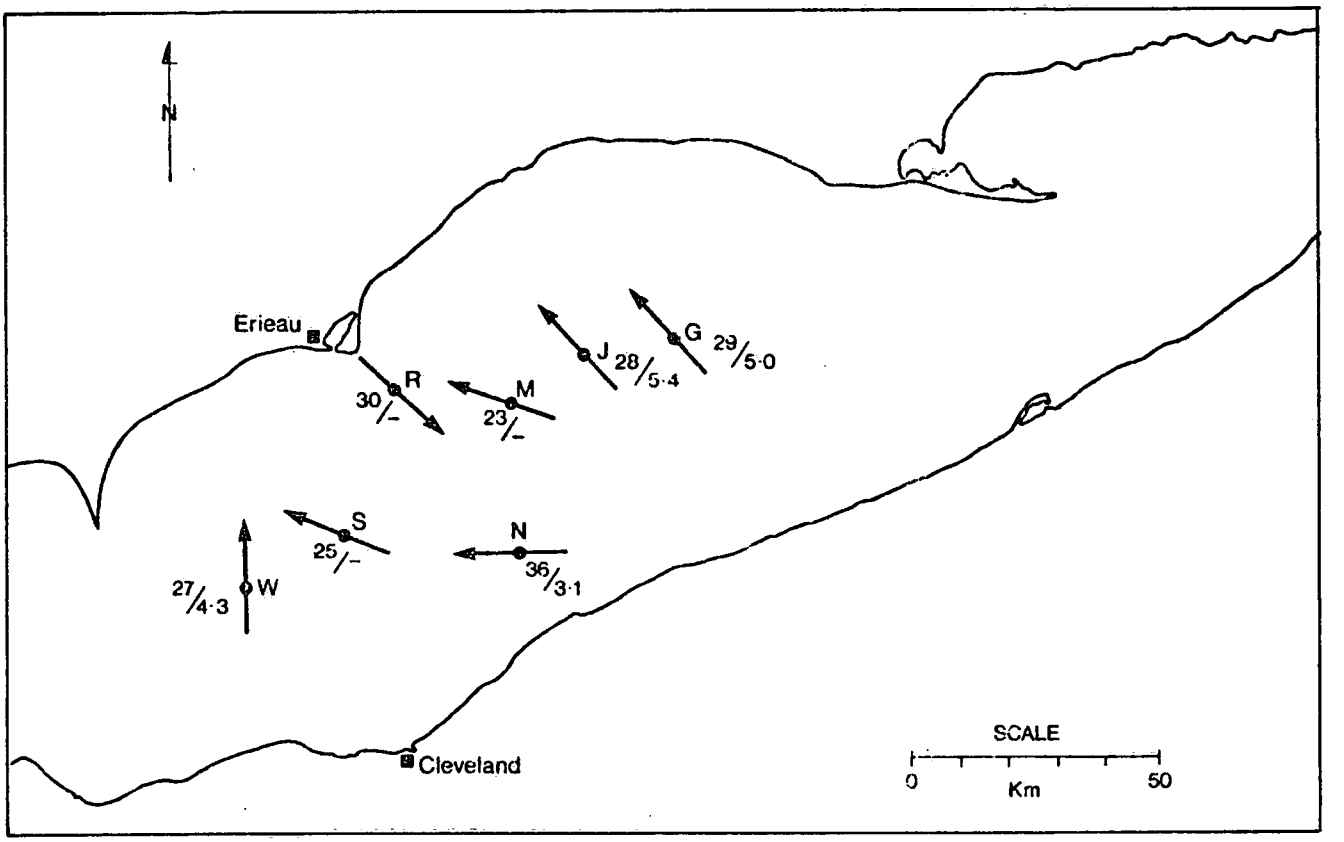


Figure 14. Dominant currents in the hypolimnion during the period 14 July through 3 September, 1970. The arrows represent the dominant direction toward which the currents are moving. The number to the left of each slash represents the percentage frequency of occurrence of all currents within ±30° of the dominant direction. The number after the slash is the average speed in cm/sec of the currents associated with the dominant direction.

because of their fundamental importance to thermal and dynamic processes. During 1971, direct measurements of energy fluxes were made by the Eddy Correlation technique using triaxial hot film anemometers, Lyman α absorption hygrometer, and fine wire resistance thermometers in Lake Ontario, near the Niagara Bar.

Sixteen periods of observations, each lasting forty minutes, were recorded under a wide range of atmospheric and sea-state conditions. Mean vertical gradients of wind, temperature, and water vapor were measured throughout the period giving a total of about six weeks of data. In addition, the Thornthwaite Unit Parcel Momentum Fluxmeter was operated for a total of 170 hours to provide evaluation of that sensor system. Many of the data periods coincided with periods of observation by Atmospheric Environment Service and Atlantic Oceanographic Laboratory groups and two periods of coincident observations were obtained with a research aircraft from the National Aeronautical Establishment, Ottawa.

The early results indicate that sensible heat transfer is one-tenth of the latent heat transfer during the autumn period. A Bowen Ratio of 0.1 to 0.2 was observed during periods processed to date. All periods have been thermally unstable. Values of computed surface drag coefficient have indicated that the previously used value of 1.3×10^{-3} is likely valid. Range and variation of values will be determined after all data are analyzed.

The *modeling* program, which relies upon updated input from studies such as described above, exhibited substantial progress during 1971. Efforts were specifically directed toward the development of models which take into account the physical characteristics and stratification of Lake Ontario for the broad purpose of examining general circulation characteristics with some specific applications in mind, such as transport of pollutants in the main body of the lake, and dispersal of effluents nearshore. (Figure 15).

A summer model, which is presently employed in studies of the lake circulation under stratified conditions, consists of four layers. These layers are separated by rigid horizontal levels positioned at depths of 10, 25, and 50

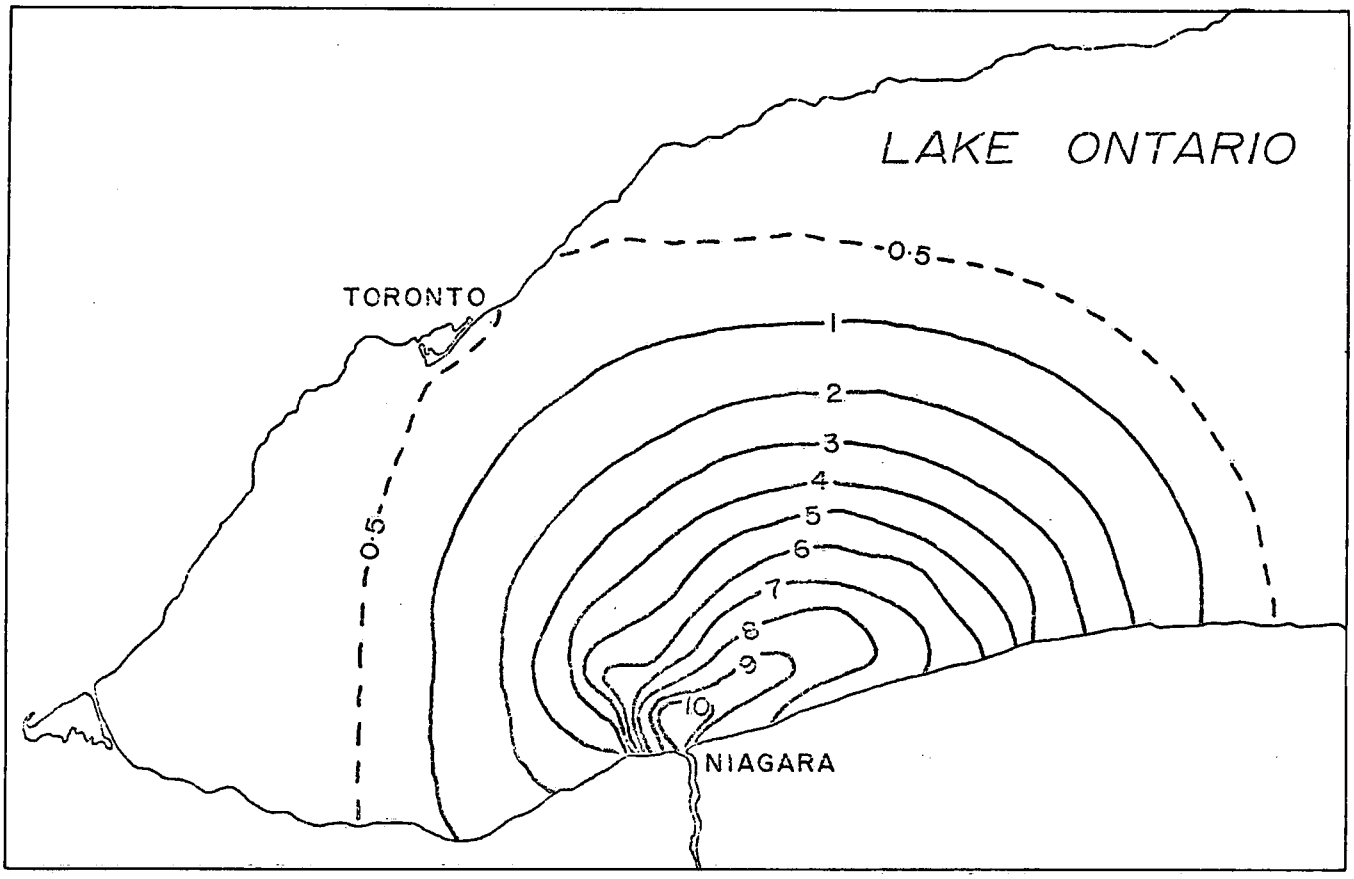


Figure 15. Advection and diffusion of a pollutant from the Niagara River as computed with a homogeneous model (hydraulic flow, no wind).

metres, respectively. This means that the lowest layer is essentially homogeneous, whereas the stratification cycle is to be simulated by the upper three layers.

Preparations are underway for an extensive verification program to evaluate the performance of both the multi-layer model and the previously developed homogeneous models during IFYGL.

Also in the framework of the numerical modelling program, a meeting, attended by most members of the Great Lakes scientific community in this field, was convened by the Centre under the title "Workshop on the Numerical-Dynamical Modelling of the Great Lakes", August 23-24, 1971. Communication was improved and future annual meetings are anticipated.

Studies of the behaviour of *oil* in the lake environment, though not as directly related to the above programs, have been conducted in this Section. Progress has been made in evaluating the effects of oil quality and environmental factors on mousse formation and dispersion of oil in the water. This study is expected to provide us with the means of predicting oil behaviour in oil-spill incidents.

An experimental oil-containment boom was constructed and tested in Burlington Bay. While the oil-filtering plastic material was deteriorated by sunlight, the basic structure survived several weeks' exposure and some storms while moored in the Bay. A critical evaluation of this performance may lead to the eventual construction of a heavy duty boom for the protection of the harbour.

In cooperation with the Environmental Quality Coordination Unit and other Sections of CCIW, a contingency plan was prepared outlining CCIW's activities in spills of oil and other hazardous materials.

Developmental Work

Many of the basic physical relationships determined in one of the Great Lakes will be, generally, applicable to any of the Great Lakes. Consequently, a great deal of effort has been spent by CCIW in preparation for IFYGL, in order to make the most of this extensive study of Lake Ontario.

In the water movements category, a substantial effort was devoted in 1971 to the design, development, and field testing of reliable *dye injection and sampling systems*. In particular, a new mooring arrangement for the dye raft

(Figure 16) was developed and field tested successfully. To improve the reliability of the dye injection system on board the dye raft automatic switching circuits were installed in order to activate a second dye injection system in the event of failure of the main dye injection system. To ensure an uninterrupted power supply, a diesel generating power plant was permanently installed on the dye raft. With these major modifications and extensive field testing, a sound and reliable dye injection system capable of generating point-source plumes, line-source plumes, and instantaneous patches at any specified depth, is now available for diffusion studies during the 1972 IFYGL.

Common to the water movements' interests and those of the energy balance and boundary layer categories of IFYGL is the *CCIW buoy system.* The current meter, water temperature, and surface meteorological components all underwent final developmental work and field testing. Comparisons of all components with those of the U.S. system (Texas Instruments system, prepared for NOAA) took place in Lake Ontario during the autumn. On 8 September, a current meter mooring was established about 10 miles off Rochester, N.Y., close to a U.S.A. mooring. Water current and temperature data were obtained from five CCIW current meters during the first 28 days, and, after a four-day gap, from two meters during the next 27 days. Comparison of these data with those obtained simultaneously by the U.S.A. system is underway. Preliminary assessments indicate more than 90% return of data from the CCIW meters.

Field deployment of the meteorological components of the buoy system had three objectives:

(1) operational experience to assess equipment endurance and to provide experimental data for development of data management and processing techniques.

(2) to provide field measurements of meteorological variables over western Lake Ontario for other continuing studies;

(3) to provide for comparison of the system with the U.S.A. system.

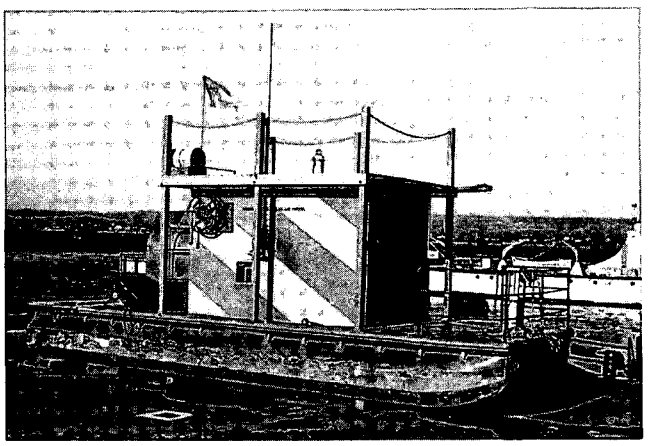


Figure 16. Raft used for dye injection in diffusion studies.

Three systems were moored in western Lake Ontario on 19 April and through 8 October, operated in a manner similar to that planned for IFYGL, giving about a 90% return of valid data. A fourth system was moored off Rochester. The three station network in western Lake Ontario provided over 10,000 hours of information on the over-lake meteorological fields. This is the longest and most complete set of measurements of these variables which has been obtained over the actual lake surface. The data have been used to provide realistic wind stress input to numerical lake circulation models and will be included in computations of energy fluxes in development of IFYGL data processing methods. Several weeks of coincident observations with the U.S.A. system has provided data which will serve to evaluate biases which may exist between the two systems and which can be used to make adjustments to planned programs of IFYGL. These data have been interchanged with agencies of the U.S.A. and some preliminary evaluation has been completed.

Also in preparation for the boundary layer aspects of IFYGL, a program of *direct measurement of fluxes of momentum, latent, and sensible heat* was carried out over Lake Ontario at a site 3 miles from Niagara on-the-Lake during September and October 1971 in cooperation with scientists from the Atmospheric Environment Service (AES), the Atlantic Oceanographic Laboratory (AOL), and the National Aeronautical Establishment (NAE).

Measurements were made by instrumentation supported on three bottom-mounted towers with recording and other logistic support housed on a barge anchored nearby.

A major component of the Energy Balance program is the *heat storage term.* Since 1968, CCIW has been developing instrumentation and techniques appropriate to the detailed description of Lake Ontario's thermal regimes. In 1971, an effort was concentrated on improving both instruments and techniques in preparation for IFYGL. This work entailed:

(1) Improvements to the towed thermistor array system comprising a better design for the thermistors, shock absorbing towing gear, more stable electronics, and more efficient calibration and operating procedures.

(2) Acquisition and commissioning of a Bedford Batfish system (a diving towed body which may be controlled electrically from the towing vessel). The output from this system in its undulating mode is equivalent to a

vertical temperature profile from the surface to a preset maximum depth every 1000 metres of steaming at speeds from 4 to 14 knots.

(3) Improvements to the technique of collecting and processing temperature data using the standard ships EBT (electronic bathythermograph). A theoretical study of the influence of the ship's drifting motion on the measured temperature profile suggested that non-negligible error could result from the smooth displacement of the isotherms due to flow under the hull of the ship. Experiment confirmed the theory, thus, procedures were developed to minimize the errors.

(4) Development, procurement, and testing of a moored, autonomous temperature profiling system. Four of these instruments will be employed in the IFYGL. Each system is capable of sampling up to 18 thermistors arranged initially in an array through 100 m of water and can operate unattended for up to 6 weeks at a time.

(5) Development and improvement of methods for reducing and displaying data from the instruments mentioned above. By April, 1972, the emphasis of this project will switch from instrumentation development to measurement and interpretation. An ambitious field program is planned for 1972 with analyses extending into 1973. It is anticipated that the instruments will prove valuable to many experiments in the future.

A series of *shore stations* around Lake Ontario to measure near shore surface and near bottom temperatures is being set up in conjunction with shore meteorological sites of the Atmospheric Environment Service and water level sites of the Water Survey of Canada. The observations will be used during the International Field Year on the Great Lakes and, over the long term, to correlate the variation of the temperatures at the shore sites with the heat content of the lake. Initial installations were made during 1971 at Oshawa, Cobourg, Pt. Petre and Kingston.

Applied Studies and Climatology

In a joint Canada – Province of British Columbia study of the *Okanagan* system, the Physical Limnology Section accepted responsibility for data collection and interpretation of physical factors relevant to this large water quality and quantity study.

Field work, including 6 monitor cruises on Lakes Okanagan, Osoyoos, Skaha, Woods, and Kalamalka, was completed in October, 1971. Comparative studies of each lake revealed:

(1) Woods Lake – had a very slow rate of warming of deep water – only slightly larger than the two very deep lakes.

(2) Woods Lake – the most eutrophic of the lakes, has severe algal blooms that best correlate with high rates of mixing entrainment between hypolimnion and epilimnion water.

(3) There has been a noticeable decrease in water transparency in Lakes Woods and Kalamalka over the past 5 years. Transparency data for other lakes in the basin are inclusive on this matter.

In addition, experiments to study diffusion of Okanagan River water into Lake Skaha were performed in conditions of weak stratification (May) and strongly stratified conditions (September). The portions of the lake which were most influenced by the river discharge, and the governing conditions, were clearly revealed. Reports on general program and the special diffusion study will be available by June, 1972.

During 1971, a follow-up study to the previous year's report by H. G. Acres Company on predicted *thermal loading* of the Great Lakes was performed to assess the physical consequences of thermal inputs.

Periodic surveys of surface temperature in the thermal effluent of two local electric generating stations were terminated in May, 1971. A total of 13 sets of surface isotherms (Figure 17, for example) was obtained during the measurement program which commenced in September, 1970. Much additional data spanning a two-year period at one site have been provided by Ontario Hydro. Calculations based on this data show that an average of less than 8% of the waste heat is transferred directly to the atmosphere within the 1°C "excess" isotherms. The temperature decrease within a thermal effluent is predominantly a result of mixing of the effluent with ambient lake water.

An estimate of possible physical effects of the waste heat load predicted in the Acres report for the year 2000 is almost completed.

A *current monitoring program* was initiated in 1970 to study the statistical properties of near shore lake currents at selected locations in Lake Ontario, and establish a climatology of coastal currents and water temperature particularly relevant for planning of municipal works. In 1971, the program was broadened to include measurements at a few sites in Lakes Erie, Huron, and Superior. The data collection included 12 meter-months of current and temperature record from each of 11 current meters in western Lake Ontario; 6 meter-months from 6 meters in the eastern basin of Lake Erie; 12 meter-months from 3 and 7

Figure 17. Surface temperatures from scanning infrared thermometer at Douglas Point, Lake Huron. Temperature contours, 1°C interval, March 2, 1971.

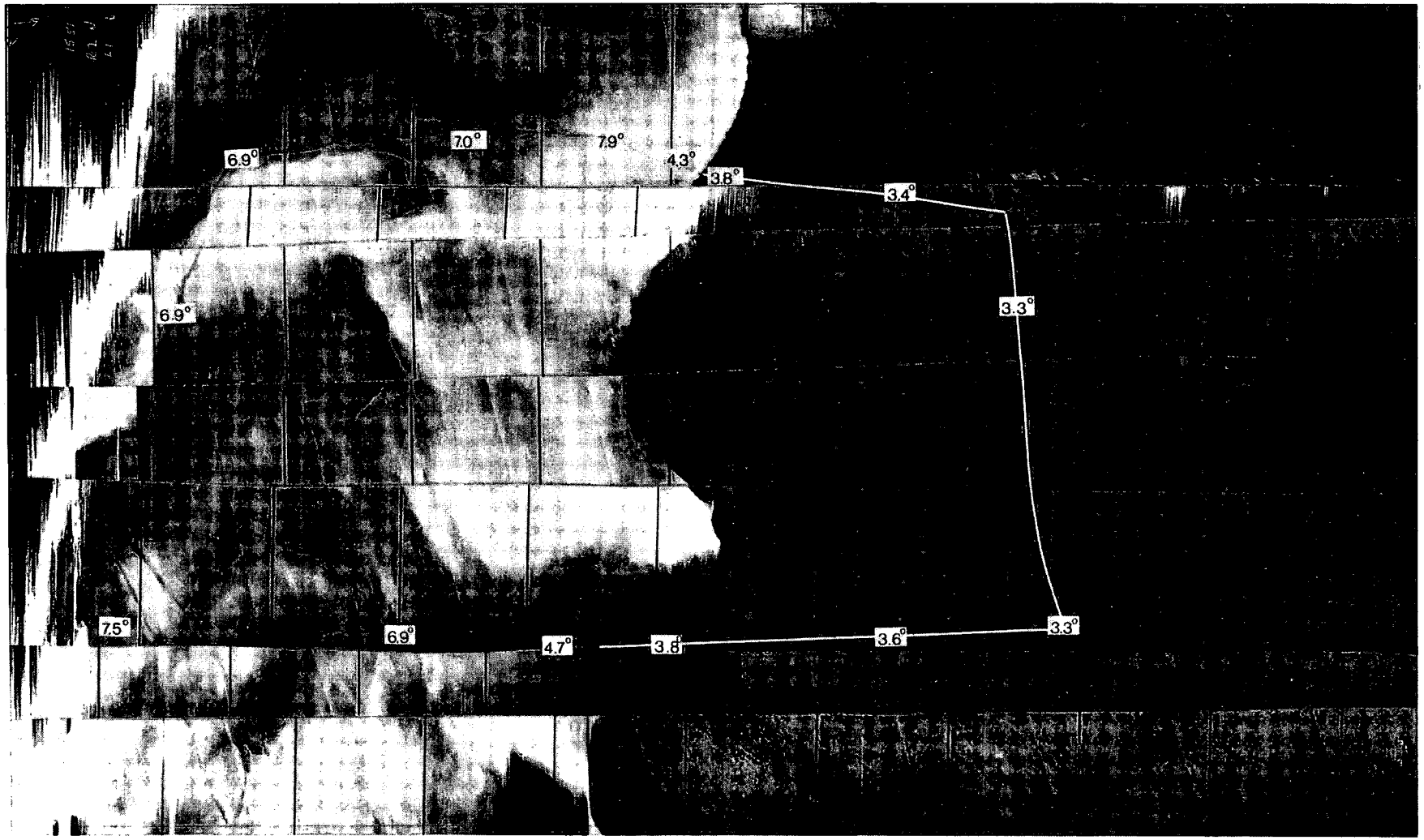


Figure 18. Infrared scanner mosaic May 23, 1971 (surface temperatures from launch data). Infrared imagery 8-14 μ, Lake Ontario-Oshawa, Code M-2A, Temperature $^{\circ}$C.

meter-months from 2 m in Lake Huron; and 2 meter-months from a single current meter in Thunder Bay, Lake Superior. The results of the measurements are to be published in a technical report.

During 1971, a descriptive analysis program of *lake nutrients* became associated with this Section. The objectives are to clarify the history of nutrient conditions, to elucidate the seasonal cycles, to provide background for the International Joint Commission upper lakes reference, and to compare the present nutrient conditions in all of the Great Lakes.

A study of nutrients in Lake Huron has been completed. The Lake's plankton production is apparently limited by a shortage of phosphorus. Secchi depth transparency and reactive silicate are decreasing over the years, indicating a slight increase in fertilization with phosphorus. It is suggested that a particulate phosphorus value of 10μP/l is the lower limit for eutrophy; Lake Huron now has a mean particulate phosphorus value of 2.4μP/l.

Studies of nutrients in Lakes Superior, Erie, and Ontario are planned for 1972, and also a comparative study of all the Great Lakes.

A general consolidation of the *remote sensing* program occurred during 1971, with completion of a summary of imagery obtained since the inception of the program. Field programs this year had two main objectives: continued evaluation of both infrared scanning and photographic techniques; and conduction of surveys in support of limnological studies. Table 1 contains a summary of survey activities.

Studies of the time scale of surface thermal features were combined with flights to evaluate a new Daedalus line scanner in the Oshawa area (see Figure 18). Both objectives were met and will substantially influence IFYGL surveys.

Photographic surveys in support of other programs included: ice surveys for the ice breaker N.B. McLean in the Detroit River; support of small lake dye diffusion studies near Kenora (see above); and shoreline surveys for sediment studies by the Limnogeology Section.

Medium and high altitude photography of Lake Ontario was provided from both a NASA satellite simulation experiment which benefitted from IFYGL coordination, and a CCIW program coordinated by the Canada Centre for Remote Sensing, which used a Canadian Forces CF-100. New information on the occurrence of surface manifestations of internal waves has resulted and interpretation continues.

Aerial surveys of the Bay of Quinte in July and September for the purpose of detecting biolimnological factors provided new experience and will stimulate future surveys of surface algae and cladophora crops.

Two proposals for future studies using data from the forthcoming U.S. satellites ERTS-A and SKYLAB were submitted.

During 1971 preparations were made to take advantage of technological advances in the field of *data retransmission via satellites*. Arrangements were made to acquire an IRLS surface package through cooperation with NASA-LEWIS, Cleveland, and a DCP package for use with the ERTS-A satellite. Deployment of these systems aboard CCIW buoys is planned for 1972.

Data processing and display activities of this Section included the completion and submission for publication of a Summary Data Atlas of Lake Ontario (Monthly distributions of surface and bottom temperatures and dissolved oxygen). A similar atlas for Lake Erie will be completed in 1972.

In support of heat content studies, and to facilitate use of lake temperature profile data, an ambitious program to digitise all CCIW bathythermograph traces was performed. Through contract, Great Lakes Institute data was similarly treated. Editing is in progress. Closely related to this work was a project which has digitised on a 2 km grid the bathymetry of Lakes Ontario, Erie, Huron, and Superior. A general contouring program was also modified to permit production of contour charts of lake monitor data.

Surface distribution charts of temperature, wind vectors, and bathythermograph observations of Lake Ontario during cruises of 1970 were subjected to analyses to determine the spatial and temporal thermal variation over the entire year. Using a heat content program, the volume of water of the lake contained between successive isotherms was computed. These results are assembled in the form of a report showing the thermal structure and changes in heat storage between successive surveys. A similar report is being prepared for Lake Huron from observations taken in 1971 and will be completed in early 1972.

TECHNICAL OPERATIONS

Major Ships

As in 1969 and 1970, the Section used the two major vessels, C. S. S. LIMNOS and the charter vessel M. V. MARTIN KARLSEN, for scientific data collection and monitoring. The C. C. G. S. PORTE DAUPHINE, through contract arrangements with Great Lakes Institute, Univer-

TABLE 1. SUMMARY OF 1971 CCIW REMOTE SENSING SURVEYS

DATE	AIRCRAFT	SENSORS	GROUND TRUTH	LOCATION
Jan. 28–Feb. 2	Piper YTE	Photographic	Ice breaker N.B. MCLEAN	Detroit River, Lake St. Clair
March 1–9	Piper YTE	Photographic		Western Lake Ontario shoreline
April 14	Piper YTE	Photographic	Limnogeology	Western Lake Ontario shoreline
May 21–24	Aztec	Thermal Scanner PRT-5	Ship Data	Oshawa
May 29	RB 57F	Photographic	Ship Data	Lake Ontario
June 11	Piper YTE	Photographic	Limnogeology	Western Lake Ontario shoreline
July 27	CF 130	Photographic	Ground Party	Bay of Quinte
August 9–20	Piper Colt	Photographic	Surface instruments & launch	Kenora
August 18–19	CF 100	Thermal IR Scanner Photographic		Lake Ontario
September 10	Piper YTE	Photographic	Limnogeology	Western Lake Ontario
September 22	CF 130	Photographic	Ground Party	Bay of Quinte
September 22–24	CF 130	Thermal Scanner PRT-5	Ship Data	Oshawa
October 5–6	CF 130	Thermal Scanner PRT-5	Ship Data	Oshawa
December 1	Piper YTE	Photographic	Limnogeology	Western Lake Ontario

sity of Toronto, continued to augment the monitor program, particularly in Georgian Bay. For the first time, samples were collected from an M.O.T. icebreaker, the N. B. MCLEAN, during winter operations on Lake Erie, ranging from Port Colborne to Windsor.

C. S. S. LIMNOS carried out a large variety of highly specialized cruises including organic particle studies, pesticide surveys, seismic and geological surveys on Georgian Bay, and heat content surveys on Lake Ontario; in the latter, newly-developed temperature sensors were evaluated. LIMNOS laid and retrieved more current meters than ever before, and a unique monitor cruise was carried out off Cleveland at the beginning of July. This was to determine whether a large increase in sewage effluent (caused by a breakdown of sewage treatment facilities) could be traced across Lake Erie into Canadian waters.

M. V. MARTIN KARLSEN concentrated on monitoring the upper lakes, including twelve cruises on Lake Huron. Two comprehensive geology cruises were completed – one on Lake Superior for Lakehead University, and the other on Lake Huron in cooperation with Geological Survey of Canada. An additional project was a dye experiment, involving two aircraft overflights, with Columbia University.

C. C. G. S. PORTE DAUPHINE was under contract during the periods when the other major ships were unavailable for monitor work. These surveys were mainly carried out in Georgian Bay. Technical Operations coordinated her movements, and staff from the Great Lakes Institute and CCIW participated in the cruises.

C. C. G. S., N. B. MCLEAN, wintered in Lake Erie for ice-breaking duty and ice observations associated with the

OPERATIONAL TABLE – 1971

Ship	Commenced Operations	Completed Operations	Miles Steamed	Total Active Days	Days on Survey	Per Cent
C.S.S. LIMNOS	March 16	December 10	11,631	193	153	79.3
M.V. MARTIN KARLSEN	March 29	December 9	22,852	190	165	86.8

St. Lawrence Seaway Authority. Technical Operations was able to use her facilities, with some modifications, for two monitor cruises during February and March. Samples were drawn from over the side and through the ice at short distances from the ship. Results obtained were of great value chemically, although the ship is not well suited for monitor-type cruises.

Niagara Towers

Three scientific towers were erected near the outlet of the Niagara River for *in situ* studies of physical and meteorological parameters. Two of these were regular wire-guyed towers with explosive-implanted anchors; the other was a self-mooring platform type (S.M.P.).

Minor Ships

The barge HANDY BOY, containing laboratories that included a detachment from Atmospheric Environment Service, was moored for most of the field season adjacent to the Niagara Towers.

The tug W. R. MORGAN, converted to a diving tender and renamed C. S. L. SHARK during 1971, saw service implanting underwater sensors on the north shore of Lake Ontario, installing the Niagara Towers, operating in support of the dye barge program, and participating in the experimental oil boom installation in Burlington Bay. She was also involved in a mission near Niagara-on-the-Lake when a yacht and its crew were rescued.

The chartered tug M. V. LAC ERIE continued to support the Limnogeology Section for most of the year, sampling sediments in the Kingston Basin area. In December, she sampled Western Lake Ontario for the MOSES program and for NTA experiments. Staffed by Technical Operations personnel, she will continue NTA sampling programs throughout the winter in Hamilton Bay and Western Lake Ontario.

Small Craft

Technical Operations, through Marine Sciences Branch, coordinated small craft assignments to all required surveys.

Okanagan Basin Study

Two Operations personnel coordinated and carried out the main sampling program in the Okanagan Basin as part of CCIW's commitment to the Canada – British Columbia Okanagan Basin Study. The operation, which lasted from February to October, consisted of a series of monthly chemical and temperature surveys on the five main lakes of the Okanagan Valley. In addition, two series of dye diffusion experiments – one in the spring and one in the fall – were completed. Continuous near surface temperature data were obtained for the lakes over the entire field season, as well as two continuous temperature-depth profiles which were obtained from thermograph moorings established in predetermined positions for two of the lakes. The data obtained from these studies will be used to evaluate the existing trophic state of the lakes and the probable future conditions under a range of management alternatives.

Diving Unit

Thirteen CCIW employees successfully completed the course in basic SCUBA given by the Senior Diving Officer – three of those were from Technical Operations. This course concluded with a medical examination by an Environmental Medical Specialist. During the field season, this training was put to use in various projects, notably the Organic Particle Study. A contract diver was also employed for much of the season. With the acquisition of C. S. L. SHARK, which has proved to be a versatile addition, diving support at CCIW continues to grow.

Stores

With the spring demolition of the Quonset hut and other small storage buildings, Technical Operations began some out-of-doors areas for equipment storage. Frequent trips were made to transport men and equipment to and from field projects, and to major ships and chartered vessels, which this year spent the majority of the survey season in the Upper Lakes.

Personnel

Junior staff members attended a 210-hour course in Basic Limnology, sponsored by scientific and technical groups from CCIW. Following this course, ten staff received their Maritime Radio-Telephone Operators Certificate from D.O.T. Throughout the field season, personnel were assigned to major and minor ships and to small craft supporting shore-based studies at various locations, including Niagara-on-the-Lake, Kingsville, and the Okanagan Project. The staff were responsible for all deck observations, field equipment, coordination of vessel movements, and meteorological observations.

An electronics technician was taken on strength early in the year. He has been assigned to work in conjunction with the Physical Limnology Section installing, maintaining, and monitoring Hy-Met units on buoy and tower systems.

The Section employed nine student assistants during the height of the field season in the summer months. Most of these students were involved with chemical work on monitor cruises.

GREAT LAKES STUDIES — 1971 — MV MARTIN KARLSEN

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
	31	1	2	3	4	5	6
FEB	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	1	2	3	4	5	6
MAR	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	29 Depart CCIW 1834 hrs.	30 Monitor Lake Ontario	31 Monitor Lake Ontario	1 Monitor Lake Ontario	2 Monitor Lake Ontario	3 CCIW Arrive 1753 hrs.
APR	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 CCIW	13 Depart CCIW 1811 hrs.	14 Monitor Lake Erie	15 Monitor Lake Erie	16 Monitor Lake Erie	17 Monitor Lake Erie
	18 Arrive Sarnia 1635 hrs.	19 Depart Sarnia 1645 hrs.	20 Monitor Lake Huron	21 Monitor Lake Huron	22 Monitor Lake Huron	23 Monitor Lake Huron	24 Monitor Lake Huron
	25 Monitor Lake Huron	26 Monitor Lake Huron	27 Monitor Lake Huron	28 Off Tobermory Arr.0927 Dep.0927	29 Moorings Lake Huron	30 Arrive Sarnia 0700 hrs.	1 Sarnia
MAY	2 Sarnia	3 Sarnia	4 Sarnia	5 Sarnia	6 Sarnia	7 Sarnia	8 Sarnia
	9 Sarnia	10 Sarnia	11 Sarnia	12 Sarnia	13 Sarnia	14 Sarnia	15 Sarnia
	16 Sarnia	17 Depart Sarnia 1300 hrs.	18 Monitor Lake Huron	19 Monitor Lake Huron	20 Monitor Lake Huron	21 Monitor Lake Huron	22 Monitor Lake Huron
	23 Monitor Lake Huron	24 Monitor Lake Huron	25 Sault Ste.Marie Arr.0900 Dep.1705	26 Monitor Lake Superior	27 Monitor Lake Superior	28 Monitor Lake Superior	29 Monitor Lake Superior
JUNE	30 Monitor Lake Superior	31 Monitor Lake Superior	1 Moorings Lake Superior	2 Thunder Bay Arrive 1505 hrs.	3 Dep. Thunder Bay 1019 Coring	4 Arr. Thunder Bay 1539 Coring	5 Thunder Bay
	6 Thunder Bay	7 Thunder Bay Depart 1000 hrs.	8 Coring Lake Superior	9 Coring Lake Superior	10 Coring Lake Superior	11 Coring Lake Superior	12 Coring Lake Superior
	13 Thunder Bay Arrive 2304 hrs.	14 In Transit	15 Dep. Tobermory 1720 hrs. Moorings	16 Arrive Sarnia 1546 hrs.	17 Sarnia	18 Sarnia	19 Sarnia
	20 Sarnia	21 Depart Sarnia 1200 hrs.	22 Monitor Lake Huron	23 Monitor Lake Huron	24 Monitor Lake Huron	25 Monitor Lake Huron	26 Monitor Lake Huron
	27 Monitor Lake Huron	28 Monitor Lake Huron	29 Sault Ste.Marie Arr.0800 Dep.1855	30 Monitor Lake Superior	1 Monitor Lake Superior	2 Monitor Lake Superior	3 Monitor Lake Superior
JULY	4 Monitor Lake Superior	5 Monitor Lake Superior	6 Monitor Lake Superior	7 Moorings Arr. Thunder Bay 1353	8 Thunder Bay Depart 1502 hrs.	9 Coring Lake Superior	10 Coring Lake Superior
	11 Coring Lake Superior	12 Coring Lake Superior	13 Thunder Bay Arrive 1510 hrs.	14 In Transit	15 In Transit	16 Arrive Sarnia 1657 hrs.	17 Sarnia
	18 Sarnia	19 Depart Sarnia 1335 hrs.	20 Monitor Lake Huron	21 Monitor Lake Huron	22 Monitor Lake Huron	23 Monitor Lake Huron	24 Monitor & Moorings L. Huron
	25 Monitor & Moorings L. Huron	26 Monitor Lake Huron	27 Sarnia Arr. 0755 Dep. 0942	28 In Transit	29 CCIW Arrive 0612 hrs.	30 CCIW	31 CCIW
AUG	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW	7 CCIW
	8 CCIW	9 Depart CCIW 1030 hrs.	10 Monitor Lake Ontario	11 Monitor Lake Ontario	12 Monitor Lake Ontario	13 Arrive CCIW 1330 hrs.	14 CCIW
	15 CCIW	16 Depart CCIW 1215 hrs.	17 Monitor Lake Erie	18 Monitor Lake Erie	19 Monitor Lake Erie	20 Monitor Lake Erie	21 Arrive Sarnia 1340 hrs.
	22 Sarnia	23 Depart Sarnia 1210 hrs.	24 Monitor Lake Huron	25 Monitor Lake Huron	26 Monitor Lake Huron	27 Monitor Lake Huron	28 Monitor Lake Huron
SEPT	29 Monitor Lake Huron	30 Detour Passage Arr.0956 Dep.0956	31 Moorings Lake Huron	1 Moorings Lake Huron	2 Arrive Sarnia 2340 hrs.	3 Sarnia	4 Sarnia
	5 Sarnia	6 Sarnia	7 Depart Sarnia 1712 hrs.	8 Limnogeology Lake Huron	9 Limnogeology Lake Huron	10 Limnogeology Lake Huron	11 Limnogeology Lake Huron
	12 Limnogeology Lake Huron	13 Limnogeology Lake Huron	14 Limnogeology Lake Huron	15 Limnogeology Lake Huron	16 Limnogeology Lake Huron	17 Arrive Sarnia 1425 hrs.	18 Sarnia
	19 Sarnia	20 Depart Sarnia 1300 hrs.	21 Limnogeology Lake Huron	22 Limnogeology Lake Huron	23 Limnogeology Lake Huron	24 Arrive Sarnia 1155 hrs.	25 Sarnia
	26 Sarnia	27 Sarnia	28 Depart Sarnia 0009 hrs.	29 Monitor Lake Huron	30 Monitor Lake Huron	1 Monitor Lake Huron	2 Monitor Lake Huron
OCT	3 Monitor Lake Huron	4 Sault Ste. Marie Arrive 2343 hrs.	5 Sault Ste.Marie Depart 1306 hrs	6 Monitor Lake Superior	7 Monitor Lake Superior	8 Monitor Lake Superior	9 Monitor Lake Superior
	10 Monitor Lake Superior	11 Moorings Lake Superior	12 Monitor Lake Superior	13 Monitor Lake Superior	14 Thunder Bay Arr.0824 Dep.1045	15 In Transit	16 In Transit
	17 In Transit	18 In Transit	19 CCIW Arrive 2143 hrs	20 CCIW	21 CCIW	22 CCIW	23 CCIW
	24 CCIW Depart 1939 hrs.	25 In Transit	26 Arrive Sarnia 1953 hrs.	27 Depart Sarnia 1223 hrs.	28 Monitor Lake Huron	29 Monitor Lake Huron	30 Monitor Lake Huron
NOV	31 Monitor Lake Huron	1 Monitor Lake Huron	2 Monitor Lake Huron	3 Monitor Lake Huron	4 Sarnia Arr. 0208 Dep. 0554	5 In Transit	6 CCIW Arrive 0132 hrs.
	7 CCIW	8 CCIW Depart 1100 hrs.	9 Moorings & C. Chain L. Ont.	10 CCIW Arrive 1727 hrs.	11 CCIW	12 Moorings & C.C. CCIW D.1000 A.1445	13 CCIW
	14 CCIW	15 CCIW Depart 1005 hrs.	16 Monitor Lake Ontario	17 Monitor Lake Ontario	18 Monitor Lake Ontario	19 CCIW Arrive 1200 hrs	20 CCIW
	21 CCIW	22 CCIW Depart 0900 hrs.	23 Monitor Lake Erie	24 Monitor Lake Erie	25 Monitor Lake Erie	26 Monitor Lake Erie	27 Sarnia Arrive 1447 hrs.
	28 Sarnia	29 Sarnia Depart 1232 hrs.	30 Monitor Lake Huron	1 Monitor Lake Huron	2 Monitor Lake Huron	3 Monitor Lake Huron	4 Monitor Lake Huron
DEC	5 Monitor Lake Huron	6 Monitor Lake Huron	7 Sarnia Arr. 0923 Dep. 0932	8 In Transit	9 CCIW Arrive 0334 hrs.	10 CCIW	11
	12	13	14	15	16	17	18

GREAT LAKES STUDIES – 1971 – CSS LIMNOS

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
	31	1	2	3	4	5	6
FEB	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	1	2	3	4	5	6
MAR	7	8	9	10	11	12	13
	14	15	16 Dep. CCIW 0855	17 Moorings Lake Ontario	18 Arr. CCIW 0830	19 CCIW	20 CCIW
	21 CCIW	22 CCIW	23 Dep. CCIW 1130	24 Moorings Lake Ontario	25 Moorings Lake Ontario	26 Arr. CCIW 1520	27 CCIW
	28 CCIW	29 Depart CCIW 1230 hrs.	30 Moorings Lake Ontario	31 Arr. CCIW 1320	1 CCIW	2 CCIW	3 CCIW
APR	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 CCIW	13 Dep. CCIW 1255 Moorings	14 Arr. CCIW 2210 Lake Ontario	15 CCIW	16 CCIW	17 CCIW
	18 CCIW	19 Depart CCIW 1240 hrs.	20 Pesticide Study L. Ontario	21 Pesticide Study L. Ontario	22 Arr. CCIW 1605	23 CCIW	24 CCIW
	25 CCIW	26 CCIW	27 Dep. CCIW 0905	28 Bact. & Thermal Bar Studies	29 Lake Ontario	30 Bact. & Thermal Bar Studies	1 Lake Ontario
MAY	2 Bact. & Thermal Bar Studies	3 Lake Ontario	4 Bact. & Thermal Bar Studies	5 Lake Ontario	6 Arr. CCIW 1620	7 CCIW	8 CCIW
	9 CCIW	10 Depart CCIW 1015 hrs.	11 Pesticide Study L. Erie	12 Pesticide Study L. Erie	13 Pesticide Study L. Erie	14 Pesticide Study L. Erie	15 Arr. CCIW 0820
	16 CCIW	17 Dep. CCIW 1100 Moorings	18 Arr. CCIW 1430 Lake Ontario	19 Dep. CCIW 1030 Moorings	20 Arr.P.Colborne 1950 L. Erie	21 Port Colborne	22 Port Colborne
	23 Port Colborne	24 Port Colborne	25 Port Colborne Dep. 1602 hrs.	26 Organic Part. Study L. Erie	27 Organic Part. Study L. Erie	28 Organic Part. Study L. Erie	29 Port Colborne Arrive 2037 hrs.
JUNE	30 Dep.P.Col. 1130 Arr.P.Weller 2035	31 Port Weller Dry Dock	1 Port Weller Dry Dock	2 Port Weller Dry Dock	3 Port Weller Dry Dock	4 Port Weller Dry Dock	5 Port Weller Dry Dock
	6 Port Weller Dry Dock	7 Port Weller Dry Dock	8 Port Weller Dry Dock	9 D.0805 P.Weller Arr. 1155 CCIW	10 CCIW	11 CCIW	12 CCIW
	13 CCIW	14 Dep. CCIW 0915 Pesticide Study	15 Arr. CCIW 1140 Lake Ontario	16 CCIW	17 Dep. CCIW 1235 Moorings	18 Arr. P.Colborne 1235 L. Erie	19 Port Colborne
	20 Port Colborne	21 Port Colborne Depart 1833 hrs.	22 Organic Part. Study L. Erie	23 Organic Part. Study L. Erie	24 Organic Part. Study L. Erie	25 Arr. CCIW 0555	26 CCIW
	27 CCIW	28 Dep. CCIW 1017 Moorings	29 Arr. CCIW 1930 Lake Ontario	30 Dep. CCIW 1318	1 Moorings Lake Erie	2 Bact. Survey Lake Erie	3 Port Colborne Arrive 1110 hrs.
JULY	4 Port Colborne	5 Port Colborne	6 Port Colborne Depart 1042 hrs	7 Grid Survey & Organic Part.Study	8 Lake Erie	9 Grid Survey & Organic Part.Study	10 Lake Erie
	11 Grid Survey & Org.Part. Study	12 Lake Erie	13 Grid Survey & Org.Part. Study	14 Lake Erie	15 Grid Survey & Org.Part. Study	16 Port Colborne Arrive 0705 hrs	17 Port Colborne
	18 Port Colborne	19 Port Colborne Depart 1100 hrs.	20 Lake Erie	21 Grid Survey & Organic Part.Study	22 Lake Erie	23 Port Colborne Arrive 0215 hrs.	24 Port Colborne
	25 Port Colborne	26 Port Colborne	27 Port Colborne Depart 0810 hrs	28 Lake Erie	29 Grid Survey & Org.Part. Study	30 Lake Erie	31 Arr. CCIW 1220
AUG	1 CCIW	2 CCIW	3 CCIW	4 Dep. CCIW 0940	5 Heat Content Survey L. Ontario	6 Arr. CCIW 1435	7 CCIW
	8 CCIW	9 Dep. CCIW 1020 Moorings	10 Arr. CCIW 1310 Lake Ontario	11 Dep. CCIW 1000	12 Heat Content Survey L. Ontario	13 Arr. CCIW 0610	14 CCIW
	15 CCIW	16 Dep. CCIW 1155	17 Coastal Chain Lake Ontario	18 Coastal Chain Lake Ontario	19 Arr. CCIW 1525	20 CCIW	21 CCIW
	22 CCIW	23 Dep. CCIW 1035	24 Moorings Lake Erie	25 Moorings Lake Erie	26 Port Colborne Arrive 2125 hrs	27 Port Colborne	28 Port Colborne
SEPT	29 Port Colborne	30 Port Colborne Depart 1055 hrs.	31 Organic Part. Study L. Erie	1 Organic Part. Study L. Erie	2 Organic Part. Study L. Erie	3 Arr. CCIW 0600	4 CCIW
	5 CCIW	6 CCIW	7 Dep. CCIW 1750	8 Towed Instrument Trials,L.Ont.	9 Arr. CCIW 2400	10 CCIW	11 CCIW
	12 CCIW	13 Dep. CCIW 1145	14 Pesticide Study L. Ontario	15 Pesticide Study L. Ontario	16 Pesticide Study L. Ontario	17 Arr. CCIW 1500	18 CCIW
	19 CCIW	20 CCIW	21 CCIW	22 CCIW	23 Dep. CCIW 1115	24 Port Colborne Arrive 1515 hrs	25 Port Colborne
	26 Port Colborne	27 Port Colborne Depart 1050 hrs.	28 Lake Erie	29 Pesticide Survey&Org.Part. Study	30 Lake Erie	1 Arr. CCIW 0830	2 CCIW
OCT	3 CCIW	4 Dep. CCIW 0901	5 Moorings &	6 Towed Instrument Lake Ontario	7 Trials	8 Arr. CCIW 2345	9 CCIW
	10 CCIW	11 CCIW	12 Dep. CCIW 2130	13 Moorings Lake Erie	14 Moorings Lake Erie	15 Sarnia Arrive 2048 hrs	16 Sarnia Depart 0000 hrs.
	17 Moorings Lake Huron	18 Moorings Lake Huron	19 In Transit	20 Port Colborne Arrive 1130 hrs	21 Port Colborne	22 Port Colborne	23 Port Colborne
	24 Port Colborne	25 Port Colborne Depart 1315 hrs.	26 Organic Part. Study L. Erie	27 Organic Part. Study L. Erie	28 Sarnia Arrive 0700 hrs	29 Sarnia	30 Sarnia
NOV	31 Sarnia	1 Sarnia Depart 1515 hrs.	2 Geological	3 Survey	4 Georgian Bay	5 & North	6 Channel
	7 Geological	8 Survey	9 Georgian Bay	10 &	11 North	12 Channel	13 Arr. CCIW 0920
	14 CCIW	15 CCIW	16 Dep. CCIW 0955	17 Moorings Lake Ontario	18 Arr. CCIW 1400	19 CCIW	20 CCIW
	21 CCIW	22 Dep. CCIW 0855 Moorings	23 Arr. 2115 Port Colborne Lake Erie	24 Port Colborne	25 Port Colborne	26 Port Colborne	27 Port Colborne
	28 Port Colborne	29 Port Colborne	30 Port Colborne Depart 0950 hrs	1 Organic Part. Study L. Erie	2 Organic Part. Study L. Erie	3 Sarnia Arr.0335 Dep.1100	4 Moorings Lake Huron
DEC	5 Sarnia Arrive 1310 hrs.	6 Sarnia	7 Sarnia Depart 0810 hrs	8 In Transit	9 A.0105 CCIW D. 1250 A.1600 Moor.	10 Dep. CCIW 0843 Arr.1418 Coring	11 CCIW
	12 END	13 OF	14 FIELD	15 SEASON	16	17	18

International Field Year for the Great Lakes

By mid-December, an extensive study had been completed for IFYGL planning, and the Canadian Field Operations Plan was ready for distribution. The manual describes in detail the methods, procedures, and schedules for the bulk of field operations for IFYGL.

Miscellaneous

A Hewlitt-Packard Model 9810-A calculator was introduced on board M. V. MARTIN KARLSEN for complete and prompt calculations of chemical and biological parameters measured during monitor cruises. A plotter to be used in conjuction with this calculator will be utilized in 1972.

As a result of plans initiated by the Public Service Commission, Conestoga College, and Georgian College, students from these community colleges joined the staff on M. V. MARTIN KARLSEN during two autumn monitor cruises for a first-hand look at sampling and observational procedures.

A "Manual of Limnological Methods" (zero draft) was completed in February by Technical Operations staff and distributed throughout CCIW.

Greatly improved ship-to-shore communications have been most evident since the new equipment has been installed on both D.O.T. radio stations and on vessels based at CCIW.

Two new systems have been developed by Engineering which have speeded up station time on monitor cruises considerably:

- A pump water sampling system utilizing an E.B.T. (Electronic Bathythermograph) to obtain depth and temperature in conjunction with a submersible pump is now pumped directly into the laboratory area.
- Similarly, the remote-controlled E.B.T., which is operated from the laboratory, has replaced the bathythermograph as a depth-temperature profiler. With the increase in depth capacity to 400 metres, E.B.T. profiles may now be obtained throughout the Great Lakes System by this method.

LAKES MANAGEMENT RESEARCH SECTION

The study of man's use of the water resources of the Great Lakes Basin and some of the economic ramifications of current concern with heavy metals and other environmentally hazardous substances, preoccupied the Section's staff during 1971. These projects required very close contacts with industrial and statistical specialists of other agencies and valuable information was collected.

The Section has participated in a number of joint studies with other units at the CCIW, particularly the Environmental Quality Coordination Unit, and with other agencies. Members of the staff have represented the CCIW and the Department of the Environment at a number of meetings and have participated in international programs including the negotiations with the United States on a Water Quality Agreement for the Great Lakes, the Organization for Economic Co-operation and Development, and the United Nations Conference on the Human Environment.

Great Lakes Studies

A project, undertaken jointly with the former Economic Geography Section, Resources Research Centre, successfully produced the first map entitled "Great Lakes Water Use"[1] showing some of the most significant aspects of the human use of the Great Lakes.

The map illustrates the complexity of the water management problem and its severity, particularly in the Lower Lakes. On a basis of population density, it depicts water withdrawals, waste disposals, fish catches, generation of electrical energy and irrigated crop acreage. A number of insert maps show physical characteristics and land use, both for the basin as a whole and the shoreline. This work was extended to allow the production of a series of data of different social and economic indicators using water related boundaries. A systematic assembly of information on all water related activities in the Canadian Upper Lakes basin was started during the year.

In co-operation with the Environmental Quality Co-ordination Unit, detailed historical and future estimates of phosphorus loadings into Lake Erie were made.

Economics of Environmental Quality

A number of investigations have been undertaken in the Section's project to evaluate the use of materials which are potentially harmful to the environment and in the Canadian economy. Collection of data has been

[1] Copies of the map are obtainable from the Chart Distribution Office, Canada Centre for Inland Waters or Information Canada at a cost of $1.00.

TABLE 2. POPULATION OF GREAT LAKES BASIN, CANADA, 1971, UNITED STATES, 1970

	Basins				
	Lake Ontario	Lake Erie	Lake Huron	Lake Michigan	Lake Superior
CANADA Total Population 6,273,034	3,730,752	1,504,559	894,897	–	142,826
UNITED STATES Total Population 25,395,936	2,898,485	10,111,272	1,390,880	10,566,266	429,033

Source: Canada, Statistics Canada, Preliminary Bulletin, 1971 Census of Canada.
United States, Department of Commerce, Bureau of the Census, 1970, Census of Population.

completed on mercury and selected pesticides; work is in progress on lead and cadmium and a preliminary examination has been made of a number of other substances, e.g., polychlorinated biphenyls, beryllium, cyanide, and arsenic.

Each of these studies presents an inventory of the sources and uses of the material and its major compounds in Canada. The movement of the substance from the point of extraction through to consumption is traced. As far as possible the quantities involved are estimated and possible points of entry into the environment are identified.

A pilot study is being made to apply input-output techniques to the examination of the problem of the differing environmental impact of alternative economic strategies. Tables showing direct and indirect use of a selected group of heavy metals and their compounds have been developed for Ontario as a pilot study. Empirical industry and regional studies will be developed and aspects of the transport of hazardous materials will be examined.

In co-operation with the Energy Sector, Department of Energy, Mines and Resources, a contract study was undertaken for CCIW by Montreal Engineering Co. extending the estimates of thermal inputs to Canadian inland and tidal waters outside the Great Lakes basin and examining some alternatives for reducing thermal loads on water bodies. It was estimated that thermal inputs were 2.86×10^{10} BTU/h in 1970 and will

TABLE 3. LEVEL OF AWARENESS AND EDUCATION

Detergent Phosphates and Eutrophication Survey

Level of Awareness	Respondent's Education		
	Public School or Less %	Part High School %	High School Graduate or more %
1. Unaware of controversy.	49	37	19
2. Aware but no mention of phosphates.	32	28	31
3. Mentioned phosphates but no explanation.	14	23	25
4. Well-informed	4	11	25

N = 204
2 of SP = 4.25
Significant at .001 level.

TABLE 4. WATER REQUIREMENT FORECAST MATRIX

WATER USE SECTOR \ DEMAND FACTORS	POPULATION	POPULATION DENSITY	AGE STRUCTURE	FAMILY SIZE	INCOME LEVEL	NATURE OF ACTIVITY	LEVEL OF PRODUCTION	SCALE OF PRODUCTION	PRODUCTION PROCESS	SYSTEM LOSS	COST OF WATER PER UNIT*	NATURE OF WATER / UNIT	ACCESSIBILITY OF SOURCE	CLIMATE	WATER QUALITY	WATER QUALITY REGULATIONS	MAGNITUDE OF SOURCE
DOMESTIC (Residential)	■	■	■	■	■					■	■	■	■	■	■	■	■
COMMERCIAL (Trade a Finance)	■				■	■	■			■	■	■	■	■	■	■	■
PUBLIC (Institutional)	■	■	■		■	■				■	■	■	■	■	■	■	■
MFG.						■	■	■	■	■	■	■	■		■	■	■
MINING						■	■	■	■	■	■	■	■		■	■	■
AGRICULTURE						■	■	■	■	■	■	■	■	■	■	■	■
ELEC. POWER GENERATION							■	■	■	■	■	■	■	■	■	■	■
NAVIGATION							■	■	■			■					■
RECREATION	■	■	■	■	■	■						■	■	■	■		■
AESTHETIC		■			■							■	■	■	■		■

*Cost is opportunity cost which in some cases may be expressed as price

increase to 76.7×10^{10} BTU by the year 2000 on the basis of firm peak generation at a level of 80% of installed capacity for thermal power plants, and other sources of thermal inputs operating at full capacity.

While attempting to evaluate potential beneficial uses of waste heat, case studies of some actual electricity generation stations suggested that joint, central electrical power and heat energy production plants might be useful. The demand for heat energy must follow a similar pattern to the demand for electrical energy for economic operations.

Social and Institutional Studies

The study of housewives' knowledge of the effect of detergent containing phosphate on eutrophication and the attitudes towards detergent reformulation was completed. Respondents were generally concerned about pollution but in August, 1970, a large proportion was unaware of the phosphate controversy. The socio-economic status and the education of the housewife and the husband appeared to be the most important factor determining the level of awareness (Table 3).

During the summer of 1971 three projects were supported by the Section: a study of municipal authority over environmental quality matters in Ontario as embodied in the Municipal Act; and two field studies conducted by McMaster University and the University of Western Ontario. The former was a comparative study of environmental quality by-laws and municipal councillors and officials attitudes towards them in Ontario towns on Lake Erie and Lake Superior. The second was a study of the native shoreline problems on Lake Erie and the extent of cognizance of these problems by the municipalities.

Projects are currently being developed to investigate attitudes towards waste water recycling and to analyze the management structure on the Upper Great Lakes.

Miscellaneous

The Section continued to act as the secretariat for the advisory committees to the CCIW and to co-ordinate the seminar series. In addition, staff took part on a number of occasions in public presentations including press and broadcast interviews and speaking engagements.

A number of special projects were undertaken during the year. One of the more unusual was a study of the effectiveness of the CCIW Public Relations program through a telephone survey of residents of Burlington, Hamilton and surrounding district. Of those interviewed 27% had heard of the Canada Centre for Inland Waters. Only 25% of those who had heard of the CCIW were aware that it was a research institute although half knew of its connection with pollution.

Two national reports were prepared by the Section, one for the Detergent Working Group of the OECD Committee on Eutrophication and the second, on water requirements forecasting for a special United Nations Seminar to be held in 1972. Some of the economic characteristics of different water uses described in that report are shown in Table 4. The preparation of these papers was a result of participation by the staff in departmental, national and international committees and working groups.

WATER QUALITY DIVISION

The Water Chemistry Subdivision Detachment was actively engaged in the biochemical monitoring of the Great Lakes and Georgian Bay, co-ordination of analytical requests, and provision of analytical support to a number of different sections, agencies and special projects. During the year, a total of about 55,600 samples were processed and analysed for various chemical constituents.

In June, the laboratories and personnel were temporarily relocated from the trailer complex to the Pilot Plant building pending completion of the main laboratory building at CCIW.

Major projects undertaken during the year were as follows:

Great Lakes Monitoring

The Unit participated fully in 17 biochemical monitor cruises of the Great Lakes and partially in one cruise of Lake Erie by the C.C.G.S. PORTE DAUPHINE. Of these, 3 each were conducted on Lake Ontario and Lake Superior, 4 on Lake Erie, and 8 on Lake Huron. Monitor stations visits amounted to about 250 and a total of approximately 5,700 water samples, collected from designated stations, were analysed aboard ship for soluble silica, ammonia, nitrite, nitrate + nitrite, orthophosphate, total alkalinity and about 10,000 for filtered and unfiltered total nitrogen. A total of approximately 35,500 water samples were processed aboard ship by the detachment's staff and returned to the shore laboratory for further chemical analysis. Of these, approximately

12,130 were analysed for total phosphate, 4,000 for total and inorganic carbon, 2,500 for calcium, magnesium, sodium, potassium, sulphate, chloride, lithium, strontium, about 2,400 were or would be analysed for cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, vanadium, zinc, and 595 for boron. Also, samples were analysed aboard ship for dissolved oxygen, pH, specific conductance and turbidity by the Technical Operations Section personnel with guidance and supervision from this detachment. A total of approximately 24,480 tests were performed and as in the past, instruments, reagents and other requirements for the performance of these tests were provided by WCS detachment.

Georgian Bay Project

The C.C.G.S. PORTE DAUPHINE undertook four monitor cruises of Georgian Bay on behalf of the Centre. Approximately 54 monitor stations were visited each time. Water samples were collected and analysed aboard ship for pH, specific conductance, dissolved oxygen and turbidity by personnel from the Great Lakes Institute of the University of Toronto. Operational and technical instructions, sample bottles, some reagents and necessary equipment were provided by WCS detachment. Water samples from 32 of the 54 monitor stations were treated by G.L.I. personnel and returned to our shore laboratory for chemical analysis. Approximately 475 of these samples were analysed for soluble nutrients, total and inorganic carbon, a variety of major ions and heavy metals and about 950 for total phosphate.

Bioassay Studies

Analytical support was provided to the Biological Limnology Section's (FRB Detachment) bioassay studies on Lake Huron and Lake Superior. A number of 1 to 10 m integrated water samples were analysed aboard ship for soluble nutrients and total alkalinity while others were processed and returned to shore laboratory for further analysis. Also, a number of plankton organisms, collected by the Biological Limnology Section, were analysed.

Precipitation Chemistry

Throughout the year, continuous analytical support was provided to the precipitation chemistry studies being conducted by the Chemical Limnology Section of Lakes Division. Approximately 260 precipitation samples were analysed for pH, total alkalinity, total and soluble nutrients, major ions and selected heavy metals.

Interstitial Water Samples

About 80 interstitial-water samples from lake sediments were analysed for selected major ions on behalf of the Chemical Limnology Section of Lakes Division.

Air Sudbury Project

Twelve 'air-fallout' precipitation samples collected by McMaster University in the Sudbury area in January were analysed for heavy metals. The extremely heavy work load during the year, however, necessitated our discontinuation of analytical support to this project.

Round Robin Series

The Water Quality Division continued its analytical quality control throughout its laboratories by means of the Round Robin Series. The Water Chemistry Subdivision's laboratory at CCIW participated and analysed a series of special samples for nutrients, major ions, and heavy metals during the year.

Sample Representivity

This program was initiated in mid-August by Chemical Limnology Subdivision with the collaboration of the Water Chemistry Subdivision and the Technical Operations Section. A series of statistical evaluations were conducted during subsequent monitor curises on Lakes Ontario, Erie and Huron. Quintuplicate water samples were collected from specified depths at certain stations and samples were subjected to the full range of chemical analyses conducted aboard ship. These exercises proved to be very useful in assessing sample representivity and the quality of chemical analysis data provided for the Great Lakes Monitor Program.

NTA Monitoring Program

Some support is provided to the following programs:

(i) NTA monitoring of Hamilton Harbour

(ii) Winter monitoring of NTA in western Lake Ontario. Sample bottles, instructions, and necessary equipment for sample treatment were provided for the latter program. This detachment also has been acting as a liaison between CCIW and Water Quality Division Analytical Services Section, Ottawa, where samples are being analysed.

Work Introduction Program

The detachment participated in the Public Service Commission's Work Introduction Program and accommodated 4 final-year students from Mohawk College in Hamilton during a two-week period in November.

Special Studies, Research and Development

During the year, the staff conducted a number of special investigatory and developmental exercises pertaining to detachment's laboratory work:

(i) The effect of freezing on samples of lake water for soluble nutrient analysis.

(ii) Effects of filtration on results of analyses of lake water for ammonia and total nitrogen.

(iii) The effects and comparison of the use of an all-glass and all-plastic filtration equipment for sample filtration prior to soluble nutrients analysis.

(iv) Investigation and development of an automated and sensitive method for total organic carbon analysis using the Technicon Autoanalyser (a modification of Manfred Ehrhardt's method).

Marine Sciences Branch - Central Region

The Central Region is comprised of elements of the Canadian Hydrographic Service, Ship Division and an administrative support staff. The Canadian Hydrographic Service is responsible for hydrographic surveys required for the production of nautical charts and related publications; maintenance of the I.J.C. Shore Property Inventory; operation and maintenance of electronic positioning, sonar and distance measurement systems in use at CCIW, and operation of a Nautical Chart Distribution for the benefit of the general public as well as the scientific community. A Section of the Ship Division provides and operates the ships, launches, and other marine craft required in support of hydrographic surveys and scientific research programs.

CANADIAN HYDROGRAPHIC SERVICE

Arctic Program

The field unit attached to the Polar Continental Shelf Project completed the through-the-ice survey in the Beaufort Sea and carried out sounding and ground-control surveys in Nares Strait. A preliminary position was determined for Hans Island, which lies close to the tentative boundary of the territorial seas of Canada and Denmark. Plans were completed for the final determination of the island's position in 1972 by a joint Canadian-Danish expedition.

Two Central Region hydrographers took part in the Beaufort Sea Survey carried out by the survey ship PARIZEAU.

Surveys

Ontario – Ottawa River

The survey of the Pembroke to Rapides-des-Joachims reach of the Ottawa River was completed. Modern nautical charts can now be produced for the entire stretch of the river between Temiscaming and Montreal.

Georgian Bay

A survey of McGregor Bay was carried out to determine whether the route from Georgian Bay to the eastern side of Cloche Peninsula is navigable by seaway draught ships. The detailed survey established the routes to be used by seaway draught ships and Canada Cement Lafarge Limited is proceeding with the development of a new shipping terminal in McGregor Bay.

Existing charts of Georgian Bay will be updated as a result of the 1971 revisory survey.

Lake Huron

A revisory survey was carried out and existing charts of the eastern part of Lake Huron will be updated prior to the next navigation season.

Lake of the Woods

The hydrographic survey was continued in 1971 and completion is planned for 1972 so that modern nautical charts will soon be available for the whole of Lake of the Woods.

St. Lawrence River – Kingston to Gananoque

Surveys required for the production of modern commercial and recreational nautical charts were continued in the Thousand Islands area as far eastward as Gananoque.

St. Lawrence River – Cornwall to Montreal

Navigation ranges and other fixed aids in the stretch of the seaway between Cornwall and Montreal were resurveyed.

Manitoba

A hydrographic survey of Playgreen Lake was commenced and will continue until the routes from Lake Winnipeg to Whiskey Jack Portage and Norway House are adequately charted. The survey will also provide a base from which the effect on navigation of the Nelson River Power Project, can be determined.

Quebec

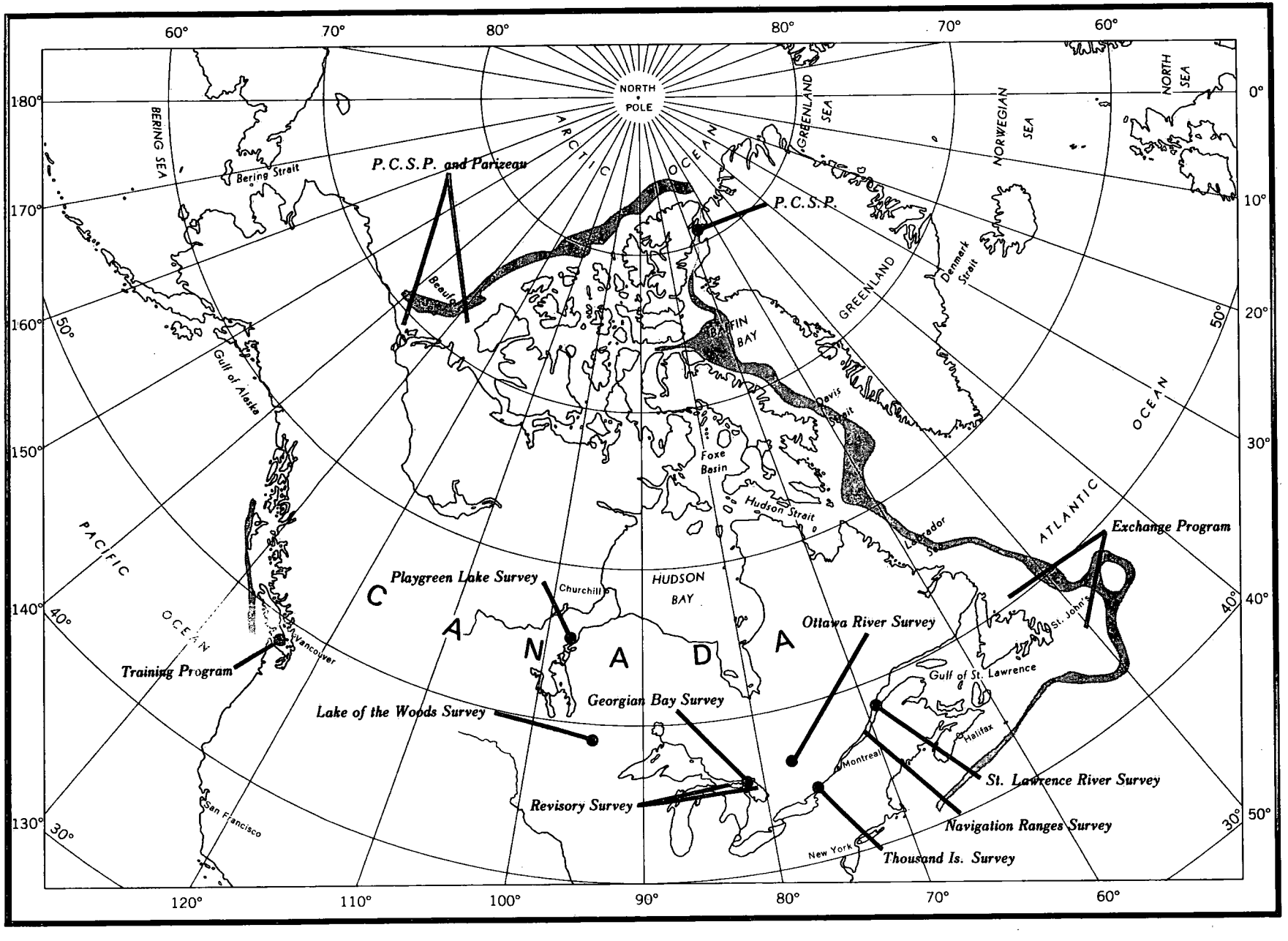
The hydrographic survey of the lower St. Lawrence River upstream to Ile-aux-Coudres was continued to facilitate production of modern nautical charts for deep draught shipping. Large scale surveys were also carried out in Quebec Harbour adjacent to new port facilities.

Limnogeology

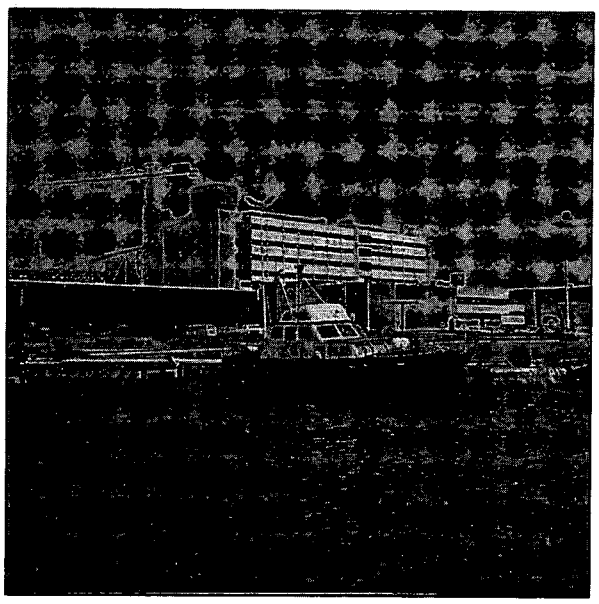
Two field units established survey control and supplied and maintained navigational systems in support of the limnogeology programs in Lake Ontario and Lake Erie.

IFYGL

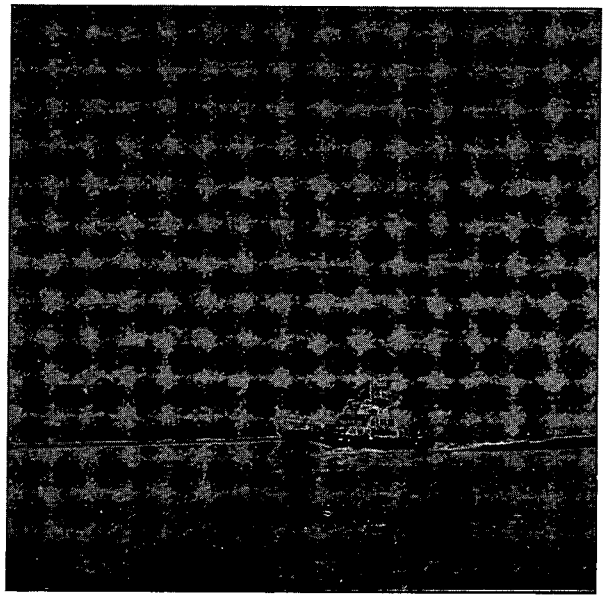
A contract was awarded to Computing Devices of Canada, Ottawa for the rental and operation of a Decca Lambda Survey system to facilitate positioning of survey and research vessels and aircraft engaged in IFYGL (1972) operations on Lake Ontario.



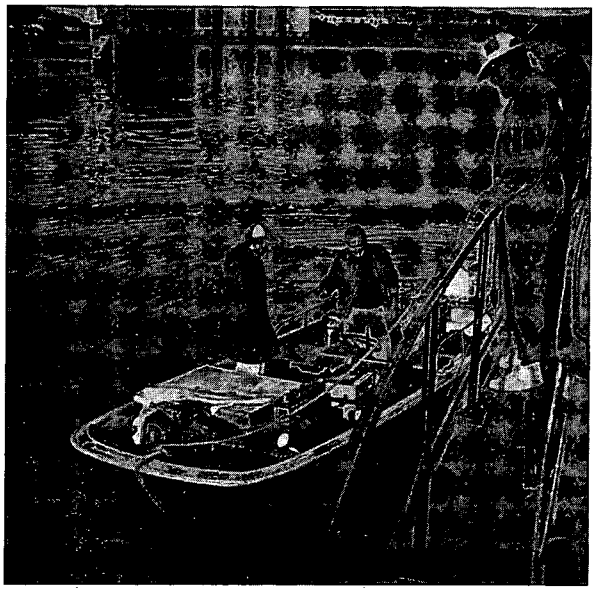
1971 SURVEYS



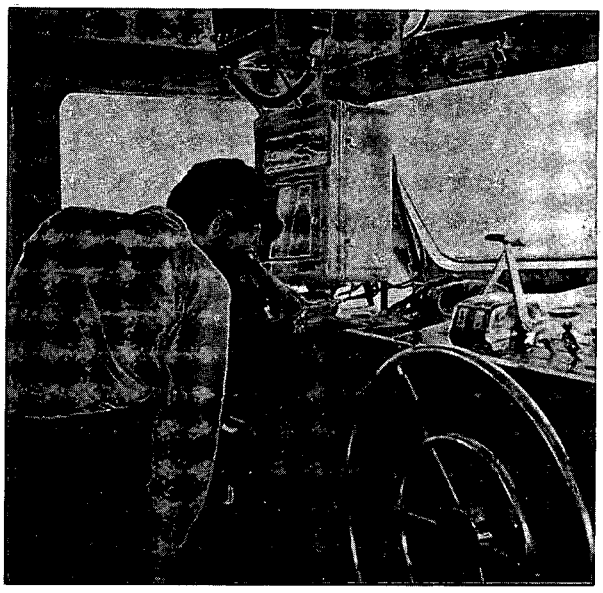
Revisory Survey Vessel "Vedette" at CCIW.



Revisory Survey Vessel "Vedette" at work.



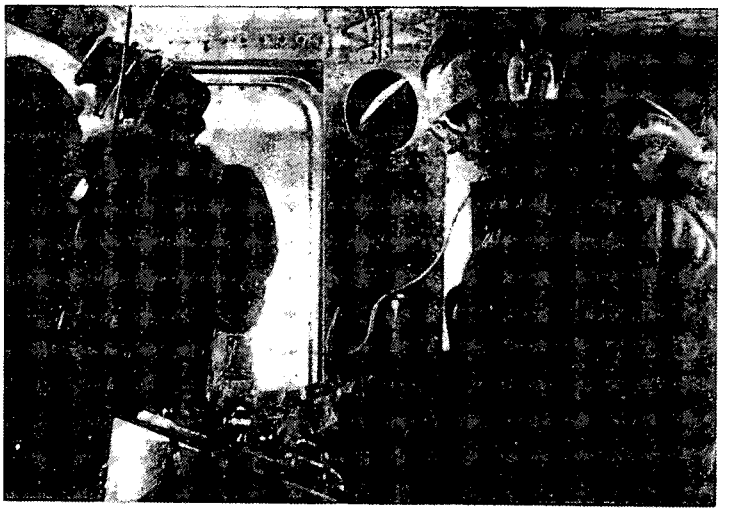
Inshore work by 17-foot Boston Whaler



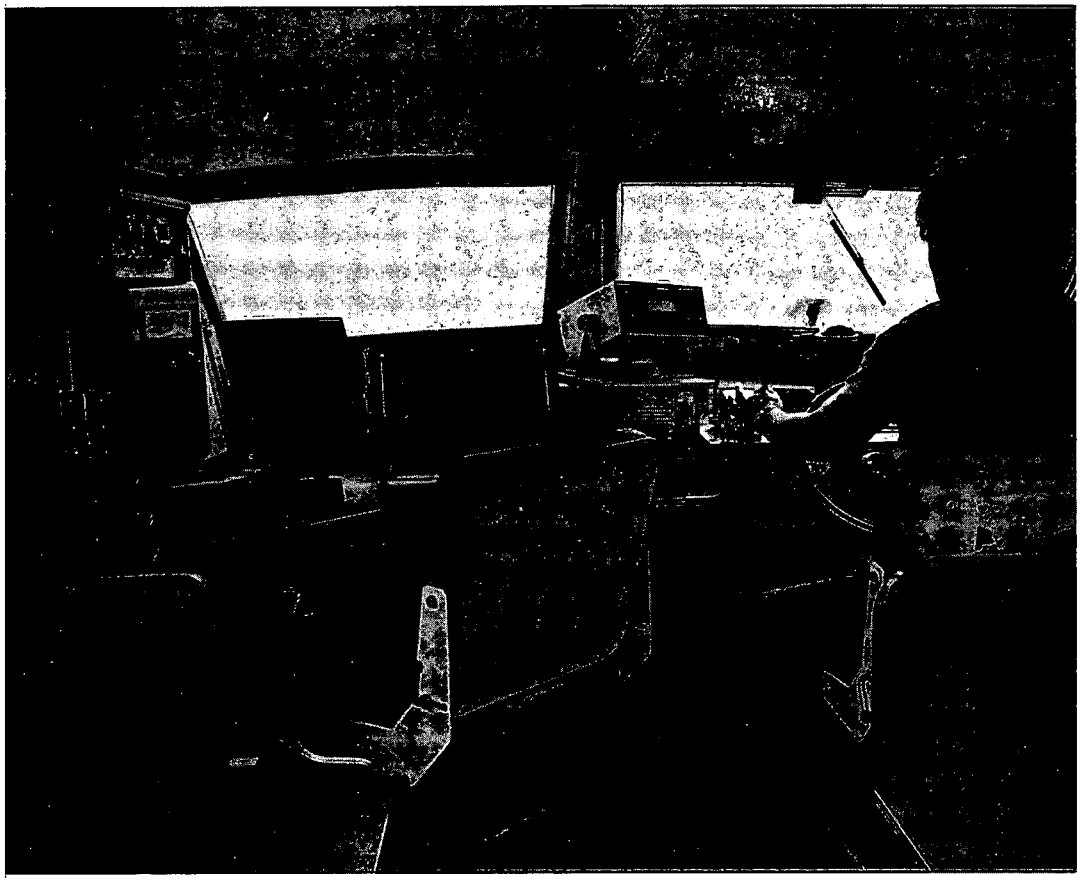
"Vedette" wheelhouse.

Ice camp 200 (1971).

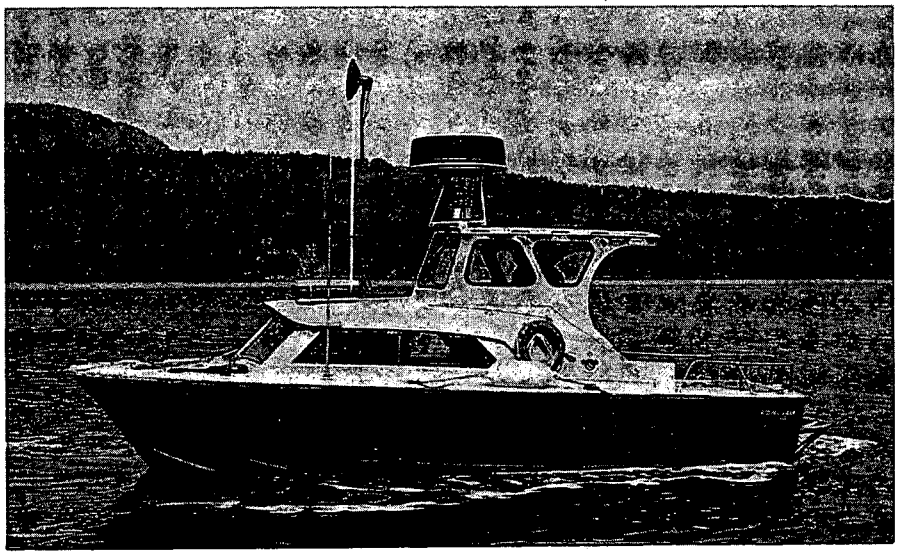
Removing transducer from helicopter.



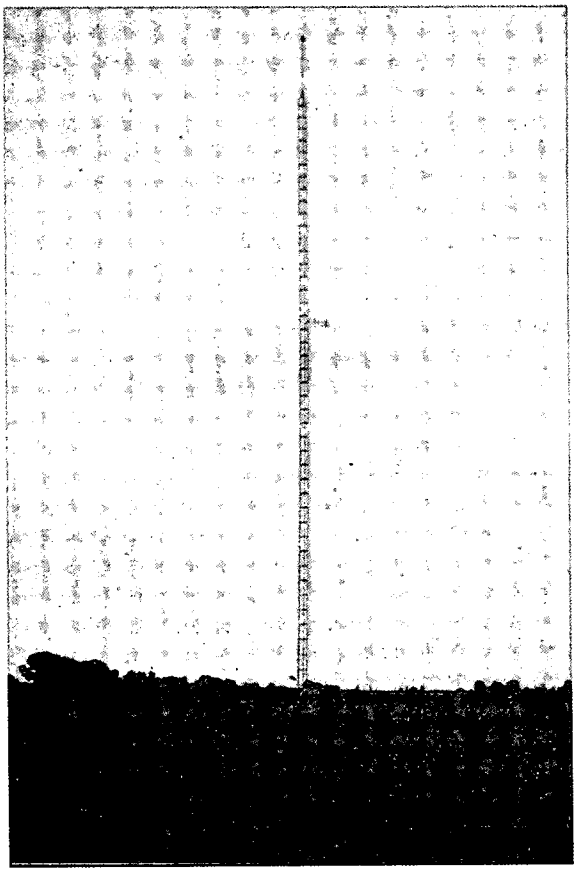
Hydrograph obtains sounding using Gifft Echo Sounder.



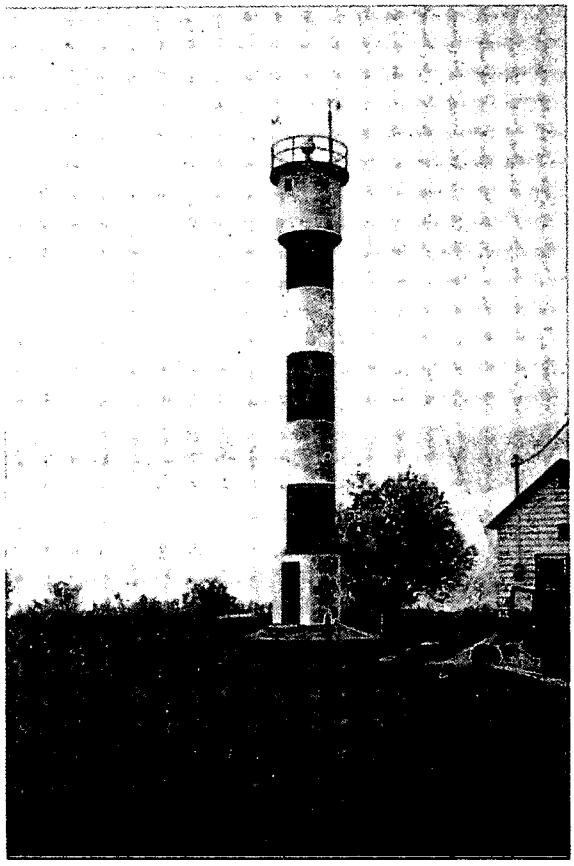
Interior of a 25-foot Bertram Launch.



25-foot Bertram Launch.



R.P.S. transponder installed on a 90 T.V. tower.



R.P.S. transponder installed on a lighthouse.

Field plotting sheet projections and Decca lattices were prepared on Central Region's Gerber–22 plotting table and supplied to Canadian Hydrographic Service headquarters where the final field sheets were compiled.

Nautical Chart Sales

A Sales outlet for nautical charts, sailing directions, and related publications of interest to commercial and recreational mariners was established at CCIW as a part of the Canadian Hydrographic Service's Marine Information Centre. Bathymetric maps of the Canadian Arctic, Lake Erie and Lake Ontario are available. The Great Lakes water use map prepared by the Economic Geography Section and the Lakes Management Research Section (CCIW) is also available through this office.

I.J.C. Shore Property Inventory

The IJC Shore Property Inventory is maintained by the Hydrographic Service and is available to the public through the Marine Information Centre, CCIW.

Tides, Currents and Water Levels

The Tides, Currents and Water Levels Section was established in July of 1971 by the appointment of a regional tidal officer. The prime responsibility of this section is to provide hydrodynamic support, specifically tidal, current, and water level, for hydrographic surveys and navigational requirements, while maintaining a strong scientific expertise. The first six months of operation consisted mainly of familiarization with the responsibilities, definition of planning guidelines, establishment of operational functions, acquisition of temporary water level gauging, review and submission of temporary gauge records, and preparation for the 1972 field season. In addition research was undertaken, in conjunction with shore property studies, into the erosive and inundative effects as well as the spatial and temporal scales, in the water level variations resulting from the storm surge on Lake Huron in August 1971.

Research and Development

The main efforts were in the areas of data processing and plotting on the Gerber 22. In the field of data processing, modifications were made to the Hypos programs so that Gerber plots could be produced on a stable base material and to ensure that the depth selection program removed redundant data. The Hypos system was again used on the Lower St. Lawrence with position data being transmitted via TWX link and sounding rolls via the mail. The quality of the processed data was vastly superior to that of past years.

A shipboard hydrographic acquisition and processing system (HAAPS) was purchased, assembled, and field tested on the St. Lawrence River with very favourable results. The most obvious weakness of the system was the spacing of soundings. However, this fault is being modified and new programs being developed.

In the area of plotting on the Gerber, programs have been developed to plot lattices (Mini-Fix, Decca, etc.) on U.T.M. and polyconic projections, U.T.M. grids with geographic graticules and stations, polyconic projections with stations, and Lambert conformal Projections. The base Polyconic projections, Decca 6f Lattices, and U.T.M. grids were plotted for IFYGL program in 1972. The program for plotting U.T.M. grids was one of the most widely requested for field sheets in 1971.

A PDP-8/E was acquired and has been made available to hydrographers. All the programs were documented and several new programs written for survey and positioning system computations. The program library now contains 29 Focal and 26 Fortran programs with several additional programs still in the development stage.

Further trials were conducted on the Omni-directional Scanning Sonar after modification by the manufacturer. These trials indicated a good potential for utilization on hydrographic and scientific surveys.

During the year, Hydrodist Digital Display Systems were designed, purchased, tested and put into operational use on hydrographic surveys. The use of these units results in a considerable increase in production operations.

Electronic Maintenance

Field support was provided for eight hydrographic survey units and four research units (IWB) as well as the survey vessels LIMNOS and MARTIN KARLSEN.

The maintenance facility was improved and test procedures developed for new equipment.

This unit is now staffed by an engineer and ten fulltime technicians who provide the field support and perform normal maintenance routines on positioning systems, distance measurement systems, sonar, radar and communications systems valued at nearly two million dollars.

SHIP SECTION

The chartered tug LAC ERIE commenced operation in February and continued up to Christmas Eve for another very active season, principally with the Limnogeology Section.

The major vessels LIMNOS and MARTIN KARLSEN were engaged in a variety of programs from March to December, when both returned to CCIW for major refitting.

A 56 foot landing craft, the DUFRESNE M58, was taken on short term charter for the inshore sediment program. The recessed propellers permitted the craft to work in much shallower water than would normally be the case with a vessel this size. The 100 foot barge HANDY BOY was also chartered briefly for use as an instrumentation platform servicing instrumented towers on the Niagara Bar.

The revisory survey launch VEDETTE was delivered by the builder in May and after experiencing some teething problems, worked successfully in Georgian Bay.

Launch support was extended to Playgreen Lake, Manitoba, where a new hydrographic survey was mounted and also to the Okanagan project in British Columbia. Here, a "Sea Truck", a new mini-landing craft with its own specially modified trailer was used with a good measure of success.

The marine workshops continued to provide wood and fibreglass fabrication service to various units at the Centre in addition to launch and machinery maintenance.

ADMINISTRATION

The administrative support section provided budgeting, payroll, personnel, secretarial, stores and procurement services to the region. Peak manpower was over 250 members, including seasonal ships' personnel.

TECHNOLOGY DEVELOPMENT AND DEMONSTRATION DIVISION

The Technology Development and Demonstration Division, Technology and Scientific Services Branch, Water Pollution Control Directorate, Environmental Protection Service, is charged with the conception, development, and implementation of technical development programs as related to water pollution for industrial and municipal wastewaters across Canada.

The nucleus of the Division, presently consisting of 23 people, is made up of three originally separate groups: the Water Pollution Research Subdivision of the Water Quality Division with one detachment from Ottawa and another at CCIW Burlington; and the Water Pollution Research Subdivision of the Public Health Engineering Division from the Department of National Health and Welfare, Ottawa.

The Division which became operational in September is divided into four functional sections: the Process Development Section, the Laboratory Services Section, the Facilities Services Section and the Demonstration Section.

PROCESS DEVELOPMENT SECTION

The Process Development Section comprises four groups organized along process lines: (1) biological processes, (2) physical processes, (3) chemical processes, (4) soil processes.

Biological Process Group

This group is responsible for examining the biological and microbiological aspects of water pollution control systems, e.g., nitrification-denitrification, activated sludge systems, anaerobic and aerobic digestion processes, and phosphate removal processes which are biological in nature, and for toxicity and biodegradability studies.

Project priority was assigned to assess the impact of the complexing phenomenon of heavy metal–NTA–phosphate on biological waste treatment processes. Consequently, a cross-mission project between the Environmental Protection Service and the Water Management Service was initiated toward the end of the year. Bench-scale biological reactor systems were used in conjunction with controlled, metal-NTA-phosphate complex types and concentrations under controlled environmental conditions. Nutrient control by nitrification-denitrification systems are in progress; a pilot plant scale nitrogen removal system is scheduled to go on stream later in 1972.

Toxicity of ethylene glycol is studied as related to biological waste treatment systems.

Physical Process Group

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

The main thrust of developmental work will be directed at the chemical sludges generated in the nutrient removal programs.

Preliminary studies were carried out at the Burlington Drury Lane Wastewater Treatment Plant on the parameters affecting "luxury phosphorous uptake". In conjunction with these investigations phosphorus mass balances were carried out at the plant and mathematical models were obtained for the mixing in the aeration tank.

Soil Process Group

The chief area of responsibility of this group lies in investigating methods suitable for the disposal of effluents and chemical sludges using soil systems. Areas of concern consist of characterizing the leachate from these sludges and the role different soil systems play in removing various waste constituents. Close co-operation with the Department of Agriculture on both federal and provincial levels and agricultural colleges has been established.

A recent project consisted of spray irrigating a plot with a waste effluent from a fish-processing plant. The objective of the program was to assess the capacity of the *in situ* soil system to remove carbon and nitrogen.

Chemical Process Group

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

As a pilot project, a number of federal facilities (DND bases) are under investigation in order to determine the optimum process for removal of phosphate at each location. A highly controlled study of effects of various detergent formulations is being conducted at Canadian Armed Forces Base Gloucester. Detergents with phosphate content ranging from zero to a high concentration and NTA-based detergents are used by the consumer. The response of the consumer, and the waste treatment system are assessed. The relationships between detergent formulation and chemical phosphorus removal are also being investigated.

In addition, an experimental program for jar testing was designed in conjunction with each detergent formulation. The purpose of this investigation was to assess possible interrelationships between NTA, phosphate and heavy metals and the chemical removal of phosphate by using Ca^{++}, Al^{+++} and Fe^{+++} salts. The relative contributions of each detergent formulation to wastewater and the overall nitrogen and phosphorus budgets of the Gloucester wastewater-treatment plant were evaluated. This study is scheduled for completion in April 1972.

The effect of NTA on the phosphate removal process is being investigated at Waterdown Ontario Sewage Treatment Plant.

DEMONSTRATION SECTION

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

From July to December, a study was conducted at Omstead Fisheries Limited, Wheatley, Ontario, in co-operation with McMaster University. The object of the study was to characterize the effluent from a freshwater fish-processing plant and to conduct physio-and bio-treatability studies. Information obtained from this program will aid in establishing rational design parameters for waste treatment systems used for freshwater fish-processing plants. While limited biological treatability was demonstrated, air-flotation as a pre-treatment process was found to show considerable promise.

Studies continued on the development of a suitable biological process for the treatment of mine wastewaters containing thiosalts. Engineering parameters to be used for the design of full-scale mine water wastewater-treatment systems were developed. Partially, as a result of these studies, a major base metal mine in New Brunswick installed a full-scale biological system for the treatment of their mine wastewater.

To assist in finding a solution to the complex problem of the removal of toxic heavy metals from acidic mine waters, studies were conducted to determine the minimum residual metal concentrations in synthetic solutions after the addition of precipitation chemicals.

LABORATORY SERVICES SECTION

This Section is responsible for providing the analytical support required for the various projects in which the Division is engaged.

During the year the laboratory facilities were established in the pilot plant and new analytical equipment and instrumentation installed.

To meet the anticipated requirements of continuous pilot plant operation great emphasis is being placed on automated analyses.

FACILITIES SERVICES SECTION

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

During the year the pilot plant building was completed and one pilot unit put on stream. A pilot unit was moved with Public Health Engineering Division and was set up in the pilot plant area of the building. It was expected that the installation of the mezzanine floors would be completed by the end of December permitting an early start in 1972 on the piping, electrical and other service contracts that in part use the mezzanine structures for support.

Present projections are that the additional pilot plant facilities consisting of physical, chemical, and biological process systems will be on stream by late 1972.

CANADA-ONTARIO AGREEMENT FOR NUTRIENT CONTROL IN THE LOWER GREAT LAKES

Mr. A.R. Townshend and Dr. E.E. Shannon served as EPS representatives on the Technical Committee for the Canada-Ontario Agreement which recommended priority projects to the Board of Review for funding under the Agreement.

As a consequence the following EPS projects were funded under the Agreement:

1. NTA level and phosphorus removal relationships at the Waterdown sewage-treatment plant.
2. Use of quicklime for phosphorus removal. This is a

EPS pilot plant project at CCIW.

3. Purchase of a centrifuge to be used in full-scale sludge handling studies to be carried out at Canadian Forces Bases Camp Borden, Trenton, Petawawa, and Uplands.

MICROBIOLOGY

The Microbiology Laboratories moved from Public Health Engineering (PHE) Division offices in Kingston to new temporary quarters in the Research and Development Building, CCIW, in the spring of 1971. By the end of the fiscal year another move will have been made, this time to our new permanent quarters on the fourth floor of the Administration and Laboratory Building.

The Microbiology Section continued to broaden its horizons and initiated or supported studies in the following areas: NTA degradation; oil degradation; contract reviews; monitoring of St. Lawrence River and the upper Great Lakes; Water Pollution Control and Abatement; Indian Reserves; pulp and paper mill lagoons, Lake Ontario thermal bar; Lake Erie organic particle study; nitrogen cycle in Lake Ontario sediments; and determination of bacterial nutrients in Lake Erie sediments.

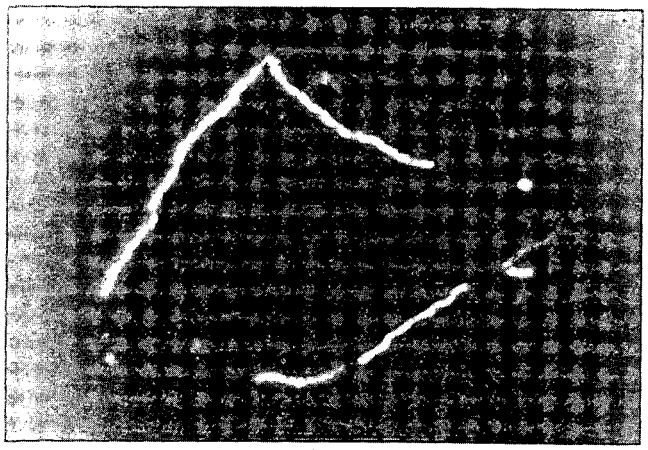


Figure 19. Recently-developed fluorescent microscopy techniques combined with membrane filtration are used to estimate bacterial biomass in water samples.

Monitoring Programs

Using a field laboratory set up in the Kingston PHE Division offices, bacteriological support was provided to three monitor cruises of the International Section of the St. Lawrence River. These studies (May, June, and September) were of approximately ten days duration. With the completion of the eight monitor cruises listed below, the planned Great Lakes off-shore monitoring program was finally completed.

Vessel	Date	Lake
Port Dauphine	April 18–April 26	Georgian Bay
Port Dauphine	Aug. 23–Aug. 31	Georgian Bay
Port Dauphine	Oct. 25–Nov. 5	Georgian Bay
M.V. Martin Karlsen	May 17–May 25	Lake Huron
M.V. Martin Karlsen	July 19–July 27	Lake Huron
M.V. Martin Karlsen	Oct. 25–Nov. 5	Lake Huron
M.V. Martin Karlsen	May 25–June 2	Lake Superior
M.V. Martin Karlsen	Oct. 5–Oct. 16	Lake Superior

In July, a staff member participated in a special Lake Erie cruise designed to monitor and trace the effects of a raw sewage spill from Cleveland, Ohio.

	River	Lakes	Total
No. of Samples	207	1521	1728
No. of Tests	1642	10643	12285

Lake Erie Organic Particle Study

A multidisciplinary research study of Lake Erie was carried out jointly with the Chemical Limnology, Limnology, and FRB Sections of Rakes Division. A total of 170 samples were collected and 1313 tests performed.

Lake Ontario Thermal Bar

Thermal bar studies – April 27 – May 6: 403 samples; 1612 tests – confirmed the interpretation of data collected during 1970 that the thermal bar does have a significant effect on the distribution of bacteria in areas of Lake Ontario influenced by the bar.

Sediment Studies

Several projects were initiated and supported in this area. A joint project to study the nitrogen cycle in Lake Ontario sediments was undertaken with Lakes Division. Support was provided to investigate seasonal and spatial distribution of bacteria in selected Lake Ontario sediments.

Several studies were initiated to investigate the effect of organic nutrients on the distribution of heterotrophic bacteria in Lake Erie sediments. Analytical techniques were modified and developed to determine carbohydrate, protein, and lipids in these sediments – 87 samples, 1320 tests – to support this project.

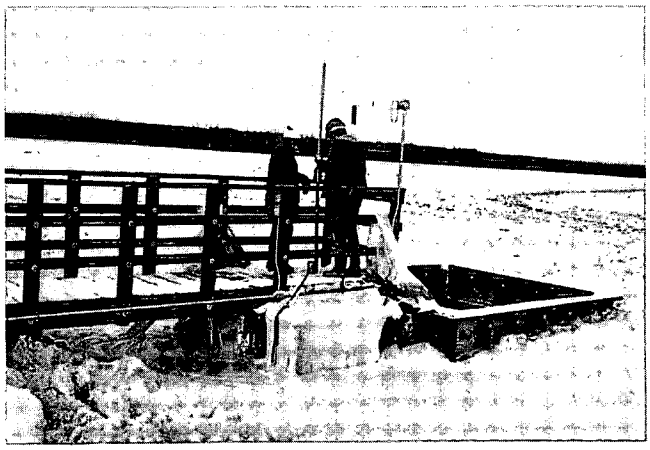


Figure 20. Bacteriological sampling conditions at Ontario and Minnesota Pulp and paper Mill Lagoon, Fort Francis, Ontario, December 1971.

Indian Reserve Studies

Support was provided to bacteriological studies (136 samples, 581 tests) carried out by the PHE Division, Kingston, Ontario, in four Indian Reserves: Oshweikan, Dokis, Nippissing, and Oneida.

Water Pollution Control and Abatement Studies

Bacteriological support was provided to seven WPC & A studies (124 samples, 483 tests) carried out by PHE Division, Kingston at Canadian Forces Base Trenton and Warkworth Penitentiary.

Ontario and Minnesota Pulp and Paper Mill Lagoon

The Ontario and Minnesota Pulp and Paper Co. Ltd. in Fort Francis, Ontario, began using a new aerated lagoon to treat the wastes from its newly built Kraft Mill. Several

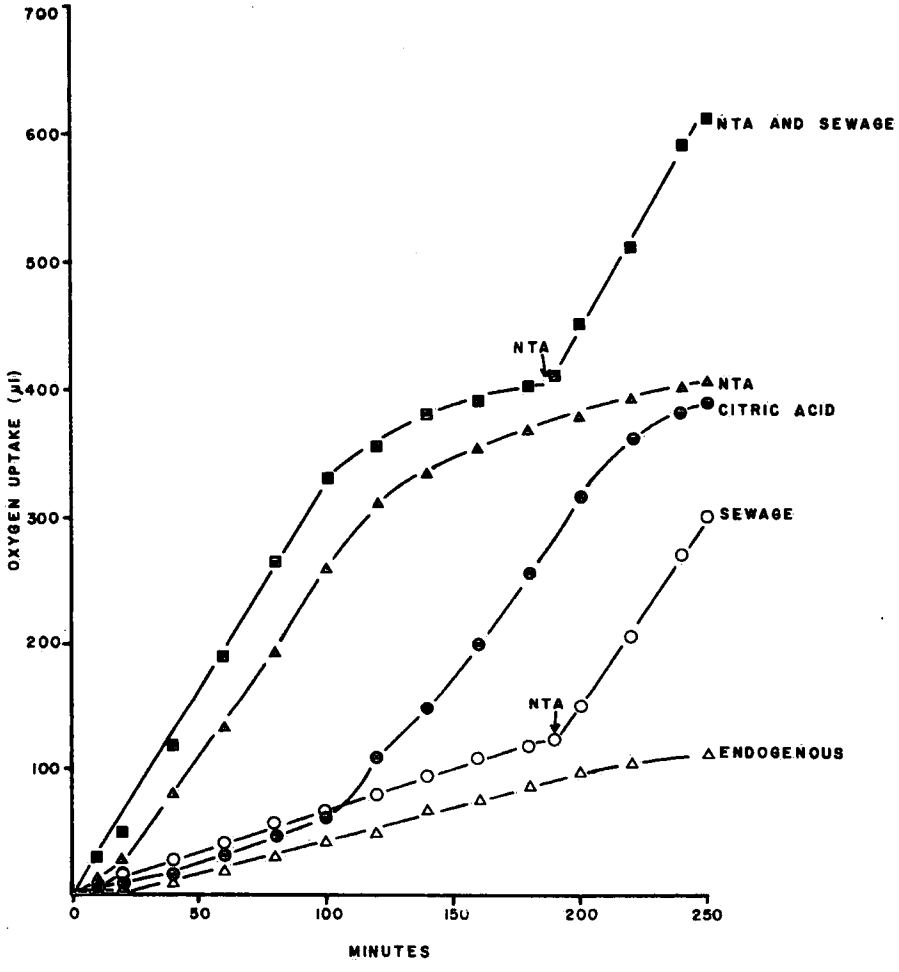


Figure 21. Rate of oxidation of nitrilotriacetic acid (NTA) (▲ – ▲), citric acid (● – ●), sewage (○ – ○) and NTA plus sewage (■ – ■) by the bacterial mutant. After 180 minutes incubation, additional NTA was added to flask containing sewage or sewage plus NTA. Note the immediate increase in oxygen consumption after the addition suggesting that NTA was being utilized by the bacterial mutant.

investigations have been planned to study the bacterial flora of this lagoon during its first few years of operation (Figure 20). The principal aim of these studies is to detect whether *Klebsiella pneumoniae* and other potential pathogens such as Salmonella are propagated in this lagoon and are discharged into the receiving stream, the Rainy River. The initial study of this project was carried out from November 24 – December 3, 1971. About 132 samples were collected and 1380 tests carried out.

Hydrocarbon Degradation Studies

Several contracts and grant applications related to bacteriological and mycological degradation of various hydrocarbons were reviewed.

Detergent Biodegradation Project

The main objective of this project is to study the factors influencing biodegradation of detergents, in which phosphate was replaced by other compounds within the sewage treatment system. Emphasis has been given to the study of the mechanisms of NTA degradation; later the study will be expanded to include detergents having other potential substitutes for phosphates.

A bacterial mutant was isolated from sewage after UV mutagenization and penicillin selection. This mutant was found to readily use NTA as sole carbon, nitrogen and energy source at temperatures varying from 4°C to 37°C. Studies have shown that the mutated strain multiplied at a faster rate in sewage in the presence of NTA than in the absence of NTA (figure 21).

It is hoped that this mutant can be used in seeding techniques to remove NTA from sewage.

After field trials, attempts will be made to extract enzyme (s) from the mutant and use the enzymes to treat sewage or to hydrolyse NTA in detergents.

Central Services (Provided by Inland Waters Branch)

CANADIAN CENTRE FOR INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES

The Centre provided staff and facilities for the coordination of the Canadian scientific program for the International Field Year for the Great Lakes (IFYGL). The Program is being implemented by means of about 90 individual projects carried out in, or supported by, the following laboratories:

AGENCY	LABORATORY LOCATIONS	
Environment Canada	Atmospheric Environment Service Toronto, Ontario.	(AES)
	Atlantic Oceanographic Laboratory Dartmouth, Nova Scotia.	(AOL)
	Canada Centre for Inland Waters Burlington, Ontario.	(CCIW)
	Canadian Wildlife Service, Ottawa, Ontario.	(CWS)
	Great Lakes – St. Lawrence Study Office, Cornwall, Ontario.	(GLSL)
	Hydrologic Sciences, Ottawa, Ontario and Calgary, Alberta.	(HS)
	Marine Sciences, Ottawa and Burlington, Ontario.	(MS)
	Water Survey of Canada, Guelph, Ontario.	(WSC)
Department of Energy, Mines and Resources	Canadian Centre for Remote Sensing, Ottawa, Ontario.	(CCRS)
	Earth Physics, Ottawa, Ontario.	(EP)
	Geological Survey of Canada, Ottawa, Ontario.	(GSC)
National Museum of Canada	Ottawa, Ontario.	(NM)
Ontario Water Resources Commission	Toronto, Ontario.	(OWRC)
Ontario Department of Lands and Forests	Picton and Wheatley, Ontario.	(ODLF)

The Universities of Toronto, Waterloo, Queen's, McMaster, Trent, Windsor, and Western Ontario are conducting various projects.

During 1971 the most significant features have been the confirmation of U.S.A. participation through the National Oceanic and Atmospheric Administration (NOAA) partly supported by ear-marked National Science Foundation (NSF) projects, and the development of the Canadian and U.S.A. parts of the biological and chemistry program. The observational phase of the project was reviewed and finally set to run from 1 April 1972 to 31 March 1973 with a review of the program late in 1972 to consider performance. Feasibility studies continued, a publications policy was evolved, a study of the Canadian Summarized Data File was completed, and agreement was reached to establish a cost-shared position fixing system. An International Workshop on the Scientific Program was organized, and the scientists' plans were translated into operational schedules.

Feasibility Studies and Intercomparisons

During the summer season, an intercomparison of fishing gear and techniques was conducted between the Ontario Department of Lands and Forests and the U.S. Bureau of Sport Fisheries and Wildlife. The results of the study have led to the experimental design of the Canadian-U.S.A. cooperative program of IFYGL fish studies.

From 3 September, to 14 October 1971 direct measurements were made of atmospheric boundary layer fluxes of heat, vapour, and momentum. The work was done at an over-lake site near Niagara-on-the-Lake. Scientists from the CCIW, the Atmospheric Environment Service, the Bedford Institute of Oceanography, and the National Aeronautical Establishment made simultaneous observations using several individual sets of ground level and airborne equipment. Logistic support on the lake was provided by CCIW.

From 7 September, to 8 November 1971 the newly-developed U.S.A. radio-telemetered buoy system for lake-wide atmospheric observations, lake currents, and temperatures was compared with the two Canadian tape-recording systems which make the same observations. The Canadian data return from the test site near Rochester, New York, was 95% complete and, after scrutiny and checking, was delivered to the U.S. scientists within one month of recovery. An international team is now evaluating all the observations.

On 29 May 1971 the third 60,000 ft. altitude NASA over-flight of the western Lake Ontario Basin was undertaken. The previous flights were conducted on 6 July 1970

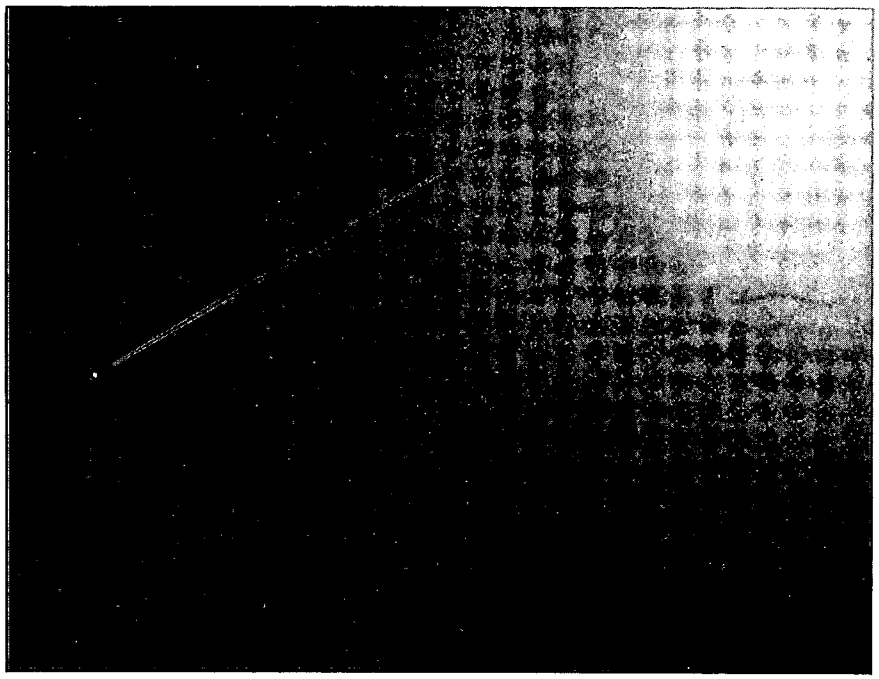


Figure 22. A 15 by 15 km portion of Lake Ontario, photographed from 60,000 feet on 6 July 1970. The line running diagonally across the frame is the track of the CCRS CF100 aircraft working at a lower altitude. The regular wave-like features are the surface indications of internal waves probably associated with lines of surface convergence.

Figure 23. The mouth of the Niagara River and its pollution plume in Lake Ontario, photographed from 60,000 feet by NASA in a cooperative program. Clearly shown are the sail boats moored up to the line of the International Boundary from Youngstown, New York, about 2 km from the river mouth.

and 19 October 1970. The 10,000 sq. mile area extended south from latitude 44°20′ to 42°45′N and west from 78°15′ to 80°20′W. All flights were timed to simulate the lighting conditions planned for the U.S.A. Earth Resource Technology (ERTS) satellite, which is now due for delayed launching in June 1972.A major objective of this feasibility study is to fill gaps in our knowledge of the ground-water (soil moisture component) storage term, but limnological information for CCIW scientists was also obtained. There were indications of internal waves (See figure 22), the turbulent characteristics of large plumes were noted (See figure 23), and observations were made of sediment transport in coastal regions. The land basin studies were undertaken at Guelph and McMaster Universities with support from the United States Geological Survey. At Guelph University a technique was developed to derive consistent and representative tonal values and density readings from the photographs. These arrangements for the provision of remotely sensed data to CCIW and other Canadian scientists is the culmination of plans laid in June 1970, following discussion between CCIW, AES, OWRC, Guelph University and the USGS, in the framework of the International Field Year for the Great Lakes held at CCIW.

The instrumentation system for the atmospheric water budget experiment was decided. Previous feasibility studies, and an error analysis, showed clearly that standard wind-finding equipment was not accurate enough to observe directly the atmospheric transport of water vapour over Lake Ontario. A suitable equipment which uses the LORAN-C system was available and is being procured by Canada and the U.S.A. to equip a total of six shoreline stations. On 30 November 1971 a special radio sounding flight was made during a lake-effect storm as a part of the preparation for this project.

Publications and Data

A detailed study was made of the Canadian data, and formats for summarization (e.g., hourly value tables, etc.) were drawn up to examine the size, nature and cost of a summarized data file on both microfilm and magnetic tape. It would comprise hourly or daily value tables and lead sheets giving brief details of the instruments and methods used, and the nature and availability of raw data. The report will be published by the IHD Secretariat in the Proceedings of the IHD Workshop Seminar on Computer Storing and Processing of Hydrological Data, held in Quebec City, October 1971.

A part of the groundwater studies was completed with the publication of Inland Waters Branch Technical Bulletin No. 23, (Regional Groundwater Flow between Lake Simcoe and Lake Ontario), by C.J. Haefeli of Hydrologic Sciences Div. Work on the IFYGL bibliography with abstracts and background reading list has continued; five sections have now been issued from CCIW Library.

The Second International IFYGL Workshop was held at McMaster University, Hamilton, Ontario, from 7-9 July 1971. The Proceedings of the Workshop were prepared at the Centre and distributed in September to 300 IFYGL participants.

The coordinator was appointed editor of the Canadian part of the International IFYGL Bulletin. Material of Canadian origin will be prepared in Canada and replicated and bound in the U.S.A.

The editing of IFYGL manuals has continued by the coordinator for publication by the IHD Secretariat.

Staff

For over 11 months of the year staff comprised of Mr. J. MacDowall, Canadian coordinator, IFYGL and Mrs. A. O'Hara (Secretary). In December, Mr. B. Farnworth joined as editorial assistant and Mrs. R. Veerdonk as stenographer. For a period of the year, Mr. Paulos Youakim, from CCIW Technical Operations Section, was assigned to the coordinator in order that all scientific program demands could be quickly translated into technical operations plans with regard to schedules of ship observations, track placement, and service of tower and buoys, etc. Final plans will be published in March 1972.

Remote Sensing

Mr. J. MacDowall was Vice-Chairman of the Canada Centre for Remote Sensing, Working Group on Sensors. Four meetings were held and the group assisted with the monitoring of sensor development contracts in Canadian industry and universities. The first year's work of the group was published in December 1971 as a special remote sensing supplement to the Canadian Aeronautics and Space Institute Journal edited by Mr. MacDowall.

ENGINEERING AND SCIENTIFIC SUPPORT DIVISION

The Engineering and Scientific Support Division provides the major portion of the technical and professional support required for the scientific programs at the Centre. It consists of four sections. The activities of each section

are discussed below.

ENGINEERING SYSTEMS

The Engineering Systems Section provides instrument engineering services to all divisions and agencies of CCIW and the scientists of the Association of Universities and Colleges of Canada participating in the research program of the Centre. These services include the design, development, construction, and maintenance of instrumentation systems and automatic data acquisition and processing systems. A major portion of the year's effort was directed to preparation for the forthcoming IFYGL.

Table 5 shows those projects or systems which required Engineering Systems involvement in terms of development, modification, up-grading, procurement, maintenance and related engineering participation. A description of representative engineering projects in 1971 follows.

Precipitation Sampler – Type ARC MKV–Wind Direction Sensor

A system was developed to permit sampling from a specific wind direction of precipitation for chemical analyses. This was achieved by designing for the sampler, a wind direction sensor and placing it in series with the precipitation sensor. Thus, both precipitation and correct wind direction must be present for the lid of the sampler to open. Since sampling is required year-round, a heating element was added to the sampler, with a thermostat calibrated to turn on at 0±1°C, to prevent freezing of the moving parts. The sampler was put into use in the field in September, 1971.

Sedimentation Rate Water Sampler

This apparatus (Figure 24) has been evolved to enable the rate of free fall of organic particles in lake water to be determined with minimal interference from the wind, waves

TABLE 5. PROJECT/SYSTEM SUMMARY CHART (1971)

System, Equipment, or Project	Quantity	Salient System Characteristics
Moored, Current-Measuring Buoy Systems	15	Each with 1 to 4 self-recording current meters. Spares extra.
Moored, Meteorological Buoy Systems (Met. Packs)	11	Each with 8-channel self-recording data-logger. 11 spares extra.
Towed, Remotely-Controlled Probe (Batfish)	2	Temperature instrumentation and hydrodynamic controls.
Shipboard Pumped Water-Sampling System	2	Hose-connected systems allow on-deck water quality analysis.
Moored, Temperature-Profiling Systems (FTP)	4	18-channel automatic temperature data-acquisition system.
Tower Supported Micro-Meteorological Instrument System (with 3 major sub-systems)	1	36 data channels. Wind-profile subsystem flux subsystem, air/water turbulence subsystem.
Shipboard EBT Systems	14	EBT instrumentation incorporated in major ships, launches, pumped system, batfish and spares.
Towed Thermistor Chain	1	13 channel automatic temperature-depth data acquisition system.
Shoreline Temperature	7	BT equipment – sensing, recording, and telemetry.
Benthos Core Extruder	5	
Portable Towed T/D Systems	2	Simpler towed BT equipment.
Dye Diffusion Experiments	9	Dye release mechanisms, samplers, anchors.
Solar Radiation Integrator – Printer Units	5	Part of ship's permanent data acquisition system. Also on towers.
Sedimentation Rate Bottles	6	Free-fall, organic particles determination.
Underwater Camera System	1	Special features and triggering.
Sediment Water Interface Sampler	1	Diver operated.
Precipitation Samplers	4	Direction-Sensing Facility.
Monitor Printout Unit	10	Met. pack test set.

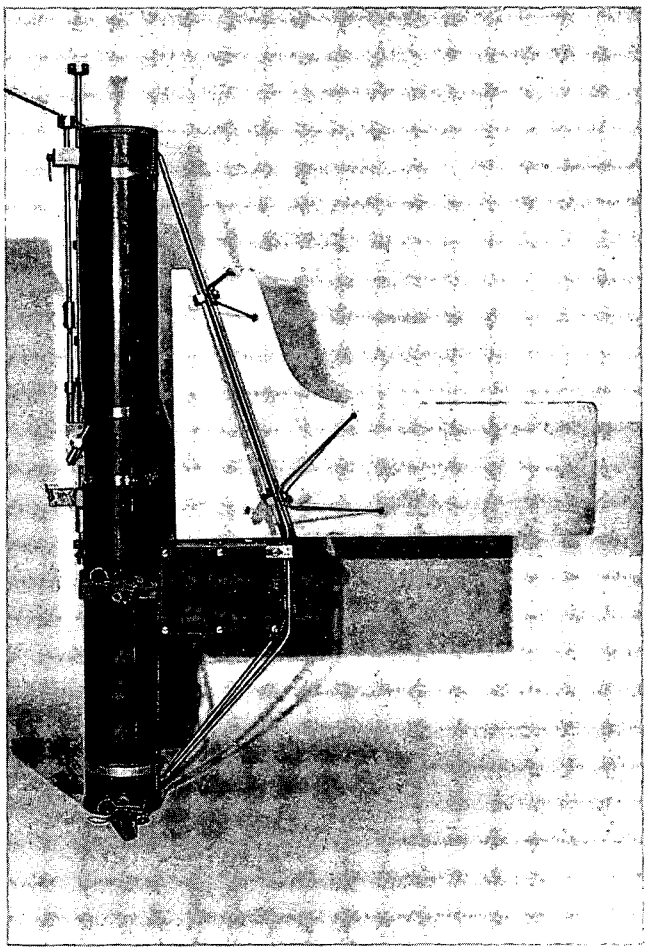


Figure 24. Sedimentation-rate water sampler.

and from the support vessel. The system consists of one or more sampling bottles fastened to a wire which is kept taut by the upward pull of a spar-type subsurface float. At the base of the float is a battery operated timing device and at the top is a release mechanism for a small surface marker buoy. The sampling bottles consist of a 1-m long P.V.C. cylinder, with end plugs and an actuating mechanism from a standard Van Dorn bottle. At a position one-third up the cylinder is a shutter mechanism which, when actuated, will close off the two portions of the cylinder.

The method of operation is as follows: the entire system is lowered into the water from the side of the vessel. Upon releasing a slip line to the subsurface float, a mechanical messenger is released, which closes the end plugs of the sampling bottles and starts the timer. The vessel then moves away and after a predetermined interval, the timer releases a second messenger which closes the shutters of the sampling bottles and simultaneously releases the surface marker buoy. The entire system is then retrieved and the samples of water are collected separately from the lower and upper sections of the bottles.

Sediment/Water Interface Sampler

This sampler (Figure 25) consists of a box with dimension of 18 X 18 by 12 inches, which is lowered to the bottom of the lake by cable from a vessel and is diver operated. Initially, the sampler is open at the top and bottom so that it can be set into the sediment to the desired depth. The top and bottom lids are then slid into position to seal completely the sediment and interstitial water sample with minimal disturbance. The sampler is then raised to the deck of the vessel where it is immersed in a bath of water to eliminate any gradual leakage of sample material.

Tests can be effected through the lid of the sampler to determine such parameters as sediment/oxygen demand rates of the sample, and also the chemical changes that occur as the sample goes into the anoxic state.

Ships' Pumped Water Sampling

Due to the effectiveness during the past season of the original breadboard pumping system for routine monitor sampling, a more refined, operational system has been developed. The new system is capable of pumping from depths to 100 m with a clearing time in the pipe of $1^1/_2$ minutes. Handling of the system is greatly improved by the use of integral electrical conductors molded around the outside of a flexible pipe.

Additional remote water quality sensors can be added to this system as they become developed. Other refinements consist of improved handling of the special hose reel, plus an anti-icing provision.

COMMON USER SCIENTIFIC LABORATORIES

Radiochemistry Laboratory

The laboratory became operational during 1971, with the acquisition of instrumentation for measuring disintegration rates of radionuclides and appointment of staff. Installation and testing of instrumentation occupied most of the time during the year, but a start was made on two projects which support CCIW objectives.

The first is a neutron activation analysis service, aimed initially at identifying the source of polluting oil. Samples of oil, crude and processed, from various sources are being analyzed for trace elements, by irradiating with neutrons in the McMaster University nuclear reactor, and then measuring the γ-rays emitted by the radio-isotopes produced. These γ-rays are detected with a liquid nitrogen-cooled germanium (lithium-drifted) diode, which resolves

them with respect to energy. The output pulses from the detector are sorted with a pulse-height analyzer based on a minicomputer. Analysis of a Bunker C oil sample showed lanthanum 0.17 ppm; antimony 0.86 ppm; bromine 0.60 ppm.

The second project involves determining environmental radio-activity, natural and weapons fallout, in lake sediments. A profile of individual fallout radionuclides in a core taken from a lake bottom will yield information on recent sedimentation rates. Determination of ^{90}Sr requires chemical separation of added strontium carrier from the dissolved sediment and the β-particle emission rate measured with a low background β-counter. An automatic counting system is in use, which serially measures the β-emission rate of up to 50 sources stacked in the changer and prints out the counting data on a teletypewriter. The detector is a thin-window, gas-flow proportional counter surrounded by a plastic scintillator detector as an anti-coincidence shield to cut down cosmic ray backbround. A separation scheme is being developed to separate zirconium, cesium, thorium, cerium, ruthenium, and strontium from the dissolved sediment as stable compounds for β-particle and γ-ray emission measurement.

Electron Microscope Laboratory

The laboratory, which operates a Siemen's high resolution electron microscope, has been equipped with a vacuum evaporation unit for preparing carbon films to support specimens and for shadowing the specimens with heavy metals. A darkroom for processing the exposed plates from the electron microscope has also been set up.

A joint project with the Microbiology Section has been started to investigate changes in structure of bacteria which are able to degrade NTA when they are grown in a pure NTA medium. A technique for mounting cultures of the bacteria and negative staining with ammonium molybdate has been developed which allows observation of external structure. An ultramicrotome will be needed to cut the bacteria into thin slices in order to observe their internal structure.

COMPUTER AND DATA SERVICES

The Computer and Data Services Section has the responsibility for planning and implementing electronic data processing systems at CCIW. The three units which comprise the Section are : (1) the Computer Applications Unit, which develops and maintains computer software and assists the staff at CCIW in preparing programs and data; (2) the Computer Operations Unit, which schedules and operates the hardware computing facilities at the Centre; and (3) the Data Unit which processes, quality controls and collates manually collected data.

The Section's hardware facilities include a PDP-8 system which is used to reformat instrumentation data tapes to "computer compatible" magnetic tape; the larger PDP-15 which is equipped with magnetic tape drives, disc

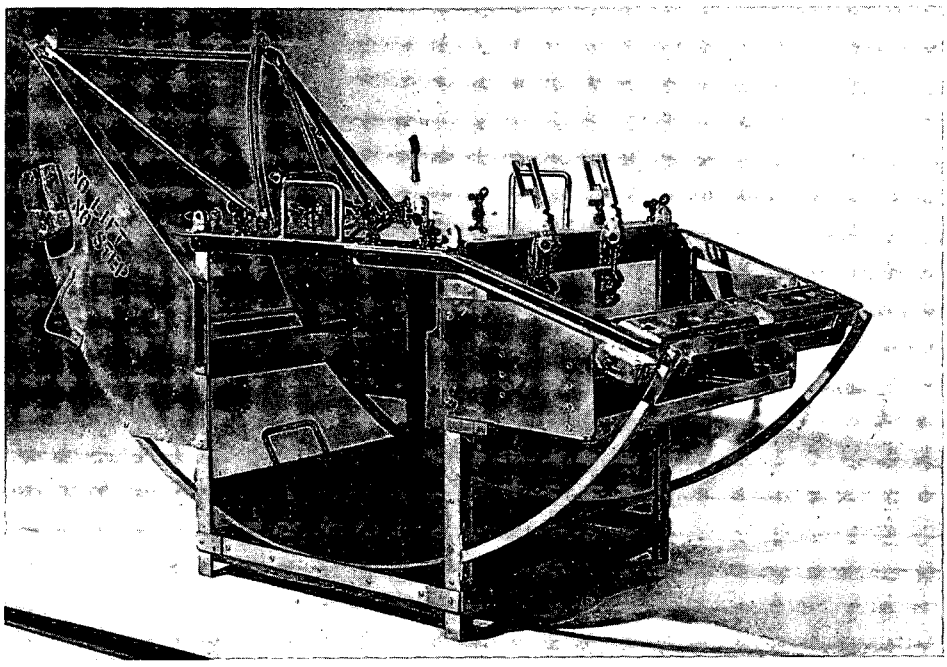


Figure 25. Sediment/water interface sampler.

storage, an interactive graphics system and a CALCOMP drump plotter and is used for special applications such as analog to digital conversion, contour and three dimensional plotting, data quality control and experimental programming languages; teletype terminal services to COMSHARE Limited Sigma-7 and Multiple Access Limited CDC 3500 were available for users to interactively develop and run programs. Two larger terminals to off-site computers carried the majority of CCIW's EDP load; one terminal was connected to a Control Data 6400 at McMaster University, the other terminal was connected to a Control Data 6600 at Multiple Access Limited in Don Mills, Ontario. Approximately sixteen thousand jobs were processed during 1971. To increase CCIW's in-house computing capability, an interim computing system was installed in January 1972 until DEM&R's surplus Control Data 3100 arrives. The installation of the CD 3100 occasioned the move from the trailers, home of the Section for the last four years, into the quarters in the main laboratory building.

The Computer Applications Unit's detailed responsibilities are (1) to provide consultative services to users; (2) to provide reference facilities to users; (3) to write software on request for scientists; (4) to anticipate, and plan future software needs; and (5) to develop software used in large-scale data base management.

During the year, a cumulative total of 49 requests for programming services were received, and acted upon. Of this number, 19 were "ongoing projects" of more than two months duration, and the rest were shorter requests. The requests ranged all the way from a short program to carry out chemical computations, to a whole software system designed to handle shipboard data.

Data handling procedures, and software systems were developed for shipboard (monitor) data, filed under the STAR (Storage and Retrieval) system, and time-series data, filed under the TSAR (Time Series Storage and Retrieval) system. Also, systems analysis for the shipboard data flow was carried out to speed up data handling procedures for monitor data, as well as preliminary studies for a system to handle biological data, and the initial planning for handling data from the IFYGL. Program documentation was carried out in all cases for reference by external users, and a program library was started for the scientific staff. A series of packages for scientific analysis of data was started, which includes time-series analysis as well as statistical packages. This will be continued into 1972.

Of the 77 surveys carried out on the Great Lakes, or as part of the Okanagan Project, forty were monitor type surveys requiring processing through to the preliminary report stage, with the data eventually to be stored on magnetic tape or discs. The supplementary data such as, solar radiation, meteorological observations, mooring positions, etc. were indexed and filed; bathythermograph data were summarized and forwarded to CODC for further processing onto aperture cards. Past data of 1967 to 1970 was run through the STAR data editing and quality control program prior to being stored on tape. Listings of 1969 data, along with track charts, survey methods and references, are in the process of being printed for distribution.

As part of our data quality control program, a performance review of all reversing thermometers and bathythermograph instruments used in the field was carried out, with recommendations for recalibration of instruments being forwarded to the Operations Section.

LIBRARY AND REFERENCE SERVICES

The Library collection includes: 7,300 books, current subscriptions to 850 journals and related abstracting services, and 216 series of annual reports, data reports, etc.

Requests for 1,740 Inter-library loans were handled by Library staff and 340 items were loaned from CCIW collection to other libraries.

Collected Reprints, volume 3 (1970) was produced for distribution to institutions which exchange publications with CCIW. A quarterly bibliography of staff publications and presentations, a list of serial holdings, and monthly acquisition lists were compiled.

A computer-produced Key-Word-in-Context index to CCIW report holdings is nearing completion. It will contain in one alphabetical order subject key-words and names of authors.

Developments in information retrieval were watched during the year. One new interest profile was submitted to the National Science Library's GEOREF current-awareness service. Three demand searches on material of environmental concern were submitted to computer services.

Environmental Quality Coordination Unit

The Environmental Quality Co-ordination Unit (EQCU) co-ordinates 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 co-ordinates the contributions of CCIW to the Canada – U.S.A. Contingency Plan for Oil and Toxic Material Spills on the Great Lakes; research results and technical input to national contingency plans for freshwater regions; contributions of CCIW to Canada – U.S.A. pollution control negotiations concerning the Great Lakes, and to the International Joint Commission studies, surveillance, and control programs. Supervision is provided by EQCU for CCIW research contracts of a multi-disciplinary nature.

The Unit has 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 participated in the drafting of the Joint U.S.A. – Canadian plan for the Great Lakes, provided liaison with the Ontario Contingency Plan Co-ordinating Committee, provided the Chairman for the Technical Working Group for the Federal Contingency Plan and the Chairman for the CCIW Task Force on Spills of Oil and Other Toxic Material, and represented CCIW as a member of the local Hamilton Harbour Spill Control Group. During the year the joint U.S.A. – Canadian plan became operational, a Field Manual was produced by the Technical Working Group, and in support of CCIW's role in the Great Lakes Contingency Plan, considerable efforts were made to organize and co-ordinate the response of Canadian agencies in the region to possible spills. In late August the Joint U.S.A. – Canadian and Federal Contingency Plan was activated as a result of the collision and grounding of the vessel TRANS-MICHIGAN in the St. Clair River. EQCU provided support to the Director, CCIW, the Regional Coordinator, in the immediate clean-up activities and provided advice on the subsequent measures necessary to clean the ship and allow it to proceed to dry dock. In September EQCU co-ordinated and organized a debriefing session of personnel from the U.S.A. and Canadian agencies involved in the operation.

The problems of nutrient control, and particularly substitution for phosphates in laundry detergents continued to be an active topic. EQCU continued to co-ordinate output of government research scientists and industrial representatives. Arrangements were made for a further multi-national meeting on NTA research during October. Since NTA was by then being used in modest quantities in Canada, a monitoring program for NTA in the environment was initiated to permit prediction of possible environmental concentrations if more wide-spread use is permitted. The monitor program included a number of elements with samples being collected from both coasts, the Great Lakes region, liaison with an on-going monitoring program at the Freshwater Institute in Winnipeg, initiation of a ground-water sampling program, and incorporation of information from the on-going Procter and Gamble monitoring program. NTA usage data was obtained from the Soap & Detergent Association. In addition, EQCU is responsible for liaison for a contract with the Ontario Research Foundation concerning evaluation of the washing effectiveness of various detergent formulations with phosphates, NTA, and citrates, at several water hardnesses. Overall co-ordination has been provided to the Departmental NTA program. This involves the monitor program, assessment of the potential problem of mixed NTA/phosphate complexes interfering with phosphorus removal at sewage treatment plants, and studies on the bacteriological degradation of NTA under various conditions. A policy paper based on the results of these programs is to be prepared early in 1972 and co-ordinated with studies on health aspects underway in the Department of National Health and Welfare.

EQCU participated in the preparation of a paper on historical oxygen depletion rates in Lake Erie which was presented at the 14th Great Lakes Conference. As a follow up to this paper, and a follow up to Project Hypolimnion, an intensive study of the hypolimnion of the central basin of Lake Erie, EQCU co-ordinated the development of a paper to assess the phosphorus loading to Lake Erie which might just prevent the bottom waters of the central basin from becoming anoxic. In conjuction with the Lakes Management Research Unit a paper which compared the historical oxygen depletion rate with the historical phosphorus loading to the lakes was developed. This material was subsequently expanded as a report to the International Joint Commission Lower Lakes Boards. An additional expansion was made to attempt to predict the impact on the oxygen conditions in the hypolimnion in Lake Erie of proposed reductions of phosphorus loading to Lake Erie for the period 1970-75. A draft paper was produced and presented to the Boards. Subsequently an abstract of this material was used for developing a phosphorus reduction program in the context of the Canada – U.S. negotiations

for an Agreement on Water Quality Control in the Great Lakes.

EQCU participated extensively in the drafting of the proposed Canada – U.S.A. Agreement on Water Quality in the Great Lakes, both in support of the Canadian negotiating team and in the preparation of a number of draft Annexes to the Agreement.

EQCU continued to co-ordinate the pesticide surveys in the Lower Lakes during the year and two cruises on each of Lakes Erie and Ontario were completed. In addition to measurements of the organochlorine-insecticide residues, measurements were made of PCB's.

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 assisted and co-ordinated the preparation of background material for meetings of the IJC Advisory Boards as well as the preparation of the Reports of the Board to the IJC.

Building Program

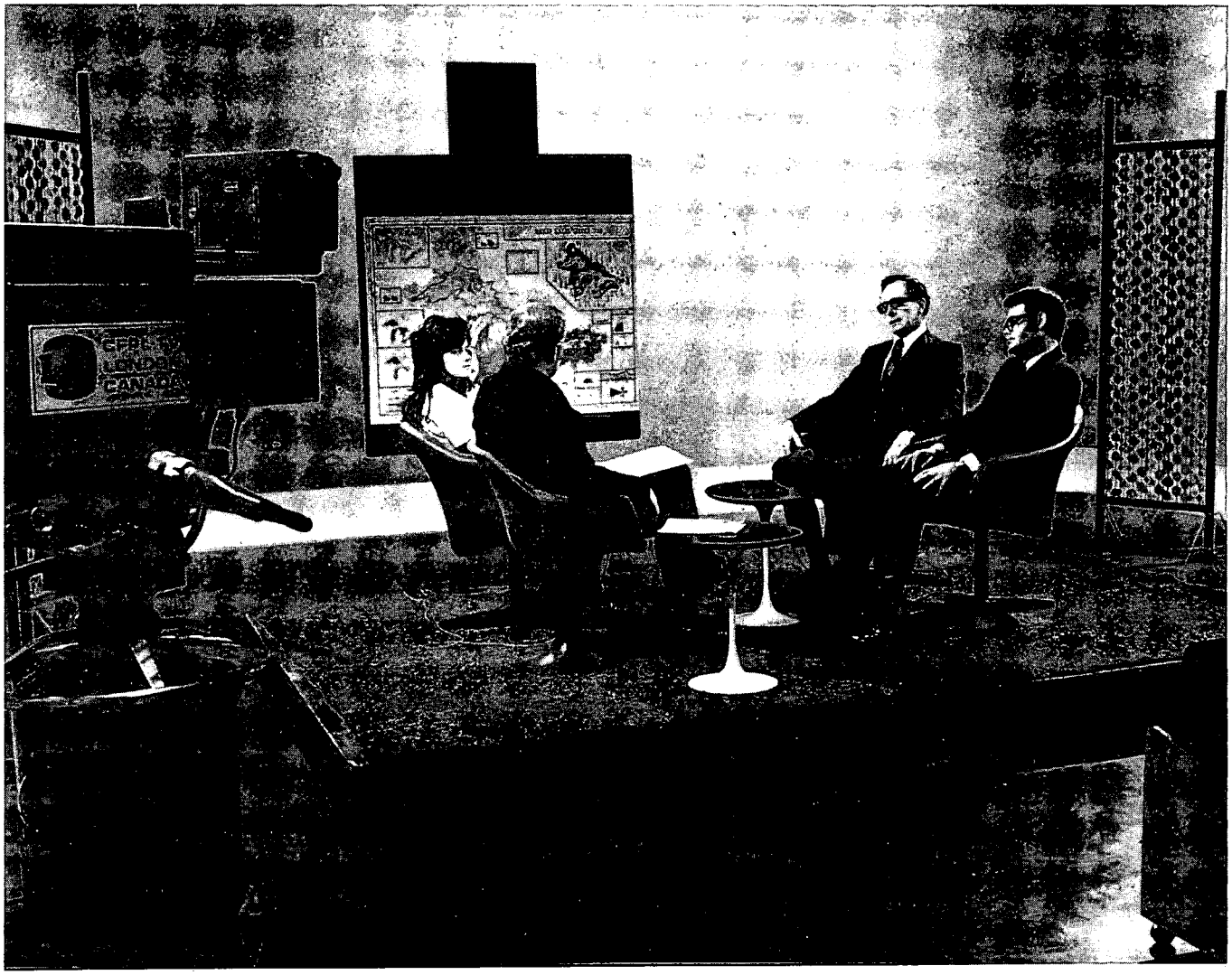
The construction of permanent quarters has proceeded on schedule throughout 1971 and the project continues to be within the budgetary limits established in 1967. The Water Quality Pilot Plant was completed in May 1971, and personnel moved into the building on June 3. The Laboratory and Administration Building neared completion and plans have been made to move into the first and second floors during January 1972. These floors contain the administration offices, the computer and data areas, the cafeteria, drafting, library, and auditorium. The laboratory floors of the building are still on contract schedule and are expected to be occupied in March 1972. Work commenced on the Hydraulics Laboratory in June 1971 and its completion is presently scheduled for June 1972. This is the last phase in building construction. Other work continuing into 1972 includes outside signage, landscaping, interior graphics, and fine arts.

Public Relations & Information Services

Management initiatives and future research depend on the understanding and active support of the general public.

Of the 78 public speaking engagements in 1971, a series of four invitations from the Erie Region Economic Council to address mayors, reeves and councillors of various cities in south-western Ontario, and an invitation from the University of Windsor's Pollution Probe were of special interest. Through the year, the demand for public speakers exceeded the resources of the Unit. Subsequently, a Speakers' Bureau Service was inaugurated and some twenty members of the Centre's staff volunteered for the first roster, so that a better response could be effected.

In all, the Public Relations Unit handled 33 separate visits by various groups of people. To meet the demand for tours of the Centre, plans were being made to set up a new Tours Service which could be facilitated through the auditorium and pedestrian mall in the Centre's permanent quarters.



Staff members of the Centre are the guests of CFPL-TV's Dick Berryman on "At Random"—a popular television programme in London, Ontario and the surrounding region. Under discussion is the Centre's Water Quality Pilot Plant, and the publication of the Lake Management Research Section's map of Great Lakes water use patterns.

Left to right are: Miss Margaret Sinclair, Lakes Management Research Section; the show's host, Dick Berryman; A. R. Kirby, Public Relations Unit; A. R. Townshend, Environmental Protection Service.

A new publication, in folder form, entitled "Water and We, An Investment Report", addresses itself to the tax-paying public. The folder explains the Centre's purpose, work and achievements and points out the vital role of the public in ensuring full dividends from their investment. The folder incorporates a tear-off coupon which invites the reader to seek further information on water management in Canada, the Centre itself, other services of the Public Relations Unit and of Environment Canada as a whole. As a contribution to the Centre's effort to distribute the new publication, the Windsor Utilities Commission undertook to send 60,000 copies to residents of the area.

Print and broadcast media continued to show keen interest in and active support of, the Centre. In addition to news stories, feature stories on the Centre and its work were published by Canadian Press, the Toronto Globe and Mail, the Hamilton Spectator, Dofasco Illustrated News, Country Guide Magazine and Ontario Hydro News, and in the United-States, the Buffalo Courier-Express. Researchers and management personnel were featured guests on radio and television programmes in both regional and national broadcasts. The British Broadcasting Corporation sent the producer and crew of BBC-2's "Horizon" series to interview the Director and senior researchers on work in the Great Lakes. Many interviews were arranged for London, Hamilton and Toronto television stations, and cable as well as educational television stations also broadcast programmes on the work of the CCIW.

The Ontario Science Centre cooperated in setting aside, space, manpower and other facilities to help tell the Centre's story to its more than 500,000 annual visitors through a new exhibit entitled "Spaceship Earth".

CCIW Staff List

CCIW

Director, CCIW – J.P. Bruce

Secretary – Mrs. L. Ward-Whate

Executive Assistant to Director – T.S. Hillis

Building Services Superintendent – D.F. Stewart

Support Staff, CCIW – D. Haswell, C.F. Hicks, A.W. Mayes, D. Niles, J. Slaz, Mrs. E. Rae, Mrs. B.D. Titley

Personnel Administration, CCIW – Miss R. Kelly, W.B. Christopher, Mrs. M. Duggan, Mrs. C. Shepherd, Miss M.R.J. Warren

HYDRAULICS UNIT (INLAND WATERS BRANCH)

Head – Dr. T.M. Dick

Secretary – Mrs. L. Kay

C.K. Jonys, Dr. L. Lau, J. Marsalek

LAKES DIVISION (INLAND WATERS BRANCH)

Chief – Dr. R.A. Vollenweider

Secretary – Mrs. S.M. Horne

BIOLOGICAL LIMNOLOGY (FISHERIES RESEARCH BOARD)

Head – Dr. A. Nauwerck

Secretary – Mrs. D. Moore

Dr. W. Glooschenko – pigments, toxic substances

Dr. N. Watson – bottom fauna, zooplankton

Dr. M. Munawar – phytoplankton

Dr. P. Stadelmann (Post Doctoral Fellow) – primary production limiting factors

G. Carpenter – zooplankton culturing, biomass

J. Moore – primary production, bioassays

J. Leslie – particle counting

H. Shrivastava – bottom fauna

L. Mansey – bottom fauna; nekton

H.F. Nicholson – chlorophyll, Great Lakes bibliography

R.H. Collins – field work, pigments

CHEMICAL LIMNOLOGY

Head – Dr. Mary E. Thompson – specific ion electrodes; low temperature aqueous geochemistry

Secretary – Mrs. Rosemary E. Morrison

Dr. N.M. Burns – nutrient cycles, especially particle settling in lakes

Dr. Y.K. Chau – trace elements and natural complexation in lakes

*Dr. A. Lerman – geochemistry of brines; radioisotopes in lake sediments

Dr. R.F. Platford – physical chemistry of aqueous solutions

Dr. W.M.J. Strachan – organic chemistry applied to lakes

Dr. R.R. Weiler – carbon cycles in lakes ; sediment geochemistry

Post Doctoral Fellows

**Dr. C.W. Childs – physical chemistry of aqueous solutions

Dr. J.O. Nriagu – sulfur cycle, authigenic minerals in lakes

Dr. V. Cheam – complexation reactions of humic compounds

Chemists

M.E. Fox – soluble organic compounds in large lakes

H. Saitoh – trace elements and complexation reactions in lakes

K. Lum-Shue-Chan – trace elements and complexation reactions in lakes

C.H. Chan – chemistry in the lakes

M.T. Shiomi – atmospheric precipitation chemistry; nutrient cycles in large lakes

Technical Staff

R.D. Coker, K.W. Kuntz

---

*A. Lerman terminated his employment here at CCIW, October 1. His forwarding address is: Dept. of Geological Sciences, Northwestern University, Evanston, Illinois, 60201.

**C.W. Childs concluded his fellowship and left for New Zealand June 21, 1971. His address there is: Soil Bureau, D.S.I.R., Private Bag, Lower Hutt, New Zealand.

LIMNOGEOLOGY

Head – Dr. P.G. Sly – distribution and variance of lake bottom sediments

Secretary – Miss. J. Brouwers

Dr. T.W. Anderson – palynology of recent sediments (Post Doctoral Fellow) (GSC)

Dr. A.L.W. Kemp – distribution and diagensis of organic compounds in recent sediments

Dr. C.F.M. Lewis (GSC) – post-glacial uplift and stratigraphic correlation of recent sediments

Dr. N.A. Rukavina – interpretation of sediment distributions in the nearshore zone

Dr. B.E. St. John – trace element geochemistry

Dr. R.L. Thomas – distribution, occurrence and authogenesis of minerals, major elements and heavy metals in recent sediments

Dr. J.D.H. Williams – sediment/water interface exchange, with particular emphasis on the phosphate and iron cycles

J.P. Coakley – distribution, occurrence and relation to erosion, transportation and deposition of active sediments

C.B.J. Gray – diagenesis of recent organic compounds

B.J. Henry – geophysical characteristics of unconsolidated sediments

W. Warwick (educational leave) – palaeoecological interpretation of chironomid faunas

TECHNICAL OPERATIONS

Head – H.B. Macdonald

Secretary – Miss R. Gruhl

D.J. Cooper – Senior Operations Officer; special assignments

J.T. Roe – Senior Diving Officer

D.H. Hanington – C.S.S. Limnos, Operations Officer

D.J. Brooks – M.V. Martin Karlsen, Operations Officer

D.J. Williams – A/Standards and Development Officer; Okanagan Basin Study

P.R. Youakim – special projects

L.E. Benner – shore party

T.J. Carew – M.V. Martin Karlsen

H.K. Cho – M.V. Martin Karlsen and shore party

B.E. Clemmens – M.V. Martin Karlsen

F.J. de Vree – seconded to Marine Sciences Branch

F.H. Don – C.S.S. Limnos and M.V. Martin Karlsen

J.M. Gervais – seconded from Marine Sciences Branch

H. Greencorn – rigger

P.M. Healey – M.V. Martin Karlsen and C.S.S. Limnos

R.D. Hore – M.V. Marin Karlsen and C.S.S. Limnos

G.J. Koteles – M.V. Martin Karlsen

J. Lomas – Foreman-Rigger

M.R. Mawhinney – Okanagan Basin Study

B.H. Moore – C.S.S. Limnos

G.M. Perigo – rigger

J. Ross – M.V. Martin Karlsen

S.B. Smith – M.V. Martin Karlsen

W.B. Taylor – electronics technician

M.R. Thompson – M.V. Martin Karlsen and C.S.S. Limnos

S.P. Withers – C.S.S. Limnos

Technical Staff

W. Booth, Mrs. J. Coons, G. Duncan (A/Chief Technician), Mrs. L. Hoffman, Mrs. N. Harper, J. Horsman, G. LaHaie, Mrs. T. Mayer, T. Morton, Mrs. A. Mudrochova, R. Sandilands, D. St. Jacques

PHYSICAL LIMNOLOGY

Head – Dr. R.K. Lane

Secretary – Mrs. C. McMunn

Dr. E.B. Bennett – circulation, descriptive limnology

Dr. J.O. Blanton – thermal structure, demonstration basin studies

F.M. Boyce – internal waves, heat content

Dr. M.A. Donelan – air-lake interaction

F.C. Elder – air-lake interaction, descriptive limnology

P.F. Hamblin (educational leave)– circulation, seiches

B.C. Kenney – small lakes studies, circulation

H.W. MacPhail – electronics, satellite data retransmission

Dr. C.R. Murthy – diffusion, circulation

Dr. E. Nagy – oil/water studies

D.G. Robertson – descriptive limnology

Dr. T.J. Simons – hydrodynamics, modelling

Dr. K.P.B. Thomson – remote sensing

Support Staff

D. Beesley, J. Bond, R. Chapil, F. Chiocchio, H. Dobson, S. Fauman, R. Gottinger, P. Greenway, J. Hart, D. Jordon, W. McColl, K. Miners, J. Mollison, W. Moody, H. Ng, H. Nicholson

CANADIAN CENTRE FOR INTERNATIONAL FIELD YEAR FOR GREAT LAKES (IFYGL)

Canadian Co-ordinator – J. MacDowall

Secretary – Mrs. A. O'Hara

Administration Section

Head – J. Aris

Support Staff – D.G. Jefferson, Miss. I. O'Connor

LAKES MANAGEMENT RESEARCH SECTION (Inland Waters Branch)

Head – Dr. T.R. Lee – water use, economic growth and environmental policy

Secretary – Mrs. R. Riggs

G. Bangay – water use and environmental quality in the Great Lakes Basin

R. Shimizu – institutional studies

Miss M. Sinclair – perception and attitude studies

J.N. Thomson (educational leave) – economics of environmental quality

WATER QUALITY DIVISION – ANALYTICAL LABORATORIES (Inland Waters Branch)

Head – F.J. Philbert

Scientific and Technical Support: H. Alkema, K.D. Austen, W.D. Blythe, O. El Kei (educational leave), Y.M. Sheikh, G.Y. Stoddart, Miss C. Furlong

MARINE SCIENCES BRANCH – CENTRAL REGION

A/Chief, Central Region and Regional Hydrographer – T.D.W. McCulloch

Secretary – Miss L. Ram

CANADIAN HYDROGRAPHIC SERVICE

Assistant Regional Hydrographer – H.R. Blandford

Secretary – Mrs. E.M. Gervais

Hydrographers-in-Charge – Field Surveys

R.D. Courtnage	Thousand Island
J.V. Crowley	Playgreen Lake
F.L. DeGrasse	Great Lakes Systems & Thousand Is.
M. Grant	Marine Information Centre
G. Macdonald	Revisory
R.A. Marshall	Revisory and Georgian Bay
A.R. Rogers	Upper Ottawa River
N. Stuifbergen	Navigational Ranges
E. Thompson	Lake of the Woods
G. Wade	Polar Continental Shelf Project
B.M. Wright	Lower St. Lawrence

Hydrographers – R. Beri, M. Casey, R. Chapeskie, M. Crutchlow, K. Daechsel, P. DalBianco, P. Davies, W. Doering, B. Eidsforth, G. Goldsteen, K. Hipkin, D.J. Kean, D. Kelly, R. Langford, C. Leadman, J.R. MacDougall, R.J. Mahaffey, H.J. Marshall, J. McCarthey, J. Mendendorp, R.L. Moulton, E.I. Norman, P. Pagé, D.G. Philpotts, H. Pulkkinen, R. Rehbein, P.Richards, S.J. Statham. R. Treciokas, J.H. Weller, A.P. Welmers, J.H. Wilson.

Research Development

Head – E. Brown

Technical Staff – E. Lewis, R. Tripe, W. Silvey

Electronics Maintenance

Head – E. Lewis

Technical Staff –

D. Chambers	M. Moore
L. Deavu	A. Prud'homme
R. Desilets	D.W. Pyatt
T. Dyas	W.W. Smith
G. Kavanagh	M. Van Gendt
P. Millette	B. Waldock

Tides, Currents & Water Levels

Head – N. Freeman

Shore Property Studies

W. Haras – J. Shaw

SHIPS AND LAUNCHES

Head – A. Quirk

Engineering Superintendent – A.T. Hughes

General Foreman – K.D. Robertson

Shop Staff – J. Allen, J.W. Boyle, F.M. Morrison, V. Rahelic

CSS LIMNOS – Capt. D.R. Young

Officers – N.L. Golding, N.L. Keeping, T.C. Kenney, G. Sproule, J.W. Stansfield (10 Seasonal Ships Crew)

Launches – Scientific support (19 Seasonal Ships Crew)

Launches – Hydrographic Surveys (84 Seasonal Crew)

Regional Administration and Personnel

Head – A.W. Appleby

Officer Manager – J.R. Dobson

Accounts – A.B. Mitchell

Stores – E.R. Gibbons

Support Staff – A. Desprey, C.J. Fulton, F.M. Haaka, F. Hannay, W.J. MacDougall, E. Montgomery, L.A. Mortimer, J.G. Rothwell, P.L. Taylor

ENVIRONMENTAL PROTECTION SERVICE

TECHNOLOGY DEVELOPMENT AND DEMONSTRATION DIVISION

A/Assistant Chief – A.R. Townshend

Secretary – Mrs. V. Westaway

PROCESS DEVELOPMENT SECTION

A/Head – Mr. N.W. Schmidtke

Biological Process Group – Dr. R.N. Dawson

Physical Process Group – Dr. B.P. LeClair

Soil Process Group – Dr. V.K. Chawla

Chemical Process Group – Dr. E.E. Shannon

Demonstration Section – Mr. R.E. Mills

Laboratory Services Section – Mr. K. Conn

Facilities Services Section – Mr. A.D. Stephenson

MICROBIOLOGY

Head – B.J. Dutka

Secretary – Mrs. M.B. Jurkovic

Scientific and Technical Staff – J.B. Bell, W.K. Bedford, A.A. Jurkovic, D.L. Liu, A.S. Menon, H.R. van Otterloo, P.T. Wong

ENGINEERING & SCIENTIFIC SERVICES SUPPORT DIVISION

Chief – A.S. Atkinson

Secretary – Miss L. Sully

ENGINEERING SYSTEMS SECTION

Head – G.A. Jones

Electronics Engineering Unit – A.S. Watson

Electronics Engineers – K.N. Birch, A.S. Eatock, J. Valdmanis

Technologists – J.A. Diaz, D. Fekyt, J.G.M. Larocque, K. Mollon, M. Pedrosa, A. Tyler

Mechanical Engineering Unit – A.E. Pashley

Mechanical Engineers – B.P. Brady, P.M. Ward-Whate

Technologists – R. Boucher, J.D. Heidt, H.A. Savile

Machinists – R.V. Chumley, K. Kalter, D.H. Whyte

Drafting Office – W. Finn, Miss S. Longstaffe, A.P. Gris

SCIENTIFIC SERVICES SECTION

Acting Head – Dr. R.W. Durham

Radiochemistry Support Staff – R.J. Goble, C. Scutt

COMPUTER AND DATA SERVICES SECTION

Head – D.M. Francis

Computer Applications Unit – Dr. H.S. Weiler

Programmers – G.S. Beal, Miss J.E. Dowell, B. Hanson, Miss B. Pyde

Computer Systems Unit – C. Pulley

Support Staff – Mrs. M. Kinder, Mrs. P.A. Moody

Data Unit – 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

Technical Services Assistant – Mrs. C.E. Davidson

Circulation and Reference Assistant – Miss A.E. Boerchers

ENVIRONMENTAL QUALITY CO–ORDINATION UNIT

Head – Dr. A.R. LeFeuvre

Secretary – Mrs. H. Hetherington

Assistant – J.W. Schmidt

PUBLIC RELATIONS & INFORMATION SERVICES

Head – A.R. Kirby

Secretary – Mrs. R. Mikoda

Assistant – Mrs. J. Bracewell

Publications and Presentations

PUBLISHED PAPERS

Blanton, J.O. and A.R. Winkelhofer. Circulation of hypolimnion water in the central basin of Lake Erie. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 788-798. 1971.

*Blanton, J.O. Exchange of Gulf Stream water with North Carolina shelf water in Onslow Bay during stratified conditions. Deep-Sea Research 18: 167-178. 1971.

*Newton, J.G., O.H. Pilkey and *J.O. Blanton.* An oceanographic atlas of the Carolina continental margin. North Carolina Department of Conservation and Development, Raleigh. 1971.

Burns, N.M. and C. Ross. Project Hypo; a description of an intensive study of the Lake Erie central basin hypolimnion and related surface water phenomena. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 740-742. 1971.

Burns, N.M. and C. Ross. Nutrient relationships in a stratified eutrophied lake. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 749-760. 1971.

Burns, N.M. and C. Ross. Project Hypo; discussion of findings. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 761-767. 1971.

Chau, Y.K. and M.E. Fox. Gas chromatographic method for the determination of NTA in lake water. J. Chromatographic Sci. 9: 271-275. 1971.

Chau, Y.K., V.K. Chawla, H.F. Nicholson and R.A. Vollenweider. Distribution of trace elements and chlorophyll *a* in Lake Ontario. Proc. 13th Conf. Great Lakes Res., Part II, Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 659-672. 1971.

*Grundnes, J., S.D. Christian, *V. Cheam* and S.B. Farnham. Solvent effects on strong charge transfer complexes. IV. Trimethylamine and sulfur dioxide in the vapor phase. J. Am. Chem. Soc. 93: 20-23. 1971.

Childs, C.W. Calcium(II) and magnesium(II) binding by L-serine orthophosphate in aqueous solutions. Can. J. Chem. 49: 2359-2364. 1971.

Childs, C.W. Chemical equilibrium models for lake water which contains nitrilotriacetate and for normal lake water. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 198-210. 1971.

Coakley, J.P. Natural and artificial tracer studies in Lake Ontario. Proc. 13th Conf. Great Lakes Res., Part I, Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 198-209. 1970.

Dick, T.M. Forces on a submerged breakwater. Proc. 14th Congress of the International Assoc. for Hydraulic Res. Vol. 2, paper B13. 1971.

Dobson, H.H. and M. Gilbertson. Oxygen depletion in the hypolimnion of the central basin of Lake Erie, 1929-1970. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 743-747. 1971.

Elder, F.C. and K.P.B. Thomson. Thermal scanner observations over Lake Ontario. Proc. 7th Int. Symp. on Remote Sensing, Institute of Science & Technology, Univ. of Mich., Ann Arbor, Mich., pp 1095-1107. 1971.

Glooschenko, W.A. The effect of DDT and Dieldrin upon ^{14}C uptake by *in situ* phytoplankton in Lakes Erie and Ontario. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 219-223. 1971.

*Glooschenko, W.A. Diel periodicity of chlorophyll *a* in the Gulf of Mexico. Quart. J. Fla. Acad. Sci. 33(3): 187-192. 1971.

**Glooschenko, W.A.* and H. Curl, Jr. Influence of nutrient enrichment on photosynthesis and assimilation ratios in natural North Pacific phytoplankton communities. J.

Where a paper on report was prepared jointly by a CCIW author and an author from another organization, the name of the CCIW author is shown in italics.

*Papers marked thus report on work done by the authors prior to joining CCIW staff.

Fish. Res. Bd. Can. 28: 790-793. 1971.

Gray, C.B.J. and A.L.W. Kemp. A quantitative method for the determination of chlorin pigments in Great Lakes sediments. Proc. 13th Conf. Great Lakes Res., Part I, Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 242-249. 1970.

Hamblin, P.F. An investigation of horizontal diffusion in Lake Ontario. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 570-576. 1971.

Kemp, A.L.W. Organic carbon and nitrogen in the surface sediments of Lakes Ontario, Erie and Huron. J. Sed. Pet. 41(2): 537-548. 1971.

Kemp, A.L.W. and Alena Mudrochova. Electrodialysis: A method for extracting available nutrients in Great Lakes sediments. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 241-251. 1971.

Kemp. A.L.W. H.A. Savile, C.B. Gray and Alena Mudrochova. A simple corer and a method for sampling the mud-water interface. Limnol. & Oceanogr. 16(4): 689-694. 1971.

Kenney, B.C. and I.S.F. Jones. Relative diffusion as related to quasi-periodic current structures. J. Phys. Ocean. 1(3): 224-232. 1971.

Jones, I.S.F. and *B.C. Kenney.* Turbulence in Lake Huron. Water Res. 5: 765-776. 1971.

Lane, R.K. Physical Limnology. Encyclopaedic Dictionary of Physics. Supp. Vol. 4. Pergamon Press. 1971.

Lane, R.K. Waste heat inputs to the Great Lakes of North America. Proc. Int. Water Conserv. Conf. 1970, Jonkoping, Sweden. pp 6/43-6/54.

Lee, T.R. Symposium Chairman "Public involvement in the water management problems in the Great Lakes". Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 731-737. 1971.

Lee, T.R. Water use in the Great Lakes Basin. Can. Geog. J. 82(6): 200-205. 1971.

Lee, T.R. and J.P. Bruce. The Canada Centre for Inland Waters and the university. University Affairs 12(9): 17-18. 1971.

Lee, T.R. and A. Beaulieu. A water use map of the Great Lakes. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 677-680. 1971.

Lerman, A. and G. Brunskill. Migration of major constituents from lake sediments to lake water, and its bearing on lake water composition. Limnol. & Oceanogr. 16(6): 885-895. 1971.

Lerman, A. and R.R. Weiler. Diffusion and accumulation of chloride and sodium in Lake Ontario sediment. Earth & Planetary Science Letters 10: 150-156. 1970.

Lerman, A. and R.R. Weiler. Diffusion of chloride and sodium in Lake Ontario sediment: 1. Ionic interactions, and 2. accumulated amount of a reacting species. Earth & Planetary Science Letters 13(1): 220-221. 1971.

Lerman, A. Time to chemical steady states in lakes and oceans. *In* Advances in Chemistry Series 106: 30-76. Amer. Chem. Soc. 1971.

Lerman, A. Book Review: Aquatic chemistry by W. Stumm and J.J. Morgan. Amer. J. Sci. 271: 414-416. 1971.

Lerman, A. and G. Brunskill. Migration of major constituents from lake sediments to lake water, and its bearing on lake water composition. Limnol. & Oceanogr. 16(6): 885-895. 1971.

Lewis, C.F.M. Recent uplift of Manitoulin Island, Ontario. Can. J. Earth Sci. 7(2): 665-675. 1971.

Lewis, C.F.M. Submersible trials and Lake Ontario studies. *In* Report of Activities, April to October 1970. Geol. Surv. Can. Paper 71-1A, pp 170-172. 1971.

Lewis, C.F.M. and T.W. Anderson. Quaternary geology of the Great Lakes (Project 680055). *In* Report of Activities, April to October 1971. Geol. Surv. Can. Paper 72-1A, p. 167. 1971.

Lewis, C.F.M. and L.A. Jaskula. Uplift studies of the Lake Huron basin. *In* Report of Activities, April to October 1970. Geol. Surv. Can. Paper 71-1A, p. 172. 1971.

Lewis, C.F.M. and B.V. Sanford. Marine activities in Hudson Bay, NWT – *In* Report of Activities, April to October 1971. Geol. Surv. Can. Paper 71-1A, pp 168-169. 1971.

Lewis, C.F.M. and P.G. Sly. Seismic profiling and geology of the Toronto waterfront area of Lake Ontario. Proc. 14th Conf. Great Lakes, Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 303-354. 1971.

Menon, A.S., C.V. Marion, and A.N. Miller. Microbiological studies of oxygen depletion and nutrient regeneration processes in the Lake Erie central basin. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 768-780. 1971.

Menon, A.S., B.J. Dutka and A.A. Jurkovic. Preliminary bacteriological investigation of the Lake Ontario thermal bar. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 59-68. 1971.

Munawar, M. and A. Nauwerck. Composition and horizontal distribution of phytoplankton in Lake Ontario during the year 1970. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 69-78. 1971.

Murthy, C.R. An investigation of diffusion characteristics of the hypolimnion of Lake Erie. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 799-804. 1971.

Murthy, C.R. and G.T. Csanady. Experimental studies of relative diffusion in Lake Huron. J. of Phys. Oceanog. 1(1): 17-24. 1971.

Murthy, C.R. and G.T. Csanady. Outfall simulation experiment in Lake Ontario. Water Res., 5: 813-822. 1971.

*Nriagu, J.O. Experimental investigation of a portion of the system PbS-NaC1-HC1-H_2O at elevated temperatures. Amer. J. Sci. 271: 157-169. 1971.

*Nriagu, J.O. Expressions for calculating the solubilities of mineral sulfides in hydrothermal solutions. Can. J. Earth Sci. 8: 813-819. 1971.

**Nriagu, J.O.* and G.M. Anderson. Stability of lead (II) chloride complexes at elevated temperatures. Chem. Geol. 7: 171-183. 1971.

Platford, R.F. Osmotic and activity coefficients of some simple borate solutions at the freezing point. Can. J. Chem. 5: 709-711. 1971.

Platford, R.F. Thermodynamics of mixed salt solutions: Excess Gibbs energies of mixing for the six ternary systems formed from aqueous $MgCl_2$, $Mg(NO_3)_2$, $CaCl_2$ and $Ca(NO_3)_2$ at 25°. J. Chem. Thermodynamics 3: 319-324. 1971.

Rukavina, N.A. and D.A. St. Jacques. Lake Erie nearshore sediments, Fort Erie to Mohawk Point, Ontario. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 387-393. 1971.

Rukavina, N.A. Nearshore sediments of Lake Ontario. Abstracts, 8th Int. Sed. Congress, p. 85. 1971.

Simons, T.J. A note on the non-geostrophic baroclinic stability problem. Tellus, 23(1): 99-103. 1971.

Simons, T.J. Development of numerical models of Lake Ontario. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 654-669. 1971.

Sinclair, Margaret. A survey of housewives' attitudes centered around the phosphate debate. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 706-719. 1971.

Sinclair, Margaret. A survey of housewives' attitudes centered around the phosphate debate. Great Lakes Basin Commission Communicator, 2(8): 3-4. 1972.

*Stadelmann, P. Stickstoffkreislauf und Primärproduktion im mesotrophen Vierwaldstattersee (Horwer Bucht) und im eutrophen Rotsee, mit besonderer Berücksichtigung des Nitrats als limitierender Faktor. Schweizerische Zeitschriff für Hydrologie 33: 1-65. 1971.

*Buncel, E., *W.M.J. Strachan*, H. Cerfontain. Mechanism of sulfonation of 4-hydroxyazobenzene. Can. J. Chem. 49: 152-156. 1971.

Thomas, R.L. The distribution of mercury in the sediments of Lake Ontario. Abstracts, 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., p 65. 1971.

Brewer, A.W. and *K.P.B. Thomson.* A radiometer-sonde for observing stratospheric emission due to water vapour in its rotational band. J. Roy. Met. Soc. 98(415): 187-192. 1972.

Vanderpost, J.M. and B.J. Dutka. Bacteriological study of the Kingston Basin sediments. Proc. 14th Conf. Great Lakes Res., Int. Assoc. Great Lakes Res., Ann Arbor, Mich., pp 137-156. 1971.

**Williams, J.D.H.*, J.K. Syers, S.S. Shukla, R.F. Harris, and D.E. Armstrong. Levels of inorganic and total phosphorus in lake sediments as related to other sediment parameters. Environ. Sci. Technol. 5: 1113-1120. 1971.

**Williams, J.D.H.*, J.K. Syers, R.F. Harris, and D.E. Armstrong. Fractionation of inorganic phosphate in

calcareous lake sediments. Soil Sci. Soc. Amer. Proc. 35: 250-255. 1971.

*Williams, J.D.H., J.K. Syers, D.E. Armstrong, and R.F. Harris. Characterization of inorganic phosphate in noncalcareous lake sediments. Soil Sci. Soc. Amer. Proc. 35: 556-561. 1971.

*Shukla, S.S., J.K. Syers, *J.D.H. Williams,* D.E. Armstrong and R.F. Harris. Sorption of inorganic phosphate by lake sediments. Soil Sci. Soc. Amer. Proc., 35: 244-249. 1971.

*Syers, J.K., T.D. Evans, *J.D.H. Williams,* and J.T. Murdock. Phosphate sorption parameters of representative soils from Rio Grande do Sul, Brazil. Soil Sci., 112: 267-275.

*Lee, C.C., R.F. Harris, *J.D.H. Williams,* D.E. Armstrong, and J.K. Syers. Adenosine triphosphate in lake sediments: I. Determination. Soil. Sci. Amer. Proc. 35: 82-86. 1971.

*Lee, C.C., R.F. Harris, *J.D.H. Williams,* J.K. Syers and D.E. Armstrong. Adenosine triphosphate in lake sediments: II. Origin and significance. Soil Sci. Soc. Amer. Proc. 35: 86-91. 1971.

PAPERS PRESENTED AND/OR ACCEPTED FOR PUBLICATION

Blanton, J.O. and H.Y.G. Ng. Okanagan Basin studies: results and data reports of the fall survey, 1970. Submitted to Okanagan Basin Study Committee. 1971.

Bruce, J.P. Science and Great Lakes management. Presentation to Royal Canadian Institute, Feb. 27, 1971.

Bruce, J.P. The implication of the hydrology of the Great Lakes in assessing the potential values of weather modification. Presented at the 52nd Annual Meeting of the American Geophysical Union, Washington, D.C. April 12-16, 1971.

Bruce, J.P. Role of universities in environmental management. Presented at the Conference on Role of Universities in Environmental Studies, Univ. of Toronto, May 19-21, 1971.

Bruce, J.P. Meteorological aspects of Great Lakes pollution. WMO Special Environmental Report No. 2, Selected papers on meteorology as related to the human environment, in press.

Bruce, J.P. Pollution control on the Great Lakes – a progress report. Prepared for 1971 International Youth Conference on the Human Environment, McMaster University, Aug. 20-30, 1971.

Bruce, J.P. The Canada Centre for Inland Waters. Presented to the Great Lakes Basin Commission, Buffalo, Oct. 6, 1971.

Bruce, J.P. Canada's water; the governmental role. Presented at Queen's University, W.W. King Lecture, Oct. 13, 1971.

Prince, A.T. and *J.P. Bruce.* Development of nutrient control policies in Canada. To be published in "Nutrients in Natural Waters", 161st National American Chem. Soc. Meeting, Los Angeles, Mar. 28- Apr. 2, 1971.

Burns, N.M. and C. Ross. Chemical processes in the central basin of Lake Erie. *In* "Nutrients in Natural Waters", Ed. H.E. Allen and J.R. Kramer, Wiley-Interscience, in press.

Burns, N.M. and C. Ross. Ed. Project Hypo. CCIW Paper No. 6, in press.

Chau, Y.K. Determination of trace elements in lake water. Invited paper presented to International Symposium on Identification and Measurement of Environmental Pollutants, June 14-18, 1971, Ottawa. Accepted for publication in report of the symposium.

Chau, Y.K. Some aspects of determination of trace metals in natural waters by atomic absorption spectroscopy. Presented at Spect. Soc. of Can. Symposium, October 18-20, 1971, Toronto.

Chau, Y.K. and M.T. Shiomi. Complexing properties of NTA in the lake environment. Water, Air and Soil Pollution. 1(2), in press.

Childs, C.W. NTA equilibrium in lake water. Invited presentation to Gordon Research Conference on Chemical Oceanography, Santa Barbara, California, Jan. 1971.

Childs, C.W. and R.F. Platford. Excess free energies of mixing at temperatures below 25°. Isopiestic measurements on the systems H_2O-NaCl-Na_2SO_4 and H_2O-NaCl-$MgSO_4$. Australian Journal of Chemistry, in press.

Coakley, J.P. SEDAN – A computer program for sediment particle size analysis. Submitted for publication to Inland Waters Branch Tech. Bull. Series.

Lounsbury, M. and *R.W. Durham.* The Alpha Half-Life of U-234. Presented at the International Conference on Chemical Nuclear Data, Canterbury, England, September, 1971.

Dutka, B.J. and J.B. Bell. Isolation of salmonellae from moderately polluted natural waters. J.W.P.C.F., in press.

Glooschenko, W.A. and J.E. Moore. Distribution of chlorophyll *a* and degradation products in Lake Ontario. Presented at 34th Annual Meeting American Society of Limnology and Oceanography, Winnipeg, Manitoba, 1971.

Glooschenko, W.A. and J.E. Moore. The effect of citrate upon phytoplankton in Lake Ontario. Presented to Division of Water, Air and Waste Chemistry, American Chemical Society meeting, Washington, D.C. 1971.

Kemp, A.L.W., C.B.J. Gray and Alena Mudrochova. Changes in C, N, P, and 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, Wiley-Interscience, in press.

Lane, R.K. Lakes and lake systems. Accepted for publication by Encyclopaedia Brittanica.

Lau, Y.L. A note on the prediction of B.O.D. profile due to a source of effluent discharged in a uniformly flowing stream. Water Research, in press.

Lau, Y.L. Discussion of "Dispersion in natural stream". ASCE Journal of Hydraulics Division, in press.

Lee, T.R. Approaches to water requirement forecasting, a Canadian perspective. Paper prepared for the United Nations Ad Hoc expert group on water requirements forecasting, Budapest, 1972, in press.

Lee, T.R. Water use, water quality and regional economic development in Ontario. Paper prepared for the Oceanology International 72 Conference, Brighton, England, March, 1972, in press.

Lerman, A. Strontium-90 in the Great Lakes: Concentration-time model. Journal of Geophysical Research, in press.

Lerman, A. and H. Taniguchi. Strontium-90 and cesium-137 in water and deep sediments of the Great Lakes. Proceedings of Third National Symposium on Radioecology, Oak Ridge, Tenn., 1971, in press.

Lerman, A. Transport of radionuclides in sediments: generalized models. Proceedings of Third National Symposium on Radioecology, Oak Ridge, Tenn., 1971, in press.

Lerman, A. Models of chemical transport in sediments and water. Invited presentation to Sea Grant Program. Distinguished lecture series at Madison, Wisc., 1971.

Lerman, A. Sr^{90} in Great Lakes. Presented at 52nd annual meeting of the American Geophysical Union, Washington, D.C., April 12-19, 1971.

Lerman, A. and B.F. Jones. Salt transport between sediments and brine in saline lakes. Presented at 1971 annual meeting of the Geological Society of America held in Washington, D.C., May 1971.

Lerman, A. Vertical transport in lakes and oceanic basins. Presented at Scripps Institution of Oceanography, La Jolla, California, January, 1971.

Lerman, A. Transfer of ionic species across the sediment-water interface. Seminar presented at Gordon Research Conference on Chemical Oceanography, Santa Barbara, California, January, 1971.

Liu, D.L. and B.J. Dutka. Mechanism of biological oxidation of hydrocarbons in aqueous phase. J.W.P.C.F., in press.

Munawar, M., J. Verduin, and I. Fatima. Primary production studies in shallow aquatic environments of Southern Illinois. Presented at the 18th Limnological Congress, August, 1971, Leningrad, USSR.

Munawar, M. and R.A. Vollenweider. Effect of Nitrilotriacetatic Acid (NTA) on natural phytoplankton populations of Lake Erie, Ontario and Hamilton Harbour. Presented at the 34th annual meeting of the American Society of Limnology and Oceanography, June 1971; Winnipeg, Manitoba.

Murthy, C.R. Complex diffusion processes in coastal currents of a lake. Accepted for publication in J. of Phys. Oceanography.

Murthy, C.R. On the buoyant motion of a line thermal in unstratified surroundings. Accepted for publication, Proc. First Nat. Heat and Mass Transfer Conference, Madras, India.

Murthy, C.R. Dispersal processes in coastal currents of a lake. Presented at Fluid Mechanics Symposium, Indian Institute of Science, Bangalore, India.

Nriagu, J.O. Solubility equilibrium constant of strengite. Amer. J. Sci., in press.

Nriagu, J.O. Stability of vivanite and ion-pair formation in the system $Fe_3(PO_4)_2$-H_3PO_4-H_2O. Geochim. Cosmochim. Acta., in press.

Nriagu, J.O. Solubility studies on vivanite and strengite. Program with abstracts, Annual meeting Geol. Soc. Amer., Washington, D.C. 1971.

Platford, R.F. Isopiestic determination of solubilities in mixed salt solutions. Presented at Gordon Research Conference on Electro-chemistry, Santa Barbara, California, January, 1971.

Robinson, R.A., *R.F. Platford* and *C.W. Childs*. Thermodynamics of aqueous mixtures of sodium chloride, potassium chloride, sodium sulphate and potassium sulphate at 25°. J. Sol. Chem., in press.

Simons, T.J. Numerical modelling of the three-dimensional water motions in the Great Lakes. Presented at the 9th Stanstead Seminar, Montreal, July 15, 1971.

Simons, T.J. and D.B. Rao. Nonlinear interaction of waves and zonal currents in a two-layer baroclinic model. Tellus, 24(1), 1972, in press.

Simons, T.J. The non-linear dynamics of cyclone waves. J. Atmos. Sci. 29(1), 1972, in press.

Simons, T.J. On the theory of atmospheric development. Monthly Weather Review, 100, 1972, in press.

Sly, P.G. and C.F.M. Lewis. The Great Lakes of Canada – Quarternary geology and limnology, Excursion A43 guidebook. Manuscript accepted for publication by 24th Int. Geol. Congress.

Thomas, R.L., A.L.W. Kemp, and C.F.M. Lewis. Distribution, composition and characteristics of the surficial sediments of Lake Ontario. J. Sed. Pet., in press.

Thomas, R.L., A.L.W. Kemp and C.F.M. Lewis. Report on the surficial sediment distribution of the Great Lakes. Part 1: Lake Ontario. Submitted for publication to the Inland Waters Branch Tech. Bull. series.

Thomson, J. National and provincial statistics on the use of pest control products. Social Science Series, Inland Waters Branch Publications, in press.

Williams, J.D.H. and T. Mayer. Effect of diagenetic formation of apatite on regeneration of phosphorus from sediments of Lakes Erie and Ontario. *In* Nutrients in Natural Waters, Eds. H.E. Allen and J.R. Kramer, Wylie-Interscience, in press.

Williams, J.D.H., A.L.W. Kemp and Alena Mudrochova. Forms and availability of phosphorus in lacustrine sediments. Presented to Div. WAW, Amer. Chem. Soc. 161st National meeting, Los Angeles.

Weiler, R.R. and R.D. Coker. Some chemical effects of the thermal bar in Lake Ontario. Presented at the 14th Conf. on Great Lakes Research. 1971.

Wong, P.T.S. Studies on a lactose transport mutant of Escherichia coli. I. Characterization of the transport defect. Submitted for publication to Can. J. of Micro.

Wong, P.T.S. Studies on a lactose transport mutant of Escherichia coli. II. Restoration of active transport by fatty acids. Submitted for publication to Can. J. of Micro.

REPORTS

Bangay, G. Production and use of mercury in Canada. Policy Planning and Research Service, Discussion Paper No. 71-8, 1971.

Boyce, F.M. (a) Proposals for IFYGL measurement and computation of heat storage in Lake Ontario. Part A: Estimate of survey accuracy; Part B: Instruments, survey techniques and computational schemes; Part C: The study of large-scale water movements using temperature profile data. Unpublished report. 1971.

Boyce, F.M. (b) Proposals for IFYGL field procedures and data processing. Appendix: A note on flow regimes in the vicinity of a drifting ship. Unpublished report. 1971.

Boyce, F.M. (c) Report on instruments and techniques used in collecting temperature profiles. Cruise Report to Limnos 71-0-35, Part A, 1971.

Boyce, F.M., W.J. Moody and J. Bull. A progress report on instrumentation – the CCIW towed array system. Unpublished report. 1971.

Dobson, H.H. Nutrients in Lake Huron. Unpublished report. 1971.

Hamblin, P.F. Circulation and water movement in Lake Erie. Inland Waters Branch Scientific Series No. 7. 1971.

Kenney, B.C. Interim report on the physical effects of waste heat inputs to the Great Lakes. Unpublished report. 1971.

Lau, Y.L. Temperature distribution due to the release of heated effluents into channel flow. Inland Waters Branch Tech. Bull. No. 55. 1971.

Lee, T.R. and A. Beaulieu. Great Lakes water use map. Department of Fisheries and Forestry, Ottawa. 1971.

Menon, A.S., B.J. Dutka and A.A. Jurkovic. Preliminary studies on the effect of the Lake Ontario thermal bar in confining bacteria to the near-shore region. Dept. of National Health & Welfare, Public Health Engineering Div., Manuscript Report No. KR 70-2, 1970.

Menon, A.S. and A.A. Jurkovic. Microbiological studies of oxygen depletion in the Lake Erie central basin. Dept. of National Health & Welfare, Public Health Engineering Div., Manuscript Report No. KR 70-4, 1970.

Schmidt, J.W. Mercury and other trace metals in the environment – A compilation of federal government research projects and surveys. Environment Canada. 1971.

Simons, T.J. and D.B. Rao. Summary of discussion at the workshop on the numerical-dynamical modelling of the Great Lakes, Aug. 23-24, Canada Centre for Inland Waters. 1971.

Sly, P.G. Submersible operations in Georgian Bay and Lake Erie – 1970. Inland Waters Branch Tech. Bull. No. 44. 1971.

Thomas, R.L. Report on the occurrence and distribution of mercury in the sediments of Lake St. Clair. Unpublished report. 1971.

Thomas, R.L. Report on the sampling program of lakes on the Bell-Nottaway River system, N.W. Quebec. Unpublished report. 1971.

Thomas, R.L. The distribution of mercury in the sediments of the Detroit River. Unpublished report, 1971.

Thomson, K.P.B. Limnological applications of data retransmission. Report to the Working Group on Data Retransmission, Canada Centre for Remote Sensing. 1971.

Vanderpost, J.M. and B.J. Dutka. A bacteriological study of sediments in the Kingston Basin and Lake Ontario Outlet of the St. Lawrence River, 1970. Dept. of National Health & Welfare, Public Health Engineering Division, Manuscript Report No. KR 70-3, 1970.

Van Otterloo, H.R. Bacteriological survey of Cleveland sewage spill, July 2, 1971. Unpublished report. 1971.

Van Otterloo, H.R., A.S. Menon and B.J. Dutka. Bacteriological investigation of Ontario and Minnesota Pulp and Paper Co. Mill, Lagoon, Fort Francis, Ontario, November 24-December 3, 1971. Preliminary report.

Weiler, H.S. and Murthy, C.R. The Niagara River Plume. Inland Waters Branch Tech. Bull. No. 36. 1971.

Weiler, H.S. A short note on the speed calibration of the Geodyne Model 920 current meter. Inland Waters Branch Tech. Bull. No. 57. 1971.

Weiler, H.S. and N. DeZeeuw. Speed calibration of the Plessey Model MO21 self-recording current meter. Inland Waters Branch Tech. Bull. No. 58. 1971.

CONTRACT REPORTS

McMaster University. Erie and Superior communities project. Hamilton, Ontario. 1971.

Montreal Engineering Company Limited. Thermal inputs into Canadian waters. Montreal, Quebec. 1971.

Paskausky, D.F. Winter circulation in Lake Ontario. Canada Centre for Inland Waters, Contract report. 1971.

University of Western Ontario. The Erie shoreline study. London, Ontario. 1971.

COLLECTED REPRINTS

Canada Centre for Inland Waters, COLLECTED REPRINTS, Vol. 3 inter-Library exchange program.

IFYGL MANUALS – EDITOR, J. MACDOWALL

Latimer, J.R. Radiation measurements. IFYGL Tech. Manual No. 2. IHD Secretariat 1971. (in press).

Palmer, J. Nearshore current measurements. IFYGL Tech. Manual No. 3. IHD Secretariat 1971. (in preparation).

Wilson, R.G. Methods of measuring soil moisture. IFYGL Tech. Manual No. 1, IHD Secretariat 1970.

OTHER IFYGL REPORTS

MacDowall, J. and C.J. Callahan. Proc. of Second Int. IFYGL Workshop IFYGL Centre, CCIW, Burlington, 1971.

MacDowall, J. and E.A.C. Fosdick. Abstracts of IFYGL Publications and background reading list. June 1969; List 2 – August 1969; List 3 – March 1970; List 4 – June 1971; List 5 – December 1971.

Nodwell, B.H. and *J. MacDowall.* Planned data storage methods for the International Field Year for the Great Lakes. Proc. Hydrological Data Seminar. IHD Secretariat. (in press).

Staff Participation in Committees and Associations

Advisory Board to State University of New York's Sea Grant Programs (Lake Ontario) – J.P. Bruce

Advisory Committee on Air and Water Resources Technology, Conestoga College – Dr. R.K. Lane

American Water Resources Association, Board of Directors – J.P. Bruce

American Water Resources Association Symposium on Remote Sensing of Water Resources, 1973

- General Chairman – Dr. R.K. Lane
- Program Chairman – Dr. K.P.B. Thomson
- Program Committee – J. MacDowall
- Public Relations – A.R. Kirby
- Local Arrangements – G.A. Jones
- Technical Arrangements – H. MacPhail
- Ladies Program – Mrs. E. Fosdick

Canada Spectroscopy Society, 4th International Symposium on Atomic Spectroscopy, June 1973, Toronto

- Program Chairman – Dr. Y.K. Chau

Canada Centre for Remote Sensing

- Sensor Committee – J. MacDowall, Vice-Chairman
- Working Group on Data Retransmission – Dr. K.P.B. Thomson

Canada-Ontario Agreement for Pollution Control on Lower Great Lakes

- Technical Committee – J.P. Bruce, Federal Chairman – Dr. E.E. Shannon, N.W. Schmidtke

Canada-U.S. Agreement for Great Lakes Pollution Control

- Negotiating team – J.P. Bruce, J.W. Schmidt (assistant to team)
- Sub-group on Contingency Plans – Dr. A.R. LeFeuvre

Canadian Advisory Committee on Remote Sensing – Dr. R.K. Lane

Canadian Aeronautics and Space Journal – Associate Editor, Remote Sensing, J. MacDowall

Canadian Committee on Oceanography

- Great Lakes Working Group – Dr. R.A. Vollenweider

Canadian Committee on Oceanography – continued

- Third Canadian Symposium – May 1972
  - Local Arrangements Committee – T.D.W. McCulloch, A.S. Atkinson
  - Program Committee – Dr. R.F. Platford
  - Public Relations Committee – A.R. Kirby

1st Canadian Symposium on Remote Sensing

- Chairman (Limnology & Oceanography) Session – Dr. K.P.B. Thomson

Canadian Institute of Surveying

- Chairman of Hydrographic Committee – T.D.W. McCulloch
- Associate Editor (Hydrography) – H.R. Blandford
- Chairman, Ottawa Branch – H.R. Blandford

Canadian Standards Association

- Sub-Committee on Analytical Methods for Air Pollutants – Dr. R.W. Durham

Committee on Water Resource Applications, Program Planning Office of Interdepartmental Committee on Resource Satellites and Remote Airborne Sensing – Dr. R.K. Lane, Chairman

Cross Mission Task Force on Research Institutes and Facilities – J.P. Bruce

Departmental Subcommittee on Marine Pollution – Dr. A.R. LeFeuvre

Geological Association of Canada

- Environmental Study Group – Dr. P.G. Sly

Geological Society of America

Organizing Committee, Northeast Section – Dr. R.L. Thomas

Interdepartmental Committee on Pesticides – Dr. A.R. LeFeuvre

Interdepartmental Committee on Submersibles – J.T. Roe, Dr. P.G. Sly

Interdepartmental Technical Working Group on Contingency Plans – A.R. LeFeuvre, Chairman

Interdepartmental Working Group on Surveys of Offshore Canada Lands

Co-ordinating Committee on Development of Offshore Resources – H.R. Blandford

Instrumentation Advisory Committee, Mohawk College of Applied Art & Technology – G.A. Jones

International Association for Hydraulic Research (IAHR)

Maritime Hydraulics Subcommittee – Dr. T.M. Dick

International Association of Hydrological Sciences (IAHS)

Commission on Water Resources Relations & Systems
National Correspondent – Dr. R.K. Lane

Editorial Board for IAHS Bulletin – Dr. M.E. Thompson

International Commission on Water Quality
Secretary – Dr. M.E. Thompson

Subcommittee on Hydrology
National Correspondent – Dr. M.E. Thompson

International Association for Great Lakes Research (IAGLR)

Chandler-Misener Award Committee – Dr. P.G. Sly
Editorial Board – Proceedings – Dr. R.K. Lane, Dr. P.G. Sly
Publications Committee – Mrs. E. Fosdick
Scientific Editor – Proceedings 15th Conference – Dr. N.A. Rukavina

International Field Year for the Great Lakes (IFYGL)

Canadian Co-ordinator – J. MacDowall
Data Management Committee – D.M. Francis
Editor-in-Chief – J. MacDowall
Publications Committee – J. MacDowall
Publication of Bibliography – Mrs. E. Fosdick
Steering Committee – J.P. Bruce

Boundary Layer Panel – Canadian Co-Chairman – F.C. Elder

Committee on Remote Sensing – Chairman – Dr. K.P.B. Thomson

Energy Balance Panel – Canadian Co-Chairman – Dr. E. B. Bennett, F.C. Elder, member

Water Movements Panel – Canadian Chairman – Dr. E. B. Bennett, Dr. C.R. Murthy, member

International Great Lakes Study Group

Dr. R.A. Vollenweider, member
Steering Committee – J.P. Bruce
Ad Hoc Committee on Data Processing – D.M. Francis

International Joint Commission

Great Lakes Levels Working Group – Dr. T.R. Lee

National Research Council

Associate Committee on Avionics – J. MacDowall
Associate Committee on Environmental Pollution Research – Dr. R.A. Vollenweider
Subcommittee on Hydrology – Dr. R.K. Lane

National Water Needs Study Working Group – Dr. T.R. Lee

Organization for Economic Co-operation and Development (OECD)

Steering Group on Eutrophication – J.P. Bruce, Dr. R.A. Vollenweider

Working Group on Measuring & Monitoring – Dr. R.A. Vollenweider
Working Group on Detergents – Dr. T.R. Lee
Working Group on Treatment – A.R. Townshend

St. Lawrence Seaway Authority, Extension of Great Lakes Shipping Season

Environmental Impact Working Group – J.P. Bruce, Chairman

Special Libraries Association, Natural Resources Division, Editor, Newsletter, Mrs. E. Fosdick

Task Force Committee on Sedimentation and Geochemical Work – C.K. Jonys

World Meteorological Organization, Commission for Hydrometeorology

Working Group on Hydrological Aspects of the World Weather Watch – J.P. Bruce

Advisory Committee to the Canada Centre for Inland Waters

CONVENOR

Dr. A.T. Prince, Director,
Inland Waters Branch,
Department of the Environment,
Ottawa, Ontario. K1A 0H3

CHAIRMAN

Dr. E.G. Pleva
Dept. of Geography,
Middlesex College,
University of Western Ontario,
London, Ontario.

SECRETARIAT

Dr. T.R. Lee, Secretary, ACCC,
Head, Lakes Management Research Section,
CCIW, Box 5050, Burlington, Ontario.

Dr. H.F. Fletcher,
Executive Secretary,
NACWRR, Department of the Environment,
Ottawa, Ontario. K1A 0H3

MEMBERS

Dr. A.H. Booth,
Acting Director,
Environmental Health,
Dept. of National Health & Welfare,
Ottawa, Ontario. K1A 0K9

Prof. 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

Prof. K.S. Davar,
Dept. of Civil Engineering,
University of New Brunswick,
Fredericton, N.B.

Mr. J.P. Gourdeau,
Vice-President,
Surveyer, Nenniger and Chenevert, Inc.,
1500 O. Boul. de Maisonneuve,
Montreal, Quebec.

Dr. W.E. Johnson,
Director,
Freshwater Institute,
Fisheries Research Board of Canada,
501 University Crescent,
Winnipeg, 19, Manitoba.

Prof. J.R. Kramer,
Department of Geology,
McMaster University,
Hamilton, Ontario.

Mr. J.W. MacLaren,
James F. MacLaren Limited,
Consulting Engineers,
321 Bloor St. E.,
Toronto, Ontario.

Prof. W.K. Oldham,
Department of Civil Engineering,
University of British Columbia,
Vancouver 8, B.C.

Dr. G. Shane,
Director of Research,
(Head Office),
Shell Oil Canada Limited,
Box 400, Terminal A,
Toronto 1, Ontario.

Mr. F.A. Voege,
Asst. General Manager,
Ontario Water Resources Commission,
135 St. Clair Ave. West,
Toronto, Ontario.

Dr. A.D. Misener,
Director,
Great Lakes Institute,
University of Toronto,
Toronto 181, Ontario.

Dr. D.R. Stanley, President,
Stanley Associates Engineering Ltd.,
11810 Kingsway,
Edmonton, Alta.

M. M.S. Slivitzky, Directeur,
Centre Québecois des Sciences de l'eau,
Institut National de la Recherche Scientifique,
Université du Québec,
C.P. 7500,
Québec 10, P.Q.

Mr. N. Mitchinson,
President,
Committee of a Thousand,
P.O. Box 185,
Niagara Falls, Ontario.

Mr. T.L. Richards,
Superintendence of Hydrometeorology,
Atmospheric Environment Service,
4905 Dufferin Street,
Downsview, Ontario.

Mr. T.E. Weber,
Director,
Water Control and Conservation Branch,
Department of Mines & Natural Resources,
693 Taylor Avenue,
Winnipeg 9, Manitoba.

Mr. N.E.R. Campbell,
Dept. of Microbiology,
University of Manitoba,
Winnipeg, Manitoba.

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, Asst. to the
Chairman and Legal Adviser,
International Joint Commission,
151 Slater Street,
Ottawa, Ontario. K1P 5H3

Mr. H.G.P. Taylor, Director,
Resource Programs Division,
Department of Finance,
Confederation Bldg.,
Ottawa, Ontario.

Dr. A. DesMarais,
Principal Science Adviser,
Science Secretariat,
Privy Council Office, East Block,
Parliament Buildings,
Ottawa, Ontario. K1A 0A3

Mr. H.C. Kingstone,
Deputy Head, U.S.A. Division,
Department of External Affairs,
Ottawa, Ontario. K1A 0A3

Mr. Wm. A. Johnston,
Economic and Scientific Programs Division,
Treasury Board,
Confederation Bldg.,
Ottawa, Ontario. K1A OR5

Dr. E.Y. Spencer,
Director, Research Institute,
Canada Department of Agriculture,
London, Ontario.

Dr. W.J. Waines,
Associate Director (Domestic Programmes),
Association of Universities and Colleges of Canada,
151 Slater Street,
Ottawa, Ontario.

Alternate:

Monseigneur J. Garneau,
Directeur adjoint (Programmes internationaux),
Association des Universités et Collèges du Canada,
151, rue Slater,
Ottawa, Ontario.

Dr. T.M. Dick, Hydraulics Working Group
Mr. A.R. Townshend, Water Quality Pilot Plant Working Group
Dr. R.A. Vollenweider
Mr. A.S. Atkinson
Mr. T.S. Hillis

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 Management &
Operations 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 Ave.,
Box 219, Stn. K,
Toronto, Ontario.

Dr. B. Michel,
Dept. of Civil Engineering,
Laval University,
Ste-Foy, Quebec.

Mr. Hans Neu,
Atlantic Institute of Oceanography,
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 Building,
Riverside Drive,
Ottawa, Ontario K1A 0M2

Mr. R.H. Smith,
Director of Marine Hydraulics Branch,
Department of Transport,
Ottawa, Ontario. K1A 0N5

Mr. W. Stichling, Sediment Surveys,
Water Survey of Canada,
Inland Waters Branch,
Department of the Environment,
Ottawa, Onatrio. K1A 0H3

Prof. K.S. Davar,
Dept. of Civil Engineering,
University of New Brunswick,
Frederiction, N.B.

ACCC WORKING GROUP ON THE WATER QUALITY PILOT PLANT

A.R. Townshend,
A/Assistant Chief,
Technology Development & Demonstration
Division,
Environmental Protection Service – CCIW,
Burlington, Ontario. (Chairman)

Dr. W.R. Drynan,
Department of Civil Engineering,
University of Waterloo,
Waterloo, Ontario.

Mr. P. Budzik,
Manufacturing Department,
Shell Oil Canada Ltd.,
Box 400, Terminal "A",
Toronto 1, Ontario.

Mr. W.F. Bell,
Staff Process Engineer,
Ontario Paper Company,
Thorold, Ontario.

Dr. K.L. Murphy, Associate Professor,
Department of Chemical Engineering,
McMaster University,
Hamilton, Ontario.

Mr. C.S. Dutton, P. Eng.,
Proctor and Redfern.
Consulting Engineers,
75 Eglinton Ave. E.,
Toronto, Ontario.

Dr. C.J. Edmonds, P. Eng.,
James F. MacLaren Ltd.,
Consulting Engineers,
321 Bloor St. E.,
Toronto, Ontario.

Mr. M. Fielding,
Supervisor, Applied Sciences Branch,
Ontario Water Resources Commission,
135 St. Clair Ave. W.,
Toronto, Ontario.

Mr. W.M. Ward,
Chief Public Health Chemist,
Dept. of Health and Social Services,
300 – 419 Graham Avenue,
Winnipeg 1, Manitoba.

Dr. C.P. Fisher, Acting Director,
Technology Development & Scientific
Services Branch,
Environmental Protection Service,
Department of the Environment,
Ottawa, Ontario. K1A 0H3

Contracts 1971

Study of thermal inputs to Canadian waters. (Montreal Engineering Co. Ltd. – $42,000).

Development of analytical techniques and methodology for the analyses of sediments and water from Lake Ontario. (Univ. of Calgary, Exobiology Research Group – $15,000).

Conduct a study to examine the nearshore thermal and current regimes in Lake Ontario in the vicinity of Oshawa and Cobourg. (Univ. of Waterloo – $42,000).

Evaluation of water quality data result from projects under the Okanagan Lakes Study. (Dr. A. Lerman, Evanston, Ill – $4,600).

Examination of fundamental physical processes in lakes development of numerical models of lake dynamics. (Colorado State Univ. – $4,500).

Special investigation, modification and study of recording water current meters. (Canadian General Electric Co. Ltd. – $15,300).

Assistance in the development of computational programs for determining epilimnion and hypolimnion volumes of various lakes in Canada. (Dr. A. Gilbert – $960).

Theoretical study of diffusion of a line source of effluents located in the hypolimnion. (Dr. T.E. Unney, Univ. of Waterloo – $2,700).

Analysis of 250 sediment samples for differential results of mercury. (Barringer Research – $17,270).

Development of instrumentation for the measurement of lake temperature structures from moving vessels and anchored buoys. (J. & P. Assoc. – $5,000).

Underwater photography, sampling and topographical observations. (Underwater Survey Unit, Burlington, Ont. – $8,250).

To provide continuous research on a project involving the geological studies of the nearshore zone of Lake Superior from Nipigon Bay to Marathon. (Lakehead Univ. – $13,500).

Repair, maintenance and servicing of Plessey and Geodyne water current meters and Hymet recorders. (Canadian General Electric Co. Ltd. – $41,450).

Study of methods for summarizing, compiling, storing and distribution of data to be obtained during the International Field Year for the Great Lakes in 1972. (McMaster Univ. – $7,890).

The following contracts from headquarters funds were monitored by CCIW staff.

Cannery waste treatment by soil biofiltration. (Canadian Canners Ltd.)

Use of plastic-media filter for wastewater treatment. (Univ. of Waterloo).

Partial nutrient removal system at Penetanguishene sewage treatment plant. (Univ. of Toronto).

Study on the efficacy of non-phosphate based detergents. (Ontario Research Foundation).

Design of hydraulic research equipment. (R.J. Kennedy).

Study on dredging of contaminated sediments (H.G. Acres Ltd.).

Evaluate the use of polyurethane as a filter medium for separating petroleum products and water, and to produce criteria for the design of full-scale filter plants. (Canadian Plant and Process Engineering Ltd.).