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AQUATIC ECOSYSTEM PROTECTION RESEARCH BRANCH ANNUAL REPORT FY 2000-2001

J.K. Cooley and M.J. Scott

NWRI Contribution No. 02-340

AQUATIC ECOSYSTEM PROTECTION RESEARCH BRANCH
ANNUAL REPORT
2000/2001

Edited by

J.K. Cooley and M.J. Scott

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DIRECTOR'S FOREWORD

It is my pleasure to present this report of research highlights from the Aquatic Ecosystem Protection Research Branch (AEPRB) of Environment Canada's National Water Research Institute for fiscal year 2000-2001. I hope that this report will provide useful information to our numerous governmental, university, private sector, non-governmental organization and international partners and collaborators. The National Water Research Institute is located at the Canada Centre for Inland Waters in Burlington, Ontario and at the National Hydrology Research Centre in Saskatoon, Saskatchewan. Most of the sixty AEPRB staff are in Burlington, but five staff members are located in Saskatoon and one research scientist is located in Ottawa.

Research highlights this year are in the areas of toxic substances fate and effects (including endocrine disrupting substances), the role of biofilms in the fate of toxic substances, metal accumulation and toxicity in invertebrates, hazards of genetically-modified organisms under Canadian field conditions, brominated fire retardants, mercury isotopes in sediments, and fish bioassay development. These will be discussed in the Project reports below.

The Director of AEPRB is "issue lead" for the Institute in the following areas: toxic substances (Canadian Environmental Protection Act Priority Substances Lists, Toxic Substances Management Policy Tracks 1 and 2 substances, pesticides), Great Lakes 2020 Program (Healthy Citizens component), Lakes Ontario and Superior Lakewide Management Plans, biotechnology, hazards of microorganisms, 5 Natural Resource Departments committees on endocrine disrupting substances and metals, environmental quality guidelines, St. Lawrence River program, Metals in the Environment program, Long-Range Transport of Persistent Organic Pollutants, and the Northern Contaminants and Northern Ecosystems Initiative programs (toxics components).

I thank Mary Jo Scott, Linda Gysbers, Jenn Dykeman, Devinder Kaur, Ada Dabek and Kathy Faulkner for their support to the AEPRB research programs.

R. James Maguire, Ph.D., F.C.I.C.
Director, Aquatic Ecosystem Protection Research Branch

MOT DU DIRECTEUR

Il me fait plaisir de présenter ce rapport sur les faits saillants de la recherche au sein de la Direction de la protection des écosystèmes aquatiques (DPEA) de l'Institut national de recherche sur les eaux d'Environnement Canada, pour l'année financière 2000-2001. J'espère qu'il s'avérera utile à nos nombreux partenaires et collaborateurs des organismes gouvernementaux, des universités, du secteur privé, des organisations non gouvernementales et de la communauté internationale. L'Institut national de recherche sur les eaux est logé au Centre canadien des eaux intérieures à Burlington, en Ontario, et au Centre national de recherche en hydrologie à Saskatoon, en Saskatchewan. La plupart des cinquante employés de la DPEA travaillent à Burlington, seulement quatre se trouvant à Saskatoon.

Cette année, les faits saillants de la recherche sont dans les domaines du devenir et des effets des substances toxiques (notamment des substances perturbatrices des systèmes endocriniens), du syndrome de mort précoce chez les salmonidés des Grands Lacs, des effets des pratiques d'utilisation des terres urbaines et agricoles et de la biodiversité. Ces faits saillants sont présentés plus bas dans les rapports sur les projets. De plus, le directeur de la DPEA assume pour l'Institut la responsabilité principale des domaines suivants : 1) produits chimiques toxiques (LSIP de la LCPE, pesticides, produits chimiques considérés dans les Voies 1 et 2 de la Politique de gestion des substances toxiques, SPSE, Recommandations canadiennes pour la qualité de l'environnement); 2) agriculture durable; 3) surveillance écologique; 4) impacts des substances toxiques aquatiques sur le milieu urbain; 5) fleuve Saint-Laurent; 6) plan d'aménagement panlacustre du lac Ontario; 7) Voie 2 de l'Accord Canada-Ontario; 8) biotechnologie; et 9) dangers des microorganismes.

La DPEA a accueilli l'atelier d'Environnement Canada sur les effets potentiels des organismes génétiquement modifiés sur les écosystèmes les 28 et 29 février 2000. Cet atelier avait pour objectif de bien faire comprendre à tous le rôle d'Environnement Canada en matière de recherche et de surveillance concernant les effets potentiels des OGM sur les écosystèmes, et de déterminer les activités que le Ministère devra entreprendre pour remplir ce rôle. Les résultats de l'atelier aideront à définir les activités scientifiques relatives aux écosystèmes du futur plan stratégique d'Environnement Canada concernant la biotechnologie.

Je tiens à remercier Mary Jo Scott, Linda Gysbers, Jenn Dykeman, Devinder Kaur, Ada Dabek et Kathy Faulkner pour le soutien qu'elles offrent aux programmes de recherche de la DPEA.

R. James Maguire, Ph.D., M.I.C.C.
Directeur, Direction de la protection des écosystèmes aquatiques

THE NATIONAL WATER RESEARCH INSTITUTE (NWRI)

"Generating, applying and communicating knowledge for a better environment"

The National Water Research Institute (NWRI) is Canada's largest freshwater establishment. It conducts a comprehensive program of research and development in the aquatic sciences, in partnership with the Canadian and international science communities.

THE INSTITUTE MISSION

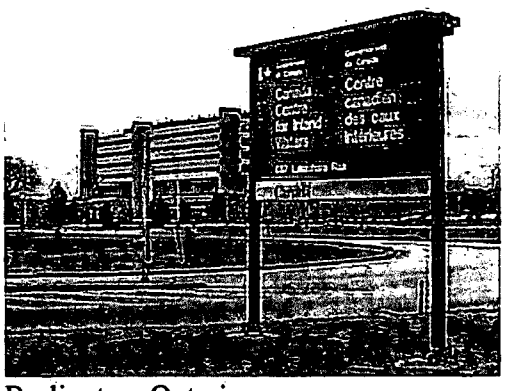
Through ecosystem-based research, the National Water Research Institute creates and disseminates new knowledge and understanding of aquatic ecosystems required for the resolution of environmental issues of regional, national or international significance to Canada.

AQUATIC ECOSYSTEM PROTECTION RESEARCH BRANCH (AEPRB)

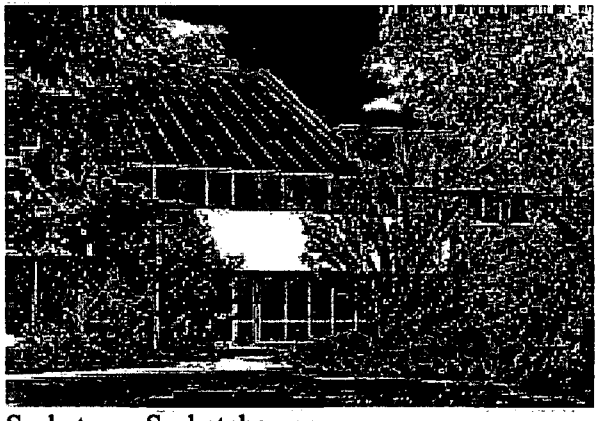
THE BRANCH MISSION

AEPRB conducts research to protect aquatic ecosystems from the deleterious effects of toxic chemicals by developing knowledge and understanding of priority pollutants to support informed environmental decision-making and sustainable practices. Studies focus on knowledge requirements of the Toxic Substances Management Policy, the Canadian Environmental Protection Act and the Pest Control Products Act. AEPRB research is directed towards a fundamental understanding of such issues as priority chemicals, regional ecosystems, pollution prevention, ecosystem sustainability and biodiversity.

Director	Jim Maguire
Executive Assistant	Mary Jo Scott
Science Liaison Officer	Janet Cooley
Administrative Officer	Linda Gysbers
Administrative Assistant	Devinder Kaur (Ada Dabek)
Word Processor Operator	Jenn Dykeman (Kathy Faulkner)



Burlington, Ontario


Saskatoon, Saskatchewan

L'INSTITUT NATIONAL DE RECHERCHE SUR LES EAUX (INRE)

« Acquérir, appliquer et diffuser des connaissances sur les eaux pour contribuer à faire des choix éclairés en matière d'environnement »

L'Institut national de recherche sur les eaux (INRE) est le plus grand établissement de recherche sur les eaux douces du Canada. On y exécute un programme de recherche et développement complet dans le domaine des sciences aquatiques de concert avec les communautés scientifiques du Canada et de l'étranger.

LA MISSION DE L'INRE

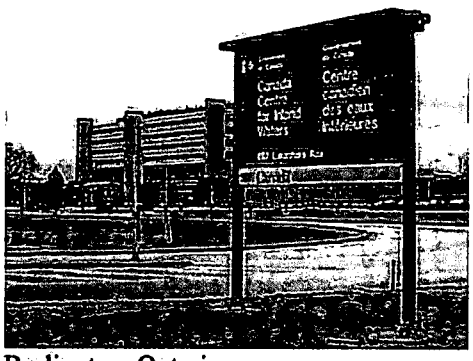
Grâce à la recherche écosystémique, l'INRE acquiert et diffuse des connaissances sur les écosystèmes aquatiques qui permettent de résoudre les problèmes environnementaux de portée régionale, nationale ou internationale importants pour le Canada.

DIRECTION DE LA PROTECTION DES ÉCOSYSTÈMES AQUATIQUES (DPEA)

LA MISSION DE LA DIRECTION

La Direction de la protection des écosystèmes aquatiques (DPEA) effectue des recherches dans le but de protéger les écosystèmes aquatiques des effets nocifs des substances chimiques toxiques; pour ce faire, elle cherche à mieux connaître les polluants d'intérêt prioritaire pour la prise de décisions éclairées en matière d'environnement et l'instauration de pratiques respectueuses de l'environnement. Les études sont axées sur les besoins en connaissances liés à la Politique de gestion des substances toxiques, à la *Loi sur les produits antiparasitaires* et à la *Loi canadienne sur la protection de l'environnement*. Les scientifiques de la DPEA contribuent à l'accroissement des connaissances sur des questions comme les substances chimiques d'intérêt prioritaire, les écosystèmes régionaux, la prévention de la pollution, la pérennité des écosystèmes et la biodiversité.

Directeur	Jim Maguire
Adjointe exécutive	Mary Jo Scott
Agente de la liaison scientifique	Janet Cooley
Opératrice de traitement de texte	Jenn Dykeman (Kathy Faulkner)
Agente administrative	Linda Gysbers
Commise à l'administration	Devinder Kaur (Ada Dabek)



Burlington, Ontario

Saskatoon, Saskatchewan

ATMOSPHERIC CONTAMINANT IMPACTS PROJECT

PROJECT CHIEF: DEREK MUIR

Atmospheric deposition is one of the major pathways for contamination of many important aquatic ecosystems in Canada. The Project provides essential scientific information and advice on trends of atmospherically derived persistent organic pollutants and metals (especially mercury) in water, precipitation and sediments, as well as in aquatic food chains and subsistence human food sources. This work supports departmental activities under Great Lakes Basin 2020, Northern Contaminants Program, Northern Rivers Ecosystem Initiative, and Hazardous Air Pollutants. The Project conducts research on pathways and dynamics of contaminants in food webs, at the air-water interface, and in sediments (for example, mercury diagenesis and biogeochemistry and toxicity of heavy metals in lakes polluted by smelter emissions). In the next few years, the Project will develop information on issues of new and emerging persistent chemicals, especially in the Arctic.

IMPACTS DES CONTAMINANTS ATMOSPHÉRIQUES

RESPONSABLE: DEREK MUIR

Les dépôts atmosphériques constituent l'un des principaux vecteurs de contamination de nombreux écosystèmes aquatiques importants au Canada. Les travaux visent à recueillir des données scientifiques essentielles et à fournir des avis scientifiques sur les tendances du devenir des polluants organiques persistants et des métaux (en particulier le mercure) d'origine atmosphérique dans l'eau, les précipitations et les sédiments, ainsi que dans les chaînes alimentaires en milieu aquatique et les sources d'aliments destinés aux êtres humains. Ces travaux sont des contributions au programme Bassin des Grands Lacs 2020, au Programme de lutte contre les contaminants dans le Nord, à l'Initiative concernant les écosystèmes des bassins hydrographiques du Nord et au programme sur les polluants atmosphériques dangereux du Ministère. Il porte sur l'étude des voies et de la dynamique des contaminants dans les réseaux trophiques à l'interface air-eau et dans les sédiments (par ex., dans la diagenèse du mercure et la biogéochimie et la toxicité des métaux lourds dans les lacs pollués par les émissions de fonderie). Dans les années à venir, le projet recueillera des renseignements sur les nouvelles substances chimiques persistantes qui sont détectées, particulièrement dans l'Arctique.

Derek Muir (left) received the Founder's Award from the Society of Environmental Toxicology and Chemistry at its annual meeting in Nashville this week. This award is SETAC's highest scientific award given annually to individuals who have outstanding scientific productivity combined with active participation in SETAC. Derek is the first Canadian government scientist to win the award. His award address was entitled "Using Remote Environments to Evaluate Persistent Organic Pollutants (POPs)". The presentation dealt with contamination of the arctic environment and with the unique characteristics of the ecosystem and the chemicals (cold waters, long food webs, dietary traditions of indigenous people) that have given rise to high levels of contamination in people and top predators. The presentation also covered recent work to examine new POPs in the same environments and called for more studies of POPs in other environments such as the tropics.

PATHWAYS AND PROCESSES OF BIOACCUMULATION AND FATE OF AIRBORNE POLLUTANTS IN TEMPERATE & TROPICAL FRESHWATER & TERRESTRIAL SYSTEMS

Study Leader Derek Muir
Study Team Camilla Teixeira
Bob Wilkinson

STUDY OBJECTIVES

Develop new approaches for studies of pathways and processes of bioaccumulation and fate of toxic chemical contaminants.

RESULTS

A study on toxaphene, funded by USEPA-GLNPO, is complete and a final report is in preparation. Toxphene congener and enantiomer levels and patterns were used to obtain a better understanding of the pathways of bioaccumulation of this persistent pesticide in Lake Superior. Studies on temporal and spatial trends in toxaphene (Jackfish Bay, Lake Superior, Clay Lake, Kamloops Lake) at the congener and enantiomer levels, using dated lake sediments near pulp mills, were completed. Results showed that toxaphene was not emitted in significant amounts by pulp mills which used elemental chlorine bleaching until the early 1990s.

Pesticides and persistent organics in air and surface waters of tropical lakes are being investigated in collaboration with Dr. Hecky, of the University of Waterloo. A paper co-authored by K. Kidd on DDT in the Lake Malawi food web was published by ES&T. The results showed that the rate of bioaccumulation of DDT was higher in the pelagic than benthic food web of Lake Malawi.

The TSRI/Great Lakes project on fluorinated surfactants with Drs. Scott; NWRI; Solomon, Guelph; Mabury, University of Toronto and graduate student Jon Martin is examining levels of these very persistent chemicals in Great Lakes air, water and biota. A report on the study has been provided to TSRI. Results for the TSRI collaborative project on Bioaccumulation of POPs and mercury in lake food webs were presented at SETAC. This study involves measurements of contaminants in fish and food webs of 36 lakes across Canada. A significant negative correlation was found between mercury levels in salmonid fishes (lake trout and brook trout) and longitude, i.e., higher in Eastern Canada.

New Research Initiative.

A study on airborne POPs near Lake Victoria was begun in collaboration with Dr. R. Hecky of the University of Waterloo. Funding for this new research was requested from the Lake Vicitoria Environmental Management Program in collaboration with the United Nation University/ International Network on Water Environment and Health (UNU/INWEH). Graduate student Michael Wejuli, from Uganda, visited NWRI several times as part of organizational meetings. Initial air monitoring results from Uganda showed significant levels of chlorinated pesticides especially endosulfan and DDT in air within the Lake Victoria basin.

PERSISTENT ORGANIC POLLUTANTS IN THE ARCTIC - BIOACCUMULATION, SPATIAL AND TEMPORAL TRENDS

Study Leader Derek Muir
Study Team Camilla Teixeira
Bob Wilkinson

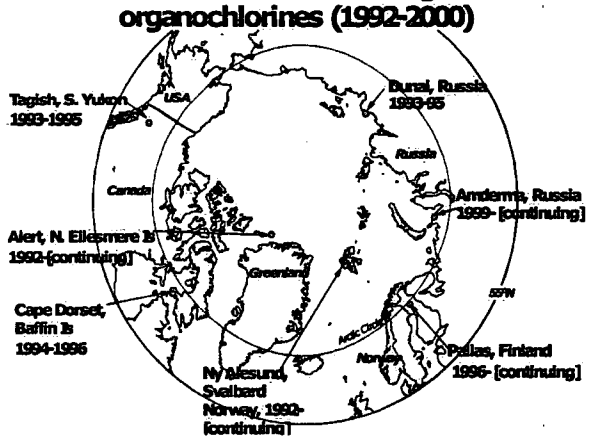
STUDY OBJECTIVES

Conduct studies on spatial and temporal trends of POPs, including emerging/potential POPs, in the Canadian and circumpolar Arctic in order to develop an improved understanding of the pathways and processes.

RESULTS

The Greenland AMAP persistent organic pollutants (POPs) analysis continued in collaboration with the Danish National Environmetal Research Institute (NERI). A quality assurance (QA) audit of the work was completed in late November. This work contributed to a report on contaminants in the Greenland diet that was prepared for the Greenland Dept of Environment by project leader Poul Johansen. Results showed low levels of POPs in terrestrial and marine biota from all locations.

POPs in Arctic Air - monitoring sites for organochlorines (1992-2000)



The TSRI project on spatial trends of POPs in lake sediments continued with dating and analysis of cores in the Arctic and subarctic.

Work was completed on a study that interpreted data on organochlorines in lichen and moss from Alaska and Russia. This study had been conducted in the early 1990's by Dr. Jesse Ford (Oregon State). A report on the work, was issued in December by USEPA (Corvallis). The results showed higher levels of PCBs in moss and lichen from Russia's Tamyr Penninsula than those in the north Slope area of Alaska.

A study was initiated with Dr. Mark Hermansen (U of Pennsylvania) to measure current use and chlorinated pesticides in snow from Svalbard and Greenland. Initial results were reported by Camilla Teixiera, NWRI technologist, and showed that pesticides were present in snow cores dating back to the 1950's in Svalbard.

Drs. Derek Muir and Aaron Fisk , AEPRB -NWRI, are responsible for preparation of the Biological Chapter of the forthcoming Canadian Arctic Assessment Report (CACAR) which is due to be completed in April 2002. Results will be collated from about 20 other scientists who are part of the NCP. CACAR will deal with recent (post 1996) results on spatial and temporal trends and biological effects of contaminants in biota in the Canadian arctic.

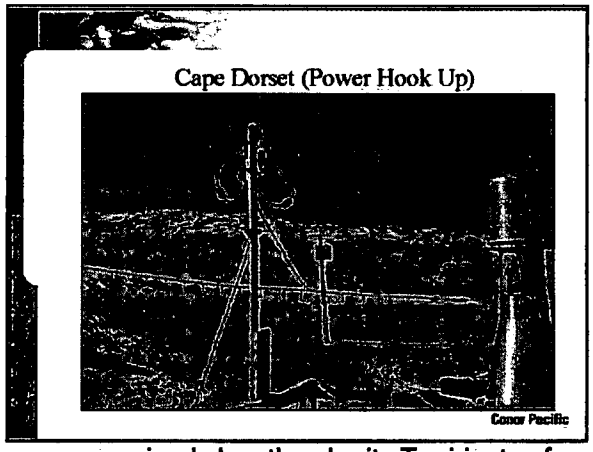
Work by Muir and Fisk is all continuing on the preparation of the POPs chapter of the AMAP assessment report (due in March 2002) with preparation of a bibliography by contractors K. Hobbs and X. Wang and preparation of letters to all contributors by the new scientist Aaron Fisk.

An organizational meeting for the US AMAP contributions on POPs was held in December, in Seattle and in Tromso Norway in March 2001.

Scientists, from this project, participated in the annual results workshop of the Northern Contaminants Program (NCP). Derek Muir presented results for mercury in landlocked arctic char from Resolute and Char Lakes near Resolute (Nunavut) and showed that there was no increase or decline in mercury over an eight year period. He also presented a final report on contaminants in marine biota in northern Quebec and Labrador. Marlene Evans presented initial results of a temporal trend study of contaminants in Great Slave Lake as well as results of investigations of sources of mercury in lakes in the Fort Simpson (NWT) area. Ven Cheam prepared a poster (presented by Derek Muir) on his initial survey of mercury and lead deposition in dated lake sediment cores that showed anthropogenic enrichment of mercury even in the high Arctic. Mehran Alaee presented the first results on the presence of brominated diphenyl ethers in Arctic air. Aaron Fisk presented a study investigating the origins of elevated beta-HCH in top predators and humans in the arctic and included results from his recent studies on bioaccumulation of contaminants in the North Water polyna between Canada and Greenland. The meeting provided a good opportunity to discuss progress on ongoing NCP projects with collaborators and to communicate results to residents of the north. Jim Maguire, NWRI's representative on the NCP management committee, attended the meeting and chaired the "Biotic" monitoring session.

Drs. Derek Muir and Aaron Fisk visited the Polar Environmental Centre (PEC) in Tromso, Norway to meet with Norwegian scientists and latter scientists in Oslo working on contaminants in the Arctic. At the PEC Muir presented an overview of the Canadian Northern Contaminants Program and results of his studies on spatial and temporal trends of PCBs and other contaminants in the Arctic. Fisk presented results of his research with Ross Norstrom (CWS) on the bioaccumulation of persistent organochlorine compounds in the North Water Polynya food web. In Oslo they met with Dr. Janneche Skaare, who has led studies into the effects of contaminants on polar bear in Svalbard. Skaare and colleagues have recently concluded that the bears immune systems are compromised and their reproduction is affected by elevated PCBs. Muir and Fisk also discussed the contributions by Norwegian scientists to the assessment of POPs in the Arctic which they are co-leading. In Oslo, they met with Lars-Otto Reiersen, Executive secretary of the Arctic Monitoring and Assessment Program to report on progress on the assessment. Muir also attended a meeting at the AMAP offices on the design of monitoring programs for contaminants in the Russian arctic and provided advice to the program on sampling and analysis of POPs.

Northern communities have expressed concern about intercommunication of research results and advice from samples collected near their communities. To address this issue, Dr. Muir, again participated in a contaminants tour of 3 communities in Nunavut. The tour



was organized by the Inuit Tapirisat of Canada and by Indian and Northern Affairs Canada as part of an effort to bring results and advice, developed by the Northern Contaminants Program (NCP), directly to each community. Presentations were made

in Cape Dorset, Coral Harbour and Hall Beach.

Work by Derek Muir continued for a final year on the Pew Foundation program on Marine Conservation (1997-2001) with presentation of the results on contaminants in the food web of the White Sea (Russia) at the annual meeting in La Paz, Mexico, in early November.

MERCURY AND METALS IN AQUATIC ECOSYSTEMS, AND ATMOSPHERIC TRENDS AND FATE OF TOXIC CHEMICALS, TOXIC CHEMICALS IN RUSSIAN ARCTIC RIVER WATERS

Study Leader W.M.J. Strachan
Study Team D. Burniston

STUDY OBJECTIVE

The study investigates elemental Hg using clean techniques and is contributing to knowledge of sources and pathways of this toxic chemical in the Great Lakes, boreal forest and high Arctic environments. Work on POPs has contributed significantly to understanding of sources of contaminants in Great Lakes and their long term trends.

RESULT

Sampling continued at the Turkey Lakes site for lake water, precipitation, air (gas phase and particles), stream flow in order to determine the retention of atmospherically deposited OCs and mercury within the watershed. During periods of heavier rainfall (May-June, October), replicate samples (100+ L ea.) of water were collected on a weekly basis for POPs determination and similar replicates (ca. 0.2+ L ea.), filtered and unfiltered, for trace HMs and Hg. Otherwise the sampling regime was biweekly. For rain (28 d regime), POPs are collected year-round (single samples) as are HMs; for Hg, triplicate samples are obtained. Air (24 hr, biweekly), is collected for POPs on PUF plugs similar to the IADN program. Snow collections are also part of the study with both event (immediate and aged) and seasonal accumulations being received. Sediments of Batchawana Lake have been collected once (6 samples), fresh leaves and needles twice (summer 1999 and 2000) and litterfall once (October 1999). Preliminary results are now available. The HCHs, dieldrin and the G-endosulfans show much higher values for the lake (and its outlet) than are observed in the input streams (and also in the harvested watershed stream) during spring and summer and there are few differences between these two seasons. A second observation is that the total for the present suite of PCB congeners (more than 100) seldom exceeds that of an earlier set (in use 1991-1993) and then only by a 10% margin. This supports the contention that earlier results in a number of other studies are largely comparable with present-day values and that there have been few reductions over the 7-8 years.

IMPACTS OF COAL MINES AND POWER PLANTS, AND LONG-RANGE TRANSPORT POLLUTION IN THE ARCTIC

Study Leader Ven Cheam

STUDY OBJECTIVE

This study undertakes of ^{210}Pb dating of sediment cores, including those from the Arctic. Sample collection is undertaken from mines and power plants and chemical analysis and bioassay tests are undertaken.

RESULTS

Five dated cores have been analysed for Mercury, Lead, Iron and Manganese and sediment samples have been collected, processed and freeze-dried. Chemical analyses and bioassay tests continue.

Laser Excited Atomic Fluorescence Spectrometry (LEAFS) was applied to environmental analyses with emphasis on thallium (Tl) pollution and distribution in Canada. Thallium is present in the environment as monovalent and trivalent form. The majority of published papers point to the predominance of Tl^{+} species. Recently Lin and Nriagu published a very interesting, important finding that nearly 70% of Tl in the Great Lakes waters was in trivalent form. However, the discussions on two critical points were lacking; namely the sample acidification before the critical speciation-determining step; and the use of very high standards (10,000 x the actual concentration) followed by low recovery of Tl^{+1} species in the validation of their extraction procedure. Acidification alters the chemistry of thallium favoring the formation of Tl^{3+} species, particularly when a huge amount of NO_3^- (3.3×10^{-2}M) was added to a natural lake water containing only ~10^{-10}M of Tl. Since Tl^{3+} and NO_3^- form fairly strong complexes, chemical thermodynamics dictates that Tl^{3+} species must increase at the expense of Tl^{+} species. This suggests an overestimation of Tl^{3+} species.

ATMOSPHERIC AND LOCALIZED ANTHROPOGENIC IMPACTS ON BOREAL AND PRAIRIE AQUATIC ECOSYSTEMS

Study Leader Marlene Evans

STUDY OBJECTIVES

Contribute to the Northern Contaminant Studies and identify anthropogenic impacts on prairie and boreal lakes and wetlands.

RESULTS

Research on the Northern Contaminants Program (NCP)-Mackenzie Basin Lakes focused on the analysis of biological samples collected in 1999. Fish samples provide by Dr. Lockhart, DFO, are being prepared for stable isotope analyses. In addition, a progress report was submitted to the Northern Contaminants Program based on this research.

The communities of Fort Resolution and Lutsel K'e have been contacted regarding the NCP-Organic Contaminants in Great Slave Lake study and arrangements made to begin lake trout and pike sampling at both locations. Sampling at Fort Resolution may be completed. Burbot sampling at these two sites and the Slave River will take place in the fall or winter. Fish tissue collected in 1999 are being prepared for stable isotope analyses. Earlier contaminant data for Great Slave Lake biota has been complied and possible errors identified. Information was provided to DIAND Yellowknife (C. Mills) on comparisons in contaminant concentrations in Great Slave Lake and Laurentian Great Lakes fish. A progress report was submitted to the Northern Contaminants Program based on this work. The proceedings of the upper Mackenzie River Basin workshop were completed and the report submitted to be published.

New knowledge was gained on hydrocarbon composition and concentrations in Lake Athabsaca and Peace-Athabasca delta sediments, including sedimentation rates; comparison of concentrations and levels with Mackenzie Delta and Great Slave Lake; presence of petrogenic hydrocarbons evident in Athabasca and the delta and some possible temporal trends of increase; major composition difference between Athabasca and the Mackenzie; the presence of an industrial impact from downstream hydrocarbon operations under investigation; and some hydrocarbons at interim sediment quality guidelines for PEL's.

Studies continued on factors affecting elevated mercury levels in fish in lakes in the NWT, with research focused on lakes in the Fort Simpson area. Elevated mercury levels are due to a combination of trophic feeding, fish age, and some unknown factors related to water chemistry. The influence of fault lines in affecting mercury levels is still under investigation. Community presentations are planned for later in the year. NREI research investigated contaminants and food webs in the Wapiti River. This study will investigate the role of food web and productivity in elevated POPs and mercury levels opposed to inputs in burbot from municipal and industrial discharges

Dr. Evans was invited to become a member of the RAMP Technical Advisory Committee.

A sixth draft of the Road Salt report has been prepared and submitted to the Environmental Resource Group. Extracts from this report have been placed into the Road Salt assessment document that will be released shortly for pubic review. I have reviewed the Road Salt assessment report that will soon be distributed, for public comment. Continued work with Road Salt Environmental Work Group. Supporting document on aquatic ecosystem effects sent out for public review along with assessment document concluding road salt should be considered CEPA toxic

FATE OF SEDIMENT METALS

Study Leader T.A. Jackson

STUDY OBJECTIVE

Continue collaborative research on the variations in the stable isotope composition of mercury in cores from selected Hg-contaminated lakes; on the biogeochemistry of mercury in lake and stream environments in the Mackenzie Valley, NWT and investigate the interactions of heavy metals with bacteria and associated nonliving material as revealed by energy dispersive X-ray microanalysis combined with electron microscopy.

RESULTS

Results of previous mercury isotope research performed on a sediment core and food chain animals from Lake Ontario will be published in the *Canadian Journal of Fisheries and Aquatic Sciences* and have already been made public at the Web site of the journal.

Two experiments, designed to measure the relative mercury-methylating and -demethylating capabilities and carbon dioxide-producing activities of the microbial communities in sediments from the field sites; parts of two other experiments were completed. The carbon dioxide analyses were carried out, and the sediments were frozen and then submitted to NLET for methyl mercury analysis, which is to be carried out before 31 March, 2001.

Analysis of sediments from several lakes polluted by fallout from the smelters at Sudbury, Ontario is still in progress. Two papers are in preparation: (1) a comprehensive review paper on microanalysis techniques and their applications in biogeochemical research (a book chapter), a draft of which has been completed and submitted for peer review (see Part I, Section C, below); and (2) a paper on microanalysis data for sediment from Larder Lake, Ontario.

New Research Initiative

A new research project began this year on effects of heavy metals on microbial communities in sediments of Jack of Clubs Lake, B.C. and Larder Lake, Ontario, which are polluted with metals from mine wastes, using ribosomal ribonucleic acid (rRNA) analysis and other methods [collaboration with T.M. Finan (McMaster University) and G.G. Leppard (NWRI)].

The project on rRNA has been initiated. At present our collaborator, T.M. Finan, is trying to recruit a technician who has the special skills required to carry out the rRNA analyses.

Initiated a project on bacterial fatty acids and phospholipids in metal-polluted lake sediments. A series of previously collected, frozen sediment samples from lakes polluted by fallout from the smelters at Sudbury, Ontario was analysed for a number of fatty acids that are useful for the characterisation of microbial communities in natural environments. The technical work was done by a contractor (W.-C. Li). Arrangements were made to have the same samples analysed for phospholipids before the end of the fiscal year. The purpose of the project is to obtain information on the effects of heavy metals on the nature and activities of microbial communities in the sediments of metal-polluted lakes. The data will be used in conjunction with results of other kinds of analyses performed previously on the sample samples.

- Initiated a project jointly with G.G. Leppard (NWRI) and A. P. Hitchcock (McMaster University): Analysis of mineral coatings and cell walls of individual bacterial cells in metal-contaminated sediment from Larder Lake, Ontario using the synchrotron technique of "soft X-ray spectroscopy." The purpose of the project is to determine the atomic environments of heavy metals bound to the bacteria, thereby supplementing and helping to elucidate the results of previously performed energy dispersive X-ray microanalysis of the same sample material.

METHOD DEVELOPMENT AND FATE OF NEW CHEMICALS

Study Leader Brian F. Scott

Study Team Christine Spencer

STUDY OBJECTIVES

To develop analytical methods for the analysis of perfluorinated organic acids and apply these methods to environmental samples; to continue investigations into the sources of chlorinated and fluorinated organic acids

RESULTS

The method used to analyze haloacetic acids was adapted to determine perfluoroalkanoic acids (PFAs). The technique had to be altered as only two of the perfluoro acid anilides were obtained at sufficient purity to be used as standards. Consequently, PFA stock solutions were used as external standard during every quantitation. Analysis of the PFA suite (C_2 to C_9) could proceed knowing the reaction for analysis was complete and instrument response over several decades of concentrations (10^{-9}-10^{-12} g) was linear. The method could be used simultaneously for HAA and the PFAs. In addition SPE techniques were investigated to concentrate the heavier PFAs successfully. The method has been used on over 150 samples to date for simultaneous determination of HAAs and PFAs.

Samples were collected around the Great Lakes Basin. This included profiles of Lakes Erie and Ontario, to determine if there were changes from the previous profiles. In 2000, there was more uniform distribution of the chloroacetic acids and the TFA concentrations had decreased in each of the lakes by 20 ng/L. throughout the water column. Perfluorobutoanoic acid was detected at all depths in both the Great Lakes. Also chlorodifluoroacetic acid was found at all levels of both lakes. This was not the case for Lake Ontario during the last profile determination. Previously, an increase in the TFA values from Lake Superior (18ng/L) to Ontario (155ng/L) was noted with the largest increase between Lake Huron (55 ng/L) and Lake Erie (150 ng/L). The concentration levels in the Detroit River reflected values of Lake Huron rather than Lake Erie. Accordingly, one of the tributaries of Lake Erie, Big Creek, was monitored on a regular basis, and the CAA levels were similar to those of a water filtration plant or STP (6000ng/L). The TFA levels were considerably higher than in Lake Erie (>200 ng/L). These levels of TFA and CAAs were noted in samples of a tributary to Big Creek and above the major population centre on Big Creek, Delhi. Two other tributaries were sampled and although the CAA levels were ~100 ng/L, the TFA values were in excess of 250 ng/L. PFAs were detected in 2 collections on Big Creek.

Work was completed on the comparison of HAA levels in the Northern and Southern Hemispheres. The major effort was to investigate the distribution of the HAAs in the soils by analyzing 1cm slices of the top 10cm of soil. This was completed for 11 Chilean and 3 Malawi sites as well as bulk samples from 5 Canadian and 9 UK sites including 4 archived UK samples. The lowest trichloroacetic acid concentrations in the precipitation samples were found in Malawi and the highest in Canada. Malawi had low monochloroacetic acid concentrations as well, but they were slightly higher than those taken in Canada or Chile. In soil samples, HAA concentrations were highest in the United Kingdom and lowest in Malawi, with Chilean samples having higher levels than Canadian ones. Malawi soil and precipitation samples also contained small amounts of monobromoacetic acid, but this particular HAA was found in only one of 11 Chilean sites. In general, dichloroacetic acid was the most prevalent HAA found in all samples. Overall, results showed that concentrations of HAAs were greatest in the industrialized Northern Hemisphere supporting the theory that levels of these substances are higher in industrialized areas.

POINT SOURCE TOXIC METAL IMPACTS: ATMOSPHERIC AND TERRESTRIAL

Study Leader H.K.T. Wong

STUDY OBJECTIVES

To determine the evolution and source characterization relating to the atmospheric input of CEPA priority metals

RESULTS

Worked in a multi-discipline study which contributions both to environmental fate of metals and to laboratory protocols for metals--collection and analysis methodology. Sampling was undertaken at the Horne Smelter, Quebec and Nanticoke which is a coal-fired plant. Preliminary results were presented at MITE : characterizes the evolution and behavior of CEPA priority metals with respect to their physical and chemical components from source to 30 km downwind. Part of the results will be used to assess the influence of potential emission control strategies.

Studies determine the evolution and source characterization relating to the atmospheric input of CEPA priority metals in the Great Lakes, Ontario, by the signature of noble metals (Au, Ag, Pd, Pt) and other heavy metals (e.g. Hg) in aerosol and in sediments. Data analysis is in progress, and preliminary results showed a significant amount of Al, Fe, As and Pb in aerosol form. Normalized ratios of Pt, Pd and Ag can quantify contributions from automobile exhausts.

RADIONUCLIDE DATING SERVICES

Study Leader Fan Yang

STUDY OBJECTIVES

To analyse Arctic, Great Lakes, and peat cores from northern Ontario. and to update the Pb210 system. This study will a initiate new data analysis model, and will continue the collaborated project on effects of exposure to MMT (methylcyclopentadienylmanganese tricarbonyl) on public health.

RESULTS:

Sediment cores from Romulus lake, Rabbitkettle lake, and B1-3, B2-1 from Rivere Boniface area have been dated with the Pb^{210} method.

Data of three dated cores have been analysed with CIC1, CIC2 and CRS models and the results reported. The data from B1-3 core is complicated and is being analysed using a number of methods, and four additional sediment cores have been subsampled, freeze dried and weighted for dating.

The report of "Bioaccumulation of TBT by freshwater mussels from contaminated aquatic areas" has been completed and submitted. Results continued to provide the consultation for the occurrence and analysis of TBT and MMT.

ECOSYSTEM HEALTH ASSESSMENT PROJECT

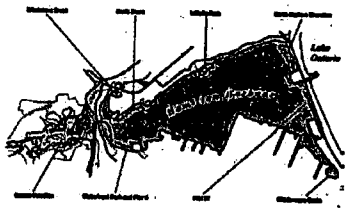
PROJECT CHIEF: JIM SHERRY

Anthropogenic activities impact the health of Canadian aquatic ecosystems. The Project develops strategies and tools for the assessment of ecosystem health and the diagnosis of impaired health. The Project develops diagnostic indicators and predictive bioassays, identifies causative agents and explores the mechanisms by which chemical stressors exert deleterious effects on ecosystem health. This knowledge supports regulatory and monitoring activities of the Environmental Effects Monitoring programs under the *Fisheries Act,* chemical assessments under the *Canadian Environmental Protection Act* and contributes to Environment Canada's Ecosystem Initiatives. Combinations of field and laboratory studies link impaired ecosystem health to chemical exposure of aquatic biota. Field studies describe effects on biota. Laboratory studies establish cause-effect relationships, explore underlying mechanisms and develop biomarkers of exposure and effect.

ÉVALUATION DE L'ÉTAT DES ÉCOSYSTÈMES

RESPONSABLE: JIM SHERRY

Les activités humaines influent sur l'état des écosystèmes aquatiques du Canada. Ce projet vise à l'élaboration de stratégies et au développement d'instruments d'évaluation de l'état de ces écosystèmes et de diagnostics de leurs dysfonctionnements. Les travaux permettent de créer des indicateurs diagnostiques et de mettre au point des bioessais prédictifs, d'identifier les agents causaux et d'explorer les mécanismes par lesquels des facteurs de stress nuisent au bon état des écosystèmes. Les connaissances acquises servent à la mise en oeuvre d'activités réglementaires et de surveillance réalisées dans le cadre des programmes de surveillance des effets environnementaux aux termes de la *Loi sur les pêches,* et d'évaluations des produits chimiques aux



termes de la *Loi canadienne sur la protection de l'environnement.* Elles contribuent également aux initiatives sur les écosystèmes prioritaires d'Environnement Canada. Les combinaisons d'études en laboratoire et sur le terrain font ressortir les liens entre l'état des écosystèmes endommagés et l'exposition des biotes aquatiques à des composés chimiques. Les études réalisées sur le terrain décrivent les effets sur les biotes, tandis que les études en laboratoire font ressortir les relations de cause à effet, explorent les mécanismes sous-jacents et permettent de trouver des indicateurs d'une exposition et de ces effets.

IN VITRO AND ANTIBODY TECHNIQUES TO MEASURE SUBLETHAL RESPONSES OF AQUATIC ORGANISMS TO CHEMICAL STRESSORS

Study Leader Jim Sherry
Study Team Tina Hooey

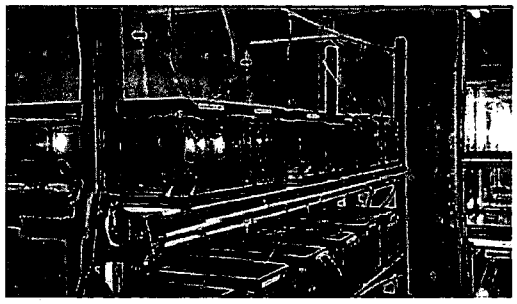
STUDY OBJECTIVES

Develop and characterize ELISAs for brook trout, cutthroat trout, and carp vitellogenin (Vg). Assess the ability of refinery and municipal effluents to induce Vg in fish and report on the sublethal effects. Assess the ability of pesticides used in PEI potato fields to caused anti-estrogenic and estrogenic effects in fish; the ability of bioassays to detect estrogenic responses in fish exposed to municipal waste waters and characterize the estrogenic potencies of various alkylphenol and alkylphenol ethoxylates. These goals will be achieved through collaboration with St. Mary's Paper (SSM), ULERN, Sault College, NWRI, AGRA (NB), and DOE Ontario region. The capability of water and sediment from contaminated harbours in Canada and Germany to cause endocrine disrupting effects in fish, will be investigated within an International collaboration.

RESULTS

Induction of the egg yolk precursor protein vitellogenin (Vg) in male or immature fish has emerged as an important indicator of exposure to environmental estrogens. NWRI scientist Dr. Sherry working with two University of Guelph Co-op. students (Robert Halford and Dax Torti) has run some interesting laboratory experiments that will help place Environment Canada's use of the Vg indicator on a sound scientific footing. The time course of Vg induction in juvenile rainbow trout injected with a single dose of 17ß-estradiol was investigated. The results show that Vg response peaked at 7-days but declined rapidly until little Vg was remained in the plasma after 21-days. Those results have serious implications for the use of estradiol primed fish to detect the presence of anti-estrogens in environmental waters. The results also suggest that the duration of the post exposure interval is likely to be important when assessing the response of fish to pulse doses of environmental estrogens. This is likely to occur in streams impacted by agricultural runoff. Estimates were made of the low dose response threshold for rainbow trout to 17ß-estradiol under flow through conditions in the laboratory. This study used a modern flow through bioassay unit based on microprocessor controlled pumps which was recently developed by this project. This bioassay unit is used to expose the trout to a series of low estradiol doses for 21-days. Plasma Vg levels indicate whether the fish respond to the applied doses. This experiment will indicate whether the duration of exposure can affect the ability of the test system to detect or respond to the low concentrations of estrogens likely to occur in environmental settings.

The bioassay unit technology was transferred to Dr. Servos for use in a flow through apparatus in the Wet Lab. for use in assessing the response of fish to various dilutions of alkylphenols and their carboxylates and ethoxylates. The laboratory bioassay and on-site flow-through components of the municipal effluent study was canceled because the main collaborators have decided that in the face of decreased resources it is more important to focus on the alkylphenol aspects of the study. The experiment will be undertaken at the earliest opportunity with additional collaborators. ELISAs were run on sample sets from fish exposed to hog farm impacted creeks and on fish caged downstream of Ontario Hog Farms and on fish caged close to potato fields in PEI. Summary data reports were prepared on samples from the hog farm and PEI the studies. So far, no



indication of Vg induction has been seen at hog farms or PEI potato fields.

DEVELOPMENT AND APPLICATION OF TOXICITY-IDENTIFICATION-EVALUATION (TIE) METHODOLOGIES

Study Leader Mark Hewitt

Study Team Lynne Luxon

STUDY OBJECTIVES

This study isolates and identifies substances associated with mixed function oxygenase (MFO) activity and endocrine disruption in tissues of fish exposed to pulp and paper effluent. Effluent extracts are prepared, and bioassay testing used to determine the estrogenic, androgenic and MFO activity of pulp mill effluents before

and after treatment. The study investigates bioactive chemicals in waste streams from chemical recovery condensates at bleached kraft mills. Chemicals associated with effects on circulating steroids in mummichogs (fish) are isolated and characterized from these streams. Investigations are made of the potential of hydrophobic residues in agricultural runoff from potato operations on PEI and in New Brunswick to affect endocrine function in fish. Method development studies are undertaken to quantify agrochemical residues in surface and groundwater in New Brunswick, and on polar, water soluble agrochemical residues in surface water for potential to affect endocrine function in fish.

RESULT

Extracts were prepared and fractionated from two different pulp mills and MFOs from exposed fish are complete. Fish livers were extracted, lipids removed and lipid free extracts fractionated. SPMD extracts from both mills were fractionated and the H4IIE results on liver fractions and SPMD fractions are complete.

Studies have been initiated to investigate bioactive chemicals in waste streams from chemical recovery condensates at a bleached kraft mill in Saint John NB. Reverse osmosis streams from the mill have been characterized according to extractable organics by full scan GC-MS and molecular weight distributions have been completed on each stream. Method development for extraction of bioactive components using solid phase extraction has been undertaken and evaluated prior to bioassay

testing using residues detected by HPLC. HPLC method development has been undertaken to analyze detectable extractives in reverse osmosis streams and

used to evaluate SPE method development. The first experiment coupled with bioassay testing with mummichog at UNBSJ has been initiated and results are pending.

Method development studies for a broad spectrum of pesticides associated with potato production in northern New Brunswick was initiated. Instrument methods for pesticides using GC-MS have been developed and instrument detection limits calculated. Extraction methods using different forms of SPE and elution regimes have been evaluated and an extraction method for large volumes of groundwater and surface water has been developed. This method will be used by Agriculture Canada personnel in the field for extraction of fresh samples and also for the evaluation of polar, water soluble pesticide residues, in runoff, to affect sex hormone binding.

ENVIRONMENTAL ENDOCRINE DISRUPTORS: ISOLATION AND IDENTIFICATION FOR BIOASSESSMENT

Study Leader Mohan Kohli

STUDY OBJECTIVES

To test several pulp mill effluents and various pulp wood extracts for Vg activity and isolate and separate a sterols mixture in order to test estrogenic activity in rainbow trout hepatocytes. Prepare quantities of chlorinated products of pinosylvins I, II, and III so that their structures can be established prior to study for MFO and Vg activity in exposed to fish.

RESULTS

Avenor-Bo and Espanola water tested positive for Vg activity in rainbow trout hepatocytes. The hexane, dichloromethane and acetone extracts from

several pulp wood species white cedar, black spruce, Scotch pine and balsam fir have already been tested for VG activity. Investigation of other wood species used in pulping industries for MFO and Vg induction. Jack pine,white pine, balsam fir, black spruce, poplar, cedar and hemlock were extracted . All these extracts were analysed by GC/MSD. Only white pine and jack pine revealed the presence of stilbenes, which are different in steriochemistry from the compounds isolated from scotch pine. The extracts from jack pine and white pine are currently investigated for MFO induction. In connection to the isolation of pterostilbene for the synthesis of compound "X" three crystalline products were isolated from Scotch pine. The sturcture of these products were confirmed as 3,5-dimetyoxystilbene, 3-hydroxy-5-methoxystilbene and 3,5-dihydroxystilbene by comparing with the synthesized compounds. All the isolated compounds demonstrated positive response in MFO and vitellogenin assays. The chlorinated derivatives of 3-hydroxy-5-methoxy gave higher values in MFO testing. A poster entitled "Isolation and identification of EROD/ vitellogenin inducers from several pulp wood species" was presented at the 27th Annual Aquatic Toxicity Workshop held in St. Jones.

Completed work on the distribution of toxaphene in Clay Lake sediment core samples. Completed work on distribution of toxaphene in Clay Lake sediment core samples. In all forty five samples were processed. All the extracts are currently being investigated for pesticides and PCBs.

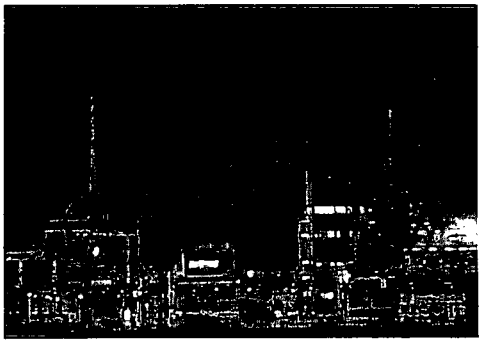
Several standards of beta-sitosterol in purity ranging from 45 to 99.7% were tested for vitellogenin activity. The concentration of beta-sitosterol tested was in the range 0.0001uM - 25mM. None of the standards tested positive for vitellogenin activity. in St.Jones.

ENDOCRINE DISRUPTORS

Study Leader Mark McMaster
Study Team Neil Jones

STUDY OBJECTIVES

The aim of this study is to Environment Canada's program on endocrine disruptors (EDSs) by expanding ability to examine these compounds, and by determining the extent to which EDSs alter the Canadian environment. Methodologies will be developed to assess cumulative effects using fish populations and by through support for the Environmental Effects Monitoring (EEM) programs for both the pulp and paper and mining sectors. Cumulative effects monitoring metrologies will be developed.



The laboratory will be expanded for hormone analysis and potential other measures of reproductive function. Collaborative studies will continue to examine waterways contaminated with agricultural runoff for evidence of endocrine disruption--intersex in fish and steroid reductions. Continuing studies will investigate the effects of pesticides used in the PEI potato industry and investigate the effects of hog farm operations in Southern Ontario, and the effects of sewage effluents.

RESULTS:

A manuscript entitled "An interlaboratory study on the use of steroid hormones in examining endocrine disruption" was submitted for internal review prior to submission to the Environmental Toxicology and Chemistry.

Methods development has continued for the investigation of the use of muscle samples for steroid measurements. Samples from the Moose River Basin and Jackfish Bay, Lake Superior, have been examined. Statistical analysis will determine whether muscle tissue, gonadal tissue or liver tissue is a better predictor of circulating levels of steroid hormones and whether muscle steroid levels will be a suitable predictor of reproductive fitness in small forage fish species.

FISH BIOASSAY DEVELOPMENT

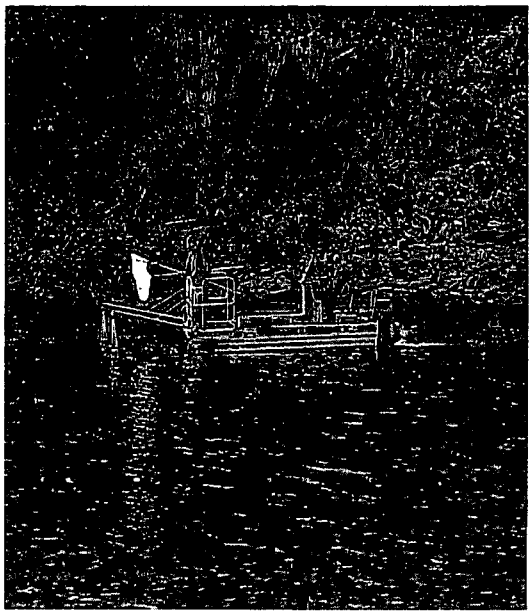
Study Leader J. Parrott
Study Team B. Blunt

STUDY OBJECTIVES

This study investigates the exposure of fish to pure compounds (estradiol, testosterone, nonyl phenol) and effluents to measure reproductive (age to maturity, sex ratio, time to breeding, # eggs) and endocrine effects (serum and gonadal estradiol and testosterone levels). Experiments aim to refine and shorten tests and endpoints for fathead minnow and modify exposure conditions to maximize sensitivity of detection endpoints in other test species.

RESULTS

The eggs will hatch in 5 days and the growth, development and reproductive maturity of the larvae will be assessed. A range of effluents, from 1 % to 100 % final effluent will be studied. Wild fish in the receiving environment are often exposed to the 1-10 % effluent range. This is the first on-site fathead minnow full life-cycle reproductive bioassay in Canada, and represents and ideal opportunity to assess this bioassay for ability to predict changes in wild fish, downstream of the pulp mill. In a lifecycle exposure to ethinyl estradiol study, over three thousand fathead minnow eggs were hatched in a flow through system under exposures to different concentrations of a model synthetic estrogen, ethinyl estradiol (EE). Environmentally significant concentrations were tested, ranging from 0.32,1.0, 3.2, 10, 32 ng/L. Fish were sampled at 8, 15, 30 and 60 days, and will be followed until maturity at 120 days The results to date show feminization of the fish at 60 days, with most fish in the 10 and 32 ng/L treatments having ovipositors (while none have developed at this point in control fish). The goal of the study is to assess the effects of a known estrogen on the fathead minnows in the lifecycle bioassay, and to determine if responses seen at earlier lifestages (shorter exposures) are predictive of long term reproductive effects in the fish.



The fathead minnow was used in lifecycle studies of fish exposure to bleached sulphite mill effluent. In this case over four thousand fathead minnow eggs were counted into small beakers to begin a 120 day exposure to bleached sulphite effluent on site at the mill in Edmundston NB. The 5-month long study is the second in a collaborative research agreement between NWRI and Nexfor Forest and environmental staff at the mill in Edmundston NB, to assess the potential of the mill's final effluent for causing reproductive changes in fish exposed for a whole lifecycle. The eggs successfully hatched, and the larvae will be followed in their growth, development and reproductive maturity. Exposures cover the range from 1 % effluent to 100 % final effluent, with the 1-10 % range being realistic for exposures of wild fish in the receiving environment. This

is the first on-site fathead minnow full life-cycle reproductive bioassay in Canada, and represents and ideal opportunity to assess this fish bioassay for ability to predict changes seen in wild fish downstream of the pulp mill.

Current NWRI research was presented to the US Environmental Protection Agency, at an EPA-EC Meeting on Chronic Toxicity of Pulp and Paper Mill Effluents. The meeting was arranged at the request of EPA, who wanted an update on EC's current research into the effects of pulp and paper effluents, and into the potential causative compounds and mill processes. Current USEPA regulations are based largely on chemical limits, standard lab toxicity assays, and the implementation of best available technology. The NWRI team discussed Canadian approaches to monitoring pulp mill receiving environments (such as the EEM program), as well as current and future research into fish health effects and the interpretation of environmental data. The meeting provided an opportunity to showcase some of NWRI's leading research in this area and to identify potential areas EPA may consider in future for promising regulatory or monitoring approaches.

BIOTECHNOLOGY

Study Leader T. Edge

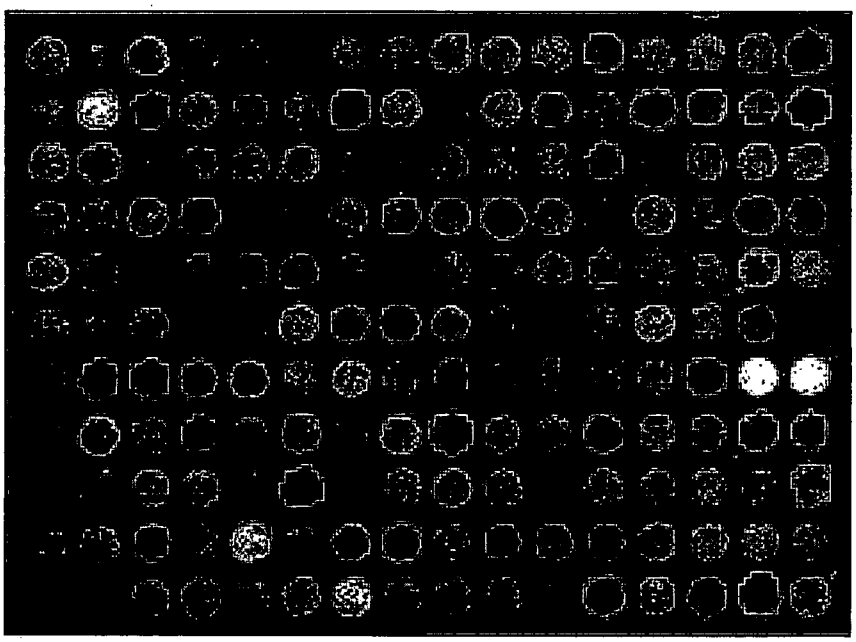
This is a new study. It investigates the sources and occurrence of waterborne pathogens and microbial GMOs/biotechnology products in aquatic ecosystems. It also investigates the potential of these organisms to pose threats to water quality. The Study goals are to: 1) understand the importance of different sources of fecal pollution in aquatic ecosystems; and 2) develop methods to detect waterborne pathogens, microbial GMOs and other biotechnology products in aquatic ecosystems and to better understand their occurrence and potential threats to water quality. Dr. Tom Edge of the Ecosystem Health Assessment Project, AEPRB-NWRI recently convened a meeting of scientists in order to make preparations for field trials this summer using a genetically modified bacterium. These preparations are part of a three-year Canadian Biotechnology Strategy project with federal and university partners to develop a laboratory test method for predicting the fate of genetically modified microorganisms and their introduced genes in soil. The project will compare the survival and associated gene transfer events for a genetically modified bacterium between laboratory microcosms and a series of $1m^2$ outdoor field plots at the Universities of Saskatchewan, Carleton and McGill. Dr. Jim Germida of the University of Saskatchewan, will submit a CEPA notification in February, and the field trials will proceed only after the 90 day Environment Canada/ Health Canada review is completed

EFFECTS OF ENVIRONMENTAL CONTAMINANTS ON THE IMMUNE SYSTEM OF FISH

STUDY LEADER Norman F. Neumann

This is a new study. Anthropogenic contaminants have the potential to modulate the immune system of vertebrates, which may lead to increased susceptibility to infectious disease. The innate immune system is essential in host defense, and is instrumental in modulating effective immunity against infectious and neoplastic disease. Experiments will focus on determining what effects contaminants have on modulating the activity of macrophages in vertebrates. Macrophages represent a first line of defense against invasive pathogens and tumors, and play key roles in initiating subsequent immune reactions (i.e., antibody production) in vertebrates. As chairperson of a workshop designed to assess the impact of developing molecular tools (i.e. genomics, proteomics, etc.) for assessing ecosystem health at NWRI, Dr. Neumann has been instrumental in outfitting NWRI to use the tools of biotechnology for environmental assessment.

Since the advent of microarray technology in 1995, the miniature research tool has increasingly become an indispensable technology in a growing number of labs throughout the world, and Canada is no exception. Microarrays - thousands of DNA targets attached to microscope slides or membrane filters -allow researchers to detect and monitor thousands of genes from a tiny sample simultaneously, analyse the expression of those genes (looking at the normal versus the altered), identify potential drug targets and predict side effects. In recent years an increasing number of Canadian laboratories have begun to appreciate and enthusiastically welcome the benefits of microarrays -also biotechnology core facility that would provide scientists with access to microarrays and the equipment to produce and read the chips.



A gene microarray.

PRIORITY SUBSTANCES EFFECTS PROJECT

PROJECT CHIEF: SCOTT BROWN

The Project provides essential scientific information on the effects of priority substances on aquatic organisms in support of departmental hazard and risk assessments, and risk management activities. Environment Canada uses this knowledge to make decisions under various initiatives including the Toxic Substances Management Policy, the *Canadian Environmental Protection Act*, the *Pest Control Products Act*, Priority Ecosystems Initiatives (for example, Great Lakes Basin 2020) and Environmental Effects Monitoring for mining. The Project accomplishes its goals by developing and applying techniques to assess priority substances and effluents for their potential to cause impacts on the survival, growth, development and reproduction of aquatic biota, and by investigating fundamental mechanisms governing the effects and exposure to toxic chemicals in aquatic ecosystems. Current activities include determining effects of priority substances on the reproduction and development of fishes; development and application of predictive methodologies to support rapid assessment of chemicals and priority substances; interactions between biofilm communities and nutrients/toxics; effects of GMOs on aquatic systems; effects of water chemistry on metal toxicity and accumulation in invertebrates; and investigating the environmental impacts and fate of high priority substances such as nonylphenol, endocrine-disrupting substances, metal mixtures and road salts.

EFFETS DES SUBSTANCES D'INTÉRÊT PRIORITAIRE

RESPONSABLE: SCOTT BROWN

Ce projet permet d'obtenir d'importants renseignements scientifiques sur les effets des substances d'intérêt prioritaire sur les organismes aquatiques, renseignements que le Ministère utilise dans ses évaluations des risques et des dangers et dans ses activités de gestion du risque. Environnement Canada applique ces connaissances dans ses prises de décisions effectuées dans le cadre de diverses initiatives, notamment: la Politique de gestion des substances toxiques, la *Loi canadienne sur la protection de l'environnement*, la *Loi sur les produits antiparasitaires*, et les initiatives concernant les écosystèmes prioritaires (p. ex. Grands Lacs 2020, l'Initiative de l'écosystème du bassin de Géorgie). Pour atteindre les objectifs de ce projet, on élabore et applique des techniques permettant de déterminer les effets potentiels des substances d'intérêt prioritaire et des effluents sur la survie, la croissance, le développement et la reproduction des organismes aquatiques, et on étudie les mécanismes fondamentaux régissant la persistance et le devenir des substances chimiques toxiques dans les écosystèmes aquatiques.

Au nombre des activités en cours, on compte la détermination des effets des produits chimiques sur la reproduction et le développement des poissons, l'étude de la biodiversité des écosystèmes aquatiques, l'établissement de relations entre structure et activité au moyen de réseaux neuronaux et de méthodes d'intelligence artificielle connexes permettant une évaluation chimique rapide, et l'étude des impacts environnementaux, de la persistance et du devenir des substances chimiques d'intérêt hautement prioritaire, comme le nonylphénol, les substances perturbatrices des systèmes endocriniens, les sels de voirie et les hydrocarbures aromatiques polycycliques.

ENVIRONMENTAL TOXICOLOGY OF PRIORITY SUBSTANCES AND EFFLUENTS

Study Leader Scott Brown
Study Team Maria Villella
Mitra Brown

STUDY OBJECTIVES

The Study investigates the toxicological mechanisms of deleterious substances on fish growth, reproduction and development in support of departmental hazard and risk assessments, and risk management activities. The study develops new techniques to identify and monitor endocrine modulating capability, responses and effects of priority substances and effluents in aquatic biota.

RESULTS

We continued investigations, with EC, OGD and university partners, on the adverse effects of priority effluents and their bio-active components on processes essential for reproductive competence,

growth, development in fishes. Year II studies for TSRI Project 173 examining the potential for environmental xenoestrogens (e.g. nonylphenol) and natural estrogens/androgens to affect development (smoltification), growth and sea water survival of Atlantic salmon were completed. Results showed that there are critical windows for exposure and that the threshold for effects is about 4 µg NP/L. Field experiments indicated that certain natural river waters are also capable of impairing sea water growth in a portion of exposed fish similar to laboratory treatments with nonylphenol or estrogens. Altered thyroid status was associated with impaired growth in smolts exposed to estrogen, nonylphenol and natural effluents.

As part of new multidisciplinary Environment Canada research planning committee developed draft study plans for ecosystem health assessments in Great Lakes Areas of Concern (AOC). We evaluated thyroid hormone status in fish collected at Jackfish Bay, AOC and collected samples to assess thyroid status in Lake Ontario salmonids from the Credit River and Port Weller. With university and DFO partners we completed analyses on the potential interactions among micronutrients, thyroid hormones, organochlorine contaminants and reproductive success of walleye from the Bay of Quinte, AOC (TSRI Project 315).

Derek Alsop, a Guelph Ph.D. Student who is working with Dr. Brown, has developed an assay capable of screening/monitoring effects of environmental contaminants and endogenous factors on retinoic acid signaling. Preliminary results, using this assay, suggest that factors in pulp mill effluent may influence retinoid receptor binding.

We continued investigations on low-dose chemically-induced reproductive and developmental disorders in fishes from the Great Lakes. Early-life stage mortality in salmonids and other species is a concern because it represents a serious impediment to the restoration and maintenance of sustainable populations of salmonids and possibly other species in the lower Great Lakes. The project closely liaises with researchers from other governmental departments (USGS, DFO) and state/provincial agencies (Michigan and Wisconsin DNR, Ontario MNR). Study results confirm that high dietary proportions of thiaminase containing alewife contribute to EMS in predatory fishes in the Great Lakes. Future investigations will determine the potential of EMS and low levels of contaminants to impair early-life stage behavior and locomotion. As Task Leader for EMS, Dr. Brown organized a fall basin-wide EMS Research Coordination Meeting in Ann Arbor.

LC-GC-MS Identification of Toxic Substances

Study Leader Don Bennie
Study Team Cheryl Sullivan

Study Objectives

This study contributes to investigations of the fate and effects of endocrine disrupting substances (EDS) on seawater adaptability, growth, and survival of salmon, and the environmental fate of EDSs (such as alkylphenolics and human hormones) and pharmaceutical substances in municipal sewage treatment effluents. Knowledge generated is used by Environment Canada to make informed decisions under the Canadian Environmental Assessment Act, the Toxic Substances Management Policy and various Great Lakes ecosytems initiatives.

Results

Experiments were conducted to determine thresholds for effects at St. Andrews Biological Station where Atlantic salmon smolts were exposed to environmentally relevant doses of low levels of water-borne 4-NP and to sustained doses of estradiol (E2). Significant uptake of 4-NP in the harvested smolt tissues was confirmed. Field work was conducted on the Miramichi River in New Brunswick to ascertain the levels of alkylphenolic substances discharged from sewage treatment plants and pulp mills to which Atlantic salmon parr-smolts might be exposed. Chemical analysis on 1999 field samples was completed and work on 2000 samples is ongoing. Low levels of 4-NP, nonylphenol ethoxylate and nonylphenol diethoxylate were detected at each site on the Miramichi. This study addresses

research needs identified for the CEPA PSL 2 assessment of nonylphenol and its ethoxylates as well as departmental issues regarding EDS.

Involvement continued in the CEPA PSL2 assessment of nonylphenol and its ethoxylates. The assessment is complete and available for viewing at http://www.ec.gc.ca/cceb1/eng/public/npe_e

.html. The final version has been submitted to the Minister's office for approval.

The final report on the characterization of sewage treatment plants and industrial sites for the occurrence, fate and release of endocrine disrupting substances in eastern Canada was been completed. It is expected that three papers will be written using this data and data from two earlier sewage treatment plant survey reports. A report on the environmental fate of nonylphenolic compounds in sludge-amended agricultural soil was completed and submitted for publication. It was found that alkylphenolic substances in agricultural soil plots at the University of Guelph, Elora Research Station that were amended with municipal anaerobically digested sewage sludge tend to diminish to non-detectable levels within 90 days. These studies address research needs identified for the CEPA PSL 2 assessment of nonylphenol and its ethoxylates as well as departmental EDS issues.

Analytical expertise was and continues to be provided to CWS in studies of the impact of alkylphenols on bird reproduction. A number of samples of sediments, bird livers and insects were received from C. Bishop of CWS and E. Birmingham of Simon Fraser University and analyzed for 4-nonylphenol.

New studies on the occurrence, fate and effects of pharmaceuticals and personal care products were initiated during the past year. These included a study to determine the potential environmental implications of continued low level releases of pharmaceutical ingredients and chemical ingredients in cosmetics and personal care products, to the Canadian environment.

DEVELOPMENT AND APPLICATION OF TOXIC EFFECT PREDICTION METHODS FOR DSL AND NDSL SUBSTANCES

Study Leader K. Kaiser
Study Team V. Palabrica

STUDY OBJECTIVES

To provide new knowledge for the protection of environmental health in Canada, through application of the Probabilistic Neural Network methodology to predict toxicity.

RESULTS

Neural network and related methodologies are rapidly becoming mainstream in the QSAR field for the prediction of environmental properties and effects of the ~75,000 substances in commerce. As strongly stated by several authors from Germany, Russia and elsewhere, artificial neural networks must not be considered as "black boxes" but as useful tools with clear mathematical algorithms and rules. Recent advances in the field allow the use of relatively simple molecular structure fragment indicators or enumerators to provide the input for the modelling of large, non-congeneric data sets and the successful prediction of properties of compounds which cannot be handled by other methods.

Application of the recently developed Probabilistic Neural Network methodology for the prediction of toxicity values to aquatic species continued with the computation of acute fish toxicity values for over 1,000 substances on the Canadian Domestic Substances List (DSL), as specified by the Commercial Chemicals Evaluation Branch (CCEB). There are over 20,000 substances

on the DSL and most of them lack any measured ecotoxicity data. These substances include potential new pesticides, their precursors and metabolites. The ability of several prediction methods were evaluated by an independent panel, and the probabilistic neural network methodology (PNN) developed and applied here was shown to have by far the best overall performance.

Building on our earlier work on fathead minnow (*Pimephales promelas*) and bacteria (*Vibrio fischeri*), research continued on the development and application of the Probabilistic Neural Network (PNN) methodology to model the effects of chemicals on other important aquatic test species. Significant progress was achieved by developing models with excellent prediction capabilities for the acute toxicity of chemicals to the waterflea *Daphnia magna* and the ciliate *Tetrahymena pyriformis*. These models have been developed on the basis of several hundreds of training compounds and have been cross-validated with independent test chemicals. Therefore, these models allow the prediction of the effects of other chemicals in these domains with great confidence. This new capability will be helpful in the assessment of those substances for which there are little or no measured toxicity data available.

ROLES OF ATTACHED MICROBIAL POPULATIONS AND COMMUNITIES IN THE FATE OF TOXIC SUBSTANCES

Study Leader John R. Lawrence
Study Team George D.W. Swerhone

STUDY OBJECTIVES

This study aims to understand the role of microbial biofilms and their polymers in the sorption, metabolism and biotransfer of pharmaceuticals, herbicides and metals, and assess the impacts of nutrients and contaminants on the development and functioning of biofilm communities. Study results are relevant to on-going programs like TSRI, STAGE and EMBRR and contribute to departmental goals related to toxic substances management.

RESULTS

Biofilms often represent the preferred mode of growth for bacteria in many environments. The interactions between river biofilm communities, and dissolved oxygen, nutrients and toxics was explored. Microcosms were designed and applied for the assessment of environmental impacts on attached microbial communities from the South Saskatchewan River. In particular the impact of stressors on the population structure and the EPS components of these systems was evaluated. Research focused on the application of novel techniques including, confocal laser microscopy (CSLM) contaminant specific antibody techniques, rRNA oligonucleotide probes, fluor-conjugated molecular probes and microelectrodes for the study of fate and effects of various stressors on biofilm communities.

A pilot study on the effects of oxygen depletion and nutrients on river biofilm development and degradation of selected pesticides and hydrocarbons has been completed (TSRI). Samples have been submitted to collaborators for further molecular analyses, metabolic capability analyses and fatty acid methyl esters.

Analysis of the effects of oxygen on

the composition of EPS, degradation of contaminants and sorption of contaminants has been completed. Significant changes in river biofilm polymers and community structure were observed and favoured sorption of heavy metals. (TSRI project).

In an investigation of pharmaceuticals in the environment, research indicated that the pharmaceutical, clofibric acid was present in treated sewage in Saskatoon, SK, whereas ibuprofen was not detected in treated sewage, neither compound was found in the river environment. Mesocosm studies indicated that clofibric acid did not degrade in South Saskatchewan river-water or biofilms. In contrast ibuprofen was microbiologically degraded, however, there was preferential degradation of the non-pharmacologically active isomer, indicating potential for accumulation of the pharmacologically active isomer in the environment. This research is particularly relevant to new knowledge on the fate and effects of toxics in Canadian aquatic ecosystems.

Metabolic and genetic signatures (DGGE/Gene Arrays) are to be assessed for the characterization of the impacts of toxics on microbial community structure of aquatic ecosystems. Although bacteria are ubiquitous in nature and among the most important components of functioning ecosystems estimates of taxonomic and functional diversity of microorganisms within communities has proven difficult. The first objective of this research is to determine whether there are carbon utilization patterns, denaturing gradient gel electrophoresis (DDGE) and fatty acid methyl ester profiles that result in "signatures" which can be detected and unambiguously interpreted for determination of the diversity of a bacterial community. The second objective is to carry out an evaluation project using these techniques and more traditional approaches using a model microbial community, and lotic biofilm communities. The impact of complex or single stressors such as PME, sewage and selected toxics are also assessed in this way.

Genomics research from this group was featured in Environmental Science and Technology. An article appeared recently in Environmental Science and Technology featuring special coverage of genomics based research in the environmental sciences. NWRI scientist, John R. Lawrence and co-investigator Charles, W. Greer of the Biotechnology Research Institute of the National Research Council were interviewed regarding their STAGE funded research on the development and application of DNA microarrays for environmental monitoring. The application of DNA microarrays offers the possibility of characterizing microbial communities based on the detection of genes for specific functions and ultimately detecting whether genes are being expressed under specific conditions. Application of these techniques may lead to significant changes in the assessment of environmental stresses and environmental monitoring

A variety of sample types have been collected, extracted for DNA microarray testing. A contractor D. Juck has been hired to assess data banks for sequences as part of the ECO-array development.

FATE AND EFFECT OF CONTAMINANTS ON THE AQUATIC ECOSYSTEM

Study Leader Tanya Mayer

STUDY OBJECTIVES

The study conducts research on contaminant and nutrient dynamics in wetlands, to improve the understanding of the effects of contaminants on the health and sustainability of natural wetlands and to assess the effectiveness of constructed wetlands to mitigate toxicity of surface runoff. Collaborative research is undertaken to determine the effect of urban contaminants such as road salts, heavy metals and PAHs on wetlands. The expertise generated from this research has contributed to the CEPA PSL-2 Assessment of the Priority Substance "Road Salts".

RESULTS

Research related to the scientific assessment of the CEPA Priority Substance "Road Salts" was completed. The five year scientific assessment, released in a form of the Assessment Report proposed to declare "Road Salts" to be CEPA toxic. The contribution to the Assessment Report was the chapter dealing with the concentrations of inorganic salts in Canadian surface waters, which was based on the paper published last fiscal year by Mayer, Snodgrass and Morin.

Research was carried out on the effects of priority substances on wetlands, including both natural and constructed wetlands. From a biodiversity perspective, wetlands are important ecosystems as they provide habitat for a broad variety of fauna and flora. Adverse effects of priority substances on wetlands have profound impacts on biota which use them as habitat. Sampling of constructed wetlands in the Greater Toronto Area (GTA) was carried out to increase the understanding of chemical transformation processes which affect the toxicity and bioavailability of broad range of substances including heavy metals. Biogeochemical transformations such as complexation of inorganic salts with heavy metals, methylation and other processes alter solubility of toxic metals, often increasing their bioavailability and toxicity. This increases the contaminant exposure to the biota for which these facilities function as habitats. The preliminary results show

elevated concentrations of inorganic salts and anoxic conditions in bottom waters of deep (>3 m) detention ponds. These conditions resulted in release of ammonium-N, and are favorable to release of heavy metals from sediments. Studies on the biogeochemistry of prairie wetlands at St. Denis National Wildlife Area, SK, forms an ongoing investigation in which the groundwater-surface water interaction and solute transport are investigated. An improved sampling device for interstitial water (peeper) for wetland application was constructed and tested.

METAL BIOACCUMULATION AND TOXICITY IN INVERTEBRATES

Study Leader U. Borgmann

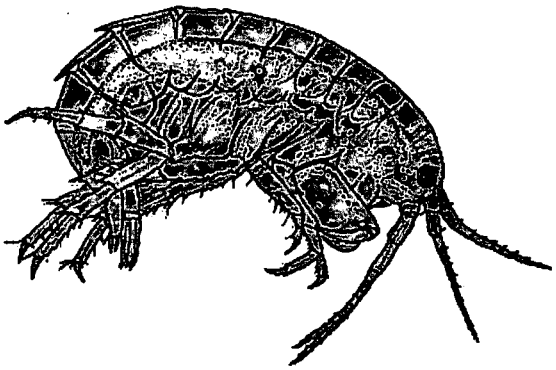
Study Team W.P. Norwood

STUDY OBJECTIVES

This study determines the biological impact, including bioavailability, toxicity and bioaccumulation, of metals, particularly those emitted by smelters.

RESULTS

Dr. Borgmann provides expertise to the Science Steering Committee of the Metals In The Environment Research Network (MITE-RN) and the MITE-RN Ecological Risk Assessment. He presented an overview to the MITE-RN ERA team which highlighted recent NWRI research on biological effects in lakes near the Sudbury smelters and demonstrated how metal impacts can be quantified and the metal(s) responsible for adverse biological effects identified. Contributions were made to the management of the Metals in the Environment Research Network, CEPA review of copper and zinc smelter and refinery emissions, and the development of EEM monitoring protocols. Quantification was made of bioavailable nickel in sediments and toxic thresholds to Hyalella azteca. This study demonstrates that Ni toxicity in sediments is variable and that toxicity is a function of bioaccumulation. The critical body concentration for Ni was determined to allow quantification of the possible role of Ni in sediment toxicity in other studies. These studies provide a better ability to predict metal impacts in the environment as a function of water chemistry and metal-metal interactions. This is evidenced by the use of Hyalella azteca in the biological impact studies of TBT, which are discussed later in this report.



Dr. Borgmann was invited to join the Intergovernmental Ecotoxicology Testing Group, which reviews biological test methods and recommends standard test procedures.

Bioavailability measurements and data analysis were completed on 1999 core samples from Richard Lake, near Sudbury, Ontario. The toxicity and bioaccumulation of As, Co, Cr, and Mn were assessed in preparation for mixture tests with As, Cd, Co, Cr, Cu, Ni, Mn, Pb, Tl and Zn presented together in a 10 metal mixture. Metal bioavailability and toxicity was assessed in sediments from lakes near Rouyn-Noranda and those causing toxicity identified. This study is part of EC's contribution to the MITE Research Network and describes metal toxicity and bioavailability in sediment samples collected by EC and NRCan near the Rouyn-Noranda smelters. Results show that Cd is responsible for toxicity in Lake Dufault sediments.

ECOLOGICAL RISK OF GMOS ON AQUATIC AND AGRO-ECOSYSTEMS

Study Leader Bin Zhu

STUDY OBJECTIVES

This study investigates the movement of an insecticidal gene (encoding for Bt toxin) and an "in vivo marker" (green fluorescence protein) transgene from canola (*Brassica napus*) into two closely related wild plant species (*Brassica rapa* and *Raphanus raphanistrum*). The purpose is to examine the ecological risk effects of insect resistance after transgenes have been introgressed into two wild plant species in terrestrial and aquatic ecosystems.

RESULTS

Studies were conducted in collaboration with EC, AAFC and university partners to determine the possibilities of transfer and introgression of transgenes (Bt and GFP) from transgenic canola into two wild plant species, wild Brassica rapa and wild radish (two important weeds in Canada). We used molecular techniques to detect transgenes (PCR, southern blot, AFLP). For hybrid identification we developed reliable protocols using different techniques such as PCR amplification, Ploidy analysis, and Bt-ELISA. We obtained hybrids between wild Brassica rapa and transgenic canola through manual cross, pair-cross in greenhouse and field trials. Hybrid rate in the greenhouse was over 80% and was 5-15% in field trials when transgenic herbicide canola was used as pollen donor.

Over 4000 seeds from pair-cross and field experiments have been screened and no hybrids observed. Consistent with observations by others, these results show that transgene flow between wild radish and transgenic canola was rare under field conditions. However, screening more seeds from manual crosses is ongoing and we do observe suspected hybrids when we used transgenic herbicide canola as a pollen donor.

We undertook a study of transgene genetic behavior in wild Brassica rapa population to determine the incorporation of transgenes into the wild rapa genome. F1, BC1 (backcross), BC2, BC3, BC4 have been developed or are under development. Results showed that as early as in the BC1 population, transgenes from transgenic canola could be introgressed into the wild rapa genome and that the transgene follows normal inheritance behavior in wild rapa.

In collaboration with AAFC partners, we investigated insect control by Bt toxin after the Bt transgene was transferred into wild Brassica rapa. If the transgene was present in wild rapa plants such as in F1 and BC1 population, there was 100% mortality of Diamondback moth larvae showing that Bt toxin was also effective on controlling this insect in wild plant population. Investigations on the development of insect resistance to Bt toxin are continuing.

Studies about the environmental effects of transgene incorporation in wild rapa are underway. We are using the BC2 population to investigate the advantage (fitness increase) for BC2 population containing Bt toxin transgene under pressure by certain insects. Future studies will determine the potential ecological effects of the fitness-enhancing transgenes when incorporated in wild plant populations.

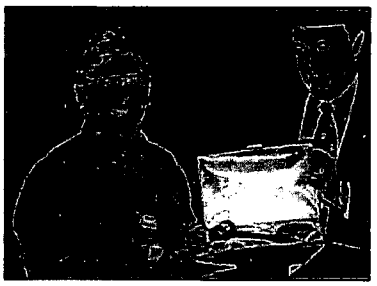
We proposed new research about the effects of Bt toxin released by roots of transgenic canola. Preliminary results show that Bt toxin was present in root exudates released by transgenic canola through Bt-ELISA testing of rhizosphere soil from Bt canola plants. Future investigations will be conducted to verify current findings, develop a reliable protocol of Bt toxin detection and to assess potential adverse ecological effects, such as impacts on biodiversity of microorganisms and change of gene expression patterns (microarray) in aquatic and terrestrial ecosystems.

PRIORITY SUBSTANCES EXPOSURE PROJECT

PROJECT CHIEF: MARK SERVOS

The Project provides important scientific information on the effects of priority substances on aquatic organisms in support of Departmental hazard and risk assessments, and risk management activities. This knowledge is used by Environment Canada to make decisions under the Toxic Substances Management Policy, the Canadian Environmental Protection Act, the Pest Control Products Act and Priority Ecosystems Initiatives (*e.g.*, Great Lakes 2000, Georgia Basin Ecosystem Initiative). The Project accomplishes its goals by researching fundamental mechanisms governing the exposure of organisms to toxic chemicals. Dose-response relationships and environmental impacts are established by identifying active components in complex mixtures, and determining the persistence, fate and bioavailability of toxic chemicals in aquatic ecosystems.

Current activities focus on determining the exposure to aquatic organisms and the impacts of priority substances and potential endocrine-disrupting substances (EDSs) such as alkylphenols, tributyltin, natural and synthetic estrogens, municipal effluents, agricultural and urban runoff. Analytical methods are developed and applied to assess the environmental occurrence, persistence and fate of high priority chemicals such as explosives, amines used in natural gas plants and new agricultural chemicals and antifouling pesticides.



Dr. Mark R. Servos, *Project Chief, became President of the Society of Environmental Toxicology and Chemistry (SETAC) during the Annual Meeting of the Society. SETAC is an international non-profit Society representing almost 6000 members from academia, government and industry worldwide. It is committed to providing a forum for the discussion and debate of scientific issues related to environmental toxicology, and chemistry as well as the application of science for environmental assessment and management.*

EXPOSITION AUX SUBSTANCES D'INTÉRÊT PRIORITAIRE

RESPONSABLE : MARK SERVOS

Ce projet permet d'obtenir d'importants renseignements scientifiques sur les effets des substances d'intérêt prioritaire sur les organismes aquatiques, renseignements que le Ministère utilise dans ses évaluations des risques et des dangers et dans ses activités de gestion du risque. Environnement Canada applique ces connaissances dans ses prises de décisions effectuées dans le cadre de diverses initiatives, notamment : la Politique de gestion des substances toxiques, la *Loi canadienne sur la protection de l'environnement*, la *Loi sur les produits antiparasitaires*, et les initiatives concernant les écosystèmes prioritaires (p. ex. Grands Lacs 2000, l'Initiative de l'écosystème du bassin de Géorgie). Pour atteindre les objectifs de ce projet, on s'efforce d'élucider les mécanismes fondamentaux régissant l'exposition des organismes aux substances chimiques toxiques. On établit des relations dose-réponse ainsi que les impacts environnementaux en identifiant les composantes actives de mélanges complexes, et en déterminant la persistance, le devenir et la biodisponibilité des toxiques chimiques dans les écosystèmes aquatiques.

Les activités en cours sont centrées sur la détermination de l'exposition des organismes aquatiques et des impacts des substances d'intérêt prioritaire et des substances perturbatrices des systèmes endocriniens (SPSE) potentielles, comme les alkylphénols, le tributylétain, les oestrogènes naturels et synthétiques, les effluents municipaux, et les eaux du ruissellement agricole et urbain. Aussi, on élabore et applique des méthodes analytiques permettant d'évaluer la distribution, la persistance et le devenir dans l'environnement de substances d'intérêt hautement prioritaire comme les explosifs, les amines utilisées dans les installations de traitement de gaz naturel et les nouveaux produits chimiques agricoles et pesticides antisalissures.

EXPOSURE OF PRIORITY SUBSTANCES IN THE ENVIRONMENT

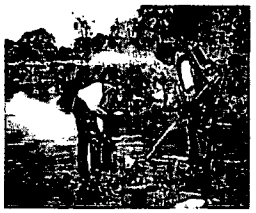
Study Leader M. Servos

Study Team A. Jurkovic

R. McInnis

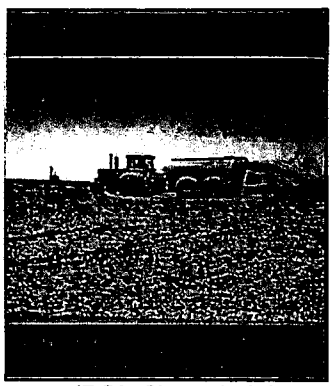
STUDY OBJECTIVES

With partners from NWRI and from the university and private sectors, field and laboratory studies on the exposure and effects of priority substances, particularly endocrine disrupting chemicals (e.g., natural and synthetic estrogens, alkylphenols, agricultural runoff and pesticides) are conducted in support of CEPA, CCME, Canada-Ontario Agreement and GL2020. Research, expertise and leadership were contributed to several departmental initiatives, committees and working groups including: EEM, CEPA (e.g. PSL-2 Nonylphenol and Its Ethoxylates risk assessment), Environment Canada and 5-NR Working Groups on endocrine disrupting substances.



RESULTS

Research was completed in support of the Nonylphenol and Its Ethoxylates risk assessment (PSL-2) and risk management process. Alkylphenol polyethoxylates (APE) and their metabolites, have been identified as trace contaminants in municipal and industrial effluents around the world. Studies demonstrated that municipal treatment plants effectively degrade alkylphenol polyethoxylates but significant amounts are still released in final effluents and sludges in Canada. The relative composition of APE metabolites in final effluent is dependent on many factors including type and degree of treatment. Most of the release in treated effluents is as nonylphenol polyethoxycarboxylates or nonylphenol that are potentially estrogenic chemicals. The PSL-2 risk assessment of nonylphenol and its ethoxylates was used as a case study to demonstrate the source and magnitude of some of the uncertainties associated with endocrine disruption. Using endocrine responses can lead to different conclusions than traditional endpoints due to a variety of factors such as differences in relative potencies for specific responses. Dr. Servos discussed this issue in his invited plenary speech at the Endocrine Disruptors and Pharmaceutically Active Chemicals in Drinking Water Workshop that was held this April in Chicago. These conclusions were also reported in the NPE risk assessment and associated scientific papers.



Potential adverse impacts of substances in the environment that act on endocrine systems of organisms are a high profile issue in Canada. Substances suspected of having endocrine disruption capability include a wide variety of chemical classes and mixtures, and have implications for many activities and programs in the federal government. Although reproduction and development have been, and continue to be, a major endpoint for environmental

and human health assessments in federal programs the EDS issue has heightened the concerns for detecting subtle effects on endocrine systems. Inasmuch as many international activities are directly influencing Canadian programs and public perception of this issue the federal government (5NR EDS Working Group) held a workshop, chaired by Mark Servos, in the spring of 2000, to address the key issues related to assessing the risk of EDSs to Canadians and the Canadian environment. The major recent research findings, and implications for risk assessment and management were reviewed and major knowledge gaps leading to uncertainties in scientific assessments were identified. A special issue of the Water Quality Research Journal of Canada, edited by Dr. Servos is dedicated to the review of EDS in the Canadian environment and the conclusions and recommendations of the 5-NR workshop. Considering the outcome of the workshop and further consultation, a National Agenda for the scientific assessment of endocrine disrupting substances in the Canadian environment was developed.

The potential exposure and effects of endocrine disrupting substances in municipal effluents were evaluated at several sites in south west Ontario. Exposures of immature trout to the effluents in streams or in the laboratory showed the potential of municipal effluents to cause estrogenic responses. However, this response quickly disappears downstream with dilution. Estrogenic responses are associated with exposure to natural and synthetic estrogens as well as a variety of other chemicals such as alkylphenols. Although the natural estrogens are found at much lower concentrations than many other substances such as alkylphenols or Bisphenol-A, they have much higher affinity with the estrogen receptor, and therefore contribute to the estrogenic responses observed in the effluents. Adult fish were collected, downstream of municipal effluent outfalls where there is documented

estrogenic response, for the examination of the potential intersex condition. Although municipal effluents in Canada contain numerous potential endocrine disruptors, the effects are not expected to be widespread except where effluent is poorly treated or dilution is minimal.

To address if animal wastes resulting from intensive agricultural operations are capable of entering waterways and exposing fish to estrogenic compounds a detailed study was conducted at several sites in south west Ontario. Estrogenic compounds were measured in the manure and tile drainage at several sites. A field study was designed to examine the runoff and potential exposure of fish to estrogens (natural estrogens and equol) in runoff. The site selected was a farm with approximately 1000 sows that had previously been shown to have the high estrogenic content. Samples of manure, soil, tile drainage and stream water were taken after the application of approximately 6,000 gal/acre of manure to fields from which tile drainage enters the stream directly. Samples were collected immediately after the manure applications as well as after major rainfall events. Samples were examined specifically for 17β -estradiol, estrone and equol using GC/MSD and EIA methods, and extracts were also assayed using the YES system. Immature rainbow trout were caged for three weeks in the streams immediately above and below the fields and plasma was assayed for estrogenic responses. Water quality, including fecal coliform, was determined for all water and tile drainage to document the exposure to manure. Estrogenic responses were observed in the tile drains immediately after application but declined rapidly until the first rainfall event. The phytoestrogen,

equol, was found in high concentrations in tile and river water immediately after application and also declined rapidly. Only during the initial peak, immediately after application were natural estrogens, 17β-estradiol and estrone, detectable in tile water. The first post-rainfall sample was elevated three-fold over the previous sample in the tiles.

XENOESTROGENIC SCREENING PROCEDURE TO IDENTIFY SUBSTANCES OF CONCERN

Study Leader K. Burnison

Study Team Donna Nuttley

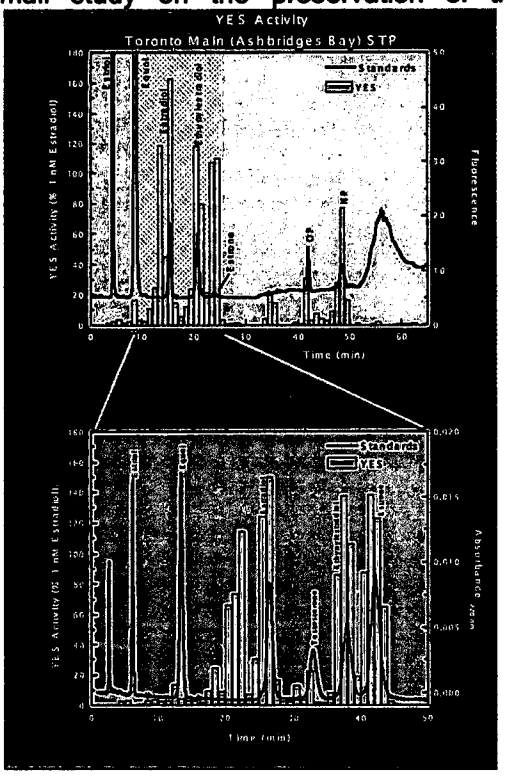
STUDY OBJECTIVES

This study investigates the identity and exposure of endocrine disrupting chemicals in municipal sewage effluents and animal waste, using toxicity identification evaluation (TIE) procedures; the yeast estrogen screen (YES); and an androgen endpoint to measure bioactivity. Research will continue on the estrogenicity of nonylphenol and its ethoxylates. Research will be initiated on phytoestrogens to investigate possible persistence in sewage treatment plant effluents, and will continue on the hydrolysis of endocrine conjugates. Under the Canada/Germany Agreement on Ecosystem Health, a new investigation will begin, in co-operation with German scientists, on the effects of endocrine disrupters in the presence of dissolved organic matter (DOM).

RESULTS

Studies have identified a variety of endocrine disrupting substances in municipal effluents and agricultural runoff in Ontario. Additional method development was conducted to validate the TIE approaches. Acidification is commonly used to preserve effluents sampled from sewage treatment plants. Investigations were therefore undertaken to determine if lowering the pH to 3 would efficiently preserve the estrogenicity of samples. Sixteen litres of STP effluent were collected at various times, from the Greenway, Stratford and Toronto Main STPs. The effluent was filtered and the pH of one half only lowered to pH 3 with sulphuric acid. Each treatment was processed with solid phase extraction columns, and subsequent HPLC-TIE fractionations. Toronto Main effluent had very high estrogenicity with similar results for acidified and unacidified samples. However, the Greenway STP samples lost the strong yeast estrogen screen (YES) response seen in the estrone region of the HPLC chromatogram, when the effluent was acidified. Similarly, the Stratford samples lost the strong YES response in the ethynylestradiol region of the chromatogram. Studies of subsequent STP samples from Ingersol, Oxford, Adelaide and Galt continued without these preservation procedures. Use of preliminary investigations; however, using a positive control of estradiol showed the formalin or sodium azide are likely preservation procedures.

The Galt STP was selected to run a small study on the preservation of the



estrogenicity by sodium azide and formalin (as compared to an "immediately processed no preservatives added" control). The addition of azide did increase the concentration of estrogenicity in the fractions containing estradiol, but the hydrophobic estrogenic fractions were decreased (perhaps caused by adsorption of these EDS compounds to storage vessel walls). The addition of formalin also decreased the hydrophobic fraction, but the estradiol region was close to the control; isolation and re-chromatograph procedures have been attempted on the estrogenic hydrophobic region of the Galt samples. We are unsure of the types of compounds that may be present in this region of the HPLC fractionation and have always "assumed" that the activity was caused by a precursor to either nonylphenol or octylphenol, but were never certain. The estrogenicity of nonylphenol-1-ethoxylate were found to have a relative potency of 3.5 x 10^{-5} when compared to 17ß-estradiol. Dr. Lee analysed this compound for purity and although it was pure, this particular isomer was not found in the Galt STP effluent. In co-operation with Dr. G. Van Der Kraak (Univ. of Guelph), we have demonstrated the presence of androgens in the Toronto Main STP HPLC fractions. The main activity corresponded to the HPLC retention time for testosterone, however GC/MS methodology was unable to detect testosterone in the STP effluent.

Results from the Toronto Main STP were very interesting. The fractions just prior to the elution of estradiol gave positive YES responses, and the estrogenicity was well separated from estradiol and was thought, by UV spectrum and literature retention time, to be Bisphenol-A. The identity was confirmed using GC/MS. All fractions from this STP were provided to collaborators at the Univ. of Guelph for bioassays of sex steroid binding protein, androgen receptor assay; and a further estrogen receptor assay.

Equol was identified as a major estrogenic substance in hog waste. Although in field studies this substance was detected in relatively high concentrations in agricultural runoff, the estrogenicity of the runoff sample was traced to estradiol, not equol. Equol was three orders of magnitude less potent than estradiol when tested in the YES system.

TRANSFORMATION OF CONTAMINANTS IN WETLANDS, NATURAL WATERS & BIOTA

Study Leader J. Headley

Study Team K. Peru

STUDY OBJECTIVES

Research in this study focus on the development of knowledge processes governing persistence, fate and effects of toxic chemicals in aquatic ecosystems, and on delivery of information on priority chemicals identified in CEPA-PSL 1 and 2, TSMP and on priority pesticides. Research was undertaken to provide advice in support of CEPA/PSL initiatives (e.g. carbon disulphide, and precursors of aquatic ammonia, PSL 2) to determine the primary mechanism of removal of amines in natural wetlands and associated vegetation, contaminated with process chemicals, gas condensates, heavy-oils and other hydrocarbon mixtures. This study both develops and applies mass spectrometry methods for determining uptake kinetics, and transformation of toxic substances in biota (e.g. wetland vegetation, biofilms, insects, and aquatic invertebrates. Emphasis was placed on oil-sands naphthenic acids, selected pharmaceuticals and cosmetics found in natural waters and Prairie biofilms. The performance of catalytic photolysis/UVB irradiation was assessed for ability to degrade toxic substances

RESULTS

Research was completed on the natural attenuation of toxic substances in wetland environments; effects of chemicals derived from oilsands on the ecology of northern rivers, and the degradation of pesticides and related chemicals in riverine biofilms and aquatic insects. This entailed the development of analytical techniques for measurement of naphthenic acids in natural waters and the determination of musk fragrances using semi-permableable membrane extraction. Sequestration of sulfolane and diisopropanolamine in wetland cattails was measured. The amount of process chemicals which partition from wetland soils and water to plants was measured. Preliminary results for PAHs and their alkylated analogues were obtained for aquatic insects, as part of a PERD collaborative project with CWS and indicated that whereas sub ppm levels of these substances are observed in the biota at the sites investigated, the concentrations and fingerprints are comparable to those found in controls (grasshoppers with no history of exposure to oilsands hydrocarbons). Experiments were conducted in support of the TSRI project entitled "Effects of dissolved oxygen/nutrient interactions on microbial biofilms and their role in the fate of toxics in microbially based ecosystems".

Studies on natural wetlands and degradation of heavy-oils has continued

with collaborators from Komex International, Utah State University, Malcolm Conly and Leslie Dickson, as part of the PERD Wetland Project and the PERD-NREI

project: "Assessment of Natural and Anthropogenic Impacts of Oil Sands Contaminants Within Northern River Basins". In support of the oilsands project, samples from the fall sampling events have been extracted and GC/MS instrumental analyses for alkylated PAHs.

OCCURRENCE OF PRIORITY ORGANIC CHEMICALS IN ENVIRONMENTAL SAMPLES

Study Leader H.-B. Lee

Study Team T. Peart

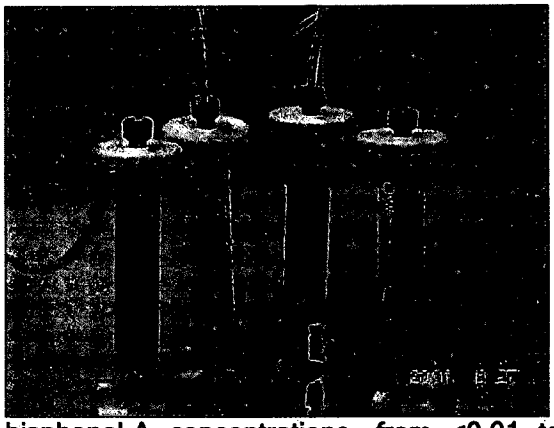
STUDY OBJECTIVES

This study continued research on analytical methodologies for estrogens and androgens in sewage treatment plant effluents, including the occurrence and fate of bisphenol-A and other endocrine disrupting substances (EDS) in environmental samples. Collaborative research on the contamination of priority substances and EDS in sewage sludge was initiated in support of the development remedial actions and management strategies.

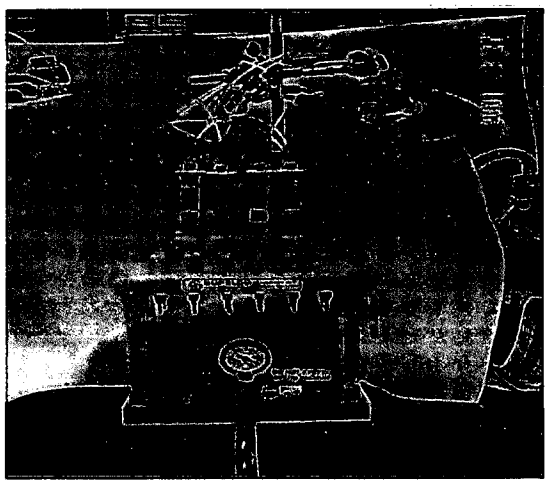
RESULTS

A new trifluoromethyl derivative is being evaluated for the GC/MS analysis of testosterone, 17ß-estradiol, estrone, and 17 α-ethynylestradiol. While their molecular ions were weak under EI conditions, they were the base peaks under NCI conditions, thus permitting sensitive (i.e. sub-ppt) and selective detection using selected ion monitoring. However, the formation of these derivatives required prolonged reaction times at elevated temperatures and its quantitativeness is still unknown. Further work is being carried out to test the ruggedness of the derivatization reaction and its applicability to sewage samples.

A study on the occurrence of bisphenol-A in industrial wastewaters in the Toronto area has been completed. Over 95 samples collected from 40 industrial facilities have been tested and a range of



bisphenol-A concentrations, from <0.01 to 149 µg/L, have been found and a final report on the study levels of BPA, nonylphenol ethoxylates and their metabolites is in preparation.



Raw and digested sewage sludge samples collected from Toronto are being examined for EDSs and priority substances such as PCBs, PAHs, chlorobenzenes, organochlorine insecticides, chlorophenols, and butyltins. Raw and digested sludge collected from Canadian treatment plants have been extracted by various techniques including SFE, ASE and conventional solvent extraction. The extracts, after extensive cleanup, are being analysed by GC/MS, GC/ECD, and HPLC. In addition to nonylphenol and its ethoxylates and bisphenol-A, many priority substances and EDSs mentioned above have been found and so studies on the occurrence of new toxic substances and EDSs in sewage sludge is planned for the future.

A comprehensive, across-Canada study on the occurrence of bisphenol-A in sewage treatment plant influent, effluent, and sludge has been completed and a paper has been published. Results indicated that bisphenol-A contamination was ubiquitous, with concentrations in µg/L levels for wastewaters and µg/g levels for sludge.

BIODEGRADATION OF PRIORITY CHEMICALS

Study Leader D. Liu

Study Team G. Pacepavicius

STUDY OBJECTIVES

Analyses for Irgarol 1051 and its major degradation product M1 in the extracts of field water samples collected during the 1999 cross-Canada Irgarol survey have been completed. The results indicate that the Canadian aquatic environment has not yet been contaminated by Irgarol 1051. A report on this survey is being prepared.

RESULTS

Re-examination of the GC and GC-MS data on the degradation of Irgarol 1051 in various waters sampled across Canada revealed the possible occurrence of Irgarol degradation in the water sample taken from Port Stanley. A new degradation product, which is significantly different from M1 based on the GC retention time, was also observed. Unfortunately, the concentration of the new degradation product was too low for structure elucidation. The low recovery associated with the extraction of Irgarol from spiked sediment samples has been positively identified. Lack of regulation of the vacuum pressure of our existing rotovap has resulted in loss of some Irgarol from the hexane, which is a part of the solvent system used in the extraction procedure.

An active Bisphenol-A degrading bacterial culture has been developed. The culture is capable of degrading 100 mg of Bisphenol-A powder in 3 days with Bisphenol-A as the sole carbon and energy source. Many degradation products were observed, with one being tentatively identified as a tri-hydroxy metabolite.

FATE AND EFFECTS OF PESTICIDES AND INDUSTRIAL CHEMICALS IN WATER

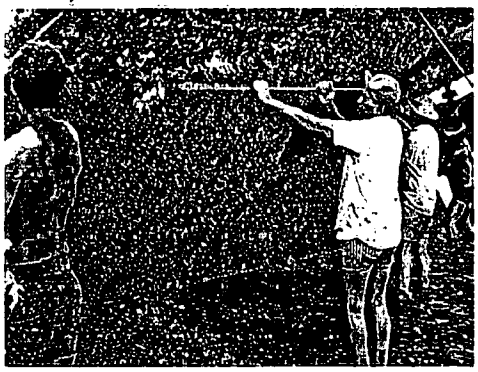
Study Leader R.J. Maguire
Study Team S.P. Batchelor

STUDY OBJECTIVES

To conduct collaborative research on the exposure, fate and toxicity of tributyltin in freshwater environments, to complete a national survey for tributyltin in the Canadian environment, and to determine if tributyltin is a candidate Track 1 substance under the federal Toxic Substances Management Policy.

RESULTS

Research on the exposure, fate and toxicity of TBT is on going with A. Bartlett (Ph.D. student) and D.G. Dixon of the University of Waterloo, and U. Borgmann of AEPRB. A chronic, spiked-sediment exposure to six species of invertebrates has been completed to assess toxicity. Water, sediment, and tissue samples from this experiment, as well as tissue samples from a chronic toxicity experiment with Hyalella azteca, are in the process of being analyzed for butyltins. The results of these experiments will be the basis for the design of further experiments to characterize the impact of TBT on freshwater invertebrates. Research also continues on the third national survey for organotins in the Canadian environment, and on the accumulation of TBT by diving ducks (with CWS).



A review was written which concluded that TBT is a candidate Track 1 chemical under TSMP. The review was published, and a TSMP Scientific Justification document was completed and submitted to the Commercial Chemicals Evaluation Branch (CCEB). The next step is for CCEB to take the document to the TSMP Interdepartmental Forum. Informal discussions have been held with PMRA and with the US EPA on next steps with respect to the outright banning of TBT in concert with the International Maritime Organization initiative to ban all antifouling uses of TBT by January 1, 2003.

Fate of Metals and Organometals in The Aquatic Environment

Study Leader C. Rouleau
Study Team G. Pacepavicius

STUDY OBJECTIVES

This study contributes knowledge on the fate of metals and organometals in the aquatic environment essential for the assessment of risks they represent for both aquatic fauna and mammals.

RESULTS

The occurrence and fate of MMT in groundwater and aquatic sediments were investigated and a report was developed on mercury levels in the brain of wild pike (Esox lucius). The fate of metals and organometals, particularly those used for pest control, was evaluated in marine fish and mammals. Platinum and gadolinium levels were measured, in the sediments of Toronto Harbour, to provide information on the metals in this aquatic environment.

Specialised equipment (high-pressure reactor, booster pump) needed for the synthesis of radioactive 54Mn-MMT has been purchased and installed. The set up of the synthesis method of radioactive MMT has progressed and results should be available during the next fiscal year. Sediment samples have been collected in Lake Erie and are preserved for their ulterior analysis for MMT.

Thirty pike have been collected from three different lakes in the Timmin's area of northern Ontario. The brain of each animal has been dissected and samples are awaiting analysis as soon as the mercury analyser, bought for this purpose, has been delivered.

Methods for the analysis of organotin compounds in blood, liver, and blubber samples have been perfected and are ready for use, and a technique for fur samples is underway. Tissue samples from 4-week old seals (liver, blubber, fur, blood) received from Peter Ross (Institute of Ocean Sciences, Sidney, BC) will be analysed in the next months.

A great deal of effort has focused on the acquisition and installation of essential equipment for the new Autoradiography and Gamma Isotopes Laboratory (AGIL), now installed in NWRI. The equipment is now functional and provides NWRI with a unique facility in North America for the study of the fate of radiolabelled metals, organometals, and organic chemicals in aquatic biota. With the availability of these facilities, arose a lot of interest from other potential partners, resulting in collaborations being initiated with researchers within and outside NWRI.

Sediment samples from Toronto Harbour and ten deep sediment samples from Lake Ontario were sent to NLET to measure Gd, Pd, and Pt levels, as well as those of Al, Fe, Mn, V, Zn, Co, Ni, Mo, Cd, La, Tl, and U. These are the first data on the levels of Gd and platinum group elements in Canadian lake sediment.

BIOGRAPHIES

R. James Maguire, Director
E-mail: Jim.Maguire@ec.gc.ca

Jim Maguire received a Ph.D. in physical chemistry from the University of Alberta in 1972. He joined Environment Canada in Ottawa in 1973 and the National Water Research Institute in 1976. His main research interests have been in the persistence, fate and effects of toxic substances in aquatic ecosystems. He has led major research projects on the antifouling pesticide tributyltin and non-pesticidal organotins; forest pesticides (fenitrothion, aminocarb) and agricultural pesticides (deltamethrin and metolachlor); dyestuffs; the role of surface microlayers in the distribution and environmental dynamics of pesticides and other substances; the effects of dissolved organic matter on the efficiency of extraction of lipophilic contaminants from natural waters; the degradation of cellulose by cellulase enzymes; and enzymic effects of toxic substances. He has published approximately 250 journal articles, reports and conference proceedings in these areas. In addition to serving on Canadian government pesticide and toxic chemical committees, he has been an associate editor of the Journal of Great Lakes Research, the Water Quality Research Journal of Canada, and Applied Organometallic Chemistry. He is currently an adjunct professor at the University of Waterloo. He is a Fellow of the Chemical Institute of Canada. He was awarded the Environment Canada Citation of Excellence for his research that led to the Canadian regulation of the antifouling pesticide tributyltin.

Janet K. Cooley, Science Liaison Officer
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After receiving her PhD (Paleolimnology) from the University of Wales, Bangor, UK, in 1977 Janet Cooley moved to Canada. Her first research program in Canada was funded by CANUSA to evaluate the impact of the forest pesticide, Matacil™, on freshwater ecosystems, including the biodiversity of the aquatic microbial community. Prior to joining the Federal government, Fisheries and Oceans Canada in 1987 and NWRI in 1990, Dr. Cooley worked in the private sector where she held the position of senior scientist in a large company. Following this experience she founded and operated her own company to provide environmental assessment and advice on resource management issues, by using her expertise in paleo-ecology. For example, the company evaluated the impact of stressors, like acid rain, on aquatic ecosystems and provided analysis of sediment cores during an energy exploration phase of the Beaufort continental shelf. A published author, Dr. Cooley has written on topics as diverse as paleo-ecology, impact of pesticides on aquatic biota and the sexual behaviour of crustaceans. Together with her interest in biological indicators, stemming from work undertaken in the early 1970s, Janet Cooley's present assignment as Science Liaison Officer with AEPRB represents a return to long-standing research interests.

PRIORITY SUBSTANCES EXPOSURE PROJECT

Mark Servos, Project Chief
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Mark Servos joined National Water Research Institute in 1996 after 7 years as a Research Scientist with

Fisheries and Oceans Canada at the Great Lakes Laboratory for Fisheries and Aquatic Sciences. He received his PhD in Environmental Chemistry from the University of Manitoba in 1988 and his M.Sc in Aquatic Sciences from the University of Guelph in 1983. The assessment of the exposure of priority substances and their ability to cause impacts on the survival, growth, development and reproduction of biota is the primary focus of his research. Techniques to isolate identify and measure substances in effluents and environmental samples responsible for biological impacts are developed and applied to document exposure of the environment in support of risk assessments and risk management options. Current studies include determination of exposure and effects of aquatic

ecosystems to pharmaceuticals and estrogenic compounds in municipal and industrial effluents, as well as runoff resulting from intensive agricultural practices; the examination of remedial options to reduce the release of toxic and estrogenic chemicals from priority substances, effluents and runoff; and the role of food web structure and function on controlling the exposure, biomagnification and effects of organic contaminants. Dr. Servos holds Adjunct professorships at University of Guelph, and Waterloo. He is a member of several national committees, including acting as co-chair of the 5-NR Working Group on Endocrine Disrupting Substances. He has served as President of the International Association of Great Lakes Research and is currently the President of the Society of Environmental Toxicology and Chemistry.

Kent Burnison
Email: Kent. Burnison@cciw.ca

After receiving his PhD in Microbiology/Biochemistry from Oregon State University (Corvallis) in 1971, Dr. Burnison went to the University of British Columbia on a postdoctoral fellowship to work on the Marion Lake IBP project. He joined NWRI as a research scientist in 1974 to study bacterial and algal productivity/activities in the Bay of Quinte. His research interests include the role of dissolved organic matter in the bioavailability of organic contaminants and metals; bacterial activities in acid lakes; and the isolation and identification of biologically active compounds in pulp mill effluents. Currently, Dr. Burnison's research is focusing on identification of endocrine disrupting compounds in municipal sewage treatment effluents and in runoff associated with hog manure fertilizer spraying activities using the Toxicity Identification and Evaluation approach. Dr. Burnison is an Associate Member of the Graduate Faculty at the University of Guelph.

John Headley
Email: John.Headley@ec.gc.ca

John Headley joined the National Water Research Institute in 1991 as a Research Scientist after working in the Environmental Sciences for 3 years in the Private Sector and 6 years for the Provincial Government of Alberta. He received his PhD in Chemistry and Molecular Sciences from the University of Warwick, England, UK, in 1981. Following his graduation, he served a one year post-doctoral fellowship at the Department of Chemistry, University of Toronto, 1981-1982. His research interests focuses on the development and utilization of mass spectrometry techniques for the determination of the fate and transport of organic contaminants in natural wetlands, northern rivers and subsurface environments. Primary activities include research on the sequestration and kinetics of organic contaminants in biota. Dr. Headley currently leads 3 major projects funded by the Program of Energy Research and Development (PERD) on the remediation of hydrocarbons and naphthenic acids in oxygen limited environments. He is an Adjunct Professor at the University of Saskatchewan, Department of Civil Engineering.

Bill Lee
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Bill Lee received his B.Sc. and Ph.D. in Chemistry from the Chinese University of Hong Kong and McMaster University, respectively. After completing a National Research Council Industrial Postdoctoral Fellowship, he joined Environment Canada in 1978 as a Chemist and has been working as a Research Scientist at the National Water Research Institute since 1988. Dr. Lee has worked on the implementation of national and international quality assurance studies and the development of Certified Reference Materials for persistent organics in sediments. He has also developed analytical methods for the determination of priority substances, pesticides, herbicides, and industrial chemicals in environmental matrices. The extraction of sediment and sludge samples with a supercritical fluid such as carbon dioxide has been incorporated in many of the above methods. Dr. Lee's current research interests relate to the occurrence and fate of endocrine disrupting chemicals such as nonylphenol, estradiol, bisphenol A, and other new and emerging chemicals in municipal sewage treatment plant and industrial wastewater samples. He has published five review articles and over 75 scientific papers and reports.

Claude Rouleau
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Claude Rouleau received a Ph.D. in oceanography from Université du Québec à Rimouski in 1994. After spending a year as a postdoctoral fellow at the Swedish University of Agricultural Sciences in Uppsala, Sweden, he worked from 1995 to 1999 at Maurice Lamontagne Institute (Fisheries and Oceans Canada). He joined NWRI as research scientist in 1999. His research interests are mainly directed toward a better understanding of the uptake and distribution of metals and organometals in aquatic biota and their geochemistry. He mostly used radioisotopic techniques, such as in vivo gamma counting and whole-body autoradiography, to study the uptake and distribution of mercury, methylmercury (MeHg), tributyltin (TBT), cadmium, zinc and silver in both freshwater and marine organisms (insect larvae, rainbow trout, starfish, snow crab, American plaice). These data were used to model the direct uptake and the trophic transfer of metals and organometals in relation to water and sediment chemistry. He has set up a laboratory at NWRI equipped with facilities for research with radioisotopic techniques, some of them being unique, such as whole-body autoradiography, which allow to visualise the fine-scale tissue distribution of radiolabelled chemicals in thin cryosections of whole animals. His current research work focuses on the uptake and distribution of some exotic metals, like gadolinium, indium, and thallium, as well as organometals, such as MeHg, TBT, and methylcyclopentadienyl manganese tricarbonyl. He is adjunct professor at ISMER (Institut des Sciences de la MEr de Rimouski), and collaborates on various projects with other researchers in Canada, Monaco, Brazil, and China. He is a member of the Canadian Chemical Institute and of the Society of Environmental Toxicology and Chemistry. He has published 28 journal articles and conference proceedings and presented 37 communications in national

ATMOSPHERIC CONTAMINANTS IMPACTS PROJECT

Derek Muir, Project Chief
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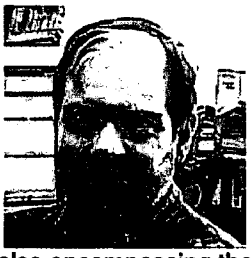

Derek Muir joined National Water Research Institute in 1997 after 20 years as a Research Scientist with Fisheries and Oceans Canada at the Freshwater Institute in Winnipeg. He received his PhD in Agricultural Chemistry from McGill University in 1977. His research interests include understanding transfer of persistent organic contaminants and metals in marine and freshwater food webs, air-water and air-plant exchanges of organics and watershed contributions of airborne contaminants to lakes and rivers. This work involves detailed measurements of persistent organohalogen contaminants in biological and abiotic samples. His recent work has been mainly in the Arctic and in western Canada but it is now also encompassing the Great Lakes and the tropics. Dr. Muir holds Adjunct professorships at University of Guelph, University of Alberta and University of Manitoba. He serves on a committee for Indian and Northern Affairs Canada, and is a member of the Northern Contaminants program Technical Committee - 1997 and 1998, and since 1996 he has been a member of the Alberta Health, Science Advisory Committee. Dr. Muir currently holds a three-year Fellowship from the Pew Foundation for Marine Conservation for work on contaminants in the Russian arctic marine environment.

Mehran Alaee
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After receiving his PhD in Analytical Chemistry from the University of Guelph in 1991 Dr. Alaee accepted a Visiting Fellowship at the National Water Research Institute where he worked on the Henry's law Constants and Mass transfer velocity of POPs. Subsequently he joined the National Water Research Institute as a research scientist working on the Northern Contaminants Program in the Arctic. In 1997, Mehran accepted an assignment with the National Laboratory for Environmental Testing where he managed the Research Support and Methods Development Project. Current research interest are related to long range atmospheric transport of emerging persistent organic pollutants such as

Brominated Diphenyl Ethers to the Great Lakes and Arctic. He is also working on a joint project with DFO scientists on bioaccumulation of PBDEs in the Great Lakes. Dr. Alaee is a member of the Special Graduate Faculty at the Department of Environmental Biology at the University of Guelph

Venghuot (Ven) Cheam
Email: Ven.Cheam@cciw.ca

Venghuot Cheam is a research scientist working in the Atmospheric Contaminant Impacts Project, headed by Dr. Derek Muir. Dr. Cheam' s present interests include two areas; 1) local and long-range transport of metal pollutants surrounding the Canadian coal mines and power plants and in the Canadian Arctic / sub-Arctic; 2) development and applications of an ultrasensitive instrument (unavailable commercially), the Laser- Excited Atomic Fluorescence Spectrometer (LEAFS), in environmental studies using environmental substrates including waters, sediments, fish, invertebrates and plants. Recently, he has concentrated his research involving three very toxic metals- lead, thallium and mercury. He had had interests and publications in other research fields such as the metal chelation/ complexation of natural ligands, a field he excelled as a postdoctoral fellow and when he first joined NWRI in 1973 after obtaining his Ph. D. degree from the university of Oklahoma; identification of asbestos fibres in the Great Lake sediments; development of water and sediment Certified Reference Materials; quality assurance and assessment of laboratory performances on a national scale; and analytical methods research in liquid chromatography and atomic spectroscopy.

Marlene Evans
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Marlene Evans has been working as a research scientist at the National Water Research Institute since 1988. Her research program has been and continues to be diverse. In the prairies, she has investigated plankton-nutrient dynamics in saline lakes, including commercially-harvested *Artemia* (brine shrimp). In the boreal region, she is investigating impacts of anthropogenic perturbations on lake ecosystem health. Most of her research focuses on contaminants in the north including: the influence of the Slave River on contaminant loading and food web biomagnification to Great Slave Lake; an investigation of factors affecting high mercury concentrations in predatory fish in certain lakes in the NWT; and hydrocarbon transport into the Peace-Athabasca delta and Lake Athabasca. With local community participation, she will begin a long-term monitoring study of contaminant trends in Great Slave Lake fish. Dr. Evans earned her B. Sc. (Honours Biology) from Carleton University and her Ph. D. (Oceanography and Zoology) from the University of British Columbia. She conducted postdoctoral studies at the Arctic Biological Station and then worked for 14 years at the Center for Great Lakes and Aquatic Studies, University of Michigan focusing on various aspects of zooplankton communities in Lake Michigan. While there, she served on the Science Advisory Board of the International Joint Commission and on the Board of Directors of the International Association of Great Lakes Research, including a term as President. Dr. Evans is an adjunct professor with the Biology Department, University of Saskatchewan, and supervises graduate students. She is Associate Editor of the Journal of Great Lakes Research. Community service projects include the Saskatoon Regional Science Fair, the Innovators in Schools Program and, more recently, the Connaught Student Biotechnology Exhibition.

Aaron Fisk
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After receiving his Ph.D. in ecotoxicology from the University of Manitoba in 1998 Dr. Fisk completed a two-year post-doctoral project on the movement of organic contaminants in an Arctic marine food web at Carleton University. Dr. Fisk joined the Atmospheric Contaminants Impact Project in 2000 and his research is focused on the environmental fate and effects of contaminants in aquatic ecosystems. A major component of his research is the study of halogenated phenolic compounds in the Great Lakes. Additional interests include the use of anthropogenic contaminants to study ecological processes.

Togwell A. Jackson
Email: T.A.Jackson@cciw.ca

Dr. T.A. Jackson received a B.A. in geology from Columbia University; a M.Sc. in geology from University of Wisconsin; and a Ph.D. in geology from University of Missouri. He received interdisciplinary training that included microbiology, other biological subjects, and chemistry. After graduation, Dr. Jackson undertook a number of postdoctoral positions which included an NSF postdoctoral fellow at Woods Hole Oceanographic Institution; a research associate at Yale University and at the Biogeology Clean Laboratory at the University of California, Santa Barbara. He joined the Canadian federal government in 1972 when he worked at the Freshwater Institute (1972-1986); National Hydrology Research Institute (1986-1990); and moved to the National Water Research Institute (NWRI) in 1990 where he works at present. Dr. Jackson's current research interest is on the biogeochemical phenomena of freshwater ecosystems. He did; however, undertake research on humic matter and its effects on primary production, specialising in the biogeochemistry of heavy metals and placing emphasis on emphasis on speciation, bioavailability, bioaccumulation, biological effects, and biogeochemical pathways of metals in different environments. He has undertaken extensive research on mercury, including methyl mercury; involved in three Canada Water Act studies of mercury in river-lake systems (Wabigoon-English and Qu'Appelle systems) and in hydroelectric reservoirs (Churchill-Nelson system)and has also worked on heavy metals in lakes polluted by mine and smelter in Flin Flon. While his current research largely concerns heavy metals in lakes polluted with mine tailings he is currently investigating the effects of metals on microbial communities in sediments using various chemical and biochemical methods, including energy dispersive X-ray microanalysis and transmission electron microscopy for analysis of individual bacteria and particles in metal-contaminated sediments to determine distribution and interrelations of elements on a microscopic scale. He has undertaken pilot projects on use of ribosomal RNA to assess effects of metals on bacterial populations in sediments, and soft X-ray spectromicroscopy to investigate metals bound to bacteria in polluted sediment.

Brian Scott
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After earning his Ph.D. in physical-organic chemistry from the University of Toronto and completing a post-doctoral fellow at University College, London, Dr. Scott joined the Inland Waters Branch of the Department of Energy Mines and Resources. Initially he performed semi-empirical mathematical calculations on ice-like and substituted ice-like structures. Next were studies on the fate and effects of oil and oil-dispersent mixtures using small lakes and mesocosms. This was followed by fate and effect studies of 2,4-D on Myriophyllum spicatum and fate and effect of TFM, both studies utilizing mesocosms. Investigations on toxaphene analysis was followed by developing an automated computer-assisted PCB congener method of analysis. This led to broad spectrum analysis which utilized new technologies such as gc/atomic-emission detection and combining this with older technologies to optimize the information available for a sample undergoing gas chromatographic analysis. Dr. Scott then headed a study on the effects of refinery effluents and then he investigated various aspects of black liquor, a component of kraft paper mill operations. Dr. Scott develop a method for the analysis of haloacetic acids, using this to determine haloacetic acids in the Canadian environment and comparing these results to other areas of the globe. Utilizing the same analytical method, he is currently analyzing for environmental levels of perfluoroalkanoic acids.

William Strachan
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William Strachan received his PhD from Queens University and joined the National Water Research Institute as a research scientist in 1970. Dr. Strachan's research studies relate to the impacts of atmospherically transport contaminants on aquatic systems. Under the Great Lakes Water Quality Agreement, Integrated Atmospheric Deposition Network, Dr. Strachan evaluates precipitation for trace metals and persistent organic pollutants in the Great Lakes. He also performs rain and snow measurements for these same compounds across Canada and in Arctic regions. In the Great Lakes, Arctic and Russian rivers flowing to the Arctic Dr. Strachan evaluates mass balance assessments. During his years with the National Water Research Institute he served on various committees such as; the committee for Canada's Northern Contaminants Program, Canada-Ontario Agreement Air Toxics

Committee, International Expert Group of Advisors to the Swedish government on test systems for the evaluation of chemicals in the aquatic environment, and the Great Lakes Water Quality Toxic chemicals Committee responsible for developing Environment Canada's study and review funding programs.

Henry Wong
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Henry Wong has been working as a research geochemist at the National Water Research Institute since 1977. He received his BSc in Chemistry from University of Waterloo 1975 with additional Geology courses from McMaster University. In Great Lakes water quality, he has participated in assessing sediment metal burdens and investigated trace metal cycles. Under the Long Range Transport of Atmospheric Pollutants program, his focus was on metal pollution from smelters and their impact on acid lakes. Mr. Wong has participated in atmospheric aerosol metal studies with international teams in the East Coasts of Canada. Current research include the evolution and impact of toxic metals such as As, Cd, Hg, Tl from abandoned mines and from industrial plumes, as well as participating in a current study for urban toxics in Lake Ontario. His publications are focused on toxic metals and metal cycles in the environment.

Fan Yang
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Fan Yang joined the National Water Research Institute as a chemist, and then a physical scientist after receiving M.Sc in chemistry from Queen's University in 1991. His research work includes the analytical chemistry of metals and organometallic compounds; and the occurrence, pathways, fate and toxicity of organometallic compounds in environment, including those of lead, mercury, tin and manganese.
At present, he is in charge of 210Pb dating method, which is commonly used to determine the sedimentation rate and chronological age of the sediment. He also collaborates with researchers in University of Montreal and Ryerson Polytechnic University on the studies of metals and metal speciation in environment.

PRIORITY SUBSTANCES EFFECTS PROJECT

Scott Brown, Project Chief
Email: Scott.Brown@cciw.ca

Scott Brown joined National Water Research Institute in 1996 after 6 years as a Research Scientist and 14 years as a Biologist with Fisheries and Oceans Canada at the Freshwater Institute in Winnipeg. He received his Ph.D. in Zoology from the University of Manitoba in 1990. Dr. Brown investigates the toxicological mechanisms of priority substances on fish growth, reproduction and development in support of departmental hazard and risk assessments, and risk management activities. Environment Canada uses this knowledge to make decisions under various initiatives including the Toxic Substances Management Policy, the *Canadian Environmental Protection Act*, the *Pest Control Products Act*, Priority Ecosystems Initiatives (for example, Great Lakes Basin 2020). Dr. Brown also develops new techniques to identify and monitor endocrine modulating capability, responses and effects of priority substances and effluents in aquatic biota. He has used the developed knowledge in regional, interregional, interdepartmental and international studies of feral fish populations receiving exposures to priority substances in the Great Lakes Basin and major river systems (e.g. Peace and Athabasca Drainages, Winnipeg River, Atlantic Canada salmon rivers). Dr. Brown has conducted detailed investigation on the underlying causes of the 'Early Mortality Syndrome' (EMS) presently found in salmonid populations from the Great Lakes and Baltic. His recent work has also identified that endocrine disruptors may impair seawater growth and survival in anadromous salmon. Dr. Brown is Associate Graduate Faculty at the University of Guelph and the University of New Brunswick. Dr. Brown is Environment Canada's Representative for OECD Endocrine Disruptor Testing and Assessment Committee and leads the Great Lakes Fishery Commission's Board of Technical Experts EMS Task.

Uwe Borgmann
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Uwe Borgmann received his Ph.D. in Biology from the University of Ottawa in 1975, after which his joined the Great Lakes Laboratory for Fisheries and Aquatic Sciences (then known as the Great Lakes Biolimnology Laboratory) in the Department of Fisheries and Oceans. There he conducted toxicological research on aquatic organisms until 1996, when he joined the National Water Research Institute in Environment Canada. Dr. Borgmann's primary research interest is metal toxicity and bioaccumulation in aquatic invertebrates, with a focus on understanding the relationship between bioaccumulation and toxicity, and determination of critical body concentrations above which adverse effects are observed. This is particularly useful in environmental assessments since it allows identification of the metals responsible for toxic impacts. Dr. Borgmann is currently involved in a number of collaborative research projects with the University of Waterloo, and with the University-Government-Industry sponsored Metals In The Environment Research Network.

Klaus Kaiser
Email: Klaus.Kaiser@cciw.ca

After receiving his Ph.D. in organo-metallic chemistry from the Technical University, Munich, Germany, in 1968, Dr. Kaiser spent time as research fellow at Munich and McMaster University and joined the National Water Research Institute in 1972. Highlights of his work include the first observation of the compound mirex in Great Lakes biota, the theoretical prediction of the stability of certain PCB isomers in optical entantiomers, contributions to several interagency and international task forces and committees, and organizing and chairing the first and second International Workshops on Quantitative Structure-Activity Relationships QSAR) in Environmental Toxicology. After supervising a number of different research groups for about two decades, Dr. Kaiser took on the responsibility of Editor-in-Chief of the then struggling Water Quality Research Journal of Canada, which now enjoys increasing national and international recognition. Dr. Kaiser continues as active researcher in the QSAR field with emphasis on modelling and prediction of chemicals' biological effects using modern mathematical methodologies.

John R. Lawrence
Email: John.Lawrence@ec.gc.ca

John R. Lawrence joined the National Water Research Institute in 1990. He received his PhD in Soil Microbiology from the University of Saskatchewan in 1987. His research interests include the roles of microbial biofilms, aggregates and their exopolymers in the fate and degradation of toxic substances, and fate and effect of products of biotechnology on aquatic ecosystems. This work involves application of advanced laser microscopy imaging and molecular biology techniques including the development of DNA-microarrays. His recent work has been focused on river systems, evaluating effects of nutrients, contaminants and oxygen levels on riverine microbial communities. This research activity extends to collaborative projects in Germany. Dr. Lawrence holds an Adjunct professorship in Applied Microbiology at the University of Saskatchewan. He also serves on the editorial boards of the journals Microbial Ecology and Journal of Microbiological Methods. Dr. Lawrence is a member of the International Committee of ISEB. He also serves on EC committees regarding biotechnology and biotechnology research activity

Tanya Mayer
Email: Tanya.Mayer@cciw.ca
Tanya Mayer received her M.Sc. in Geology from McMaster University in Hamilton. She has been working at the National Water Research Institute since 1971. In her position as a research geochemist she has been involved in diverse research projects addressing water - sediment interaction in a broad variety of aquatic ecosystems, including Great Lakes, shield lakes, rivers, urban stormwater detention ponds and wetlands. During her years with the National Water Research Institute she has conducted research on the fate and transport of pollutants such as heavy metals, nutrients, road salts and PAHs in aquatic ecosystems. Her research focuses on understanding of the biogeochemical processes controlling the concentrations and bioavailability of these substances in sediments and overlying water column. Her current work focuses on the effects of priority substances on wetlands. Recently, Ms. Mayer served on the Departmental Committee for the CEPA Assessment of the Priority Substance "Road Salts".

Bin Zhu
Email: GTIS-ZhuBinAGW@ec.gc.ca
Bin Zhu joined the National Water Research Institute as a term scientist in 2000 after receiving his PhD from the University of Manitoba. Dr. Zhu's research studies relate to the effect of release of Genetically Modified Organisms (GMO) on environment after the release of GMO into the ecosystems by using molecular biology technology. His research work involves characterization of transgene flow from GMO crops into the wild related species, the persistence and fate of transgene after transgene is introgressed into the wild population and ecological risk posed by transgene flow. He is also working on Bt (*Bacillus thuringiensis*) toxin released by Bt-transgenic crops into the soil and nearby water bodies, streams, ponds and wetlands, and the impact on microbial biodiversity and other organisms of concern in terrestrial and aquatic ecosystems.

AQUATIC ECOSYSTEM HEALTH ASSESSMENT PROJECT

Jim Sherry, Project Chief
E-mail: Jim.Sherry@cciw.ca

Jim Sherry received his PhD from the National University of Ireland, University College Dublin and joined the National Water Research Institute in 1984. His current research interests relate to using the induction of vitellogenin (Vg) in fish as a bioindicator of exposure to estrogenic substances. The egg yolk precursor Vg is a female protein that can be detected in the plasma of male fish after exposure to estrogenic chemicals. In vivo bioassays are used to measure the estrogenic potencies of ambient water, industrial and municipal wastewaters, and pure chemicals. The estrogenic potencies of frationated mixtures are measured using a vitro assay based on primary cultures of trout liver hepatocytes. Dr. Sherry is also exploring the replacement of conventional tests that use live fish for the detection of sublethal responses by tests based on fish cell lines. Further interests include the sublethal effects of waste waters from petroleum refineries and oil sands operations on the biota in recipient environments.

Tom Edge
Email: Tom.Edge@ec.gc.ca
Tom Edge joined the National Water Research Institute in January 2001 and is developing a research program to better understand the impacts of microbial pathogens in aquatic ecosystems. He completed is PhD in June 2001at Carleton University on the ability to predict the fate of environmental releases of genetically modified microorganisms. Tom has been involved in environmental microbiology research and assessing the implications of advances in biotechnology for over 10 years in positions within Environment Canada and Foreign Affairs and International Trade. He worked on developing the Federal Framework for regulating biotechnology in Canada and the New Substances Notification Regulations for biotechnology products under Canadian Environmental Protection Act. This work included establishing

an environmental risk assessment framework for screening microbial biotechnology products for hazards such as pathogenicity. He also served as a scientific advisor and member of Canadian delegations to the United Nations Biosafety Protocol negotiations that developed an international regulatory scheme for transboundary movement of genetically modified organisms. Tom is currently studying applications of molecular tools like DNA microarrays to characterize the occurrence and environmental fate of microbial pathogens and genetically modified microorganisms.

Mark Hewitt
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Mark Hewitt received his PhD in Pesticide Chemistry/Toxicology from the University of Guelph in 1997. Prior to joining the Ecosystem Health Assessment Project in 1998 Dr. Hewitt was an NSERC Visiting Fellow with the National Water Research Institute. His research interests relate to the isolation and identification of biologically active environmental contaminants in aquatic ecosystems. Currently, Dr. Hewitt's research is focusing on characterizing endocrine disruptors in pulp mill effluents and in runoff associated with agrochemical spraying activities.

Jagmohan Kohli
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After receiving his PhD from Aligarh University, Aligarh , India Dr. Kohli worked as a Research scientist with the Council of Scientific & Industrial Research, India, and the Institute of Ecological Chemistry, Bonn , Federal Republic of Germany. His research work in Germany included the uptake, distribution and identification of chlorinated pesticides metabolities in plants and soil using radiotracer methodology. Dr. Kohli joined the National Water Research Institute as Research Chemist in 1984, and in 1997 was promoted to Research Scientist. He is currently working on the isolation and identification of environmental endocrine disruptors for bioassessment ; and also the synthesis of compounds associated with biological responses. Dr. Kohli has also worked in the private sector with consulting firms, industries, government, and academia in environmental related issues. A published author, Dr. Kohli has to his credit, 31 research papers in referred journals.

Mark McMaster
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Mark McMaster received his PhD in reproductive toxicology from the Department of Zoology at the University of Guelph in 1995. Prior to joining the Ecosystem Health Assessment Project of the Aquatic Ecosystem Protection Research Branch in 1996, Dr. McMaster was an NSREC Visiting Fellow with the Department of Fisheries and Oceans with the National Water Research Institute. His research interests relate to the field of endocrine disrupting chemicals or compounds that alter the growth, reproduction and development of wild fish species. Currently Dr. McMaster is evaluating the effects of pulp and paper mill effluents, oil sands related chemicals, agricultural runoff and sewage wastes on reproductive function in fish populations. He is a member of the Environmental Effects Monitoring Programs National Team as well as the Science Committee, where he participates in the development of the new Environment Canada program as well as conducts research in support of the EEM program. He is an Adjunct Faculty member at the University of Waterloo and an Associate Faculty member at the University of Guelph where he supervises and sits on graduate committees for Master's and PhD students.

Norman Neumann
Email: Norman.Neumann@cciw.ca

Norman Neumann received his Ph.D in Cellular and Molecular Biology from the University of Alberta in 1999. His area of expertise is comparative immunology. Prior to joining the Ecosystem Health Assessment Project in 2000, Dr. Neumann was a postdoctoral fellow at the University of Alberta, in the Department of Civil and Environmental Engineering. His work involved examining the efficacy of physical and chemical disinfectants on inactivating water-borne human pathogens. His research interests at NWRI primarily relate to the field of immunology. Dr. Neumann is interested in what effects environmental contaminants have on the immune system of fish (and wildlife), and their subsequent ability to overcome infectious and neoplastic disease. Dr. Neumann is an Adjunct Assistant Professor at the University of Waterloo.

Joanne Parrott
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Joanne Parrott joined the National Water Research Institute in 1993 after receiving her PhD from the University of Waterloo. Dr. Parrott's scientific research examines the effects of toxicants on fish health. She is interested in the ways chemicals affect fish, and in particular on biochemical indicators of effects. In her capacity as a research scientist Dr. Parrott studies the impact of pulp mill effluents on oil sands wastewaters on fish, and is developing new laboratory tests of fish reproduction that link to effects seen in the field. She is Adjunct Faculty at Queen's University and Associate Faculty at the University of Guelph, where she supervises Master's and PhD students.

2000/01 Fiscal Year AEPRB Publication List

1. Refereed Publications (includes journal articles, chapters, books)

Books or Chapters

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