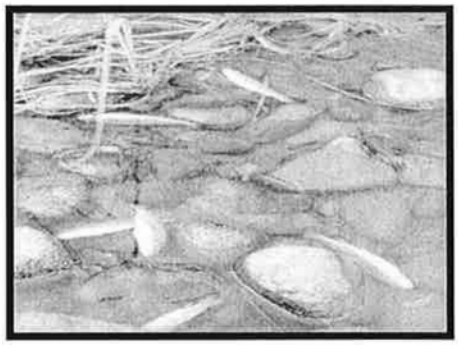
Strategic Review of

Chemicals Research in the Environmental Science Program and the Arctic Science Program, Science Sector, Fisheries and Oceans Canada



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Executive Summary

DFO's toxic chemicals research plays an important role in Departmental decision-making linked to maintaining sustainable fisheries and aquaculture, healthy and productive ecosystems, and safe and accessible waterways. DFO Sectors [Fisheries Management, Oceans, Office of Sustainable Aquaculture, Canadian Coast Guard] and other government departments use the scientific advice derived from DFO's toxics research to develop policies, regulations, guidelines, issue authorizations or closures, advise industry, etc. on issues related to the impact of toxic chemicals on the conservation of fish and fish habitat.

As a follow-up to the Science Assessment, the National Science Directors Committee [NSDC] directed that a review of the toxic chemicals research within DFO be undertaken for the period of 1997/98 to 2001/02. The goal of the review was to conduct an assessment of the relevance, success and effectiveness of DFO's past effort on toxics research and to provide options on the future direction of the Department's research on toxic chemicals. The review was conducted within the context that the Departmental status quo remains non-viable and was based on information received from regional Environmental Science managers, clients and the Science Project Inventory. Comments on the report were solicited from an external reviewer.

During the final year of the review [2001/02], the A-base allocation to toxic chemicals research was $7.0M[1] and supported 76 FTEs. Of this $7.0M, salaries accounted for $4.9M, A-based O&M accounted for $0.4M, and strategic research funds for $1.8M. An additional $3.7M in B-based funds was leveraged, to give a total budget of $10.7M for toxic chemicals research in 2001/02.

In 2001/02, funding through the Environmental Science Strategic Research Fund [ESSRF] represented about 82% of the A-based O&M dedicated to toxic chemicals research. The potential loss of almost $2M of strategic research funds, due to the ESSRF's incorporation into the amalgamated DFO Science strategic research fund, could have serious consequences for toxic chemicals research.

The review aimed to provide DFO Science with the necessary information to decide the kinds of projects that are essential, the different directions that are appropriate, and the future paths to take. Several key messages emerged:

- The toxic chemicals research undertaken within DFO is relevant to the Department's mandate and to addressing client needs.
- During the review period, 119 projects were undertaken to address five high-level objectives: 1] Regulations and Regulatory Decisions [for DFO or other government departments]; 2] Integrated Management Plans; 3] Policies, Guidelines, Agreements, and Codes; 4] Remediation or Recovery Plans; and 5] Public Awareness and Public Action.

[1] Based on regional input.

- Toxics research within DFO was very successful in leveraging funds from other sources. However, a reliance on B-based funds has resulted in external funding agencies and other government departments having a significant influence on research activities within DFO [so that research addresses the priorities of external agencies and government departments].
- Research projects have investigated biological impacts [51%], chemical fate and transport [42%] and human use of fish [7%].
- There are many good examples where toxic chemicals research has succeeded in causing significant action by decision-makers.
- Research in support of decision-making in other government departments accounted for 25% of DFO's research projects.
- Environment Canada is increasingly undertaking toxic chemicals research that overlaps DFO's research efforts, especially in the freshwater environment and the Arctic.
- Some expensive analytical equipment is becoming outdated, and there is equipment duplication in some areas.
- The task of collating resource information was difficult due to the review team's inability to reconcile resource information obtained from the Science Project Inventory and from regional input.
- Given that DFO's Environmental Science Program has a number of priorities besides toxic chemicals research [e.g., environmental issues concerning energy development, invasive species, habitat management], there is a need to coordinate, rationalize and realign the current program of toxic chemicals research in concert with the Science Assessment.

The review has identified several key issues that will require NSDC consideration. These issues include the following:

- clarification of the need and the core capacity for toxic chemicals research in DFO;
- determination of how the scientific advice can be developed and delivered; and
- identification of research priorities.

To assist the NSDC, a series of 10 questions for decision have been developed. These are summarized in a decision tree and further elaborated on in discussion points that are outlined in the section entitled Future Direction [beginning on page 24] .

The future direction and sustainability of toxics research within DFO is dependent upon the guidance provided by the NSDC. While decisions from senior management will be required to implement any new directions for toxic chemicals research, the following possible new directions are suggested.

- Maintain adequate in-house expertise for toxic chemicals research in DFO Science to address core research activities.
- Allocate higher priority to studies on the biological effects of toxic chemicals on fishery resources and the habitats upon which they depend [and lower priority to contaminant fate and residues].

- Focus on solving practical problems that are essential to DFO's mandate and obligations and the needs of key clients [and avoid research that is not crucial to DFO's mandate or client needs].
- Develop a process, such as Risk-Based Priority Setting, to help determine which toxic chemicals research projects should be funded.
- Develop and enhance alternate delivery for science functions that can be done outside of DFO through service agreements and seed funding with universities and industry.
- Investigate strengthening the relationship between DFO, Environment Canada and universities through virtual centres, especially in freshwater toxicology.
- Expand DFO's Academic Science Subvention Program to strengthen academic research on toxic chemical issues related to impacts on fishery resources.
- Clarify the science roles and responsibilities of DFO and Environment Canada and enhance cooperation between the two departments.
- Enhance partnering with Canadian universities, other government departments and industry, and create capacity in these sectors to do some of the work now being done in-house.

Résumé

La recherche sur les produits chimiques toxiques joue un rôle important dans les décisions que prend le Ministère pour assurer des pêches et une aquaculture durables, des écosystèmes sains et productifs et des voies navigables sures et accessibles. Les secteurs du MPO [Gestion des pêches, Océans, Bureau de l'aquaculture durable, Garde côtière canadienne] et d'autres ministères utilisent des conseils scientifiques qui découlent des recherches du MPO sur les produits toxiques pour élaborer des politiques, des règlements, des lignes directrices, des autorisations ou des périodes de fermeture et conseiller l'industrie, etc. au sujet des questions associées aux répercussions des produits chimiques toxiques sur la conservation du poisson et de son habitat.

Par suite de l'Évaluation scientifique, le Comité national des directeurs des sciences [CNDS] a demandé qu'un examen de la recherche sur les produits chimiques toxiques au MPO soit entrepris pour la période de 1997/98 à 2001/02. L'objectif de cet examen est d'évaluer la pertinence, les réussites et l'utilité des efforts déployés par le passé au MPO en recherche sur les produits toxiques et présenter des options pour l'orientation future des recherches du Ministère. L'examen a été effectué dans l'optique que le statu quo est toujours non viable et a utilisé l'information reçue des gestionnaires des sciences de l'environnement régionaux, des clients et de l'inventaire des projets scientifiques. Des commentaires sur le rapport ont été demandés d'un examinateur de l'extérieur.

Au cours de la dernière année de l'examen [2001/02], les affectations de crédits votés à la recherche sur les produits chimiques toxiques étaient de 7 M$[2] et comprenaient 76 ETP. De cette somme de 7 M$, les salaires représentaient 4,9 M$, les F et E votés 0,4 M$ et le Fonds de recherche stratégique 1,8 M$. En outre, 3,7 M$ de fonds pour mesures temporaires ont été obtenus, ce qui donne un budget total de 10,7 M$ pour la recherche sur les produits chimiques toxiques en 2001/02.

En 2001/02, les sommes du Fonds de recherche stratégique en sciences environnementales [FRSSE] représentaient environ 82 % des fonds de F et E de crédits votés consacrés à la recherche sur les produits chimiques toxiques. La perte potentielle de presque 2 M$ de fonds de recherche stratégique découlant de l'incorporation du FRSSE dans le fonds de recherche stratégique amalgamé des Sciences au MPO pourrait avoir de graves conséquences pour la recherche sur les produits chimiques toxiques.

L'examen visait à donner aux Sciences du MPO l'information nécessaire pour décider du genre de projets qui sont essentiels, des différentes orientations appropriées et des voies futures. Plusieurs messages clés sont ressortis :

- La recherche sur les produits chimiques toxiques entreprise au MPO est pertinente au mandat du Ministère et aux besoins des clients.
- Au cours de la période d'examen, 119 projets ont été entrepris pour atteindre cinq objectifs de haut niveau : 1] Décisions réglementaires [pour le MPO et d'autres ministères]; 2] Plan de gestion intégré; 3] Politiques, lignes directrices, ententes et

[2] Selon les informations régionales.

codes; 4] Plans d'assainissement ou de rétablissement; 5] Sensibilisation du public et mesures publiques.

- La recherche sur les produits toxiques entreprise au MPO a bien réussi à obtenir des fonds d'autres sources. Toutefois, le recours aux fonds pour mesures nouvelles a eu pour effet que les organismes de financement externes et les autres ministères concernés influent grandement sur les activités de recherche au MPO [de manière à ce que la recherche soit axée sur les priorités des organismes externes et des autres ministères concernés].
- Les projets de recherche ont porté sur les répercussions biologiques [51 %], le destin et le transport des produits chimiques [42 %] et la santé humaine [7 %].
- Il y a de nombreux bons exemples de recherche sur les produits chimiques toxiques qui ont réussi à convaincre les décisionnaires de prendre des mesures importantes.
- La recherche effectuée à l'appui des décisions dans d'autres ministères représentait 25 % des projets de recherche du MPO.
- Environnement Canada entreprend de plus en plus de recherche sur les produits chimiques toxiques qui chevauchent les efforts du MPO, surtout dans l'environnement d'eau douce et l'Arctique.
- Certains biens d'équipement analytiques coûteux deviennent désuets et, dans certains domaines, il y a duplication de matériel.
- La tâche de rassembler l'information sur les ressources a été difficile étant donné que l'équipe responsable de l'examen était incapable de concilier l'information obtenue de l'Inventaire des projets scientifiques et celle des régions.
- Étant donné que le programme des sciences de l'environnement du MPO compte un certain nombre de priorités à part la recherche sur les produits chimiques toxiques [p. ex. questions environnementales concernant l'aménagement énergétique, les espèces envahissantes, la gestion de l'habitat], il faut coordonner, rationaliser et réaligner le programme actuel de recherche de concert avec l'Évaluation scientifique.

L'examen a dégagé plusieurs questions importantes que devra étudier le CNDS, notamment :

- la clarification du besoin et de la capacité fondamentale de recherche sur les produits chimiques toxiques au MPO;
- la détermination de la façon dont les avis scientifiques peuvent être élaborés et transmis;
- la détermination des priorités de recherche.

Pour aider le CNDS, une série de 10 questions a été élaborée. Elles sont résumées dans une arborescence de décision et détaillées davantage dans des points de discussion donnés dans la section « Future Direction » [à partir de la page 24].

L'orientation future et la durabilité de la recherche sur les produits toxiques au MPO dépendent de l'orientation donnée par le CNDS. Bien que des décisions de la haute direction soient requises pour adopter toute nouvelle orientation de la recherche, les nouvelles orientations suivantes sont suggérées.

- Maintenir, à l'interne, les connaissances suffisantes pour la recherche sur les produits toxiques aux Sciences du MPO pour les activités de recherches principales.

- Accorder une priorité plus élevée aux études des effets biologiques des produits chimiques toxiques sur les ressources halieutiques et les habitats dont elles dépendent [et une priorité inférieure au destin et aux résidus des contaminants].
- Se concentrer sur la résolution de problèmes pratiques qui sont cruciaux pour le mandat et les obligations du MPO et les besoins des principaux clients [et éviter la recherche qui n'est pas cruciale pour le mandat et les clients du MPO].
- Élaborer un processus comme l'établissement des priorités fondé sur les risques pour aider à déterminer quels projets de recherche devraient être financés.
- Élaborer et rehausser un mode de rechange des fonctions scientifiques qui peuvent être assumées à l'extérieur du MPO au moyen d'ententes de services et de fonds de démarrage pour les universités et l'industrie.
- Envisager le renforcement des rapports entre le MPO, Environnement Canada et les universités grâce à des centres virtuels, surtout en toxicologie des eaux douces.
- Élargir le programme de subventions aux sciences universitaires du MPO pour renforcer la recherche effectuée dans les universités sur les produits chimiques toxiques et leurs répercussions sur les ressources halieutiques.
- Préciser les rôles et les responsabilités scientifiques du MPO et d'Environnement Canada et accroître la collaboration entre les deux ministères.
- Rehausser les partenariats avec les universités canadiennes, d'autres ministères et l'industrie, et créer la capacité dans ces secteurs d'effectuer des travaux actuellement faits à l'interne.

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Introduction

Canada has over 35,000 chemical substances in commercial use. An overwhelming majority of existing chemicals have not been tested for toxicity, and very little data exist on these substances. In the United States, for example, only 7% of high production volume chemicals have an adequate data set for assessing the risks they pose.

As a result of the release of chemicals to the environment, adverse impacts to fishery resources do occur. Examples include the following:

- endocrine disrupting substances have been linked to population decreases of Atlantic salmon;
- coal mine effluent can impact sensitive life stages of fish;
- mercury is the major cause of fishery closures in Ontario;
- B.C. killer whales are the most contaminated marine mammal;
- pesticide use in P.E.I. results in massive fish kills; and
- tributyl tin has been linked to sex alterations in marine gastropods.

To reduce the impacts of toxic chemicals on fish, fish habitat and fishery resources through regulatory and policy decisions, Fisheries and Oceans Canada [DFO] conducts research on toxic chemicals to provide the scientific advice necessary in the decision process. The Department has conducted such research since initial concerns about environmental contaminants were raised in the 1960s and 1970s. By 1986, 103 FTEs were involved in toxics research. Currently [2002/03], DFO allocates 70 FTEs to this research effort, and toxic chemicals research consumes $6.8M of the $29M allocated to the Environmental Science Program. This research provides scientific advice within the mandates of the Environmental Science Program and the Arctic Science Program and is not identified as a distinct "Toxic Chemicals Program."

The desired end-point of the toxic chemicals research is the identification of the biological impact of toxic chemicals on the aquatic ecosystem and the understanding how these changes are reflected in the health of the fishery resource. The issues facing toxics research are broad and range from cellular to population levels; from marine to freshwater systems; from toxic sources such as agriculture, municipal effluent, energy development, pulp mills and aquaculture; and are responsive to a variety of federal legislation [e.g., *Fisheries Act, Oceans Act, Canadian Environmental Assessment Act*]. To understand and advise on these issues requires not only the individual expertise of the researcher, but that of a research team that is usually multi-disciplinary, multi-regional and multi-sectoral. The research is usually conducted as a cooperative effort between researcher and client and is not conducted in isolation within laboratory walls.

As a follow-up to the Science Assessment, the National Science Directors Committee [NSDC] directed that a review of DFO's toxic chemicals research effort be undertaken for the period 1997/98 to 2001/02. The review will help DFO to coordinate and rationalize its efforts with respect to its direct clients [e.g., Habitat Management, Oceans Management], other government departments [especially Environment Canada], and provinces and territories.

The review was conducted within the following context: a Departmental Assessment and Alignment Project [DAAP] that is founded on the conclusion that the "Departmental status quo remains non-viable;" a funding climate where no new resources will be available and where existing resources will be reallocated from low to high priorities; a change from the Environmental Science Strategic Research Fund to an undefined Science Strategic Fund; and expectations that additional responsibilities will have to be assumed by the Environmental Science Program for new areas such as Species at Risk, the *Oceans Act*, and the large expansion of Habitat Management activities.

The goal of this review is to conduct an assessment of the relevance, success, effectiveness and the future direction of the Department's research on toxic chemicals. The merit of the research conducted by DFO scientists is not being questioned by this review. The Terms of Reference guiding this review are located in Appendix 1.

A drafting team led by Environmental Science, Ottawa, conducted the review following Terms of Reference approved by the National Science Directors Committee. Information on toxic chemicals research was gathered from regional Environmental Science managers and key clients at workshops in Burlington [November 14/15, 2002] and Ottawa [April 9/10, 2003]. Subsequently, managers sent in detailed data on regional projects via standardized templates [see Appendix 1]. The drafting team gathered additional information from existing reports and interviews. The regional managers and key clients reviewed the report. In addition, comments were solicited from an external reviewer.

Federal Departments or Agencies with Responsibilities for Toxic Chemicals

Mandates

Fisheries and Oceans Canada

DFO's mandate states that DFO is responsible for policies and programs in support of Canada's economic, ecologic and scientific interests in oceans and inland waters, and for the conservation and sustainable utilization of Canada's fisheries resources in marine and inland waters. Policies and programs undertaken to implement this program must be based on an understanding of how marine and freshwater ecosystems function and how they are affected. Conservation and protection can only be achieved by understanding how all anthropogenic and natural stresses, including the introduction of toxic chemicals, affect the ability of aquatic ecosystems to withstand these stresses and the capacity of fish habitats to sustain the production of fish.

The overall objective of the Department's toxic chemicals research has been to determine the effects of toxic chemicals on fish, fish habitat, aquatic ecosystems, and human use of fish and aquatic ecosystems. It is important to note that little or no freshwater research is conducted in the Pacific, Quebec and Maritimes Regions.

The following Departmental drivers collectively set the objective of toxics research [see Appendix 2 for details]:

- Legislative and Regulatory: *Fisheries Act; Oceans Act; Species at Risk Act; Canadian Environmental Assessment Act.*
- Policies and Programs: Policy for the Management of Fish Habitat; Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada; Program for Sustainable Aquaculture; Canada's Ocean Strategy; draft Freshwater Policy.
- Memoranda of Understanding: Memorandum of Understanding between DFO and Environment Canada on Section 36 of the *Fisheries Act*; Memorandum of Understanding on Research and Scientific Advice between DFO and the Pest Management Regulatory Agency, Health Canada; Memorandum of Understanding between DFO and Natural Resources Canada on Participation in the Program of Energy Research and Development.
- Regional and National Agreements: Pacific Regional Working Agreement and Atlantic Regional Working Agreement between DFO and Environment Canada; Great Lakes Water Quality Agreement; Canada-Ontario Agreement.
- International Agreements: International Council for the Exploration of the Seas.

Other federal departments also have responsibilities for toxic chemicals. These include the following:

Environment Canada

Environment Canada [EC] conducts research to protect aquatic ecosystems from the impacts of toxic chemicals by developing knowledge and understanding of priority pollutants to support informed environmental decision-making and sustainable management practices. Results contribute to the knowledge requirements of the Toxic Substances Management Policy, the *Canadian Environmental Protection Act*, the *Fisheries Act*, and the *Pest Control Products Act*. EC's projects focus on the following areas: determining the persistence, fate and exposure of toxic chemicals in aquatic environments; evaluating the effects of priority substances on aquatic organisms; developing indicators and bioassays to detect, identify, and measure contaminant effects in aquatic ecosystems; and assessing the distribution and biological effects of atmospherically transported persistent organic pollutants and metals in aquatic ecosystems and food chains. The primary focus of such research is in freshwater ecosystems.

Health Canada

Health Canada [HC] is the federal department responsible for helping the people of Canada maintain and improve their health. Health Canada monitors health and safety risks related to the sale and use of drugs, food, chemicals, pesticides, medical devices and certain consumer products.

The mandate of the Pest Management Regulatory Agency [PMRA] of Health Canada is to protect human health and safety and the environment by minimizing risks associated with pest control products while enabling access to pest management tools and strategies. Pesticides imported into, sold or used in Canada are regulated under the *Pest Control Products Act* and Regulations. The PMRA is responsible for administering this legislation and for registering pest control products.

The Agency carries out its responsibility through the following activities:

- evaluating pesticides to ensure they meet the latest human health and environmental safety standards before being registered for use in Canada;
- re-evaluating older pesticides to ensure they remain acceptable for use based on the latest standards; and
- setting the safe residue levels for pesticides in food.

The PMRA does not have an in-house capability to conduct research on the environmental impacts associated with pesticide use. The PMRA must rely on scientific information and advice provided by other science-based departments, including DFO. In cooperation with the PMRA, DFO recently received new and ongoing funding to conduct research on the aquatic impact of pesticides.

Pesticide residue levels in foods are regulated by establishing maximum residue limits [MRLs]. Canadian MRLs apply to residues in both food produced in Canada and food imported into Canada from other countries. The limits are established under the authority of the *Food and Drugs Act* [FDA] and appear in the Food and Drugs Regulations. Under the FDA, the Canadian Food Inspection Agency [CFIA] is responsible for monitoring domestic and imported foods and carrying out enforcement actions to prevent the sale of food containing excessive residues.

The Food Directorate, Health Products and Food Branch, Health Canada conducts targeted research to ensure the continued safety of food. It undertakes national monitoring studies, including the Total Diet Program and National Human Milk Survey, which provide data on the exposure of Canadians to a variety of substances, including pesticides and other environmental contaminants. This information is used by Health Canada in their ongoing human health risk assessments.

Agriculture and Agri-Food Canada

Agriculture and Agri-Food Canada [AAFC] provides information, research and technology, and policies and programs to achieve security of the food system, health of the environment and innovation for growth. AAFC has four National Science Themes. Under the theme of "Environmental Health," AAFC conducts research on protecting environmental quality that includes the development of knowledge and technologies to minimize the impact of agricultural production on soils, air, water and biodiversity. To reduce the impact of land-based agricultural activities on the quality and quantity of our water, AAFC conducts research on the off-site movement of contaminants by

investigating the environmental fate and impacts on fish of biological and chemical contaminants.

Canadian Food Inspection Agency

The purpose of the Fish, Seafood and Production Program, under the *Fish Inspection Act*, is to develop and promote appropriate process and product standards that contribute to the achievement of acceptable safety, quality and identity of fish and seafood products, and to provide reasonable assurance of compliance with these standards. This program is directed primarily at federally-registered establishments and is mandatory for fish that are imported, exported or shipped inter-provincially. This program includes the analysis of fish, seafood and seafood products for compliance with specific standards related to residues of drugs and antibiotics, pesticides, organochlorines, mercury and heavy metals, and other environmental contaminants.

Indian and Northern Affairs Canada

Indian and Northern Affairs Canada [INAC] is responsible for two separate yet equally important mandates: Indian and Inuit Affairs, and Northern Affairs. This broad mandate is derived largely from the *Department of Indian Affairs and Northern Development Act*, the *Indian Act*, territorial acts and legal obligations arising from section 91(24) of the *Constitution Act, 1867*.

In general, INAC has primary, but not exclusive, responsibility for meeting the federal government's constitutional, treaty, political and legal responsibilities to First Nations, Inuit and Northerners.

In Northern Affairs, INAC is the principal federal department responsible for meeting the federal government's constitutional, political and legal responsibilities in the North. With legislative and policy authority over most of the North's natural resources, INAC is the custodian and resource manager for an area occupying 40% of Canada's land mass. INAC's role in the North is extremely broad and includes managing natural resources, protecting the environment and fostering leadership in sustainable development both domestically and among circumpolar nations.

INAC manages the Northern Contaminants Program [NCP] with other federal departments [Health Canada, Environment Canada, DFO], territorial governments and Aboriginal organizations. The NCP was established in 1991 to work towards reducing and, where possible, eliminating contaminants in traditionally harvested country food.

Natural Resources Canada

Natural Resources Canada [NRCan] has a broad mandate to carry out scientific research under the *Resources and Technical Surveys Act* and the *Department of Natural Resources Act*. NRCan also provides, as a federal authority, scientific expertise in earth sciences under the *Canadian Environmental Assessment Act*. The Minerals and Metals Sector of

NRCan undertakes research related to the understanding of the transport, fate and chronic toxicity of metals in aquatic ecosystems. The Canadian Forest Service [CFS] of NRCan conducts research on the fate, effects and bioaccumulation of forest pesticides and other toxic materials in aquatic ecosystems. CFS also studies the impact of forestry practices, air pollution and naturally occurring deleterious elements [e.g., mercury] in aquatic ecosystems.

DFO/EC Responsibilities

During Program Review, DFO's capacity to provide science support for its freshwater mandate was severely reduced [Appendix 3]. During this period, EC enhanced its own freshwater program through the addition of ongoing research programs of ex-DFO researchers that relocated to EC. Most of the lost DFO expertise was related to toxic chemicals research. This has resulted in an apparent overlap between DFO's and EC's toxic chemicals research. This is especially true in the Arctic, the Great Lakes and the St. Lawrence freshwater ecosystem. In the Arctic, DFO and EC are both conducting research on contaminant levels in northern ecosystems. In the Great Lakes, EC is conducting research on the effects of toxic chemicals on fish, but DFO is not. Both departments have invested significantly in analytical equipment.

As part of this review of toxic chemicals research, a DFO/EC bilateral meeting was held to discuss common interests in toxics research in freshwater. The discussion focussed on identifying areas of overlap, research gaps and cooperation. EC's representative, Dr. J. Carey, initiated the discussion by stating support for DFO's toxic research program as it complemented EC's program.

The focus of EC's program is addressing the research needs of the *Canadian Environmental Protection Act,* 1999 [CEPA 99] [Appendix 4]. Under this legislation, the Minister of Environment shall conduct research relating to environmental contamination arising from disturbances of ecosystems by human activity [Part 3 of CEPA 99]. Additionally, in support of the management of toxic substances, the Minister may conduct research on the exposure and effects of substances [Part 5 of CEPA 99]. In reviewing both DFO's and EC's research programs, it was concluded that while some overlap in the study of the same toxic chemical may occur, the objectives of the research were different. For example, EC does not undertake research to address effects of toxics on fish populations. Both departments also expressed interest in enhancing cooperation on toxics research. The new program on pesticide research that is being initiated by both departments was seen as an early example to demonstrate strengthened cooperation.

Environment Canada, along with Health Canada, is in the process of preparing a Memorandum to Cabinet [MC] to seek funds to fulfil mandatory obligations under CEPA 1999. EC is requesting tens of millions of dollars over five years to conduct environmental quality research and monitoring. A key element of the MC is the need for EC to maintain a core capacity in research on the environmental effects of toxic chemicals on aquatic ecosystems.

Toxic Chemicals Research in DFO and its Predecessors

Historical Context

The importance attributed to research on toxic chemicals and other pollution effects related to marine and freshwater living resources has a long history. Indeed, one of the very first articles published on aquatic science in Canada was on the effects of polluted waters on fish life [Knight 1901].

Since these early days, pollution research has expanded, though slowly at first. To celebrate the 50th anniversary of the National Research Council, a special publication was produced that contained all federally published papers on pollution since the turn of the century. Only seven papers were published before 1950, followed by six in the next decade, and 22 in the next five years [Fisheries Research Board of Canada 1966].

By the 1970s, Canadian scientists were recognized internationally as leaders in several areas of pollution research. Their work provided the scientific basis for implementing national and international legislation to reduce the effects of toxic chemicals on the aquatic environment.

Also in the 1970s, Canada made a pronounced shift towards increased research on pollution issues. The following events contributed to this shift:

- creation of a Department of the Environment [DOE] in 1971, in which the Fisheries and Marine Service was embedded; and
- Stockholm Conference on the Human Environment in 1972 and the subsequent establishment of the United Nations Environment Programme, with Canadian Maurice Strong as the first Secretary General.

In 1975/76, as part of a wider study of the scientific requirements and priorities for fisheries and aquatic sciences in Canada, the Fisheries Research Board of Canada, acting in an advisory role to the Minister of Fisheries, commissioned a review and assessment of research on aquatic environmental quality and toxic chemicals in the aquatic environment [Hamilton 1976; Harvey 1976; Fisheries Research Board of Canada 1977].

These studies presented the first rigorous examination of research on toxic chemicals in Canada and are therefore useful as a basis for comparison with the situation today. Most of the research in 1974/75 was by the federal government, with DOE being the major player. About 15% of DOE's scientists were actively engaged in such research. This amounted to 30 research scientists from fisheries, representing expenditures of about $1.5M, and 100 from the rest of DOE, representing expenditures of over $5M. Details of the roles of these groups were published in the Canada Water Yearbook of 1975.

At the same time, grants to universities for aquatic environmental toxicology added up to $600K, and contracts let by federal departments totaled $1.7M for mostly environmental impacts of toxic chemicals, chiefly oil related. [Note: all $$ figures are in 1975 $$]

With the creation of the Department of Fisheries and Oceans in 1979, DFO's role with respect to Section 36 of the *Fisheries Act* [i.e., the pollution control provisions] was based on the original 1971 administrative arrangement that was established during the creation of the Department of the Environment. DFO was responsible for the following:

- measurement of effects outside the zone of influence;
- pre- and post-development resource inventories [kinds, densities, quality, distribution of aquatic organisms]; and
- determination of scientific requirements necessary to maintain aquatic resources.

In 1985, a Memorandum of Understanding [MOU] between DFO and EC re-affirmed the above administrative arrangement. This MOU remains in effect to this day.

In 1986, DFO's Policy for the Management of Fish Habitat identified the Department's commitment to conduct research on toxic chemicals. The bulk of toxicology and contaminants research in DFO was in the Physical and Chemical Sciences group, with 103 FTEs. An unknown number of other researchers were also working on contaminant issues in the Biological Sciences and Habitat groups.

A strategic review in 1987 of the Toxicology and Contaminants Program in the Physical and Chemical Sciences group recommended that the Program's objective should be "to control chemical contamination of aquatic ecosystems to protect, restore, maintain and enhance freshwater and marine fisheries, the ecosystems that support those fisheries, and the wholesomeness of fisheries products." The following components were identified as essential to address DFO's issues: biogeochemistry, bioaccumulation, toxicology, monitoring, risk assessment, emergency investigations, advice and analytical chemistry.

The Federal Government's Green Plan gave a big boost to toxic chemicals research in DFO over the period 1991 to 1997, with $31M being targeted to three research areas:

- assessing the impacts of toxic chemicals in aquatic ecosystems, especially related to their effects on fish, fish habitat and fisheries resources;
- determining spatial and temporal trends of toxic chemicals and their effects on aquatic biota; and
- filling knowledge gaps critical to the effective conduct of assessment and monitoring activities.

Toxic Chemicals Research [1997/98 – 2001/02]

General Overview

Toxic chemicals research is a significant element of the Environmental Science [ES] Program. During the period of 1997/98 to 2001/02, the annual ES budget ranged from $18.7M to $21.7M, of which 37-53% was allocated to toxic chemicals research, advice and data management [Table 1].

Table 1: ES Budget for Toxic Chemicals Research [1997/98 – 2001/02] [$M]

Year	Annual ES Budget	ES Allocation to Toxic Chemicals Research
1997/98	21.7	11.6
1998/99	NA	NA
1999/00	20.8	9.1
2000/01	18.9	7.0
2001/02	18.7	8.9

NA = data not available
Data were obtained from the Science Project Inventory

Resource Re-alignment

From 1997/98 to 2000/01, total funding for toxic chemicals was reduced by 40% from $11.6M to $7M. In 2001/02, funding for toxic chemical issues was increased to approximately $8.9M, as a response to increasing client concerns over the impacts on fish, marine mammals and endangered species of a new generation of toxic chemicals [Table 1]. However, the 2001/02 expenditure on toxic chemicals represents a reduction of approximately 23% from 1997/98 levels.

In 1997, DFO's initiated a competitive Toxic Chemicals strategic fund [TCRP] as an A-base follow-on to the Green Plan funds. This fund was intended to provide support for research on the fate of toxic chemicals in aquatic ecosystems and their effects on fish and fish habitat. In 2000/01, the Environmental Science Strategic Research Fund [ESSRF] was created. The competitive research fund provides resources for a variety of issues, including toxic chemicals research.

Over the five-year period from 1997/98 to 2001/02, Science strategic funds, including TCRP and ESSRF, allocated to toxic chemicals decreased by 36%, from $3.1M to $2M as resources were realigned to meet other priority research areas [e.g., habitat, marine environment, aquaculture issues] [Table 2].

Table 2: ES Strategic Funds for Toxic Chemicals Research [1998/98 – 2001/02] [$K]

Year	Effluents	Emerging Issues	Data Management	Marine Sediments	Total
1997-1998	2 168	366	300	220	**3 054**
1998-1999	2 142	422	285	210	**3 059**
1999-2000	2 025	609	225	210	**3 069**
2000-2001	1 131	682	239	0	**2 052**
2001-2002	1 226	744	0	0	**1 970**
Total	8 692	2 823	1 049	640	**13 204**

Data were obtained from the Science Project Inventory

In 1997/98, the majority [$2.2M] of the strategic funds for toxic chemicals research supported studies on the impacts of industrial and municipal effluents on fish and fish

habitat. By 2001/02, strategic funding on effluent research had decreased by 43% to $1.2M because scientific information and advice from this research led to a better design of environmental effects monitoring programs [Table 2].

Funds previously allocated to effluent research were re-aligned to address emerging chemical issues [e.g., endocrine disrupting chemicals, flame retardants, sea lice control products] that could significantly impact fisheries resources. The allocation of strategic research funds for these emerging issues doubled from 1997/98 to 2001/02.

In addition to research, strategic funds have been used to develop a national data management system for DFO's toxic chemical data [i.e., the National Contaminants Information System (NCIS)]. From 1997/98 to 2000/01, over $1M of strategic funds were allocated to the development and maintenance of the NCIS. Recognizing the important role of data management, the Science Sector allocated permanent funding and regions realigned resources to support the NCIS in 2001/02. In 2002/03, the NCIS accounted for 4 FTEs.

In 1997/98, strategic research funds were provided to DFO researchers to establish a national research program to fill existing data gaps related to the levels, fluxes and sources of toxic substances in marine sediments. This project enhanced our understanding of the cycling and fate of toxic substances in marine sediment and was completed in 1999/2000 at a total cost of $640K. Results from this study assisted in developing international protocols on the control of toxic chemicals transported long distances. This program also provided useful information for the management of contaminated sediments, including the development of criteria for disposal at sea.

As a result of its selection criteria, the ESSRF fostered the development of multi-regional, multi-disciplinary projects that addressed national issues. This enhancement of regional cooperation strengthened the ability of the Environmental Science Program to address new issues, such as emerging chemicals and sediment residues.

Program Inventory

To develop an inventory of DFO's expenditures on toxic chemicals research for the period of 1997/98 to 2001/02, regional ES managers were provided with a standardized template to list information on FTEs [full-time equivalent], salaries, and O&M from A-base and other sources. The information provided by the regions did not correspond with the values from the Science Project Inventory [Tables 1 and 2]. The difference is $3.3M. Due to differences in interpretation as to what constitutes a toxic chemicals research project, it was not possible to reconcile the differences.

Between 1997/98 and 2001/02, a total of more than $52M in A- and B-base and other funds was invested in toxic chemicals research projects for salaries and O&M [Table 3]. A-base support amounted to $36.9M [70% of total funding for toxic chemicals research]. This amount includes $26.4M of straight A-base and $10.5M from the competitive Toxic Chemicals Research Program [TCRP] and Environmental Sciences Strategic Research

Fund [ESSRF]. Approximately two-thirds of A-base support [68%] was directed to salaries, and one-third [32%] was directed to O&M, most of which was provided through TCRP and ESSRF. B-base and other sources, such as the Toxic Substances Research Initiative [TSRI] and the Program on Energy Research and Development [PERD], contributed $15.2M [30% of total funding for toxic chemicals research]. Most of this funding went to O&M.

Table 3: Total Resources: Salaries and O&M [1997/98 – 2001/02] [$K]

	A-base			B-base	Total
	Salaries	O&M	TCRP ESSRF	and other	
1997-1998	5054	365	2679	2436	**10533**
1998-1999	4629	356	2300	1857	**9141**
1999-2000	5184	355	2156	3012	**10707**
2000-2001	4904	346	1549	4214	**11013**
2001-2002	4848	403	1795	3666	**10712**
Total	**24619**	**1826**	**10477**	**15184**	**52106**

Data were obtained from Environmental Science regional managers

Each year, between 80 and 86 FTEs were dedicated to toxic chemicals research across the country [Table 4]. Most of the salaries [97%] were covered by A-base, and the small remainder was covered by B-base and other sources, such as TSRI.

Table 4: FTEs [1997/98 – 2001/02]

	A-base		B-base	Total
		TCRP and ESSRF		
1997-1998	82	4	0	**86**
1998-1999	75	3	2	**80**
1999-2000	81	2	2	**85**
2000-2001	78	0	4	**82**
2001-2002	76	0	5	**81**

Data were obtained from Environmental Science regional managers

Between 1997/98 and 2001/02, approximately $26M was directed to toxic chemicals research for O&M [Table 5]. A-base support provided $11.7M, and most of this was made available through TCRP and ESSRF. Other sources, such as PERD and TSRI, contributed $14.3M for O&M.

Table 5: Non-Salary O&M Resources [1997/98 – 2001/02] [$K]

	A-base		B-base and other	Total
		TCRP and ESSRF		
1997-1998	365	2399	2436	**5200**
1998-1999	356	2100	1740	**4196**
1999-2000	355	2021	2865	**5241**
2000-2001	346	1549	3969	**5864**
2001-2002	403	1795	3319	**5517**
Total	**1825**	**9864**	**14329**	**26018**

Data were obtained from Environmental Science regional managers

In the past fiscal year [2002/03], toxic chemicals research accounted for 70 FTEs and $6.8M for salaries and A-based O&M. The decrease in the number of FTEs from the previous years may be due to differences in classifying projects as "toxics research." In comparison, based on the Science Project Inventory, the allocation for the entire ES Program during 2002/03 was $29M and 246 FTEs [including $6.1M and 36 FTEs for the sea lamprey control program].

In August 2002, the National Science Directors Committee decided that the Science strategic funds, including the ESSRF, needed to be re-organized. As a result, there was no call for new ESSRF proposals for 2003/04. All ESSRF funding for ongoing toxic chemicals projects will terminate on March 31, 2005. In 2001/02, the ESSRF had contributed $1795K towards toxics research as compared to $403K from regular A-based O&M. This potential loss in strategic funding of about $1.5 to 2.0M annually could have significant implications to the delivery of toxic chemicals research. While a new Science Strategic Fund will be established for 2004/05, the priority that will be given to toxic chemicals research is not known. Additionally, any allocations to toxic chemicals research from the new Science Strategic Fund will not likely be as consistent on an ongoing annual basis as allocations from ESSRF.

Regional Comparisons

Each year, the Central & Arctic [C&A] and Maritimes & Gulf [M&G][3] Regions dedicated the greatest number of FTEs to toxic chemicals research [Figure 1].

[3] The Maritimes & Gulf Region are discussed together because during the review period the Gulf Fisheries Centre was part of the Maritimes Region.

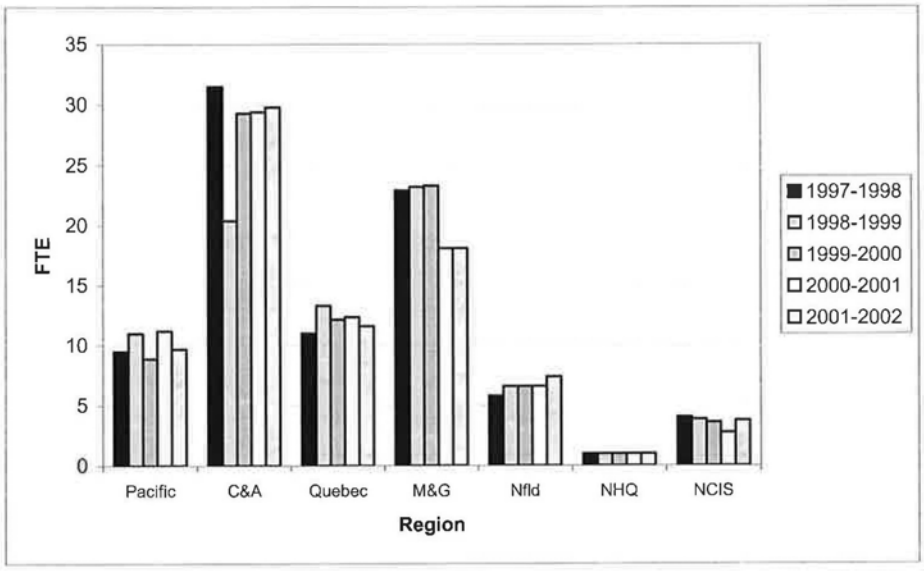

Figure 1: FTEs by Region [1997/98 – 2001/02]

All Regions received O&M funds from non-A-based sources. The Central & Arctic and Maritimes & Gulf Regions received the greatest amount for O&M [Figure 2]. The sources of the "other" funding include the following: Northern Contaminants Program, Great Lakes Action Plan and other government departments in the Central & Arctic Region; PERD, TSRI and Biotechnology in the Quebec Region; and PERD, TSRI and Joint Project Agreements in the Maritimes & Gulf Region.

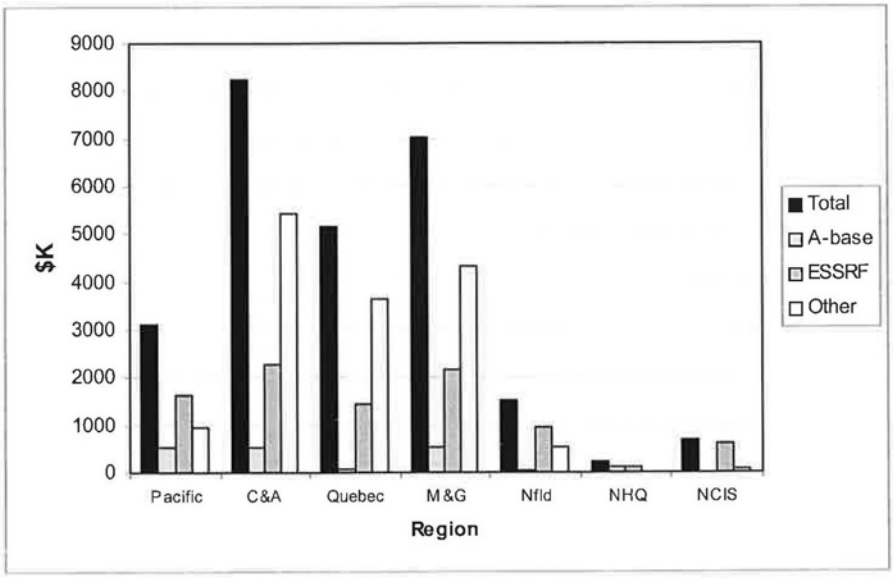

Figure 2: O&M Funding by Region [1997/98 – 2001/02]

Description of Research Projects

Regional Environmental Science managers submitted descriptions of each toxic chemicals research project, using standardized templates. Between 1997/98 and 2001/02, DFO scientists worked on 119 toxic chemicals projects [Appendix 5]. The Maritimes & Gulf and Central & Arctic Regions reported the greatest number of projects [Table 6].

Table 6: Toxic Chemicals Research Projects

Region	% of total projects
Pacific	13
Central & Arctic	27
Quebec	17
Maritimes & Gulf	32
Newfoundland	10
National Headquarters	<1
NCIS	<1

Research was undertaken in both marine and freshwater environments. The majority of research projects [64%] examined toxic chemicals in the marine environment, while a smaller number of projects examined freshwater environments [29%] or combined marine and freshwater investigations [8%]. All regions conducted a greater number of projects in marine environments than freshwater, except the Central & Arctic Region which conducted more freshwater research.

For each research project, regional managers selected one of the following as the primary research focus: biological effects on fish and fish habitat; human use of fish; and fate and transport [Table 7]. The majority of projects focused on biological effects on fish and fish habitat [51%]. Research included, for example, impacts of nonylphenol on Atlantic salmon and aquaculture pesticides on lobster larvae. Fate and transport investigations accounted for 42% of all projects and included studies on spatial and temporal distributions of contaminants. A small proportion of projects focused on human use of fish [7%], including research on contaminated country foods and fish potentially bound for human consumption.

Table 7: Research Focus

Research Focus	% of all projects
Biological effects on fish and fish habitat	51%
Human use of fish	7%
Fate and transport	42%

Regional managers also selected the primary matrix investigated: fish, marine mammals, water, sediment, aquatic flora and other fauna [Table 8]. Most of the research projects examined fish. A similar portion focused on fish habitat [i.e., water or sediment].

Table 8: Matrix Investigated

Matrix	% of all projects*
Fish	72
Marine mammals	18
Water	37
Sediment	46
Aquatic flora	13
Other fauna	41

* many projects investigated more than one environmental matrix

Assessment of DFO's Toxic Chemicals Research [1997/98 – 2001/02]

The drafting team used the information submitted by the regional managers to critically examine Science's research effort related to toxic chemicals, specifically relevance, success and effectiveness. Key clients of toxic chemicals research were also canvassed for their views. Even though there can be a lag time between science research activities and input to decision-making, toxic chemicals research and advice has made a significant contribution to the Department.

Relevance

The many mandated, regulatory and policy drivers and client expectations that direct the priority selection process of DFO's toxic chemicals research offer great latitude in defining relevance. As a result, almost any aquatic science project on toxic chemicals can fit in. Research ranges from the sublethal impact of endocrine disrupting chemicals on Atlantic salmon, profiles of contaminants in sediment of the Estuary and Gulf of St. Lawrence, contaminant levels in country foods, assessment of high levels of toxins in killer whales, or emerging issues linked to toxics in aquatic ecosystems.

An initial assessment of program relevance was conducted on the basis of the following criteria:

- whether the toxic chemicals research projects undertaken by DFO addressed the Departmental mandate of conserving and protecting fish, fish habitat and human use of fish; and
- whether the project addressed a scientific need related to one or more of the drivers identified in Appendix 2.

Based on the above criteria, all 119 of the toxic chemicals projects undertaken between 1997/98 to 2001/02 were deemed relevant to DFO. This conclusion is not unexpected, given the broad mandate that DFO Science addresses and the rigorous selection process undertaken to distribute ESSRF research funds.

Success and Effectiveness

High-level Objectives

Toxic chemicals research contributes to five high-level objectives: regulatory decision-making [within DFO and within other government departments]; integrated management plans; policy, guidelines, agreements and codes; remediation and recovery; and public awareness and action. Regional managers identified the major high-level objective for each toxic chemicals research project [Table 9].

Table 9: High-level Objectives [1997/98 – 2001/02]

High-level Objective	Number of projects	% of all projects
Regulatory Decision-making – DFO	38	33
Regulatory Decision-making – OGD	25	22
Integrated Management Plan	12	10
Policy, Guidelines, Agreements, Codes	25	22
Remediation and Recovery	13	11
Public Awareness and Action	3	3

The results demonstrate the important role toxics research plays in governmental decision-making. The majority of projects contributes to regulatory decision-making: 33% within DFO and 22% within other government departments [i.e., Environment Canada, Health Canada, provincial departments]. A list of projects that address each high-level objective is included in Appendix 5.

To further examine the research effort related to each of the five objectives, regional managers provided information on resources for the current fiscal year [2002/03] related to each objective [Table 10].

Table 10: Total Resources According to High-level Objective [2002/03] [$K]

High-Level Objective	A-base			B-base	Total
	Salary	O&M	ESSRF		
Regulatory Decision-making – DFO	1501	394	241	682	**2818**
Regulatory Decision-making – OGD	956	33	678	1303	**2970**
Integrated Management Plan	767	173	171	403	**1515**
Policy, Guidelines, Agreements	559	232	20	423	**1234**
Remedation, Recovery	422	12	184	994	**1612**
Public Awareness	13	0	13	0	**26**
Data Management and Coordination	366	75	0	171	**612**

The largest expenditure of A-based salary resources was directed to research in aid of regulatory decision-making within DFO. While A-based resources [including ESSRF O&M] were also allocated to regulatory decision-making for other government departments, researchers were able to leverage significant B-based resources for such projects. However, this reliance on B-based funds has resulted in external funding agencies and other government departments having a significant influence on research activities within DFO [so that research addresses the priorities of external agencies and government departments].

Research Themes and Key Clients

Regional managers filled out a thematic matrix for each project to further describe the role of toxic chemicals research in decision-making. The matrix includes four thematic groups: Sustainable Fisheries and Aquaculture, Healthy and Productive Ecosystems, Safe and Accessible Waterways, and Other Government Departments. In addition, the matrix identifies several key clients: Fisheries Management, Aquaculture Management, Habitat Management, Oceans Management and Canadian Coast Guard. Finally, the matrix specifies whether the project contributed to policy and regulation development or implementation, or to products and services.

The matrix [Table 11] shows that toxic chemicals research contributed to all four thematic groups and to a variety of client groups, reflecting the multidisciplinary nature of the research.

Table 11: Thematic Matrix [% of all projects]

Thematic Groups	Clients	Regulation		Policy		Products and Services	TOTAL
		Develop	Implement	Develop	Implement		
Sustainable Fisheries and Aquaculture	**Fisheries Management**	3%	10%	---	3%	<1%	**17%**
	Aquaculture	4%	---	---	---	---	**4%**
Healthy and Productive Aquatic Ecosystems	**Habitat Management**	12%	11%	6%	8%	2%	**38%**
	Ocean Management	7%	<1%	2%	2%	<1%	**12%**
Safe and Accessible Waterways	**Coast Guard**	<1%	2%	---	---	---	**2%**
Other Government Departments	**OGD**	11%	9%	2%	2%	<1%	**26%**
	TOTAL	**38%**	**33%**	**10%**	**14%**	**4%**	**100%**

Half of the research projects were oriented towards Healthy and Productive Aquatic Ecosystems. Habitat Management was the major client of toxic chemicals research: with 38% of all projects providing information for habitat management decision-making in support of healthy and productive ecosystems. Oceans Management was identified as the

main client for 12% of all research projects. The relatively low proportion reflects the relative newness of Oceans Management as a client. As the *Oceans Act* and its associated programs are further developed and implemented, the contribution of toxic chemicals research to Oceans Management is likely to be enhanced.

Slightly less than one-quarter [21%] of the toxic chemicals research projects were connected to Sustainable Fisheries and Aquaculture. Fisheries Management was identified as the main client of such research. As the aquaculture industry continues to expand, it is likely that toxic chemicals research will provide more information to Aquaculture Management.

Approximately one-quarter [26%] of the projects were identified as contributing to other government departments. This contribution reflects, in part, Departmental commitments established under current federal agreements and MOUs. Clients included Environment Canada, Health Canada, Canadian Food Inspection Agency, Indian and Northern Affairs Canada, and provincial departments.

The matrix further emphasizes the linkage between toxic chemicals research and governmental decision-making. Nearly three-quarters [71%] of all research projects were connected to regulation development or implementation. Examples include development and implementation of Metal Mining Effluent Regulations and Pulp and Paper Effluent Regulations. A smaller proportion [24%] of projects was linked to policy development or implementation. Examples include contributions to the United Nations Protocol on Persistent Organic Pollutants and Canada-USA Air Quality Agreement. Approximately 4% of all toxic chemicals research projects led to products and services, which can be used in future decision-making. These products include, for example, food web models that can be used to define management strategies and remedial actions.

Influence on Decision-making

Tables 9, 10 and 11 illustrate the important role of toxic chemicals research in decision-making. During the review period [1997/98 – 2001/02], the contribution of many research projects was significant. The following discussion describes the outcomes of toxic chemicals research related to regulations, policies, environmental assessments, fisheries closures and consumption advisories, remediation of contaminated sites, recovery plans, and integrated management plans, marine environmental quality and marine protected areas.

As stated previously, toxic chemicals research has contributed to regulations and policies to protect fish and fish habitat. Examples include development and implementation of regulations for the metal mining and pulp and paper industries, and contributions to international protocols and agreements.

Toxic chemicals research has generated substantial advice for environmental assessments [EA]. Examples include the following: screening an EA for the Coke Oven site and the Sydney Tar Pond clean-up; screening EAs for offshore oil and gas activities;

effectiveness of mitigation measures for potential impacts of offshore oil and gas; possible effects of mercury from hydroelectric reservoirs; and screening EAs that potentially remobilize contaminants in sediments. Toxic chemicals research has been used to evaluate Orimulsion toxicity as an essential component of potential impact assessment under CEAA.

In support of aquaculture decision-making, toxic chemicals research has provided a variety of advice. Research assisted Habitat Management in conducting more effective environmental assessments of potential impacts from deposition of aquaculture wastes, including the debris generated from cleaning treated nets. In an evaluation of site allocation and remediation, advice was provided for Habitat Management on the impacts of salmon aquaculture on wild fish. Toxics research also assisted Habitat Management in providing regulatory advice on the impacts of aquaculture pesticides and drugs on non-target species, and for the PMRA's regulatory development.

Under the Management of Contaminated Fisheries Regulations, toxic chemicals research has supported decisions by DFO's Regional Directors General in setting consumption advisories and fisheries closures. Consumption advisories were implemented related to a variety of contaminants, including mercury, PBDE and toxaphene. Fisheries closures were employed in the Pacific Region [due to dioxins/furans and PAHs], Maritimes Region [due to PCBs] and St. John's Harbour [due to bacteria] and Sidney Harbour [due to PAHs].

Toxic chemicals research has influenced contaminated site remediation as well. For example, DFO research contributed to the resolution of a longstanding and severe pollution problem at the abandoned Britannia Mine in B.C. DFO used the toxics data on habitat contamination and destruction in negotiations with Environment Canada and the province to successfully press for containment and diversion of toxic drainage and for the construction and operation of a treatment plant. In the Great Lakes, toxic chemicals research results have been incorporated into an Action Plan for remediation of PCB contaminated sediments in Lake Erie. In addition, data have been included in the Hamilton Harbour Remedial Action Plan to measure the effectiveness of sediment remediation in reducing contaminant levels in harbour biota. On the East coast, toxic chemicals research led to advice for Environment Canada on remediation of the Irving Whale contaminated site, and research is contributing to the final design of the Halifax Harbour cleanup and the cleanup of the Sydney Tar Ponds and Coke Oven site. In addition, toxic chemicals research has resulted in advice to the Canadian Coast Guard on oil spill contingency and clean-up.

Toxic chemicals research has contributed to recovery plans, including a plan for endangered killer whales and implementation of the St. Lawrence beluga recovery plan. Toxic chemicals research was also used in the Committee on the Status of Endangered Wildlife in Canada [COSEWIC] listing process for Pacific killer whales.

Finally, Oceans programs have benefited from toxic chemicals research. For example, toxic chemicals research has contributed to the ongoing development of marine

environmental quality [MEQ] indicators for potential use in coastal Integrated Management [IM] Plans. Modelling and predicting have supported ecosystem overviews and MEQ targets for IM plans and Marine Protected Areas [MPA].

Client Views

As part of the review process, key clients commented on the relevance and importance of toxic research within DFO.

Habitat Management [HM] confirmed that DFO's toxic chemicals research directly addresses the requirements of the Policy for the Management of Fish Habitat with respect to the need for advice on toxics issues. Although toxic chemicals were not often prioritized as an issue by regional Habitat Management staff, aquaculture, oil and gas, and effluents were frequently identified as high priorities. The release of toxic chemicals by these industry sectors is a reason they constitute a priority for Habitat Management.

Habitat Management credited toxic chemicals research with helping to inform regulatory decision-making, policy development and international policy discussions, environmental assessments, guidelines and code development, and remediation. Furthermore, HM stated that they have come to rely on the ability of Environmental Science, including its toxic chemicals research, to provide sound advice for expert witness and testimony.

Oceans Management identified future needs for toxic chemicals research in support of *Oceans Act* programs, such as MEQ as it relates to IM and MPA management plans. Field data [and laboratory results as well] would be useful for helping to build on MEQ metrics [e.g., MEQ objectives, indicators and reference points such as targets and limits]. This research would further address environmental issues related to State of the Oceans Reporting and ongoing IM and MPA processes, within the broader context of ecosystem-based management.

The Office of Sustainable Aquaculture reaffirmed its support for having toxic chemicals research continue to focus on the fate and effects of chemicals [e.g., pesticides] used in the aquaculture industry. The objectives of this research must be directed toward providing scientific knowledge to better assist the industry in further evolving best management practices. This work would also enable managers to make sound regulatory decisions. The research must also be planned in conjunction with key stakeholders [e.g., other government departments, provinces, industry] for ensuring timely dissemination of scientific advice, while acknowledging the time and resource constraints of long-term ecological research. This work would continue to provide the necessary advice in ensuring a sustainable aquaculture industry in Canada.

DFO has actively participated in a multi-departmental Working Group on Pesticides and Pest Management and has worked on a bilateral basis with Health Canada's Pest Management Regulatory System. This participation has ensured that DFO's research is closely aligned with the research and monitoring needs of the pesticide regulatory program, and that DFO will provide data to contribute to regulatory decision-making.

Issues Arising from the Assessment

The standardized templates sent to the regions provided an opportunity for regional managers to comment on future issues, such as laboratory and financial support. These issues are summarized below.

Laboratory Support

The sophisticated equipment used in toxic chemicals research is expensive and becomes out of date quickly. Much of the current equipment was acquired over 10 years ago under the Green Plan. Several regions reported that the resulting rust out problems cause reduced effectiveness of analytical capabilities. This is a recurring problem: the same comments were made in the 1987 Toxicology and Contaminants Program review.

There have been some good innovations, such as creating centralized tissue collections and dioxin analyses. However, there is equipment duplication in some areas [e.g., Burlington, Winnipeg, Sidney], and it is likely that further consolidation is possible. The question arises as to whether all of the analyses, and associated equipment, must be conducted in DFO laboratories and whether other options have been pursued aggressively enough.

Financial Support and Leverage Capability

As a result of funding declines over the years, the A-base support for research is minimal. The strategic research funds [TCRP and ESSRF] have sometimes served as supplementary A-base funds for regions rather than as a competitive fund for top priority, national research issues. In the absence of sufficient A-base resources for projects, scientists have been quite innovative in levering funds from elsewhere: $11.7M A-based O&M versus $14.3M O&M leveraged funds over five years.

The ability to leverage to this extent illustrates that the scientific reputations of the DFO scientists, as well as their capacity for entrepreneurship, are valued by the managers of the outside funds. However, there is concern that mission drift may have been experienced as a result of this excessive dependence on external funds.

Partnership Development and Linkages

Much of the external O&M funding has been the result of DFO toxic chemicals researchers having the necessary expertise to perform research required by external funding organizations and industry. Scientists have been actively involved in the federal TSRI, PERD and ESRF projects. As well, hydroelectric companies have funded a number of projects, and there is considerable involvement in the Metals in the Environment Network. In addition, DFO is the lead for PAC5 of the emerging 5NR Federal Freshwater Research Network. However, there seems to be no overall strategy in place for partnership development. Without such a strategy, and one that is enforced, mission drift is inevitable. Understandably, researchers will follow the money.

Although partnerships exist with Canadian universities, other government agencies and industry, more could be done. It is not clear that DFO research laboratories have been overly motivated to encourage universities to do more of the generation of new knowledge in areas such as endocrine disrupting chemicals and fire retardants. Likewise, industry laboratories might be encouraged to do more in the technology development and services end of the R&D continuum.

DFO's Strategic Science Fund has attempted to encourage linkages between DFO regions, but the expertise available in DFO Science overall has not yet been integrated. Research silos occur in and between most DFO laboratories and between science-based departments and agencies. This problem is not limited to toxic chemicals research in DFO Science.

Toxic Chemicals Research and the *Fisheries Act* [Section 35]

DFO's Policy for the Management of Fish Habitat identifies and confirms the Department's commitment to conduct scientific research on toxic chemicals to provide information necessary for the conservation of fish habitat. The Policy states that DFO will carry out a broad program of scientific research on Canada's fisheries to provide the knowledge, information and data to assess the effects of human-induced chemical changes on fisheries resources and the habitats that support them.

Some Habitat Management regional staff are of the view that all toxic chemicals research and related issues are the responsibility of Environment Canada under Section 36 of the *Fisheries Act*. Therefore, many regional managers within Habitat Management do not specifically include concerns for toxic chemicals as part of their responsibilities under Section 35 of the *Fisheries Act*. However, Section 35 questions raised by Habitat Management in connection with compensation and mitigation issues associated with proposals involving sediment dredging, whole lake destruction, compensation for mining, aquaculture, oil and gas, and hydroelectric development often include issues related to toxic chemicals. The development of an information package that outlines the link between Section 35 and toxics research may help clarify this issue.

Oceans Issues

Oceans Management has identified its future science needs for addressing environmental/ toxic chemical issues within *Oceans Act* programs [see Client Views above]. A key focus of their needs is MEQ metrics. Some aspects of this research, such as addressing cumulative impacts and developing MEQ indicators, are consistent with current research initiatives on toxic chemicals.

However, other aspects, such as long-term marine monitoring related to a specific MEQ objective or a State of the Oceans metric, would be difficult to justify, as such effort would provide limited benefit to understanding toxic chemical impacts on fishery resources.

Action Items Arising from the Assessment

The assessment highlighted the need for a variety of actions. These are summarized below.

Resource Inventory

The task of collating resource information was difficult due to the review team's inability to reconcile information obtained from the Science Program Inventory and from regional input. An improved financial tracking system is required to support any follow-up program audits.

Research Priorities

A reliance on B-based resources to fund some toxic chemicals research has resulted in some priorities being influenced by external funding agencies and other government departments. There is a need, therefore, to ensure that acceptance of B-based funds is consistent with the objectives of toxic chemicals research within DFO. A mechanism needs to be created to ensure that mission drift is minimized and that DFO's priorities do not suffer. Development of clear statements on what kinds of toxic chemicals research will be undertaken in DFO would be a useful start.

Given that most of the toxic chemicals research projects undertaken within DFO can be categorized as both relevant and a national/regional priority, decisions on what projects to support could be assisted by adopting a Risk-Based Priority Setting process. With such a process, only those relevant projects would be funded where there was a high risk associated with not doing the research. Projects on the effects of toxics on fish populations, toxic residues in sediment, residues in fish for human consumption, or impacts of toxic chemicals on fish habitat may all be a priority, but may not be of the same risk to DFO if not conducted. A decision needs to be made whether to realign the emphasis of toxic chemicals research. For example, should there be a greater percentage of work on effects and should the large focus on the non-direct impacts work [water and sediment] be reduced if there is no close linkage to fish?

Links to Decision-making

Further effort can be made to maintain and strengthen the link between research and decision-making. The decision-making needs of the clients must be identified and addressed on a priority basis. While the results of toxic chemicals research have been communicated to a variety of users, a greater effort can be made to communicate research results to important Departmental clients. Identifying client needs and communicating directly with clients will ensure that toxic chemicals research contributes to regulatory processes and policy decision-making within DFO.

DFO Science and Headquarters Habitat Management must strengthen their communications with the regions to ensure a common and consistent interpretation of

DFO's roles and responsibilities on toxic chemicals. Improved regional understanding of DFO's role should enhance the relationship between toxic chemical researchers and habitat managers.

Research Delivery

A variety of alternate delivery strategies are discussed in the following section [Future Direction]. One strategy is to consolidate laboratory activities. Currently, each regional laboratory has its own separate unit for most analytical procedures. Some of these activities could be combined. Another strategy might be to determine the feasibility of eliminating the most expensive equipment and buying the services from universities or the private sector. If the capacity does not currently exist in these sectors, it could be built over time.

Greater partnering with universities and other government departments represents another possible alternate delivery strategy. To be able to focus on studies that address the key priorities of DFO Science, such as solving regulatory problems associated with habitat loss, and contributing to the interdisciplinary work at the ecosystem level, a new team approach both within DFO Science and between DFO Science and partners needs to be promulgated. A clear statement on partnership principles and practices would be useful, if DFO Science is to develop partnerships in a rational and business-like way.

Oceans Sector

There is a need to clearly identify which needs of the Oceans Sector can and will be addressed within the Science Sector. For example, long-term marine monitoring data collection could be provided, in part by IM and MPA plan stakeholders [particularly regulatory stakeholders]. Science Sector support for monitoring may also be possible via the expansion of existing regional monitoring programs, such as the Atlantic Zone Monitoring Program.

Alternatively, long-term data sets are usually used to assess the need for, or the success of, control measures initiated in the management of toxic substances. Environment Canada should be approached to undertake this kind of activity both in marine and freshwater, given it has regulatory responsibility for the management of toxic substances.

Future Direction

The Way Forward

There are many challenges facing scientific research within DFO. These include the following:

- increasing demands for scientific advice;
- fewer available resources;
- loss of personnel; and
- rust-out of equipment.

As a part of Science, toxics research also faces these challenges. The continued workloads and pressures cannot be sustained with the current level of funding. Indeed, there are more demands than can be currently addressed in a satisfactory manner. Doing more with less is no longer attainable. As no new funding is expected for toxics research and there are new funding pressures on the Environmental Science Program [e.g., invasive species, energy development], it will be necessary to shift available funds from low to high priority research needs using priority-based risk assessment. Resolution of a number of key issues will ensure that DFO will still be able to meet, in a sustainable fashion, its mandated responsibilities with respect to toxic chemicals research.

This review has resulted in several questions where management decisions are required to align DFO's research on toxic chemicals with the emerging priorities of the Science Sector and its clients. To assist senior managers in this task, a series of 10 questions/ decisions has been developed. Decisions on Questions 1 and 2 will clarify the need and the core capacity for toxic chemicals research in DFO. Questions 3 to 6 outline options on "how" the scientific advice can be developed and delivered. Questions 7 to 10 address the issue of "what" the research priorities should be. The questions are summarized in the Decision Tree shown in Figure 3. To assist in the resolution of these questions, discussion points are provided after the list of questions.

Need and Core Capacity

Question 1. Does DFO need scientific advice on the effects of toxic chemicals on fish and fish habitat?

If YES, continue with the following decision tree.
If NO, terminate toxic research activities and re-direct current resources to higher priorities within Science.

Question 2. Should DFO retain in-house capability related to toxic chemical research?

If YES, Are there viable alternative research delivery systems? Go to Questions 3 and 4.
If YES, What are the research priorities? Go to Question 7.
If NO, devolve resources to other government departments.

How to Deliver*

*Questions 3 and 4 are not mutually exclusive.

Question 3. Should the approved in-house alternative delivery strategies be further investigated?

If YES, further assessment of approved in-house alternatives will be conducted.
If NO, no further action on alternative delivery.

Question 4. Should the approved outside alternative delivery strategies be further investigated?

If YES, further assessment of approved outside alternatives will be conducted.
If YES for Option 4F, go to Question 5.
If NO, no further action on alternative delivery.

Question 5. Is a mutual understanding between DFO and EC needed?
If YES, discussions with EC will be initiated.
If NO, potential duplication of effort.

Question 6. Is a Memorandum of Understanding with EC on research cooperation needed?
If YES, discussions with EC will be initiated.
If NO, informal arrangements will be strengthened on cooperation.

Priority Selection

Question 7. Should DFO give higher priority to biological impacts?
If YES, this action would place more emphasis on population and ecosystem effects.
If NO, DFO toxics research would retain a broad mandate.

Question 8. Should DFO give lower priority to non-impact research?
If YES, lower priority will be given to studies not directly linked to biological impacts.
If NO, DFO toxics research would retain a broad mandate.

Question 9. Are the proposed research areas appropriate?
If YES, research priorities will be adopted.
If NO, research priorities will be re-assessed.

Question 10. Should a risk-based priority setting process be developed?
If YES, a risk-based priority setting process will be developed for identifying research priorities.
IF NO, priority selection process will be re-assessed.

Figure 3: Decision Tree

Discussion Points

Need and Core Capacity

Question 1. Need for advice

Toxic chemicals are known to enter aquatic ecosystems and to adversely affect fish and fish habitat. DFO's toxic chemicals research contributes to maintaining sustainable fisheries and aquaculture, healthy and productive ecosystems, and safe and accessible waterways. The research plays an important role in Departmental decision-making. DFO Sectors [Fisheries Management, Oceans, Office of Sustainable Aquaculture, Canadian Coast Guard] and other government departments need scientific advice derived from toxics research to develop policies, regulations and guidelines, to issue authorizations or closures, to advise industry, etc on issues related to the impact of toxic chemicals on the conservation of fish and fish habitat. For example, toxics information is used by the following clients:

- Habitat Management to conduct environmental assessments of industry developments, to issue fish farm siting guidelines and to negotiate clean up of contaminated industrial sites;
- Fisheries Management to recommend to Regional Directors General fisheries closures and consumption advisories;
- Oceans Management to assess Marine Environmental Quality;
- Canadian Coast Guard to address spills and on site remediation; and
- Other government departments use DFO advice in regulatory decision-making to ensure appropriate conservation and protection of fish and fish habitat [e.g., Health Canada (*Pest Control Products Act*, *Food and Drug Act)*; EC (*Canadian Environmental Protection Act* 1999, *Fisheries Act*, Section 36)]. Other departments rely on DFO advice since they do not conduct research on fishery resources or on population impacts [activities that are perceived to be DFO's mandate].

Many of the above client activities are derived from legislation, Memoranda of Understanding, policies or agreements. Clients such as Habitat Management, Oceans Management, Office of Sustainable Aquaculture and Environment Canada have indicated an ongoing need for scientific advice on the impacts of toxic chemicals on fishery resources.

Question 2. Retain in-house capability

Client needs for scientific advice can be addressed through in-house research capacity for toxics or by devolving this effort to outside agencies. Two options are outlined for consideration.

Option 2A. Retain core capacity within DFO

There is no direct requirement for research under the *Fisheries Act* or *the Oceans Act*. DFO research is conducted in support of policies, MOUs and Federal

Agreements by developing expertise and information so as to be able to provide sound scientific advice related to the conservation and protection of fish and fish habitat.

Pros

- internal capability can be targeted to DFO's mandate and to client needs
- effects of toxic chemicals on fishery resources/populations is directly related to DFO's mandate
- other federal science-based departments do not undertake research on the effects of toxic chemical on fish populations
- understanding of DFO mandates/policies
- integrated with other DFO Sectors and their needs
- development of expertise to evaluate industry proposals
- expert witnesses
- available to address urgent issues [briefing notes, emergencies]
- cooperation with other government departments
- timely provision of advice
- about 30% of DFO scientists and technicians will retire before 2010. This will result in a loss of expertise in all regions. In concert with the overall DFO Science Assessment, retirements can be used strategically to create the required mix of expertise needed to make integrated teams function effectively, or to increase funding for other priority areas by transferring salary dollars to O&M.
- other departments may not want additional responsibilities without the transfer of resources [FTEs and O&M].

Cons

- costly
- Environment Canada is lead for Section 36 of the *Fisheries Act* and toxics research under CEPA 99.

Option 2B. Devolve to other government departments [e.g., EC, HC, CFIA]

Under CEPA 99, Environment Canada is directed to conduct research on ecosystem impacts. To implement CEPA 99, EC is seeking significant new funds to enhance its research and monitoring program on toxics in aquatic ecosystems. EC also has administrative responsibility for Section 36 of the *Fisheries Act* and its regulations [e.g., Pulp and Paper Effluent Regulations, Metal Mining Effluent Regulations]. Health Canada has responsibilities for protecting human health and for conducting human health assessment for toxic chemicals.

Pros

- re-direct science resources to focus on DFO mandate, not that of other departments
- cost saving to DFO
- allows residual DFO resources [i.e., those not transferred to OGDs, if any] to be re-directed to higher priorities within Science.

Cons

- OGDs do not have the resources or expertise to address DFO issues related to toxic chemicals. This action, therefore would likely involve the transfer of resources from DFO to OGDs
- if DFO does not retain in-house capacity, the Department may face negative media attention
- the availability of OGD scientists to advise DFO clients on an ongoing basis and timely manner would likely be problematic
- in response to EC's mandate, the focus of EC's research is on water quality and on assessing the effectiveness of control measures, not on impacts on the fishery resource. The risk of EC or OGDs not doing the research is unknown.

How to Deliver

Changes in program delivery can be achieved through adopting in-house and/or outside alternative systems.

Question 3. In-house alternatives

To be able to better use available expertise, to eliminate research activities that could be done elsewhere and to address problems from an ecosystem perspective, a number of mechanisms need to be considered. Among these are the following:

Option 3A. Centres of excellence or virtual centres
Centres of expertise or virtual centres could be created to reduce duplication of effort. In particular, a virtual centre for freshwater toxicology that included DFO, EC, universities and industry could serve the purpose for work needed for DFO.

Option 3B. Consolidation of laboratories
Consideration should be given to maintaining expertise within DFO to address core research activities. Such expertise need not be located within each research laboratory. Small, dispersed toxic chemicals programs in some regions could be merged to develop a critical mass of expertise in one centre.

Option 3C. Consolidation of expensive analytical equipment
Costly chemical analytical laboratories should be located at a limited number of locations

Option 3D. Decrease analytical service function
DFO would no longer provide an analytical service function for other departments and non-federal clients. This service function is, and could be, done by the private sector. DFO analytical labs would focus on DFO needs.

Option 3E. Collaboration within Science Sector
New tasks, such as long-term marine monitoring for marine environmental quality, could be undertaken by other parts of the Science Sector.

Option 3F. Interdisciplinary teams
To address problems from an ecosystem perspective, toxic chemicals research should be integrated into interdisciplinary teams developed in DFO Science.

Question 4. Outside alternatives

Alternate delivery for science functions that can be done outside of DFO should include a greater variety of mechanisms that involve partnering, networks and divestment of responsibilities. This can be delivered through the following options:

Option 4A. Subvention
Expand the Academic Science Subvention Program to strengthen academic research and interaction on toxic chemical issues related to impacts on fishery resources.

Option 4B. Graduate stipends
Provide a top-up for graduate student stipends for promise to work on priority issues.

Option 4C. University chair
Develop and support a university chair on aquatic toxicology.

Option 4D. DFO researchers at universities
Place DFO researchers on university campuses to leverage expertise and funds that can be directed to DFO priorities.

Option 4E. Private sector partnerships
Strengthen relationship with the private sector [e.g., to provide analytical services].

Option 4F. Relationship with Environment Canada
Strengthen relationship with EC [see Questions 5 and 6].

Questions 5 and 6. Relationship with Environment Canada

Environment Canada also undertakes aquatic toxics research in response to its mandate to assess environmental quality. EC research is complementary to that conducted by DFO. Issues on effort related to freshwater and Arctic research, however, need to be resolved. A key to future research on toxics is 1] a clear understanding of the respective roles of DFO and EC and 2] improved cooperation between DFO/EC. Increased cooperation would utilize government scientific resources more efficiently by capitalizing on opportunities for cooperation and avoiding duplication of effort.

The need for further discussions with EC is demonstrated by EC's recently stated interest in DFO maintaining its effort in measuring the residue levels of toxic substances in fish

and marine mammals. This element of DFO's toxic research may or may not be part of a future program, depending upon the outcome of this review.

Priority Selection

Question 7. Higher priorities

Cradle to grave knowledge of toxic chemical behaviour in the environment is needed to ensure adequate environmental protection. The regions have stated that demands for advice on toxic chemicals are increasing and that additional resources are required to meet the demand. The current framework of "doing everything" on toxics research is not sustainable given the resource demands facing the Environmental Science Program. To be sustainable, DFO's toxic research must focus on key priorities and rely on other departments and agencies to provide the complementary research.

Regional input during this review indicated that the primary focus of toxics research over the period of 1997/98 to 2001/02 was split between biological impacts [51%], chemical fate and transport [42%] and human use of fish [7%]. Biological impacts research included, for example, the effects of nonylphenol on Atlantic salmon and the impact of aquaculture pesticides on lobster larvae. Fate and transport research included studies on temporal and spatial trends of toxics in fish and contaminant levels in the Great Lakes. Studies to assess impacts on human use of fish included studies on contaminant levels in fish bound for human consumption.

During consultations with regions and clients, agreement was reached that in order to address the critical mandate of DFO [i.e., the conservation and protection of fish, fish habitat and marine ecosystems], DFO's toxic research should allocate higher priority to biological impacts. That is,

> *Biological effects of toxic chemicals on fisheries resources [i.e., the growth, survival and reproduction of commercial, recreational, and aboriginal fisheries] and the habitats that they depend upon, where there is a science question to be answered to assist with DFO decisions under mandated responsibilities or under DFO agreements with other departments / agencies.*

With this focus, the extent and causes of toxic chemical impacts on fish populations and on aquatic ecosystem can be identified and advice can be provided to internal DFO clients and to regulatory authorities [e.g., PMRA (*Pest Control Products Act*), EC (*Canadian Environmental Assessment Act*, *Fisheries Act*, Section 36)].

Question 8. Lower priorities

To meet the demands of addressing the above high priority, lower priority should be given to the following:

Long-term marine monitoring

- Long-term marine monitoring will be useful to Oceans Management in developing the concept of LOMAs [Large Ocean Management Areas] and associated ecosystem objectives and targets to determine whether these objectives and/or targets are being met.
- These data, however, would be costly to generate and would provide only limited benefit to understanding current toxic chemical impacts on the fishery resource.
- Science would continue its effort on the development of MEQ indicators and provide Oceans Management with advice on protocol development and guidance documents.
- Some of this monitoring could be captured under other monitoring programs within DFO Science.

Fish residues for human health

- DFO analyzes fish and marine mammals from subsistence fisheries. This service to Health Canada, INAC or EC and Arctic co-management boards is not a research function nor is it related to habitat protection. Science Sector is not required to address the needs of the Management of Contaminated Fisheries Regulations under the *Fisheries Act*. As the human health issue is better linked to Health Canada's responsibility for conducting health assessments and to INAC's responsibility for the health of Canada's aboriginal peoples, the responsibility for testing country foods for toxic residues may better be addressed by these departments. Alternately, DFO's Fisheries Management could set up a multi-departmental program, similar to the Canadian Shellfish Contamination Program in which it currently participates.

Spatial and temporal trend surveillance [biota, sediment, etc.]

- Surveillance programs are useful in assessing the success or failure of control strategies and thus should be addressed by regulatory authorities such as EC.

Transport and fate studies without a direct link to biological impacts

- Stand-alone studies on transport and fate complement but do not directly address toxic chemical impact on fishery resources. Cooperative projects with other departments, such as EC, could provide this information to DFO.

Forecasting for chemical issues

- This research includes searching the aquatic environment to find toxic chemical residues that have not been identified yet as a fishery resource issue.
- Searching out potential new contaminants is not a priority given the many existing known causes of impacts that urgently need further explanation and understanding. Determining the levels of contaminants in the environment is EC's responsibility. The work in DFO would be based on prior knowledge of a chemical that is potentially toxic to fishery resources being detected in the environment.

Question 9. Research areas

The next 5 to 10 years will continue to offer challenges to understand the impact of toxic chemicals on fish and fish habitat. It is anticipated that key toxic chemical issues will be

related to industrial and municipal effluents, energy development and agriculture chemicals.

Concern related to effluent discharges will be enhanced because of continuing growth in industrial development, increased regulatory activities in the management of toxic substances [e.g., environmental effects monitoring programs], and a greater understanding of environmental effects associated with endocrine disrupting effects and cumulative stressors. As well, with an aging population, the impact on the receiving aquatic environment of increased discharges in municipal effluent of excreted pharmaceutical drugs will need to be assessed and scientific advice provided to regulatory authorities.

Increasing energy demands will dictate new energy development in the areas of both hydroelectric and fossil fuels. For example, by 2020, it is expected that the demand for new and alternative electrical energy in Canada will increase by over one-third of current output.

The agriculture industry currently uses pharmaceuticals to enhance animal health and food production through the use of antibiotics, growth enhancers and feed supplements. The impact of these chemicals on the aquatic environment is only now being investigated worldwide. The use of pharmaceuticals is likely increase in response to a demand for increased food production arising from population growth in Canada.

Within the environmental assessment processes of the *Fisheries Act* and the *Canadian Environmental Assessment Act*, science advice on toxic substances will be a crucial component of the assessments of these developments.

In response to the initial call-in for information on future toxic chemicals research, the regions identified 36 different areas [Appendix 6]. Maintaining such a broad program of research is unsustainable in the context of fewer research dollars and increasing demands from clients. Therefore, regional managers were asked to identify two or three highest priorities for toxic chemicals research in the next few years. Selection was to be based on risk to the Department for not undertaking the research.

This exercise identified the following key "source determined" themes, within which projects on toxic chemical effects could be placed in priority through a risk-based process:

- industrial and municipal effluents;
- energy development issues;
- aquaculture; and
- new emerging chemicals.

The links between the above and client needs were not identified as part of this exercise. This exercise also did not identify agriculture chemicals as a priority.

The research undertaken in the above four priority areas would be conducted in support of the five high level research objectives established for toxics research:

1. Regulations and Regulatory Decisions for a] DFO and b] OGDs;
2. Integrated Management Plans;
3. Policies, Guidelines, Agreements, Codes;
4. Remediation and Recovery Plans; and
5. Public Awareness and Action.

Question 10. Priority setting

Studies supported by DFO would have to be based on a Risk-Based Priority Setting Process. Projects would receive support if they addressed the new biological focus, demonstrated a clear and direct link to specific and requested needs of key clients, and were designed to lead to the development of scientific advice for regulatory and policy decision-making.

A new Risk-Based Priority Setting process could be based on the following preliminary matrix.

- Biological Effect [severity of impact X probability of exposure]
- Success of Project [probability of achieving deliverables X significance of results]

Further assessment of the above matrix is required to ensure its applicability to toxics research within the Environmental Science Program.

The need for a rigorous priority setting process will be further enforced with the potential loss of $1.5 to 2.0M annually from toxic chemicals research due to the demise of the ESSRF.

Summary

In summary, DFO's toxic chemicals research has played an important role in Departmental decision-making. Maintaining in-house capability would ensure the Department continues to receive the necessary research and advice for the conservation and protection of fish and fish habitat. Future efficiencies could be realized by allocating higher priority to toxic chemicals research on biological effects, reducing or eliminating research on lower priority areas, employing a risk-based priority-setting process, and exploring alternative delivery strategies. Such realignment would ensure that toxic chemicals research is relevant to DFO's mandate, is effective in influencing decision-making, and is successful in causing action to reduce the impact of toxic chemicals on fish and fish habitat.

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List of Appendices

Appendix 1: Terms of Reference

The goal of this review is to conduct an assessment of the relevance, success, effectiveness and the future direction of the department's research on toxic chemicals. The merit of the research conducted by DFO scientists is not being questioned by this review.

Review Objectives

The review of DFO's research on toxic chemicals has the following objectives:

- to determine whether DFO needs scientific advice derived from toxic chemical research in order to address its legal responsibilities;
- if required, to determine what specific toxic chemical information is needed by DFO;
- to determine what toxic chemical research must be done within DFO and why;
- to determine what toxic chemical research can be delivered from outside of DFO and how;
- to critically examine Science's current effort on toxic chemical research; and
- to identify current and emerging demands and risks.

Departmental Mandate

DFO's mandate states that DFO is responsible for policies and programs in support of Canada's economic, ecological and scientific interests in oceans and inland waters and for the conservation and sustainable utilization of Canada's fisheries resources in marine and inland waters. Policies and programs undertaken to implement this program must be based on an understanding of how marine and freshwater ecosystems function and how they are affected. Conservation and protection can only be achieved by understanding how all anthropogenic and natural stresses, including the introduction of toxic chemicals, affect the ability of aquatic ecosystems to withstand these stresses and the capacity of fish habitats to sustain the production of fish.

Departmental Drivers for Toxic Chemical Research within Science

The overall objective of the Department's toxic chemical research is to determine the effects that toxic chemicals have on fish, fish habitat, aquatic ecosystems and human use of fish and aquatic ecosystems. The following departmental drivers collectively set this objective.

1. Legislative and Regulatory

    - Responsibility under the *Fisheries Act* by the Minister for the protection of fish and their habitat from pollution.
    - Responsibility under the Management of Contaminated Fisheries Regulations of the *Fisheries Act* to prohibit fishing in areas where fish are contaminated with chemical compounds.
    - Ability under the *Oceans Act* to establish marine environmental quality [MEQ] guidelines, objectives and criteria of which scientific advice on the impacts of toxic chemicals is one component.
    - Responsibility under the *Oceans Act* to implement the Oceans Strategy and to facilitate integrated management including the establishment of Marine Protected Areas will require scientific advice on the impacts of industry on marine ecosystems, including those due to toxic chemicals.

- Responsibility under the proposed *Species at Risk Act* to provide scientific advice, including the impacts associated with chemical contamination, related to the development of recovery plans and the assessment of their success.
- Responsibility under the *Canadian Environmental Assessment Act* to contribute to or review environmental assessment studies that include chemical pollution and toxic effects.

2. Policies and Programs

- The development of knowledge, data and information as required by the Policy for the Management of Fish Habitat to assess the effects of human-induced chemical changes on fisheries resources and the habitats that support them; and to determine how adverse effects on fish habitat may be mitigated and establish criteria for the continued natural production and safe consumption of fish.
- To conduct, under the Program for Sustainable Aquaculture, environmental research to increase our understanding of the impacts of aquaculture on ecosystems and aquatic resources, including the long-term fate and impact of chemicals released by the aquaculture industry.
- The federal policy on oceans management, Canada's Ocean Strategy, recognizes the need to better understand and protect the marine environment and as such requires access to scientific expertise relating to the impacts of industry and of related toxic chemicals on marine ecosystems.

3. Memoranda of Understanding

- Provide scientific advice to Environment Canada on the impacts of the deposit of deleterious substances on fisheries resources, as outlined in the Memorandum of Understanding between DFO and Environment Canada on Section 36 of the *Fisheries Act*.
- Provide scientific advice to federal regulators on the impacts of pesticides on fish, fish habitat and marine ecosystems, as outlined in the Memorandum of Understanding on Research and Scientific Advice between DFO and the Pest Management Regulatory Agency [PMRA], Health Canada.
- Provide scientific advice to Natural Resources Canada on the environmental impacts associated with the non-nuclear energy sector, as outlined in the Memorandum of Understanding between DFO and Natural Resources Canada on Participation in the Program of Energy Research and Development [PERD].

4. Regional Working Agreements

- Conduct scientific research on fish toxicology and the effects of various pollutants, including oil and chemical spills, on specific biological processes, organisms, populations, and communities as identified in the Pacific Regional Working Agreement and the Atlantic Regional Working Agreement between DFO and Environment Canada.

Background

Toxic chemical research is a significant element of the Environmental Science [ES] Program. During the period of 1997/98 – 2001/02, the annual ES budget ranged from $18.7M to $21.7M of which 37 – 53% was allocated to toxic chemical research, advice and data management. A significant portion [$2.0 – 3.1M annually] of the O&M funds allocated to toxic chemicals were derived from the Environmental Science Strategic Research Fund [ESSRF].

ES Budget for Toxic Chemical Research, 1997/98 – 2001/02 [$M]

Year	Annual ES Budget	ES Allocation to Toxic Chemical Research	ESSRF Contribution to the ES Allocation to Toxic Chemical Research[1]
1997/98	21.7	11.6	3.1
1998/99	NA	NA	3.1
1999/00	20.8	9.1	3.1
2000/01	18.9	7.0	2.1
2001/02	18.7	8.9	2.0

[1] This column is included in column three
NA = data not available

External sources of funds such as the Toxic Substances Research Initiative [TSRI], the Program for Energy Research and Development [PERD] and the Northern Contaminants Program [NCP] have strengthened substantially the department's effort on toxic chemicals.

During the period 1997/98 – 2001/02, the key elements of toxic chemical research included, for example:

- the impacts of industrial and municipal effluents on fish and fish habitat;
- emerging chemical issues (e.g., endocrine disrupting chemicals, flame retardants, sea lice control products) that could significantly impact fisheries resources; and
- the cycling and fate of toxic substances in marine sediment.

Key Questions

In order to evaluate the program, the assessment will examine the following key questions:

Program Relevance

- What research on toxic chemicals must DFO undertake internally to meet legal requirements?
- To what extent does the current program meet or surpass an actual DFO need?

Program Success and Effectiveness

- Is the program able to respond to decision-maker needs in a timely fashion?
- Has the program succeeded in causing action to be taken by decision makers [e.g., regulators] to reduce the impact of toxic chemicals on fish, fish habitat, human use of fish and aquatic ecosystems?
- Has the program succeeded in communicating the research results to the public, industry, other government departments/agencies or universities?

Program Future

- Should research on toxic chemicals continue to be delivered in DFO? If so, why, how, on what, and at what level of effort?

- Do other government departments, agencies, or universities have programs or the potential to address the effects of toxic chemicals on fish, fish habitat and human use of fish?
- What are the options for alternate program delivery [e.g., universities, other government departments or agencies, regional centres of expertise]?

Review Scope

The review will comprise:

- the time period between 1997/98 to 2001/02 to be consistent with the Science Assessment;
- fresh and marine waters; and
- A-base and other sources of funding.

Data Gathering: Key Elements

The following information will be solicited from the National Science Directors:

- resources: FTEs, O&M, salaries allocated to toxic chemical research;
- primary focus of the research: fish health, human health, fate, effects;
- primary matrix investigated: fish, marine mammal, water, sediment, aquatic flora, other aquatic fauna;
- specific project link to DFO mandate and drivers as noted on page 1
- outputs [the results of the research, i.e., the deliverables of the project];
- outreach [how were the results communicated to targeted audiences in ways that are meaningful to them];
- outcomes [how were the results used, i.e., what were the benefits of the project from the perspective of the end-user (e.g., regulators, Canadian public, DFO, etc.), was scientific advice provided in a timely manner];
- changes in regional toxic chemical research priorities over the period 97/98 to 01/02;
- programs in other government departments / agencies that have the potential to address toxic chemical issues as related to fish and fish habitat; and
- future direction: role of DFO in toxic chemical research, options for alternate program delivery [e.g., universities, other government departments or agencies, regional centres of expertise] and future issues related to research on toxic chemicals, with a focus on research priorities, costs of staff rejuvenation / capital investments, obstacles, etc.

External Review

To maximize transparency during this review, external reviewers will be consulted during the development of the review framework and as reviewers of the draft report. Two reviewers will be chosen, one from academia and one from another federal department.

Review Methodology

- The review of the program will be carried out by a small drafting team led by NHQ.
- The review will be based on information supplied by regional and NHQ Science Directors.
- Additional information will be gathered at meetings of the National Coordinating Committee of the Environmental Science Program [NCC-ESP] and by bilateral meetings with clients, as required.

- Clients of the toxic chemical research output will have an opportunity to comment on the review via participation on the NCC-ESP that will review the draft reports as noted in the time table.

Budget

The Environmental Science Branch, NHQ, will assume general costs for conducting the review. Additional costs, as outlined below, will need to be funded:

- Contractor to assist in the preparation of the review report.....$27K
- Travel.....$5K
- Honouraria for external reviewers.....$3K

TOTAL BUDGET REQUESTED.....$35K

Time Table and Next Steps

Activity	Date
Submit draft Terms of Reference to NSDC	16 October 02
Deadline for NSDC comments on Terms of Reference	18 October 02
Call to Regions to provide required information	31 October 02
Deadline for receipt of information	15 November 02
First draft of report completed	6 December 02
Comments received from NCC-ESP*	10December 02
Second draft of report completed	20 December 02
Comments received from NCC-ESP*	8 January 03
Submit report to external reviewers	10 January 03
Comments received from external reviewers	21 January 03
Final comments from NCC-ESP	24 January 03
Submit report to NSDC	31 January 03
Approval of report by NSDC	mid-February 03

*National Coordinating Committee of the Environmental Science Program [NCC-ESP]

Assessment Templates

Resources

Year	FTEs (Full time continuing)	Salaries ($K)	O&M		
			A-Base ($K)	Other Funding (Source)	Other Funding ($K)
1997-1998					
1998-1999					
1999-2000					
2000-2001					
2001-2002					

Project Description

Project	Primary Research Focus			Primary Research Matrix					
	Biological Effects	Human Use of Fish	Fate and Transport	Fish	Marine Mammal	Water	Sediment	Aquatic Flora	Other Aquatic Fauna

Research Theme and High Level Objective

Project	Research Theme *(code from below)*	High Level Objective					
		Regulatory Decision-making		Integrated Manage. Plan	Policy	Remediate/ Recovery	Public Awareness
		DFO	OGD				

Codes for Research Theme

Thematic Groups	Clients / Program Components	Regulations		Policy		Products and Services
		Development	Implementation	Development	Implementation	
Sustainable Fisheries and Aquaculture	Fisheries Management	1A	1B	1C	1D	1E
	Aquaculture	2A	2B	2C	2D	2E
Healthy and Productive Aquatic Ecosystems	Habitat Management	3A	3B	3C	3D	3E
	Ocean Management	4A	4B	4C	4D	4E
Safe, Accessible Waterways	Coast Guard	5A	5B	5C	5D	5E
Other Government Departments	Specify OGD	6A	6B	6C	6D	6E
	DFO obligation (Specify)	7A	7B	7C	7D	7E

3. Project Success and Effectiveness
[maximum limit for this section is one [1] page with Times New Roman, 11 pt, provide key/most relevant information only]

Project Name:

Specific Link to DFO Mandate and Drivers [see Terms of Reference]

Outputs [the results of the research, i.e., the deliverables of the project]

Outreach [how were the results communicated to targeted audiences in ways that are meaningful to them, be specific]

Outcomes[how were the results used, i.e., what were the benefits of the project from the perspective of the end-user (e.g., regulators, Canadian public, DFO, etc.), timely response to decision-maker needs, be specific]

4. Changes in Regional Research Priorities over the period 1997/98 -- 2001/02
[identify changes in toxic chemical research and why]

5. Future Direction

Provide comments on:

- DFO's role, if any, in toxic chemical research;
- the minimum amount of research on toxic chemicals that DFO should undertake to meet legal requirements;
- future issues related to toxic chemical research in DFO, including research priorities, costs of staff rejuvenation / capital investments, obstacles, etc; and
    - options for alternate program delivery [e.g., universities, other government departments or agencies, regional centres of expertise].

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Appendix 2: Departmental Drivers for Toxic Chemicals Research within DFO Science

The overall objective of the Department's toxic chemical research is to determine the effects that toxic chemicals have on fish, fish habitat, aquatic ecosystems and human use of fish and aquatic ecosystems. The following departmental drivers collectively set this objective.

1. Legislative and Regulatory

- Responsibility under the *Fisheries Act* by the Minister for the protection of fish and their habitat from pollution.
- Responsibility under the Management of Contaminated Fisheries Regulations of the *Fisheries Act* to prohibit fishing in areas where fish are contaminated with chemical compounds.
- Ability under the *Oceans Act* to establish marine environmental quality [MEQ] guidelines, objectives and criteria of which scientific advice on the impacts of toxic chemicals is one component.
- Responsibility under the *Oceans Act* to implement the Oceans Strategy and to facilitate integrated management including the establishment of Marine Protected Areas will require scientific advice on the impacts of industry on marine ecosystems, including those due to toxic chemicals.
- Responsibility under the proposed *Species at Risk Act* to provide scientific advice, including the impacts associated with chemical contamination, related to the development of recovery plans and the assessment of their success.
- Responsibility under the *Canadian Environmental Assessment Act* to contribute to or review environmental assessment studies that include chemical pollution and toxic effects.

2. Policies and Programs

- The development of knowledge, data and information as required by the Policy for the Management of Fish Habitat to assess the effects of human-induced chemical changes on fisheries resources and the habitats that support them; and to determine how adverse effects on fish habitat may be mitigated and establish criteria for the continued natural production and safe consumption of fish.
- The Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada specifies the use of MEQ objectives in this regard.
- To conduct, under the Program for Sustainable Aquaculture, environmental research to increase our understanding of the impacts of aquaculture on ecosystems and aquatic resources, including the long-term fate and impact of chemicals released by the aquaculture industry.
- The federal policy on oceans management, Canada's Ocean Strategy, recognizes the need to better understand and protect the marine environment and as such requires