Notes

Canada's national aquatic biological specimen bank and database

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A B S T R A C T

Long-term systematic storage of environmental specimens has become an important component of formal environmental monitoring programs in many countries. In 1977, the Contaminants Surveillance Program (CSP) began in the Great Lakes Basin. In support of the CSP, Fisheries and Oceans Canada began archiving fish tissue samples and created the Great Lakes Fisheries Specimen Bank (GLFSB). In 2006, responsibility for the GLFSB was transferred to Environment Canada and it was renamed the National Aquatic Biological Specimen Bank (NABSB). The new name better reflects the current contents and purpose of the specimen bank which now supports Canada's Chemicals Management Plan (CMP). The NABSB employs standardized banking protocols, computerized sample tracking, maintenance of all data and metadata associated with each specimen, and modern storage equipment situated in a dedicated facility located at the Canada Centre for Inland Waters in Burlington, Ontario. Since 1977, specimens from the NABSB have contributed to more than 60 scientific publications, reports, and/or book chapters on the status, trends, and bioaccumulation of metals and various organic contaminants such as PCBs, dioxins, furans, and aromatic hydrocarbons, in aquatic ecosystems. Collection and archiving of specimens in the NABSB continues such that the specimen bank currently holds more than 52,000 samples from 18,749 specimens of top predator fish, forage fish, plankton, and other invertebrates collected over 32 years of environmental monitoring in the Canadian waters of the Great Lakes and beyond.

Introduction

Long-term systematic storage of environmental specimens has become an important component of formal environmental monitoring programs. The availability of well documented and properly preserved specimens allows for the retrospective analyses for emerging contaminants, validation of results generated from new analytical methods, as well as many other monitoring and research applications. These benefits have led to the establishment of environmental specimen banking programs in several countries including the United States (Becker and Wise, 2006), Japan (Tanabe, 2006), Sweden (Odsjö, 2006), and Germany (Paulus et al., 1996).

In 1976–1977, the Fish Contaminants Surveillance Program (FCSP) and the Great Lakes Fisheries Specimen Bank (GLFSB) were established by Fisheries and Oceans Canada to meet Canada’s obligations under the Great Lakes Water Quality Agreement between Canada and the United States (Kiriluk et al., 1998; IJC, 1978). In 2006, responsibility for maintenance and management of the FCSP and GLFSB were transferred to the Water Quality Monitoring and Surveillance Division of Environment Canada. The GLFSB was renamed the National Aquatic Biological Specimen Bank (NABSB) to better reflect the current contents and purpose of the specimen bank. The NABSB allows Environment Canada to generate scientific knowledge about chemical substances in support of risk assessments under the Canadian Environmental Protection Act, 1999 (CEPA, 1999) and about the sources and fate of certain pollutants that enter aquatic habitats and food webs. For example, data from specimens stored in the NABSB are used to evaluate and monitor the concentrations of so-called legacy contaminants (such as PCBs and DDT) in aquatic biota through time, evaluate the effectiveness of current pollution abatement legislation aimed at reducing the levels of contaminants, such as mercury, in the environment, and provide an early indication of potential impacts posed by contaminants of emerging concern such as brominated flame retardants (BFRs).

Consistent with other specimen banks, the NABSB employs standardized banking protocols, computerized sample tracking, maintenance of all data and metadata associated with each specimen, and modern storage equipment situated in a dedicated facility located at the Canada Centre for Inland Waters in Burlington, Ontario. Collection and archiving of specimens in the NABSB has continued uninterrupted to the present day such that the specimen bank currently holds more than 52,000 samples of top predator fish, forage fish, plankton, and other invertebrates collected over 32 years of environmental monitoring in Canadian waters.

The NABSB is a valuable source of historical tissue specimens that are available for collaborative research and monitoring projects through inquiries to Environment Canada. The purpose of this...
document is to publicize the existence and content of the NABSB to other government agencies, researchers, and other interested parties to ensure that it is utilized to its fullest extent.

**Specimen collection and processing**

The majority of specimens added to the NABSB are collected from 12 locations in the Great Lakes as part of the Fish Contaminants Surveillance Program (Fig. 1). When necessary, other Canadian and/or US government agencies and commercial fisherman in the Great Lakes Basin are contracted to collect specimens to meet our target number of individuals per sampling location across the monitoring network. For national programs, requiring fish collection from waterbodies across Canada, specimens are collected through agreements with our collaborators. In cases where specimens are collected by third parties, we provide detailed protocols describing collection, storage, and shipping methods. All specimens are shipped whole to the Canada Centre for Inland Waters for processing and long-term storage. Collection and processing protocols are described (briefly) in the following paragraphs.

Fish collection methods vary depending on the target species and waterbody. Generally, predatory fishes such as lake trout (Salvelinus namaycush), lake whitefish (Coregonus clupeaformis), and walleye (Sander vitreus) are collected with bottom set gillnets. Forage fishes, such as alewife (Alosa pseudoharengus), rainbow smelt (Osmerus mordax), or slimy sculpin (Cottus cognatus) are collected with a bottom trawl. After capture, fishes are immediately frozen on dry ice and transported to the laboratory where they are partially thawed, weighed, measured, and sexed. Scales, fin rays, and/or otoliths are removed for ageing. All remaining portions of the fish, including internal organs, are then homogenized by passing them through a meat grinder five times. Homogenized tissues are split into 15 samples of ~20 g each. Of these, 10 samples are put into long-term storage at ~80 °C and 5 are kept at ~20 °C for use in routine chemical analyses.

Two key components of the profundal food web in the Great Lakes, the opossum shrimp (Mysis relicta) and Diporeia hoyi (Malacostraca: Pontoporeiidae), are targeted for contaminant monitoring and addition to the NABSB. Bulk samples containing both M. relicta and D. hoyi are collected using a modified epibenthic sled (Elster, 1933). Five ~20 g aliquots of each species are separated from the bulk sample, immediately frozen on dry ice, shipped to the laboratory, catalogued, and put into long-term storage at ~80 °C with no additional processing.

Zooplankton samples are usually collected using horizontal tows of a conical plankton net (153 µm mesh). Vertical net hauls are used only in circumstances where horizontal surface tows prove unproductive or when there is a significant amount of debris or unwanted material on or near the surface of the water. Five ~20 g aliquots are removed from the bulk sample and immediately frozen on dry ice, transported to the lab, catalogued, and put into long-term storage at ~80 °C.

Specific physical, biological, and chemical parameters measured in routine monitoring programs have changed over time dependant on the priorities of the day. Typically, top predators such as lake trout and walleye between the ages of 4 and 6 are selected for routine analyses. A summary of the parameters which are currently measured and recorded for selected specimens of predatory fishes is provided in Table 1.

**Storage conditions**

The storage facility contains both ~20 °C and ~80 °C electric freezers which are located in a dedicated climate controlled building.

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**Fig. 1.** Map of the Great Lakes Basin showing locations where fish, zooplankton and other invertebrates are routinely collected as part of the Environment Canada’s Fish Contaminants Program.
on the grounds of the Canada Centre for Inland Waters in Burlington, Ontario. The building’s security and specimen storage conditions are continuously monitored. In the event of power failure, electricity to the facility is maintained by back-up generators. In the event of mechanical failure in any of the freezer units, temperature sensors will trigger the release of liquid CO₂ to maintain freezing temperatures until the specimens can be manually transferred to a back-up freezer which is kept empty for this purpose.

### Holdings

Since the inception of the specimen banking program, fish have been collected and archived from additional locations within the Great Lakes Basin and across Canada to support specific programs such as the Green Plan Toxic Chemicals Program, Toxic Substances Research Initiative, and Clean Air Regulatory Agenda (CARA) (Fig. 2). As of December 2008 the National Aquatic Biological Specimen Bank

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Biological and chemical parameters routinely measured in selected specimens of top predator fish (e.g., lake trout and walleye) collected from the Laurentian Great Lakes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biophysical parameters (fish only)</td>
<td>Organochlorines</td>
</tr>
<tr>
<td>Wet weight</td>
<td>α-Chlordane</td>
</tr>
<tr>
<td>Total length</td>
<td>γ-Chlordane</td>
</tr>
<tr>
<td>Fork length</td>
<td>α-BHC</td>
</tr>
<tr>
<td>Sex</td>
<td>Dieldrin</td>
</tr>
<tr>
<td>Reproductive stage</td>
<td>p,p′-DDDE</td>
</tr>
<tr>
<td>Age</td>
<td>α-γ-DDT</td>
</tr>
<tr>
<td>% lipid</td>
<td>p,p′-DDD</td>
</tr>
<tr>
<td>Extent of lamprey scarring</td>
<td>Heptachlor epoxide</td>
</tr>
<tr>
<td></td>
<td>Hexachlorobenzene</td>
</tr>
<tr>
<td></td>
<td>Lindane</td>
</tr>
<tr>
<td></td>
<td>Mirex</td>
</tr>
<tr>
<td></td>
<td>Total polychlorinated biphenyls (PCB)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 2.** Map of Canada showing locations where specimens archived in the National Aquatic Biological Specimen Bank have been collected.

**Fig. 3.** Number of specimens added to the National Aquatic Biological Specimen Bank each year since 1977.

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**Note:** The page contains diagrams that are not rendered correctly in the text format. Please refer to the PDF version for accurate visualization.
holds 52,128 sub-samples taken from 18,749 specimens of 53 species of fish as well as various aquatic invertebrate species (Fig. 3) (Table 2).

**Information management**

All information related to the NABSB is maintained within a Microsoft Access® database on an internal server which is backed-up daily. All specimens received and or collected are registered and assigned with successive and unique identification numbers. The database maintains all biological data (length, age, etc.) associated with each specimen number as well as data with regard to location, collection methods, storage and the results of all subsequent chemical analyses. A simplified schematic of the structure of the database is provided in Fig. 4.

**Access to specimens**

Tissue samples from the NABSB and/or biological and chemical data from the database are available for collaborative research projects. The release of specimens for research purposes will adhere to Environment Canada’s policy which follows these general principles:

- The research proposed has been reviewed for scientific merit through an internal review process.

### Table 2 (continued)

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th># specimens</th>
<th># sub-samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Invertebrates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mysisidae</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mysis relicta</td>
<td>Opossum shrimp</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Bulk plankton (153 µm)</td>
<td>761</td>
<td>761</td>
<td></td>
</tr>
<tr>
<td>Other invertebrates</td>
<td>67</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

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**Fig. 4.** Simplified schematic of the National Aquatic Biological Specimen Bank database.
Fig. 5. Mean PFOS concentration (ng/g wet weight ± standard error) in whole body homogenates of Lake Ontario invertebrates and fish. Reproduced using data from Martin et al. (2004) with permission of authors.

- There is sufficient tissue to issue without unduly depleting the total specimen. If a request would exhaust the remaining tissue then the rationale for issuing it will be stringent.
- Other means of obtaining the information have been explored and are not possible.
- Co-authorship on resulting publications and acknowledgement of the tissue archive.

For more information on the rationale behind these general principals and/or the process to initiate a request for samples from the NABSB please contact NABSB@ec.gc.ca.

Selected contributions to research and monitoring

Since 1977, samples from the NABSB have contributed to several research and monitoring projects. One such project examined the bioaccumulation and magnification of perfluoralkyl contaminants in a Lake Ontario food web (Martin et al., 2004). The study demonstrated that the benthic amphipod D. hoyi was highly contaminated with perfluorooctane sulfonate (PFOS) relative to its trophic level suggesting that sediment was the major source of PFOS (Fig. 5). The study also showed that PFOS concentrations in lake trout, a top predator, were increasing through time in Lake Ontario (Fig. 6). These data were used to support Environment Canada’s ecological screening assessment reports for PFOS, its salts and its precursors (Environment Canada, 2006).

Collaborations, such as described above, have contributed to more than 60 scientific publications, reports, and/or book chapters. Topics include but are not restricted to: biomagnification of contaminants in food webs (e.g., Helm et al., 2005; Muir et al., 2004; Tomy et al., 2004), ecosystem status and assessment (e.g., Neilson et al., 2003), spatial and temporal distribution of contaminants in ecosystems (e.g., Luross et al., 2002; MacEachen et al., 2000; Whittle et al., 2000), and impacts of aquatic invasive species on contaminant transfer through food webs (e.g., Morrison et al., 1998, 2000; Kiriluk et al., 1999).

Future directions

The NABSB will continue to archive specimens collected as part of the Fish Contaminants Surveillance Program (FCSP) which has been monitoring the concentrations of various organochlorines and metals in top predator fishes in the Great Lakes since 1977. The NABSB is also receiving fishes collected from lakes across Canada as part the Clean Air Regulatory Agenda (CARA), a program which aims to establish baseline mercury concentrations in fishes across Canada from which to evaluate the effectiveness of pollution abatement strategies. The specimen bank is also receiving top predator fishes from across Canada to investigate the status and trends of brominated flame retardants (BFRs) and perfluorinated compounds in support of Canada’s Chemicals Management Plan (CMP).

Acknowledgments

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References


