

A Canadian Action Plan to Address the Threat of Aquatic Invasive Species

*Canadian Council of Fisheries and Aquaculture Ministers
Aquatic Invasive Species Task Group*

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A Canadian Plan to Address the Threat of Aquatic Invasive Species

Executive Summary

Aquatic invasive species (AIS) have been entering Canadian waters for centuries but never as rapidly as today. Every decade, some 15 alien species establish themselves in our coastal or inland waters and, in the absence of their natural predators, the most aggressive of them spread rapidly. They can radically alter habitat, rendering it inhospitable for native species.

Invading species have been implicated in both the vast reductions in, or outright extinction of, indigenous fish and the resulting devastation of local fisheries. Some invasives, such as the zebra mussel, do millions of dollars in damage annually to human infrastructure. In addition to damage to the environment, in total, invasive species cost billions of dollars every year due to lost revenue and the implementation of control measures. With more species poised to enter the country, these costs will only rise.

Canada has 20 per cent of the world's fresh water and one of the longest coastlines, thereby placing it at high risk from AIS. As a result of insufficient awareness of the nature and size of the threat, there have been limited levels of compliance with practices and regulations designed to minimize the damage.

World leaders officially recognized the threat posed by invasive species in 1992, with the adoption of the UN Convention on Biodiversity. Canada responded in 1995 with the Canadian Biodiversity Strategy. In September 2001, federal, provincial and territorial ministers of forests, fisheries and aquaculture, endangered species and wildlife agreed to develop a Canadian plan to deal with the threat of invasive alien species. In 2002, they approved a blueprint for the plan. Also in 2002, the Canadian Council of Fisheries and Aquaculture Ministers created the Aquatic Invasive Species Task Group to develop an action plan to address the threat of aquatic invasive species.

The most effective approach to dealing with the hundreds of species that are (or could become) established in Canada involves managing the pathways through which invasive species enter and spread through Canadian waters. For aquatic species, these pathways are shipping, recreational and commercial boating, the use of live bait, the aquarium/water garden trade, live food fish, unauthorized introductions and transfers, and canals and water diversions. This plan does not address authorized introductions such as aquaculture or fish stocking, as they are covered by the *National Code on Introductions and Transfers of Aquatic Organisms*.

The shipping pathway is considered the largest single source of new aquatic invasive species. Ballast water that is taken on in foreign ports, for ship stability and safety at sea, is discharged in Canadian waters, along with undesirable "hitchhikers" – foreign species ranging from bacteria to larger organisms. While other pathways can also be a source of new species, they generally serve to spread species that have already established themselves in Canada and other parts of North America.

Efforts to resolve AIS problems raise a wide variety of issues. Any given species may affect the environment, trade, shipping, recreational use of waterways, fishing, resource management, human health and more. Numerous jurisdictions, from the local to the international level, play a role in prevention, monitoring and management activities, as do industry, non-governmental organizations (NGOs), Aboriginal peoples and other stakeholders. The magnitude and nature of the problem, and the priorities for action, vary from jurisdiction to jurisdiction.

In many cases, appropriate legislation and regulations exist to combat invasive species but they have not always been adequately used. Actions have been taken to respond to specific threats but concerted and coordinated efforts are only in their early stages.

The ultimate goal of this plan is to minimize (and ideally eliminate) the introduction of harmful AIS and remediate the impact of those already in Canada. The plan's underlying principles include incorporating environmental, economic, and social factors in decision making; working cooperatively with all stakeholders; and using science-based techniques to assess the risk of aquatic invasive species.

Prevention of harmful new invasions is the first priority, as it is the most cost-effective way to deal with the problem. Once species are established, the task becomes far more complex and costly. The tools used to manage AIS must be carefully analyzed in terms of their effectiveness, how they affect the rest of the ecosystem, their cost, and so on.

While some of the tools used to prevent and control harmful introductions vary between pathways, most of them apply across pathways, between jurisdictions, and to a range of species and ecosystems. In this plan, management actions have been organized into four broad categories: legislation, regulation and compliance; risk management; engaging Canadians; and science.

Given the size of the problem and the limitations on human and financial resources, priorities for implementation must be assessed carefully. Some results can be achieved using existing resources but the urgency and magnitude of the threat suggests the need for new investment. While the federal, provincial and territorial governments bear overall responsibility for putting this plan into action, partnerships with industry, Aboriginal peoples, NGOs and all other stakeholders are imperative for its success.

Introduction

The movement of species, ranging in size from microscopic organisms such as viruses or bacteria to plants to large animals, has always been part of life on Earth. Some of it happens naturally through migration patterns, weather and other factors. Humans, however, have been responsible for extensive artificial movement of large numbers of species for some time, due to their economic and social activities throughout the world. In recent years, technological advancements and increases in world trade have led to even more intentional and unintentional movement of species to habitats where they are not native, sometimes with disastrous results.

While there are times when the intentional introduction of alien species improves quality of life (such as food production or biocontrol), the misuse of alien species has caused serious ecological and economic harm. When alien species become established in a new habitat, they can disrupt the existing balance of that ecosystem. In some cases, the new species takes over, causing radical and irreversible changes to its new environment. When this occurs, the species is defined as invasive.

Some invaders, such as the infamous zebra mussel, can damage human infrastructure at costs in excess of millions of dollars per year.ⁱ Invasive alien species pose threats to the economy, local ecology, and human health. In Canada, conservative estimates place the combined economic losses and direct costs associated with the 16 species for which published information is available at \$5.5 billion.ⁱⁱ A US report estimates the annual economic burden of invasive species in that country at \$137 billion.ⁱⁱⁱ The World Conservation Union rates invasive alien species as the second worst threat to biodiversity after habitat loss.^{iv}

World leaders have recognized the threat posed by invasive alien species since 1992, when they agreed on the UN Convention on Biodiversity. In response, Canada developed the 1995 Canadian Biodiversity Strategy, which recognized the need to conserve biodiversity and promote the sustainable use of biological resources through increased understanding, legislation, incentives and other means. In it, the federal, provincial and territorial governments expressed a commitment to take all necessary steps to prevent the introduction of harmful alien species and eliminate or reduce their effects on ecosystems.^v

In September 2001, federal, provincial and territorial ministers of forests, fisheries and aquaculture, endangered species and wildlife identified invasive alien species as a priority, calling for the development of a Canadian plan to deal with the threat. Later that year, a national workshop brought together numerous stakeholders to determine the basic approach and underlying principles for the Canadian plan.

A blueprint for the Canadian plan was approved at the Ministers' meeting in September 2002. The Ministers also created specific working groups to cover issues related to aquatic species, terrestrial animals, terrestrial plants, and leadership and coordination.

Operating under the auspices of the Canadian Council of Fisheries and Aquaculture Ministers (CCFAM), the Aquatic Invasive Species Task Group was directed to develop the Canadian action plan for aquatic invasive species. The task group includes representatives from Fisheries and Oceans Canada, every province and territory, as well

as special advisors from Transport Canada, Environment Canada and the Department of National Defense.

In addition to consultations with a wide range of key stakeholders, the development of this plan involved reviewing numerous reports and other documents for appropriate recommendations and actions.

Introductions of new species can take place deliberately or accidentally and can be authorized or unauthorized (illegal). This plan only covers unauthorized introductions. There are procedures already in place under the *National Code on Introductions and Transfers of Aquatic Organisms* (see text box) which govern authorized introductions.

Deliberate introductions can be made for such purposes as aquaculture, increasing fish stocks, biocontrol, or filling perceived gaps in certain aquatic communities.

Recognizing that there are social and economic benefits derived from fish stocking and culture, the Code addresses the concerns around transfers for these purposes by providing a standard risk assessment procedure that can be applied across all jurisdictions.

The **National Code on Introductions and Transfers of Aquatic Organisms** was developed by Fisheries and Oceans Canada and each Canadian province and territory at the request of the Canadian Council of Fisheries and Aquaculture Ministers. The Code sets out standards for assessing introductions and transfers, including a risk assessment process that can be applied to introductions and transfers of new aquatic organisms between and within regions and jurisdictions. Each Canadian jurisdiction applies the code through a provincial Introductions and Transfers Committee. Ministers from all jurisdictions signed the code in 2001 to indicate support for its use across the country. The Code can be accessed at:

www.dfo-mpo.gc.ca/science/aquaculture/code/prelim_e.htm (English) or
www.dfo-mpo.gc.ca/science/aquaculture/code/prelim_f.htm (French)

Rather than dealing individually with the hundreds of unwanted species that are (or could become) established in Canada, the most effective approach involves managing the pathways or vectors through which AIS either enter Canadian waters or spread within the country. In consultation with stakeholders, the task group identified seven key pathways: shipping, recreational and commercial boating, the use of live bait, the aquarium/water garden trade, live food fish, unauthorized introductions and transfers, and canals and water diversions. Each of these is explored in greater detail later in this document.

A glossary of the terms used in the plan can be found at the end of this document.

Challenges

Scope of the problem

AIS are a large and growing problem in Canada, one that is compounded by a lack of knowledge and understanding about the issue. Since Canada is home to 20 per cent of the world's fresh water and has one of the world's longest coastlines, the economic and environmental consequences of inaction are extreme. Few people are sufficiently aware of the nature and magnitude of the threat and, as a result, there is a widespread lack of compliance with voluntary practices and regulations designed to limit the spread of AIS resulting from human activity. Although applicable legislation and regulations exist in many cases, they have not always been adequately brought to bear on the problem.

The consequences of invasive species becoming established include damage to sensitive ecosystems, as well as negative impacts on fishing, tourism, and other industries that form the backbone of local economies.

Examples of invasive species found in Coastal waters include the green crab and clubbed tunicate. The green crab affects East Coast native clams, mussels and oysters, and now also threatens West Coast shellfish. The invasive alga codium (oyster thief) threatens oysters in Atlantic Canada. In BC, the Japanese oyster drill caused significant damage to the oyster industry until it was brought under control in the mid-1900s. Even Arctic waters are affected, with the recent establishment of rainbow smelt in Hudson's Bay.

In addition to the primary effects, which can be seen shortly after a species becomes established, the alteration of such things as food webs and water quality can cause secondary impacts that take much longer to manifest. This further complicates governments' ability to manage invasive species. For example, the filter feeding activity of zebra mussels rapidly increased water clarity in the lower Great Lakes. Over a much longer period, the increased light penetration (due to clearer water) produced significant growth and spread of aquatic vegetation and increased the frequency and severity of toxic algal blooms.

Nearly twice as many invasions occurred during the second half of the 20th century (as compared to the first half) and recent data suggests that the pace is still accelerating.^{vi} The increase in both the volume and speed of global trade, especially in the case of goods or vessels from countries with similar climates to Canada, has led to ever-higher risks of AIS entering Canada – risks that are further exacerbated by insufficient surveillance and enforcement.

The largest single source of new alien aquatic species, estimated at about 75 per cent in the Great Lakes region, is ballast water in ships.^{vii} Water taken on in foreign ports, complete with local organisms, is discharged in Canadian waters, along with undesirable hitchhikers. Ballast tanks have been known to house up to several hundred different species.^{viii} Globalization and internet-based commerce have also increased the intentional and unintentional importation of alien species for various purposes, some of which pose a threat if released into the wild. Not all invasive species come from overseas, some are

Sea lamprey are considered a significant factor in the collapse of the lake trout and whitefish fisheries in the mid-1940s and 50s. Prior to sea lamprey entering the Great Lakes, Canada and the US harvested close to 6.8 million kgs (15 million lbs) of lake trout in Lakes Huron and Superior each year. By the early 1960s the annual catch was about 136,077 kgs (300,000 lbs), a significant 98% decrease. The sea lamprey control program, implemented in 1955, has successfully resulted in reducing sea lamprey populations by 90%. The combined average annual investment by Canada and the US in the sea lamprey control program is \$22 million. Although this program has led to increased employment and growth in commercial fish stocks, the ongoing expense underscores the fact that the cost of prevention is far less than the cost of control and mitigation. If sea lamprey had been prevented from entering Canadian waters in the early 20th century, these annual, continuing costs would never have materialised. The combined economic value (in Canada and the US) of recreational and commercial fishing on the Great Lakes is currently estimated at about \$4.5 billion.

native to North America but became harmful invasives because they were introduced beyond their natural range.

The number and intensity of calls to action have increased over the last decade, both within Canada and internationally. Domestically, these have come from sources such as the Standing Committee on Fisheries and Oceans and the Commissioner of the Environment and Sustainable Development. Other organizations, including the International Joint Commission, the Great Lakes Fishery Commission and various non-governmental organizations (NGOs) have also called for urgent action to deal with invasive species.

In February 2004, the International Maritime Organization adopted a **Convention for the Control and Management of Ships' Ballast Water and Sediments**. The Convention sets standards for acceptable numbers of organisms to be present in ballast water and establishes a timetable for compliance. It does not, however, include any provision for addressing the problem of vessels with no ballast on board, which are currently exempt from regulations. Ratification of the Convention will require the signature of 30 countries with 35 per cent of the world's shipping tonnage.

A variety of issues, priorities and jurisdictions

The consequences of AIS are often wide-spread and can touch on the environment, trade, shipping, recreational use of waterways, fishing, resource management, and human health. Efforts to resolve AIS problems are complicated and the solutions often involve trade-offs. For example, allowing a species to spread may irreversibly alter the ecosystem, thereby threatening fishing, recreation, and hospitality industries. However, efforts to stem its spread may require the use of toxic chemicals, hamper trade in certain commodities, or increase shipping costs. Management strategies must provide a thorough analysis of the potential risks and benefits of specific actions in order to balance environmental and economic interests.

Numerous jurisdictions and organizations are involved, from local to international levels. Within the federal government, primary responsibility and authority rests with Fisheries and Oceans Canada and Environment Canada but, depending on the species and its pathway into Canadian waters, management actions can also involve Transport Canada, Industry Canada, the Canadian Food Inspection Agency (CFIA), the Canadian Border Services Agency (CBSA), Health Canada and others. Provincial and territorial governments share the responsibility, as do bilateral organizations such as the International Joint Commission and the Great Lakes Fishery Commission. Industry, a variety of NGOs, Aboriginal peoples and the general public are also involved.

Many actions have been taken by governments and other stakeholders in response to the threat of invasive species. On the legislative front, many federal and provincial statutes exist to protect Canada's native biodiversity. Various organizations and jurisdictions have also initiated programs designed to educate specific groups about preventing the spread of invasive species. Coordination of these programs can be enhanced.

Not every part of the country experiences the same risk from AIS. The effects of specific pathways, and their associated risks, are greater in some regions than others. For example, the shipping pathway has resulted in the greatest number of established AIS in coastal provinces and those bordering the Great Lakes. The shipping pathway and ballast water management is the highest national priority for preventing new species from being

introduced. Although the risk of introduction from the shipping pathway is less direct for Alberta and Saskatchewan, the spread of invasive species through recreational and commercial boating, inter- and intra-basin water transfers from neighbouring jurisdictions, and introductions from the aquarium trade are of greater concern. The flexibility to allow for regional and jurisdictional differences in priorities is an integral component of a Canadian AIS plan.

Efforts to coordinate laws and regulations with a bearing on aquatic invasive species are in their early stages. In many cases, broad regulatory mechanisms already exist to control the intentional and unintentional introduction of AIS but where resources will come from and who will bear enforcement responsibility needs to be addressed. In order to be effective, legislation and regulations must be coordinated within and between governments.

Strategic Direction

Underlying principles

The ultimate goal of any invasive species plan must be to minimize (and ideally eliminate) both the introduction of new AIS and the spread and impact of those already present in Canada. This includes prevention of unwanted introductions, early detection of potential invaders, rapid response to prevent establishment, and management to contain AIS that have already become established.

The basis for a Canadian plan requires a long-term approach that recognizes the relationship between a healthy environment and a sustainable economy. For many jurisdictions, the trade in live organisms is important to their economies. Governments recognize that consumer demands can be met while addressing concerns over transfer of organisms, and meeting requirements under trade agreements (WTO, NAFTA).

The *National Code on the Introductions and Transfers of Aquatic Organisms* addresses this issue. The Code provides science-based principles to be used by governments in management decisions around the intentional introductions and transfers of aquatic organisms for aquaculture, fish stocking, and scientific research. The Aquatic Organisms Risk Assessment Protocol may be used to analyze the effects of introducing or transferring aquatic species and to examine measures to minimize harmful consequences before movement occurs. This document supports the Code and promotes consideration of social, economic, and environmental issues associated with unintentional and accidental introductions.

The underlying principles of this Canadian plan include:

1. Working within existing domestic and international legislation and agreements to develop a compatible Canadian AIS strategy;
2. Developing a strategy that is science-based and utilizes the best available knowledge;
3. Adopting an adaptive management approach that incorporates and continually improves on policies and practices by learning from the outcomes of operational programs;

4. Working cooperatively with all levels of government, industry, NGOs, and other stakeholders within Canada and internationally;
5. Engaging the public and encouraging universal stewardship;
6. Respecting Aboriginal and treaty rights through consultation and inclusion in decision-making processes;
7. Ensuring traditional and other sources of knowledge are integrated into strategies to address the threat of invasive alien species;
8. Taking as many factors as possible into consideration, including environmental, social, economic, cultural and human health, while recognizing regional interests and priorities;
9. Ensuring the important social and economic role of trade in live organisms in Canada is maintained and international trade agreements are respected, while preventing invasions;
10. Taking a precautionary approach that assumes new species pose a risk and identifies rapid response actions to prevent AIS movements into Canada; and
11. Adopting an ecosystem/bio-geographical approach, recognizing the fact that the issue of aquatic invasive species transcends jurisdictional boundaries.

Strategic goals

The task group, in consultation with stakeholders, identified a number of key areas where action may prove effective in limiting the introduction and spread of alien species. The first step was identifying the specific pathways by which organisms enter and spread through Canadian waters and then developing tools to prevent their introduction or to control them.

By far the most effective way of controlling invasive species is to prevent their entry into Canada in the first place. This proactive approach will avoid increasing the existing burden of controlling species that have already established themselves, the cost of which is already many millions of dollars. Prevention efforts should address imports, exports and the movement of species within Canada. Specific activities include border control, inspection, enforcement, education and communication, risk analysis, and information management.

For species that have already been introduced, the focus turns to eradication, controlling their spread, or adaptive management. While early detection is possible for some species, the lag time between introduction and establishment is often measured in years or even decades. Regardless of when a new species is discovered, the Canadian plan must be able

Since first being discovered in Lake St. Clair in the mid-1980s, the **zebra mussel** has become one of the most notorious invaders of Canadian waters. Originally from the Black and Caspian Sea area, it has spread throughout the Great Lakes and beyond. In addition to habitat changes and threats to native species, these invaders cause significant damage to human infrastructure by fouling water intake pipes or attaching themselves to other structures. Because they are so firmly established over such a wide area, little can be done to effectively control them. In western Canada, where zebra mussels have not established, the most effective control is prevention of introduction.

to respond quickly. A rapid response plan assesses all aspects of the introduction, including the potential for successful eradication or control.

Once a species becomes established, the task becomes much more challenging. Damage to local ecosystems may already have occurred such that complete eradication may no longer be feasible. Any control measures must be subject to comprehensive analyses in terms of their potential harmful effects on other species or the ecosystem as a whole.

The level of intervention should correspond proportionally to the level of threat. Control measures are currently hampered by inadequate resources, lack of coordination, and the absence of suitable control tools or the authority to use them.

Any management activities intended to eliminate invasive species must include a restoration component. A damaged ecosystem will not always be able to regenerate itself to its previous state and is more susceptible to subsequent invasion. This may involve taking an active approach in terms of encouraging native species to thrive. The healthier an ecosystem is, the more capable it is of resisting invasions.

Basic approach

The development of the Canadian plan started with the key pathways that have been identified as significant sources of aquatic invasive species. Each of those pathways offers opportunities for immediate and longer term actions. While some actions are highly specific (applying to a single species in a certain area), many of them apply across all pathways, jurisdictions, species, and ecosystems. Education efforts, for example, are effective tools to prevent species from entering Canadian waters whether through shipping, recreational boating, or the aquarium trade.

A workable plan must include ways to determine jurisdictional priorities. Some species, even though they have become established, are not aggressive enough to be considered a serious invasive threat. Others multiply rapidly and do serious damage to habitat, native species, or economic activity. The criteria for assessing priorities include such factors as the degree of potential damage to the ecosystem, the value of the harm done to the economy, and the costs of control measures.

Flexibility is another key ingredient. The Canadian plan must allow for differences in the way priorities are dealt with at the regional level. All stakeholders must share in the development of the plan and act as partners in implementing it.

Key Pathways for Introduction or Spread

The process of minimizing the effects of invasive species begins with understanding how they get into Canadian waters in the first place and how they spread once they are introduced. This section describes the main pathways: shipping, recreational and commercial boating, the use of live bait, the aquarium/water garden trade, live food fish, unauthorized introductions and transfers, and canals and water diversions.

Developing a clear picture of the seven key pathways for introduction or spread provides the necessary information for taking effective action. While the following seven pathways have been identified as primary sources for the introduction and spread of aquatic invasive species, it is recognized that new pathways could be identified in the

future, as a result of changing trade patterns or public interest. This document is intended to provide governments with a fluid framework for monitoring and evaluating possible sources of invasion and assessing the magnitude of risk associated with other potential pathways such as fish processing effluent and grey water.

1. Shipping

This pathway includes large ocean-going vessels with ballast capability (commercial shipping, naval, and cruise vessels) that operate in Canada's offshore, nearshore and inland waters. These vessels unintentionally transport invasive species that attach themselves to ship hulls or that survive in the ballast water that is taken on in foreign ports. Historically, alien species in ballast water are considered to be the largest single source of aquatic invasive species in Canada's waterways.

Vessels require ballast water to safely balance their weight distribution and to compensate for a lack of weight by cargo, fuel or passengers. Ballast taken onboard in one port may be released in another port and with this water come invasive species from the previous port.

Organisms attached to ship hulls can also easily survive a long voyage and establish themselves in foreign ports. A variety of substances and procedures are currently used by the shipping industry to limit hull fouling. While reducing the presence of invasive species, anti-fouling hull coatings can contain toxic substances.

At present, vessels in Canadian waters are only subject to voluntary guidelines established by Transport Canada, with the exception of all vessels entering the Great Lakes that are subject to US Coast Guard regulations. Regulations under the *Canada Shipping Act*, which will be closely harmonized with similar measures adopted by the United States and the International Maritime Organization, are expected to be in place in 2004. These measures are similar to what is contained in the existing voluntary guidelines and will initially include the mandatory management of ballast water by ballast exchange at sea. This is currently the only approved form of ballast water management. In the longer term, the implementation of a performance standard for ballast water exchange is expected to provide more effective protection for receiving ports.

The current lack of technology to effectively reduce the number of organisms in ballast water remains an obstacle to setting and enforcing stricter standards. Several federal laboratories in Canada, as well as several universities and private corporations, are researching alternatives to ballast water exchange. The Canadian Marine Advisory Council, with participation from government agencies, industry and ENGOs, has national and regional working groups on ballast water in place.

Neither the voluntary guidelines nor the proposed regulations address the problems associated with the fact that more than 70 per cent of vessels entering Canadian Great Lakes waters are fully loaded and, therefore, require no additional ballast water. Although their tanks retain sludge at the bottom that may contain alien species or pathogens, such ships report that they have "no-ballast-onboard" (NoBoB) and are exempt from current regulations.

2. Recreational and commercial boating

This pathway consists of the in-water use and overland transportation of all watercraft other than large ocean-going vessels with ballast capabilities, such as commercial shipping, naval and cruise vessels, which are covered in the shipping pathway.

Powerboats, yachts, personal watercraft, sailboats, canoes, float planes, paddleboats, and associated equipment (such as trailers or fishing equipment), as well as commercial fishing, education and research, and charter boat vessels are included in this pathway.

The use and transport of watercraft can spread aquatic invasive species to lakes, rivers, estuaries and coastal areas throughout Canada when organisms like zebra mussels or clubbed tunicate and plants like Eurasian water milfoil attach to or become lodged on the hull, motor, trailer or equipment such as anchors, ropes or fishing gear. Any water that enters the watercraft during operation (bilge water, live wells, and engine cooling systems) may contain unwanted organisms. If precautions are not taken, transient boating activity poses the greatest risk for spreading aquatic invasive species within Canada as a result of the movement between waterways (by water or overland transport) of watercraft and associated equipment.

Currently there are few specific regulations directed at recreational and commercial boating related to preventing the spread of aquatic invasive species. Education and voluntary compliance are key activities for preventing the spread of invasive species through recreational and commercial boating. Governments and NGOs offer public awareness programs that provide information on AIS and promote the use of voluntary user-specific prevention procedures for recreational and commercial boating. For example, boat inspection programs can serve the dual purpose of heightening public awareness of AIS and providing inspection of trailered watercraft. Research is being done on ways in which boating activities contribute to the spread of invasive species.

3. Use of live bait

This pathway consists of the public and commercial use of live organisms (including minnows, frogs, aquatic and terrestrial worms, leeches, and aquatic or terrestrial insects and larvae) to catch fish. Recreational anglers collect their own or buy commercially-sold live bait.

The wild harvest and use of live bait creates a vector for introduction of bait fish and other organisms (non-target fish species, aquatic organisms, pathogens, parasites, aquatic plant fragments, aquatic and terrestrial worms) that may be in bait buckets or associated with harvest gear when the regulations governing the use of live bait are contravened, intentionally or unintentionally. Fish and fellow travelers can be introduced through dumping of bait buckets or anglers and harvesters hoping to establish new populations or enhance existing forage bases by increasing the size and density of game species. (*see Unauthorized introductions pathway*)

The Ontario Ministry of Natural Resources co-chairs an Exotics Committee with the Bait Association of Ontario (BAO) to work cooperatively to address issues related to this pathway. This partnership produces public awareness materials, maintains a web-site, develops best management practices for the live-bait industry, gathers data from mandatory annual reporting by licensed bait harvesters, and engages in Hazard Analysis and Critical Control Point (HACCP) training.

Even dead bait may carry live fellow travelers, such as parasites or diseases, whether in the bait itself or in the carrying medium.

Where the use of live baitfish is allowed, regulations to prevent introductions seem to have been ineffective. Many anglers release baitfish at the end of a fishing trip and various jurisdictions have noted unauthorized introductions of these species despite prohibitions against the release, and in some cases the use, of live baitfish.

Although the impacts of some of the species not native to Canada are quite clear, the effects of species native to Canadian waters that spread beyond their normal range tend to be more difficult to assess. While these have not been studied, genetic and ecological impacts are potentially similar to those identified for other species.

While there are specific regulations covering all regions of Canada restricting the use of live bait, compliance and enforcement remain major issues. Regulations cover issues such as the release of fish (including baitfish), inter-provincial and international transport of bait, and the allowable species permitted for use as bait.

4. Aquarium and water garden trade

This pathway consists of the intentional or unintentional release of aquatic organisms including fish, invertebrates, plants, amphibians and reptiles sold for use indoors in aquariums and outdoors in ornamental ponds and water gardens. Owners may intentionally release species into open waters because they have outgrown aquariums or are no longer wanted. Species may also be intentionally introduced for control of weeds or unwanted organisms like the mosquito or as part of certain cultural practices.

Unintentional release can occur when fish, aquatic invertebrates, or plants escape outdoor ponds naturally (seeds spreading) or during unexpected overflow events (flooding).

Although many aquarium species are tropical and cannot survive Canadian winters, there are numerous examples of fish, invertebrates, and plants that have been introduced or have spread in Canada as a result of aquarium releases. Concern has also been expressed regarding more temperate species available in the trade, especially those intended for ornamental ponds. Recent work in the US indicates that purchasing products over the internet contributes to long range movement of plants utilized in the water garden trade.^{ix}

The potential for the introduction of pathogens associated with aquarium organisms released to natural waters is also a concern. Links have been made between fish available through the aquarium and water garden trade and diseases that have caused significant mortality in native fish.

In most parts of Canada, it is illegal to release any aquatic organisms into the wild without a permit but this is not effectively enforced or consistently applied across the country. Little is being done in most jurisdictions to address the issue of aquarium releases. The aquarium industry remains largely unregulated. There are very few regulations specifically designed to address the concerns associated with introductions of aquatic organisms from the aquarium and water garden trades. Each year, numerous aquarium fish are captured in the open waters of Canada, emphasizing the ineffectiveness of the regulations related to release of fish.

General education programs regarding exotic species and the perils of illegal releases exist in most jurisdictions but are usually not specifically directed towards aquarium releases.

In Ontario, a multi-agency group has established a Fish Rescue Program (see text box). The Pet Industry Joint Advisory Council of Canada led the production of information flyers that are being inserted into new aquariums.

The **Fish Rescue Program** is a joint effort of the Royal Ontario Museum, the Toronto Zoo, the Canadian Association of Aquarium Clubs, the Ontario government, the Pet Industry Joint Advisory Council, the Ontario Federation of Anglers and Hunters, and Fisheries and Oceans Canada. The program makes aquarium owners aware of the dangers of releasing pets or plants into the wild and facilitates finding homes for unwanted aquarium pets.

5. Live foodfish

This pathway refers to any fish or other aquatic organisms imported or transferred live within Canada for distribution and sale for human consumption.

British Columbia and the Atlantic provinces have a long history of shipping live aquatic products from domestic commercial capture fisheries and aquaculture sources to regional, national, and international markets. These activities are regulated and controlled. Shipments of marine organisms to freshwater market areas pose a relatively low risk. However, depending on the species in question and the shipping methods/media used, activities such as the shipment of marine species from one coast to another and the importation of live marine species from other countries constitute a much higher level of risk.

Live foodfish markets are expanding in Canada's urban centres, especially those with large ethnic populations. Environmental risks include unauthorized releases of alien fish and the introduction of pathogens and "fellow-travelers" in shipping waters and material used to transport live foodfish. For example, the European green crab (*Carcinus maenus*) is believed to have been introduced to the US west coast in the packing material of live foodfish from the east coast.

Existing regulations governing importation of live foodfish and public education materials focus on addressing human health and consumer safety but do not address the need to protect native aquatic species and their habitat. Further, regulations that prohibit unauthorized introductions of any live fish to natural waters, such as the *Fishery (General) Regulations*, ss. 55 and 56, do not apply in all Canadian jurisdictions and where they do apply, they are difficult to effectively enforce.

Regulations bearing on the environmental risks of live alien fish exist but are not specific to the live foodfish trade. Introductions and Transfers Committees in some jurisdictions may deal with aspects related to the potential risks associated with the live foodfish trade.

Public education programs regarding the environmental consequences of releasing live fish into natural waters exist in some jurisdictions. They are not, however, targeted specifically to the live foodfish trade. Importers, distributors, and retailers may be aware of the environmental risks associated with unauthorized uses of non-native foodfish but this knowledge is not common or communicated across all jurisdictions.

6. Unauthorized introductions

Unauthorized introductions are defined as any introduction or transfer of fish (including shellfish) or marine plant not performed or authorized by a federal, provincial or territorial fisheries management agency.

As noted previously, authorized and intentional introductions are NOT covered by this plan as they have been addressed through the *National Code on Introductions and Transfers of Aquatic Organisms*.

Many new populations of fish of various species have been established throughout Canada because of unauthorized stocking. These introductions are often conducted by individuals with good intentions, such as creating new recreational or commercial fisheries or manipulating vegetation or existing fish stocks to introduce food into stunted fish lakes.

These practices are illegal and can cause great harm to existing recreational, commercial, and bait fisheries. The results of these activities are often not discovered until the population has expanded such that the invader is encountered in the recreational or commercial fishery.

In many instances, unauthorized introductions are range extensions of already introduced or naturalized alien species. The negative effects of these stocking activities often become widespread as the introduced species moves to other lakes through connected waterways.

As popular as some alien species are, they can create a lot of problems for both native species and for fish managers. This is especially true when they are illegally planted in lakes that are being managed for other fisheries. Strategies to eliminate or control unauthorized introduced fish are difficult to design and implement, costly, and almost entirely ineffective.

All existing federal, provincial and territorial fisheries management legislation contains sections that make unauthorized introductions of fish illegal and subject to prosecution. Initiatives to alert anglers and others to the problems posed by unauthorized introductions of fish and other aquatic organisms are currently undertaken on an *ad hoc* basis within virtually all jurisdictions.

7. Canals and water diversions

This pathway consists of canals and channels used for shipping and bulk water diversion. These create artificial connections allowing the free movement of species across physical barriers, between watersheds (inter-basin), and within watersheds (intra-basin).

Canals and diversions are important features on the North American landscape for navigation, hydro-electric power development, recreation, commerce, water supply, flood control, and agriculture. Their existence has also generated the negative by-product of increased invasion and range expansion of alien organisms into new waters.

The Government of Canada opposes any *inter-basin* water diversion projects, within Canada or in basins shared with the United States, which may result in the transfer of foreign biota to Canadian waters.

With respect to *intra-basin* water diversions, the federal government continues to ensure that all projects within Canada or in watersheds shared with the United States are subject

to the full extent of the *Canadian Environmental Assessment Act* (CEAA) process and that the environmental impacts of foreign biota are fully considered in the course of this review. The CEAA requires an environmental assessment for projects as defined by the Act (that are not excluded by the *Exclusion List Regulations* or carried out in response to a national emergency) where there is a federal trigger including where there is federal funding, the federal government is the proponent of the project, or there is a federal regulatory decision to be made in relation to the project that is included in the *Law List Regulations*. The federal government advocates exercising caution with respect to intra-basin transfers and endorses less disruptive alternatives such as demand management and water conservation to satisfy societal needs without sacrificing water related values to irreversible actions.

Strategic Management Framework

Leadership, coordination and cooperation

AIS issues are extremely complex and involve a wide variety of stakeholders, including all levels of government (and several departments within each level), many industry sectors, and numerous NGOs. Effective leadership and coordination are imperative for success, as they serve to reduce overlap and duplication and focus efforts on the most important tasks.

Overall leadership for implementing this plan is shared between the federal government and the provinces and territories. Lead agencies include Fisheries and Oceans Canada and Environment Canada and their provincial and territorial counterparts.

To ensure national implementation and coordination of the plan, lead agencies will review existing structures (including federal-provincial-territorial priority-setting mechanisms, accountability and reporting structures, and resources) and identify/ address any gaps.

Leadership and coordination actions include the following:

Inter-jurisdictional

- Identifying a national body with federal-provincial-territorial representation to coordinate the overall implementation of the Canadian AIS plan and report to competent Ministers.
- Using the Canadian AIS plan as a guide in the development of provincial plans/ planning.
- Ensuring cooperation between all jurisdictions regarding mandates/authority. Within each jurisdiction, departments responsible for the environment and for fishing/ waterways will take the lead, calling on expertise and input from other departments (such as CBSA, CFIA, Transport Canada) for those issues which require it.
- Identifying issues that call for urgent action or where short-term, relatively easy actions will yield substantial results.

- Evaluating the effectiveness of the AIS plan in achieving its goals. Recommend modifications as needed.
- Cultivating and maintaining relationships with industry, NGOs, Aboriginal peoples and other stakeholders.

Inter-departmental

- Establishing inter-departmental working groups to coordinate actions between agencies.

International

- Cultivating and maintaining international relationships, including sharing information, expertise and best practices, as well as strengthening and harmonizing agreements. In addition to other governments, international partners include the International Maritime Organization (IMO), the International Joint Commission (IJC), Great Lakes Fishery Commission and the Commission for Environmental Cooperation.

Canada shares responsibility for managing many waterways with the United States and is represented on a number of bilateral groups with a mandate to control invasive species. These include the Great Lakes Panel on Aquatic Nuisance Species, the Northeast Aquatic Nuisance Species Panel, the Mississippi River Basin Panel on Aquatic Nuisance Species and the Western Regional Panel on Aquatic Nuisance Species.

Implementation strategies

Many of the strategies required to deal with the threat of AIS call for action within a specific pathway or with respect to a single species. For the purpose of developing a Canadian plan, those actions are best organized in broad categories that apply across pathways and species and are harmonized between jurisdictions. These categories are:

- Legislation, regulation and compliance
- Risk management (risk assessment, early detection and rapid response)
- Engaging Canadians (stewardship, education and awareness)
- Science (monitoring, research, and risk analysis)

1. Legislation, regulation and compliance

Effective legislative frameworks take into account the varying needs and priorities of different jurisdictions and sectors. Although the mandates for addressing most AIS issues fall under one or more existing pieces of legislation, there is a need for better integration.

Areas for action include:

- Use the existing reviews of federal, provincial and territorial legislation that apply to AIS to identify gaps, overlap, and inconsistencies in the existing legislation.
- Consider federal and provincial regulatory amendments where necessary.

- Determine all Canadian and international agencies that play a role in enforcement and identify ways to ensure that there is the necessary capacity, awareness, cooperation, and coordination of enforcement and compliance priorities.
- Identify and resolve conflicts between regulations or control activities related to invasive species and the provisions for movement of goods in international trade agreements such as NAFTA or WTO.
- Complete the regulatory process on ballast water, including NoBoB, and ensure compliance.

2. Risk management (Risk assessment, early detection and rapid response)

Efforts to detect and respond to invasions constitute the front line work for managing AIS and are a top priority for governments.

Prevention is the primary focus of the AIS plan as it is the most cost-effective way to deal with any potential threats. Effective risk management includes identifying high risk pathways or species and developing a comprehensive rapid response strategy that includes clear accountabilities, monitoring capacity, and taxonomic expertise.

Where species have already been introduced, the priority shifts to early detection and risk assessment, including measures aimed at control, eradication, and restoration. The methods used can be physical, chemical, or biological.

Actions in this area include:

- Establish priorities for detailed risk assessment based on the relative magnitude of risks identified. Where appropriate, consider including environmental, economic, and social-cultural factors.
- Identify FPT responsibilities, monitoring capacity, and taxonomic expertise for all pathways.

3. Engaging Canadians (Stewardship, education and awareness)

Since much of the spread of invasive species occurs through unintentional actions, education and awareness campaigns can increase levels of compliance with regulations designed to prevent the spread of AIS. A stewardship perspective emphasizes the fact that managing AIS is a shared responsibility between governments and stakeholders and that action is only effective with widespread commitment. Stewardship should be locally-driven through existing organizations with programs that provide training and support.

- Involve industries, NGOs, Aboriginal peoples, and other stakeholders in identifying risks and in making management decisions.
- Develop national public education and awareness programs that build on existing initiatives and measure their success.
- Use training and licensing programs to increase awareness.

4. Science (Monitoring, research, and risk analysis)

There is currently a shortage of knowledge about the biology of invasive species, their ultimate environmental, social, and economic effects, as well as the most effective tools

and procedures to deal with them. Research into the biological, technological and socio-economic aspects of this problem needs to move toward making management of AIS a predictive rather than reactive effort. An integral part of this process involves using existing risk assessment tools and models and developing new ones as needed.

Science-based research supports resource decision-making, including the development of policy, legislation, and programs and develops best practices in controlling the spread of invasive species.

DFO has appointed an Invasions Biology Research Chair at the University of Windsor to further research into vectors and impacts of aquatic invasive species.

Discussions are underway to coordinate research efforts, both within Canada and between Canada and the US/internationally, and seek funding from the Natural Sciences and Engineering Research Council of Canada (NSERC) for a Canadian AIS research network focused on four key theme areas.

Other actions may include:

- Continue research into better procedures and technologies to minimize the risk of invasion of new species and control spread.
- Conduct research on the overall effects of AIS on ecosystems, the processes that positively or negatively influence their ability to become established, and the effectiveness of control or eradication measures based on the risk management approach.
- Collaborate with other federal-provincial-territorial agencies to ensure data collected under the Canadian Biodiversity Strategy and the National Invasives Alien Species Strategy are integrated and ensure the information is easily accessible to all jurisdictions and the public.
- Evaluate existing mandates, competencies, and capacity to develop centres of expertise.
- Develop mechanisms to estimate the social, environmental, and economic costs associated with damage done by invasive species and build a business case for incorporating those costs into budgeting processes.

Setting priorities

Although there are some obvious urgent priorities that call for immediate action, existing prevention and control programs must be maintained. Setting future priorities begins with gathering information to more clearly understand the scope of the problem. Equally urgent is producing an inventory of both current and potential invasive species threats. Some work has already been done in this area, including national reviews of existing legislation.

The focus is first on prevention, followed by early detection, rapid response, and finally eradication, control, and management. Specific priorities will include activities that:

- serve compelling short- and long-term public objectives;

- have a high probability of success;
- reflect the intrinsic economic value of biodiversity and reduce the economic effects of invasions;
- assess the ecological effects of invasion, particularly where endangered species are threatened; and
- demonstrate that there is an unacceptable risk of invasion.

Other considerations in setting priorities include:

- the availability of consistent funding;
- favourable cost-benefit analyses of actions; and
- the potential to develop partnerships and involve stakeholders in priority setting.

Roles, responsibilities and resources

As AIS are a horizontal issue, commitment from numerous departments and agencies across all levels of government as well as other stakeholders is required. The participation of all Canadians is necessary to deal with the threats to Canada's biodiversity and economy from invasive species.

Governments have committed to providing the necessary leadership in the search for solutions to the invasive species threat and the coordination of related activities.

Variations in mandates and capacity mean that jurisdictions play different roles at different times. While certain responsibilities are clearly within federal, provincial, territorial, or even municipal jurisdiction, others are less clearly defined. Further, as the job of managing waterways is shared between the federal government and the provinces/territories, coordination between jurisdictions is essential. Actions to implement this plan must, therefore, be flexible and allow for regional variations to priorities.

This plan cannot succeed without the full participation of industry, NGOs, Aboriginal peoples and the general public. All stakeholders can contribute valuable resources that will help control AIS.

While much is being done within existing structures and programs, full implementation of the Canadian plan will require new human and financial resources. Resources devoted to AIS prevention or control measures not only reduce the need for future expenditures but can generate economic benefits.

Given the scope of the AIS problem, effective use of limited resources is imperative to achieve maximum benefits. Much can be done through developing partnerships that leverage the full value of each dollar spent and maximize opportunities to pool expertise and resources. Whether proceeds from existing fee structures can be used to help combat invasive species should also be explored.

Next Steps

Aquatic invasive species and their potential damage to Canadian aquatic ecosystems pose a multi-faceted problem with no easy solutions. The scope of the problem, combined with

the fact that it will continue to grow if left unchecked, leaves no doubt that immediate steps must be taken.

There are no quick fixes for the environmental, economic and social damage done by AIS. Even if prevention efforts ultimately succeed in achieving the ideal of no new species being introduced, control efforts must continue.

The development of this plan has involved significant consultation with stakeholders. The consultation process was integral to ensuring that all factors have been considered in setting priorities for further action.

To ensure the necessary leadership and coordination is in place to support the long-term objectives of the plan, governments are working together to develop a governance model for issue assessment, decision-making and priority setting, implementation planning and resourcing, and biological-social-economic risk assessment. This involves improving coordination, refining legislation, working closely with trading partners, focusing on risk assessment, supporting research, monitoring ecosystems, and informing the public.

Increasing public awareness and raising the profile of AIS issues have also been identified as key building blocks to the success of the Canadian plan.

Finally, governments will continue their current efforts to develop and implement regulations for ballast water by completing the current negotiation process and continuing discussions with the United States and other jurisdictions to develop responses to the IMO Convention.

Participants in the Canadian AIS Plan

Federal departments
Provincial/territorial departments
Municipal governments
Aboriginal peoples
International Joint Commission
Great Lakes Fishery Commission
Shipping industry
Harbour and Port authorities
Recreational boaters
Recreational boating associations
Fish and game associations
Recreational boating industry
Commercial fishermen
Environmental NGOs
Live food fish retailers
Aquaculture industry
Live bait industry
Recreational anglers
Scientists and academics
Aquarium/water garden industry
Aquarium/water garden owners
Industries located on waterways or dependent on waterways

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United States General Accounting Office, *Invasive Species: Clearer Focus and Greater Commitment Needed to Effectively Manage the Problem*, 2002

United States General Accounting Office, *Perspectives on Invasive Species*, 2003.

United States National Invasive Species Council, *Meeting the Invasive Species Challenge: National Invasive Species Management Plan*, 2001.

AIS related Web sites

Commission for Environmental Cooperation: www.cec.org.

Great Lakes Fishery Commission: www.glfcc.org.

World Conservation Union: www.iucn.org.

Glossary

Accidental introduction (unintentional introduction) - Introduction of an aquatic organism, including "fellow travelers," by chance, not by design. For example, the release of an organism transported in ship's ballast water.

Alien species (alien, exotic, foreign or non-indigenous species) - A species occurring in an area outside of its historically known natural range as a result of intentional or accidental dispersal by human activities OR Any species in an ecosystem that enters that ecosystem from outside the historic range of the species.

Aquaculture - The controlled cultivation and harvest of aquatic animals and plants.

Aquarium fish - All species of fish and aquatic plants for ornamental use imported or transferred into strict confinement.

Aquatic invasive species - Fish, animal, and plant species that have been introduced into a new aquatic ecosystem and are having harmful consequences for the natural resources in the native aquatic ecosystem and/or the human use of the resource.

Aquatic organisms - This includes all organisms (finfish, molluscs, crustaceans, echinoderms, and other invertebrates and their life stages) defined as "***Fish***" in the *Fisheries Act*, as well as marine and fresh water plants.

Baitfish - Live fish (or other aquatic organisms) placed on a hook or in a trap in order to allure fish.

Ballast Water - Any water (with its suspended matter) used to maintain the trim and stability of a vessel.

Eradicate - To completely eliminate a population from a geographic area.

Establishment - The process of a new species in a new habitat successfully reproducing at a level sufficient to ensure continued survival without infusion of new genetic material from outside the system.

Fellow traveler - Organism which inadvertently accompanies the shipment of the species intended for introduction/transfer.

Fish - The *Fisheries Act* definition of "fish" includes:

- (a) parts of fish;
- (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and
- (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.

This document refers to all aquatic species that enter through any pathway (including reptiles and amphibians) and spend most of their life cycle in water.

Indigenous (native) species - Existing and having originated naturally in a particular region or environment

Introduction - The transfer of an organism to an ecosystem outside the historic range of the species of which the organism is a member.

Intentional introduction - The deliberate release, or holding, of live aquatic organisms in open-water or within a facility with flow-through circulation or effluent access to the open-water environment outside its present range.

Introduced species (exotic species, non-indigenous) - Any species intentionally or accidentally transported and released by humans into an environment or facility with effluent access to open-water or flow-through system outside its present range.

Invasive Species (nuisance or pest species) - A non-indigenous species the introduction of which into an ecosystem may cause harm to the economy, environment, human health, recreation, or public welfare.

Live fish for the food trade - Fish destined strictly for consumption. Imported live fish are held in containment facilities or containment units such as those in restaurants or fish stores.

Marine plant – The *Fisheries Act* states that "marine plant" includes all benthic and detached algae, marine flowering plants, brown algae, red algae, green algae and phytoplankton

Native - Existing within a historical ecological range, usually within a balanced system of co-evolved organisms.

Naturalized species - Alien species that reproduce consistently and sustain populations over more than one life cycle without direct human intervention (or in spite of human intervention).

Pathogen - Any agent that causes disease in plants or animals; typically referring to microbes such as bacteria, viruses, or protozoan parasites.

Pathway - One or more routes by which an invasive species is transferred from one ecosystem to another.

Parasite - An organism that grows, feeds, and is sheltered on or in a different organism while contributing nothing to the survival of its host.

Precautionary approach - Measures to implement the Precautionary Principle. A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the consequences of being wrong.

Range extension - The enlargement of a geographic area that is occupied by a species, usually through intentional human action; the extension is usually incremental, over short distances and contiguous.

Risk - The probability of a negative or undesirable event occurring; the likelihood of the occurrence and the magnitude of the consequences of an adverse event; a measure of the probability of harm and the severity of the hazard.

Risk analysis - The process that includes risk identification, risk assessment, risk management and risk communication.

Risk assessment - The process of identifying and describing the risks of introductions or transfers of aquatic organisms having an effect on fisheries resources, habitat or aquaculture in the receiving waters before such introductions or transfers take place; the process of identifying a hazard and estimating the risk presented by the hazard, in either qualitative or quantitative terms.

Species - A group of interbreeding natural populations that are reproductively isolated from other such groups

Stock - A population of organisms which, sharing a common gene pool, is sufficiently discrete to warrant consideration as a self-perpetuating system which can be managed

Transfer - The movement of individuals of a species or population of an aquatic organism from one location to another within their present range

Vector - The physical means by which a species is transported from one area to another, usually referring to transport by humans.

Endnotes

- i International Joint Commission, Alien Invasive Species and Biological Pollution of the Great Lakes System, 2001.
- ii Environment Canada, Toward a National Plan on Invasive Alien Species: A Discussion Document, 2003. Of the 16 species for which information is available, the economic value noted reflects the economic costs associated with 9 species. The effects of the other 7 species are considered negligible.
- iii United States National Invasive Species Council, Meeting the Invasive Species Challenge, 2001
- iv Environment Canada, Toward a National Plan on Invasive Alien Species: A Discussion Document, 2003.
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- vi Standing Committee on Fisheries and Oceans, Aquatic Invasive Species: Uninvited Guests, 2003.
- vii International Joint Commission, Alien Invasive Species and Biological Pollution of the Great Lakes System, 2001.
- viii International Joint Commission, Alien Invasive Species and Biological Pollution of the Great Lakes System, 2001.
- ix Kristine Maki and Susan Galatowitsch, Movement of invasive aquatic plants into Minnesota (USA) through horticultural trade, Biological Conservation, in press, 2003.