Preventing the Introduction and Spread of Aquatic Invasive Species in North America:

Workshop Proceedings, 28–30 March 2001

During the negotiations of NAFTA, the need for cooperation among the trading partners in the protection of their shared North American environment became clear, as did the need for the development of new tools to help them do it. They agreed on an environmental side accord to NAFTA, the North American Agreement on Environmental Cooperation (NAAEC), and established the Commission for Environmental Cooperation (CEC) of North America to steward its implementation.

The role of the CEC is to foster cooperation among the three NAFTA partners—Canada, Mexico and the United States—in responding to the challenges and seizing the opportunities that the continent-wide open markets present to the challenge of protecting the North American environment.

This project is part of the government's response to the challenge of protecting marine and aquatic ecosystems from the effects of aquatic invasive species. The initiative will assist the North American countries to develop a coordinated, multinational prevention and control approach aimed at addressing invasions from trade related pathways in North American waters.

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Foreword

Invasive alien species are unwitting travelers that have been moved, intentionally or by accident, from one region of the globe to another. Free from their natural competitors, diseases and predators, they sometimes thrive in their new homes, transforming entire ecosystems, and have the potential to push native species to the brink of extinction. This is not a new phenomenon; alien species have been introduced into new environments since trade began. Trade, globalization and increased travel between continents brings and ever increasing number of new invasives which is becoming a serious global environmental challenge.

Marine and aquatic ecosystems around the world are being transformed and degraded by these non-indigenous species. These alien species affect the structure and function of the ecosystem, causing major ecological and economic implications, undermining local and regional economies, and posing new threats to human health.

One of the main pathways for invasion into North America is ship ballast-water picked up in foreign ports. When this water is discharged, living inoculums are introduced into local coastal waters, often with devastating effects (this risk may increase as new ports are being planned along North American coasts). Other pathways of introduction include the careless dumping and transportation of live bait, the release of unwanted aquarium animals and plants, and the accidental escape of captive aquaculture breeding stocks.

In spite of the potential international consequences of transboundary invasions, the majority of management efforts to prevent and control the spread of alien species have tended to focus nationally and rarely reach across the very political boundaries so easily traversed by the invaders themselves. Current domestic laws and official programs are insufficient to guard against this global phenomenon; no unilateral approaches can cope with the magnitude of this problem. In order to be cost-efficient and effective, activities to prevent and mitigate the impact of invasive alien species have to be based on cooperation, complementary approaches and regulations, and multi-stakeholder participation.

In the six years since the North American Free Trade Agreement (NAFTA) was implemented, total trade in North America has increased significantly. On average, trade has grown as much as five-fold between the NAFTA partners. However, among the largest increases have involved bulk transport of agricultural goods. Trade between North America and non-NAFTA partners has also expanded fueled by the World Trade Organization Uruguay Round accords. How much of that trade in goods has contributed to species moving from one ecosystem to another is unknown. However, there is no question that growing trade and travel, coupled with a more liberalized customs approach among the NAFTA countries, has meant that alien species are in motion at an unprecedented rate, thus raising the odds of aquatic alien species becoming invasive in any of North America's ecosystems.

Fortunately, Canada, Mexico and the United States all consider invasive species a substantial threat to their environment and to their economies. However, their perception of its magnitude, and consequently their domestic efforts to address this problem, are somewhat different. Given its mandate, the Commission for Environmental Cooperation (CEC) of North America is well positioned to facilitate the development and implementation of a regional approach to address the invasive species problem. The Montreal workshop organized by CEC presented the aquatic invasive species challenge as it relates to North American free markets. The purpose of the workshop was to establish a common perspective on issues concerning aquatic invasive species and consequently identify priorities for trinational and multi-sectoral collaboration.

Trade related pathways, with emphasis on ballast water, live bait, aquaculture and intentional introductions were the main themes of the workshop. Scientists, government, industry and Non-Governmental Organization representatives from the three countries identified priorities for cooperation within the following crosscutting themes: voluntary approaches and economic incentives, outreach and education, bio-informatics and modeling, and legal and enforcement approaches. Based on the results of their deliberations, the CEC recommends the following five priority areas to steward cooperation:

1. Identify invasive species and invasive pathways of common continental concern
2. Develop a North American Invasive Species Information Network
3. Develop and distribute tools for raising awareness and empowering decision-makers
4. Identify tools to provide economic incentives to engage the industrial and economic sectors
5. Create a regional directory of legal institutions and frameworks for the three North American countries.

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Acknowledgements

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I. Summary of Workshop Presentations

State of the Aquatic Invasive Species Situation in North America

Priority Species and Spaces in North America

European Green Crab, Carcinus Maenas, Introductions Into North America: The Differences Between the Atlantic and Pacific Experience

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Exotic species are of interest because not being native, their dispersal and range expansions can be more easily documented and possibly correlated with oceanographic features. These correlations provide information that may be generally applicable to factors affecting the meroplanktonic dispersal of a variety of native species, information that would otherwise be difficult or impossible to obtain. The presence or absence of various native species' larvae can be documented, but where they come from or ultimately go to is impossible to discern if the larvae of these species of interest are already geographically widely distributed, which is typically the case.

This is relevant to human activities today because the dispersal characteristics of many marine species are through passive larval drift. In a metapopulation, isolated adult populations are only connected this way. Some populations, termed sources, are particularly effective in dispersing larvae to other populations, often because of their locations, while other populations, termed sinks, are not effective at all. From a conservation perspective, it is particularly important to identify source populations and protect them, yet this can be difficult to do. Having an exotic "model" to show us the dispersal characteristics of species with specific larval behaviors offers a unique opportunity to help identify potential relevant source and sink areas.

Models that predict the dispersion of particles from a point source are presently investigating alternate sites for the approved dumping of ballast water. Having a known dispersion pattern from an exotic "model" species may help validate predictions. Ideally, potential ballast discharge locations should be "sink" dispersal sites.

The subjects of discussion are:

1. the rates and characteristics of green crab range dispersal in both Atlantic and Pacific North America in the context of regional oceanographic characteristics; and
2. the impacts green crab may have in Pacific Canadian waters.

Significant events in the dispersal of green crab in the West Atlantic are that it was introduced into the west Atlantic in the early 1800s, that its southern limit of Virginia is probably temperature determined, that it reached St. Andrews, NB, in 1951 and was abundant there by 1954, that it reached southern Nova Scotia in the mid–1950s and Halifax by the 1970s, that it reached the northern tip of Cape Breton Island (St. Lawrence Bay) and eastern PEI in 1998, and that by 1999, catches of these crab in PEI by eel net fishers had increased considerably. In summary, it took 47 years to extend its range over outer Nova Scotia (600 km), but in the southern Gulf of St. Lawrence, substantial range expansion has been relatively rapid—only 2–3 years to go about 200 km.

The oceanographic features of the west Atlantic are cold water temperatures for about 9 months of the year, seemingly optimal summer water temperatures for green crab on the Scotian Shelf, periodic large-scale strong storm events (e.g., hurricanes) during the summer/fall, and no significant oceanographic differences between El Niño and non-El Niño years. My hypothesis is that a relatively short summer and cool water on the Scotian Shelf permit only one crab spawning there per year, warm surface waters in the Gulf may mean 1+ spawning there per year, and that dispersal to

date has likely been natural, as there is little ship movement between the areas involved and the scale of invasion suggests that it was not caused by accidental or intentional human transport. However, because the vertical and horizontal distributions of their planktonic larvae have not been described, the influences of currents cannot be evaluated.

The significant events of the green crab dispersal in the East Pacific are that it was first observed in San Francisco Bay in 1989; that from 1993–96 its range extended northwards about 220 km; that it was found an additional 300 km in Oregon in 1997, a further 425 km north in Washington in 1998, a further 225 km north in both Barkley Sound and Esquimalt, British Columbia, in 1999, and a further 100 km north in Clayoquot and Nootka Sounds in 2000.

Relevant Pacific oceanographic features are seemingly optimal summer water temperatures for green crab; currents generally flow northward from January to April, then southward from April to October, off the USA; strong differences in currents between El Niño and non-El Niño years. During an El Niño (the 1997–98 one was one of the strongest), there is often more northward transport, less up-welling and offshore movement in coastal areas, and water temperatures up to 5 C. warmer off BC. My hypothesis is that water temperatures are such that 2+ spawnings may occur each year, leaving a longer time period of settlement than occurs with native crab species which spawn only once, and that while the scale of movements to Oregon and Washington suggests natural dispersal, movement to British Columbia, believed to be in 1998, may have been via humans, as crab in 1999 were only been found in areas know to be frequented by vessels.

The potential impact of green crab in British Columbia is unknown, but relative predator-prey sizes and the timing of settlements of other species may minimize the impact of green crab in many habitats. It may be that the tiny shore crab, *Hemigrapsus* spp., will at times constrain green crab abundance, as it does with Dungeness crab (*Cancer magister*). Other cancrid species are also abundant in the intertidal; so impact predictions are impossible at this time. However, the reality is that green crab are now in BC, so while we may learn from this experience, we do not have control of this introduction. Potentially impacted species of particular concern are intertidal bivalve and crab species, and shorebirds, particularly during their migrations.

A green crab monitoring program is now underway, with posters distributed and fishers, shellfish farmers, and the general public being encouraged to keep a lookout for green crab and to report all observations. Intertidal and shallow subtidal ecosystem surveys are also being conducted in selected areas.

Non-indigenous Aquatic Species in the United States

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In an increasingly more mobile society, the world's fauna and flora are being mobilized to all corners of the globe. The United States has far more introduced fishes than any other country in the world (Welcomme 1988). Mexico ranks third and Canada ranks somewhat lower, but still in the upper end of numbers of species introduced. The number of introduced fish species in the United States has been growing over the past 150 years. However, there has been an especially large increase in the past 50 years, of not only native species but foreign species as well. The trend in the Southeast mimics that of the country as a whole. The numbers in the Southeast were fairly stable until the 1950s when a dramatic increase took place.

Origins

The origins of different taxonomic groups vary. For example, most of the introduced fishes in the United States are native species transplanted outside of their native range. By contrast, most of the reptiles hail from South America and Asia. These patterns also vary by geography. The states of Florida and Hawaii have high proportions of introduced fishes of foreign origin; Colorado, Arizona and Oregon have high proportions of introduced fishes native to other areas of the country but not to those states; and Virginia and North Carolina have high proportions of species transplanted within the state outside of their native ranges.

Pathways

Just as origins differ by taxonomic group and geography, so do the pathways responsible for introductions. Some states are heavily influenced by stocking of non-native species; others are more influenced by aquaculture escapes, bait releases, or aquarium releases.

Introductions related to food species appear to be a growing segment of introductions. These include species raised in aquaculture facilities that escape, and animals that are released by immigrants seeking to establish new populations in this country.

Spatial Patterns

Coastal Areas - The dominant pathway in coastal areas is shipping, including ballast water release and hull fouling. The East Coast has received Japanese shore crab (*Hemigrapsus sanguineus*), green crab (*Carcinus maenas*), and veined rapa whelk (*Rapana veinosa*). The Gulf Coast has acquired the green (*Perna viridis*) and brown mussel (*Perna perna*). The West Coast has a few species noticeable to the general public, in addition to hundreds of inconspicuous species such as tunicates, polychaete worms, and small crustaceans. Some of the more notable species include green crab (*Carcinus maenas*), mitten crab (*Eriochir sinensis*) and four species of Asian gobies: the Yellowfin goby (*Acanthogobius flavimanus*), Chameleon goby (*Tridentiger trigonocephalus*), Shimofuri goby (*Tridentiger bifasciatus*) and Shokihaze goby (*Tridentiger barbatus*).

Western US - The western movement of fishes began in earnest in early 1870s. Railroad cars were fitted with special cars to transport fish across the country. The earliest cross-country transplantations took place in 1874 when several fish species were translocated from the Hudson River in New York to the Sacramento River in California. Virtually all of these species are still found in California today and include: American shad (*Alosa sapidissima*), yellow perch *(Perca flavescens*), sunfish (*Lepomis* spp.), bass (*Micropterus* spp.), American eels (*Anguilla rostrata*) and bullheads (*Ameiurus* spp.). The Salton Sea, an inland sea in southern California was heavily stocked

with dozens of marine species from the Pacific coast of Mexico. Most of these introductions did not result in establishment; however, two successful introductions include the sargo (*Anisotremus davidsonii*) and orangemouth corvina (*Cynoscion xanthulus*).

Northeastern US - Many of the species introduced into the Northeast are species native to the region in general but only to areas west of the Applachian Divide. Several of these have been stocked east of Divide including rock bass, black crappie, and smallmouth bass. West Coast salmonids such as coho salmon, and rainbow trout have also been stocked in the region. The European brown trout, which was brought to this country in the mid-1800s, is also present here, as it is in most areas of the country.

Great Lakes - The Great Lakes has acquired a variety of exotic species through intentional stocking, canal connections with other drainage basins and via ballast water. The most notable introduction is that of the zebra mussel which was first reported circa 1988 and was introduced from Russia via ballast water. Later ballast introductions, also from the Ponto-Caspian Region of Russia, included the round and tubenose gobies (*Neogobius melanostomus* and *Proterorhinus marmoratus*), ruffe (*Gymnocephalus ceruus*), spiny water flea (*Bythotrephes cedarostroemi*) and the fish hook water flea (*Cercopagis pengoi*). Several West Coast salmonids, including the chinook salmon (*Oncorhynchus tshawytscha*), have been stocked in the Great Lakes for sportfishing opportunities. Lastly, several species including the white perch (*Morone americana*) and the sea lamprey (*Petromyzon marinus*) have gained access to the Great Lakes through man-made canals that connect the lakes to other drainages.

Interior - The majority of fish introductions into the interior of the United States have been either reservoir or large-river species. Striped bass is a species commonly stocked in interior reservoirs. Large-river species include fish that have either been deliberately stocked in the rivers or have escaped a stocked waterbody and taken up residence in the rivers. Examples of riverine species include cisco, rainbow smelt and four Asian carps (common, grass, silver and bighead).

Southeastern US - The Southeastern US has had more species introduced than anywhere else in the country. The area within the Southeast with the most introductions is South Florida. Fish have been introduced in this region in a variety of ways but the dominant pathway is escape from aquaculture and/or aquarium release. Because southern Florida is where all tropical aquarium fishes are raised, it is often not possible to determine if the presence of one of these species in Florida is attributable to escape or release. The climate in Florida allows many of these species to survive that would not be able to survive in most other areas of the country. Although most of the introduced aquarium species are freshwater and tropical in nature, marine species (i.e., *Indo-pacific batfish Platax tiera*) and temperate species (i.e., *Oriental weatherfish Misgurnus anguillicaudatus*) are also found here. The flathead catfish (*Pylodictis olivaris*) is a native transplant to Atlantic Slope drainages that is believed to be reducing native sunfish and bullhead (*Ameiurus* spp.) populations. The Asian swamp eel (*Monopterus alba*) may have been introduced via the aquarium trade or as a food fish, or both. It is currently established in one location in Georgia, and three locations in Florida.

Welcomme, R.L. 1988. International introductions of inland aquatic species. Food and Agriculture (FAO) Fisheries Technical Paper 294. Rome. 318 pp.

Engaging Industry: Examples from Aquaculture, Live Bait and Shipping

Engaging the Aquaculture Industry

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Control of invasive species is a serious issue for aquaculture industries worldwide, and imparts a significant cost to many production sectors (freshwater and marine). In order to enhance sustainable aquaculture and ensure equitable competitive production, the costs associated with invasive organisms have to be given more attention than is currently evident. Conversely, public perception of aquaculture as a contributor to introduction of exotic organisms also needs to be addressed. This is especially important, since aquaculture depends on local and rural-based communities where both employees and their neighbors are directly affected by ecological impacts from exotic invasive organisms. On a larger socio-economic scale, urban-based populations with biased perceptions of aquaculture as a source of environmental impact can have negative consequences on both political and market support. Political pressure can result in policy and regulatory decisions that render aquaculture economically unfeasible.

Introduction of invasive species with aquaculture practices has the potential to be both economically and ecologically lethal to sustainable production. Likewise, introducing disease via ballast water (e.g., the parasite *Kudoa* to Chile) or government stock enhancement (e.g., *Furunculosis* to the United Kingdom), especially that requiring chemotherapeutant control, can be disastrous. Most drugs are supplied to fish through feed. Untreated feed in the salmon farming industry constitutes as much as 40–60% of the cost of producing salmon. The use of treated feed can increase feed cost from 40–500%; no industry can survive that kind of cost increase very long. Even small increases in the cost of production, such as the million dollar plus loses associated with the escape of a cage of salmon from a fish farm, cannot be survived if they occur with any regularity.

While industry is very concerned about the unregulated introduction of aquatic species it also wants governments to acknowledge that, because of the benefits derived from them, introduction of some alien species is acceptable. For example, introduced terrestrial animal species constitute the bulk of North America's meat production and consumption. In most instances the introduction of those species have occurred without unacceptable impacts on the environment. There is even evidence that a similar situation exists where Atlantic salmon (a major aquaculture species) has been introduced outside of its natural range. This species has been introduced innumerable times to India, Asia, North America, South America, Australia, New Zealand and Africa. In British Columbia alone there have been 92 separate introduction of this species in 52 different water-bodies. In spite of this there is no place where science has been able to document a self-sustaining anadromous population outside the native territory of the species.

Expressions of industry's concern and willingness to find ways to effectively protect the environment are demonstrated in a number of national and international initiatives. Over the last couple of years the International Salmon Farmers Association has worked hard with the North Atlantic Conservation Organization to derive a mutually agreed upon Code of Containment for pen reared salmon that will reduce the number of farm-raised Atlantic salmon that might escape from farms to compete with wild salmon. The Canadian Aquaculture Industry Alliance has also been a pivotal contributor to the development of a National Code on Introduction and Transfers of Aquatic Organisms. That Code provides Canada with a risk assessment approach to the approval of permits for the transfer and introduction of aquatic organisms that is consistent across Canada. Fisheries and Aquaculture Ministers from all provinces and territories signed the Code September 20, 2001. The International Council for the Exploration of the Sea's (ICES), Working Group on Introductions and

Transfers is presently considering if the risk assessment component of the New Canadian Code can incorporated into the ICES Code on Introductions and Transfers. The ICES Code sets out a preferable manner in which to evaluate introductions and transfers for the 19 signatory countries of the ICES convention.

To continue to engage aquaculture's commitment to controlling invasive species, governments must recognize the need of the aquaculture industries to be treated as valid users of aquatic resources along with other aquatic resource users. Further, for licensing purposes, each type of culture will have to be judged on its own merits. Aquaculture is a very diverse set of enterprises and has the potential to raise a wide variety of species. Consequently, not all aquaculture activities have the same levels of risk for introducing an invasive species.

To further engage industry in managing invasive species, regulators have to be prepared to apply science and document its use in regulatory decisions. Salmon farmers have not asked to have any special exemption status in the licensing of introduction or transfer of aquatic organisms. What they have requested, is that they not be singled out for special regulatory attention simply because they are the latest and most topical resource user or, because, in the absence of evidence, there is an assumption that they are a major contributor to the over all risks associated with introduced species. Science-based analysis has yet to show that modern commercial salmon culture practices are an important route of species introduction in areas where salmon farming has been undertaken. There are other pathways that may be as important, or more important, which have yet to be properly evaluated and regulated. Examining risks associated with those pathways and regulating industries equitably in accordance to their relative risk is the best way to ensure that industry continues to engage in the process of managing aquatic invasive species.

Examples from Aquaculture in Mexico

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Aquaculture in Mexico is characterized by the culture of exotic species. Presently, from nine commercially cultured species only two are native to Mexico. Many species were stocked intentionally by federal programs and some of them, used by national programs, are and were supported in whole or part by international programs, especially the Food and Agriculture Organization (FAO).

The introduction of other species, particularly sport fishes, was supported by US federal agencies. Some introductions date from more than one hundred years ago (e.g., carp and trout) and other species were introduced recently (*Procambarus clarkii*, *Cherax quadricarinatus*, etc.). Most of these were introduced as food for local consumption, for control of aquatic vegetation, as pets in garden ponds, for repopulation of natural freshwater bodies, for diversification of rural activities related to agriculture and animal husbandry, or for export to the US market. However, due to their characteristics (omnivorous, high reproductive potential, rapid growth, resistance to diseases, and environmental adaptability), these species have had various effects on the natural populations, including the displacement of native species as a consequence of competition for food, predation, removal of vegetation with the consequent elimination of food sources, shelter and spawning substrates, hybridization, transmittal of viruses and parasites, and changes in their natural environment. Furthermore, most of these exotic species can now be found in more than half of the country.

The present threats are: the transplantation of exotic and native species to different regions of the country, the importation of virus-resistant strains that may carry other diseases, the culturing of marine species in brackish water or freshwater (e.g., shrimp), the culturing of freshwater species in brackish or marine water (e.g., tilapia), and the natural dispersion of species from other countries.

The introduction of exotic species into Mexico was a consequence of the lack of knowledge of native species, the price of exotic species in the international market and the availability of technology for their culture. Unfortunately, in Mexico a major drawback for the culturing of these species has been the lack of a scientific background to implement foreign technology. At present, the aquaculture production of most of the exotic species is relatively low and from an economical standpoint the native species of shrimp are still the more interesting species. Among the measures that must be adopted to prevent or minimize special impacts, the following should be considered: diking ponds, sand and gravel filtration of all effluents, keeping the cultures out of flood prone areas, sterilization, culturing monosexual populations, avoiding transplantation and enhancing the local production of resistant strains.

The culturing and domesticating of native species must be considered a priority because it represents a short term alternative not only to preventing their extinction but also for repopulating their natural local environments thus supporting traditional fisheries and avoiding technological dependence. Moreover, the culturing of native species is important also from the economical point of view because some of these can reach higher market prices than most exotic species and have a well-established national market. Nevertheless, some exotic species should continue to be exploited for socio-economical reasons.

Finally, considering that aquaculture is a billion dollar industry, business should contribute to cover at least a fraction of the cost of introducing each new species, including the cost of research to determine whether a particular species has the potential to be invasive.

A Commercial Marine Industry Perspective on Ballast Water Management for the Prevention of the Introduction and Spread of Non-indigenous Species into North American Waters

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The Shipping Federation of Canada is a not for profit association of Canadian companies whose primary business is ship owning, maritime agency, and chartering. The Shipping Federation of Canada Act of 1903 formed the Shipping Federation.

The Ships represented by Federation members are the ocean-going ships that call at Canada's East Coast and Great Lakes ports. Federation members are active in Canadian ports from St. John's to Thunder Bay.

In 1988, the Shipping Federation was advised for the first time that there was a means of preventing the introduction and spread of non-indigenous species to the Great Lakes. Alarmed by the allegations that ocean ships had introduced the zebra mussel to the Great Lakes, the first reaction was one of defiance and then defense. We had to be introduced to the Zebra Mussel and educated as to its devastating characteristics.

This presentation will take you briefly through the history how the shipping industry in Canada got to where it is today on the issue of preventing the introduction and spread of non-indigenous species. Along the way we will address the regulatory and political influences and review the Code of Best Practices that the industry practices today.

Following the discovery of the zebra mussel we were called upon to take preventive measures. No one in my industry had ever before considered that ballast water was harboring dangerous creatures. The biggest danger we saw was a discoloration if the water had been in the tank a long time and became rusty. No one in my education as a shipmaster ever taught us that ballast water was for anything other ballasting the ship. The focus was on the negative impact on the ship's stability of free surface effects if the tanks were not full and "pressed-up".

Working with the Fisheries Commission, Environment Canada, Transport Canada and Canadian Fisheries and Oceans, we arrived at a set of guidelines for the exchange of ballast water at sea. This was exercising the precautionary approach before the term was coined.

Marine biologists told us that deep ocean water contained fewer organisms than coastal water and, of course, it made good sense that saltwater organisms were unlikely to survive in fresh water habitat. Seafarers could understand this. The guidelines adopted in 1989 stated that ocean ships inbound for the Great Lakes in ballast should exchange ballast water in deep ocean water before entering the St. Lawrence Seaway. The ballast water to be discharged into the Great Lakes waters should be clean salt water.

These guidelines were voluntary and a reporting form was provided to shipmasters to present to the St. Lawrence Seaway lockmaster at St. Lambert upon entry to the Seaway. Scientists took advantage and were able to board the ships and conduct sampling for the purposes of establishing some degree of compliance and effectiveness.

By 1990, the US Congress had passed their first Non-indigenous Invasive Species Act. The International Maritime Organization (IMO) had adopted a resolution calling upon ships to exchange ballast water. Both the United States and IMO reproduced the voluntary guidelines produced in Canada. At the time there was no legislative authority in Canada to enforce ballast water exchange.

In 1993, the United States adopted regulations specific to ships trading on the Great Lakes and those regulations continue to be used and upgraded today, even though the law has been upgraded to include all US ports. The IMO working group continues its struggle toward a stand-alone convention on Ballast Water Management and Canada has expanded application of the voluntary

guidelines throughout the country. This has been a struggle to demonstrate the need for significant education in ports where ballast water management has never been an issue.

All is not uniform across the country and we are now faced with legislative challenges on many fronts. The states of California and Washington have their own laws. Michigan has a law that, if it had passed in its original version, would have closed the Great Lakes to shipping, as we know it today. This Bill, known to many as the Sikkema Bill, is now part of Michigan State law and incorporates a new initiative from the shipping industry in Canada, which we call our Code of Best Practices for the Management of Ballast Water.

The Code of Best Practices is a ten point code that expresses the current understanding of safe and effective ballast water management based on ballast water exchange as the primary preventive measure. The Code includes reference to cooperation in research and development that might someday lead to the invention of preventative techniques and technology that will surpass the ballast water exchange method. Filters, ultraviolet light, chlorination, biocides, hydro-cyclones and heat are but a few of the potential ballast water treatment technologies under study. Ships are fitting management technology for trials.

In Canada and elsewhere, preventing the introduction and spread of invasive species is taken seriously. Our experience and indeed the major initiatives in Canada are with respect to the invasive species transported in the ballast water of ships. Although Canada does not have a regulatory regime, the United States is 100 per cent compliant with the Great Lakes Ballast Water Regulations—ships cannot enter the Great Lakes without compliance.

The Shipping Federation's Code of Best Practices is in force and will be enforced in 2002.

No change has yet found a better prevention tool than ballast water exchange.

Potential Risk of Aquatic Invasive Species Introductions Due to International Trade in Live Bait

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The negative effects of aquatic invasive species on native organisms and habitats have been documented, yet little effort has focused on describing and quantifying vectors of introductions. In particular, the potential for intentional importation of aquatic invertebrates to facilitate biological invasions has not been explored despite significant importation of such organisms for use as live bait. The US Fish and Wildlife Service (USFWS) is quantifying the nature and extent of importation for live aquatic organisms destined for live bait trade, including documentation of source countries and destinations within the United States. The project was initiated based on knowledge that polychaetes were being imported from Vietnam and sold in US bait shops in the Chesapeake Bay and San Francisco regions. This species (*Namalycastis abiuma*) has an unknown ability to survive in temperate ecosystems, and could serve as a vector for introduction of other organisms (e.g., bacteria, viruses). This study has four principal goals: 1) describe spatial and temporal patterns in live bait importation, 2) clarify taxonomy of imported bait, 3) assess the threat of imported bait to native aquatic ecosystems, and 4) summarize state regulatory programs for live bait.

Cargo imported into the United States is subject to review by three Federal agencies: the US Customs Service (USCS), US Department of Agriculture (USDA), and USFWS. Each of these agencies has specific responsibilities, and each maintains import/export data of some sort. However, available databases suffer from several limitations that do not this study's objectives to be completely addressed. For example, imports are classified into USCS Harmonized Tariff Codes (HTCs), but these are not taxonomically explicit. Further, import documentation frequently does not contain measures of shipment quantity that are biologically meaningful (e.g., shipment weight) rather the value (US$) is reported for most shipments.

Despite these limitations, available USCS data provides many insights into the extent of international trade in live aquatic organisms. We examined records for four HTCs: Aquatic Invertebrates, NESOI (Not Elsewhere Specified Or Included); Bait, Other Than Worms; Fish, Live, NESOI; and Worms, Live. These HTCs were selected because they were taxonomically broad; NESOI codes generally contain organisms that don't fit into more explicit HTCs. Records for the period 1998–2000 revealed imports arriving from 44 countries, through 53 US ports of entry (Table 1). These HTCs alone accounted for over $78 million (US) in imports, and at least 1.6 million kg of cargo. The latter is a highly conservative estimate; quantity is often not reported, especially for organisms such as fish that are shipped in media (water) for which a separate weight can not be obtained (see Table 1). Among these shipments, only 58, with a value of approximately $500,000, were classified as "Bait, Other Than Worms". It is believed that many bait organisms are entered under other HTCs, although limitations of existing databases do not allow these organisms to be separated.

We also examined the major source countries for each of the four HTCs. Bait, Other Than Worms was imported only from Canada and South Africa during the period 1998–2000. This further illustrates the shortcomings of the existing databases, as we have documented importation of *N. abiuma* for live bait from Vietnam during this period. Among the other 3 HTCs, the top 10 importing countries were distributed throughout the world, including South American, North American, African, Asian, and European countries. Canada was the leading importer for the remaining HTCs, accounting for over 83 per cent of the imported Live Worms. The bulk of the import activity occurred via road transport, reflecting the dominance of Canada as an importer of these HTCs to the United States (Table 3). Dominant ports of entry into the United States were

Detroit ($34.7 million), Buffalo ($14.3 million), Port Huron, MI ($12.9 million), Atlanta ($3.1 million), Calais, ME ($3.0 million), Los Angeles ($1.5 million), and San Francisco ($1.4 million).

We attempted to make utility of Import Value as a measure of quantity shipped, using documentation from three shipments of *N. abiuma* that arrived from Vietnam to San Francisco during Aug–Sept 2000. By examining FWS and USCS records simultaneously, we obtained number of worms, gross weight, and shipment value for each event. Collectively, these data generated an estimated import value of $0.30 per worm. For the period 1998–2000, there were $20,041 of Live Worm imports from Vietnam (Table 2). Assuming all of these were *N. abiuma*, an estimated 66,803 individual worms were imported during that period. Total shipments of Live Worms into the United States during this period were valued at $70,279,336 (Table 1). As the majority of these are night crawlers imported directly from Canada, their import value is likely to be lower on a per worm basis than that of *N. abiuma*. Using an estimate of $0.15 per worm, this figure equates to over 450 million worms imported. Although neither fate nor presence of contaminants or pathogens is known for these organisms, the sheer number of individuals apparently imported suggests that some means for accurately monitoring this activity is needed.

This study is a first step towards more completely characterizing international trade, not only in bait organisms, but in all types of live organisms which have the potential either to be or to harbor harmful invasive species. We suggest the following information needs for international trade in live bait, and further encourage similar research to characterize extent of trade in other organisms:

- What species are traded internationally, and what potentially harmful organisms do they harbor?
- What regions of North America are most vulnerable to introductions of exotic bait?
- What is the role of the Internet in live bait trade?
- What motivates anglers and retailers to seek exotic bait?
- What is the most effective way to engage the bait industry and communicate an invasive species message?

Table 1. Summary data for cargo imported into the United States under four Harmonized Tariff Codes, 1998–2000. Data source: US Customs Service.

	Importing Countries	Ports of Entry	Number of Shipments	Total Value (US)	Quantity Imported (kg)
Aquatic Invertebrates, NESOI	23	28	3,520	$ 4,313,449	1,572,502
Bait, Other Than Worms	2	4	58	$ 498,368	0
Fish, Live, NESOI	32	30	1,376	$ 3,508,368	9,121
Worms, Live	17	31	6,211	$ 70,279,336	94,740
Total	44	53	11,165	$ 78,599,521	1,676,363

Table 2. Major source countries for imports of four Harmonized Tariff Codes into the United States, 1998–2000. The top 10 countries are shown for each Code, except for Bait, Other Than Worms, which was imported from only 2 countries during this period. Data source: US Customs Service.

	Bait, Other Than Worms	Aquatic Invertebrates, NESOI	Worms, Live	Fish, Live, NESOI
Australia		$ 356,278	$ 2,426	$ 209,275
Belgium			$ 827,960	
Canada	$ 493,950	$ 2,438,114	$ 65,076,260	$ 1,468,535
Chile			$ 38,664	
China		$ 133,359		$ 339,757
France			$ 1,817,943	
Italy				$ 23,000
Japan		$ 328,598	$ 10,220	
Malaysia				$ 46,182
Mexico		$ 237,970		$ 558,783
Netherlands			$ 1,413,190	
New Zealand		$ 236,602		
Panama		$ 85,000		
Russia				$ 29,850
South Africa	$ 4,418			
South Korea		$ 377,562		
Taiwan				$ 279,594
Thailand				$ 29,730
Turkey			$ 4,300	
United Kingdom		$ 68,438	$ 1,059,049	
Vietnam		$ 13,182	$ 20,041	$ 454,197

Table 3. Mode of transport for imports of four Harmonized Tariff Codes into the United States, 1998–2000. Data source: US Customs Service.

	Bait, Other Than Worms	Aquatic Invertebrates, NESOI	Worms, Live	Fish, Live, NESOI
Vessel		$ 603,467	$ 1,713,042	
Road	$ 493,950	$ 2,428,201	$ 64,173,392	$ 1,971,097
Air	$ 4,418	$ 1,068,879	$ 4,392,902	$ 1,533,853

Informatics, Modeling and Prediction and Aquatic Invasive Species

Prediction and Risk Assessment of Aquatic Invasion Threats

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Predicting the identity and timing of invasions should be a priority for aquatic resource management. Reliable predictions of where a potentially harmful invader is likely to spread would help us to more effectively allocate limited resources toward early detection and control. Even when invasions are unstoppable, advance information would better prepare us for their impacts. But, because prediction is difficult, many scientists and managers are pessimistic about our ability to produce useful risk assessments. This pessimism has helped to perpetuate a reactionary approach to exotic species.

However, some simple, low-cost probabilistic models might produce valuable risk assessments. To begin, two key concepts must be understood: (1) an invasion corridor is a transportation vector and pathway combination that delivers species to new sites (e.g., shipping traffic from the Baltic Sea to the North American Great Lakes), and (2) propagule pressure is the rate at which organisms are introduced to a site. The stronger the invasion corridor (i.e., the greater the vector traffic), the greater the propagule pressure.

Invasion Filters

To appreciate the value of these concepts, we must consider the obstacles a species must overcome to establish itself in a new region. We can imagine that a potential invader must pass through a series of "filters". Obviously, the first and most important filter is a geographic barrier (e.g., an ocean, a peninsula, a stretch of land between lake basins). Invasion corridors allow species to circumvent this filter; stronger corridors render the filter more permeable and provide more opportunities for dispersal.

The second filter is the physical environment of the target habitat. Species are transported to habitats that may or may not be suitable for them (e.g., European flounder and squid are found in the Great Lakes, but cannot reproduce due to low salinity). We can assume that those species whose native habitat physically matches the recipient habitat will likely pass through this filter.

The third filter is demographic resistance. To become established, it isn't enough that a species enters a suitable habitat. A sufficient number of propagules (or individuals) of the species must arrive to establish a viable population—this is particularly important for species with separate sexes. Thus, multiple introductions are often necessary before an invasion can be successful.

The final filter is biological: competition and predation from resident species could prevent an invasion, especially if the invaders arrive in small numbers.

Propagule pressure allows a species to survive the last two filters. A sufficiently large number of introduced individuals will overcome demographic resistance and will buffer the effects of negative interactions with resident species.

Sequential Invasions (Hub & Spoke) Model

We can apply these concepts to a predictive framework—a "hub and spoke" model (Carlton 1996), in which donor and recipient regions (the hubs) are connected by a network of invasion corridors (the spokes). As invasion corridors vary in strength over time and space, so will the propagule pressure at recipient sites. When a region becomes invaded, it becomes a potential donor region for

other regions connected to it by invasion corridors. Therefore, when a region with many invasion corridors is invaded, many more regions are at risk.

A simple but useful risk assessment for a potential recipient region may be generated based on (1) the identification of invasion corridors (using recent invasion patterns); (2) a ranking of habitat suitability for potential invaders from connecting donor regions; and (3) vector traffic (as an estimate of propagule pressure). For example, if all potential recipient regions were equally suitable for a species, then we could rank the risk based on the strength of the corridor alone. Once we have identified invasion corridors, the relative risk of potential invasion threats from the potential donor regions can be assessed by a simple probabilistic index:

$$\text{Invasion Risk} = I \times S$$

Where: I = probability of species introduction (e.g., estimated by propagule pressure, such as volume of ship traffic from the donor region)

S = probability of survival (e.g., a function of habitat suitability).

When applied to the Great Lakes, this approach identifies numerous invasion threats from Western Europe, including several species that have exerted significant ecological impacts outside of their native range (Ricciardi & Rasmussen 1998). Similarly, the model can be used to evaluate the relative risk of recipient regions to invasion by a particular species; for example, it suggests the likelihood of a North American invasion by the macrofouling freshwater mussel Limnoperna fortunei, currently invading South America (Ricciardi 1998). Conceivably, the model could be the basis of an early-warning system using an electronic database.

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Some Strategic Considerations

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The approach to invasive species informatics described here is distilled from a long history of collaborative projects involving multiple institutions and supporters. Notable contributors include the MAB Biosphere Reserve Integrated Monitoring program (BRIM) and numerous international projects sponsored the US Geological Survey (USGS) International Office and the National Biological Information Infrastructure (NBII), but dozens of organizations have participated. With support from the United States Agency for International Development (USAID), a first set of recommendations for international sharing of invasive species information were developed at a 1998 workshop in Santa Barbara, California, and presented to Inter-American Biodiversity Information Network (IABIN) in Brasilia in 1999. Eighteen countries expressed interest in participating in the project. The World Bank funded a pilot, and the North American Biodiversity Information Network (NABIN) provided additional support for model development. Three USGS-supported workshops involving investigators from 12 countries have since met to refine the approach.

The repeated failure of central data repositories in environmental sciences strongly suggests that any successful strategy will require a highly distributed network of information providers. The authoritative versions of data need to be maintained at or near their sources, where they may be accessed in real-time by a variety of analysts or integrative tools. A well-designed network must recognize that invasive species information is compiled for quite different purposes by different actors. As a result, mandatory content standards are doomed to failure. On the other hand, some data elements (e.g., the "Darwin Core" of species, location, observer, date, and documentation) recur in most data sets, and may be expressed and exchanged in a common format if participants agree on the language to be used. This is done by referencing "controlled vocabularies" or thesauri, that the community agrees to observe for critical attributes of the data. Environmental examples include both elements for which there are widely-accepted candidate thesauri, such as taxonomy (e.g., the Integrated Taxonomic Information System), subject (library cataloguing terms) and geolocation, and some for which there are none, such as scientific methodology. Vocabularies are always specific to particular user communities. Building distributed information discovery systems around controlled vocabularies provides natural extensions to the next-generation World Wide Web, XML, and data mining technologies.

Participation can only be built through incentives to share information. These include tools that save practitioner time, provide outlets for publication and professional recognition, and perhaps provide quality assurance and validation through peer-review. Principles for implementing this approach include:

- a highly distributed information system with local control over locally unique data;
- access through a network of "nodes" that provide cataloging and search services to both data providers and users;
- multiple points of access or portals, the network can be used by each organization to address its particular mission;
- interoperability using shared vocabularies and data exchange frameworks, and
- migration towards next generation internet standards.

NBII and IABIN are organizing provincial and country-level "nodes" for invasive species information. At the pilot stage, high-priority data types for these projects include catalogs of experts,

organizations, control or eradication projects, data holdings and a listing of which species each partner studies or manages. They will also adapt tools supported by the Commission for Environmental Cooperation (CEC) of North American for accessing species occurrences (Species Analyst for museum records, collection data) and taxonomy (ITIS). Additional information types to be integrated in future years include educational materials, laws and regulations, control/management practices, research publications, images, native range maps, ecology and risk assessments. If local information, such as species occurrences, can be successfully be reported or "harvested" into a common vocabulary-based format, it may be readily accessed through a number of specific tools tailored for the desktops of individual users. For example, NBII is developing interactive mapping tools, early warning systems, models to predict the spread of invaders, and "data mining" for weed literature.

Perhaps the most attractive tools for developing a worldwide invasive species information network arise out of the specifications for a next-generation Internet (the "Semantic Web"), as defined by the World Wide Web Consortium and other open-source standards groups. In particular, our NBII and IABIN pilot nodes plan to use Extensible Markup Language (XML) and the Resource Description Framework (RDF). XML may be thought of as a hybrid between a traditional web-page format and a database application; it can use controlled vocabularies to "tag" a wide variety of data types (e.g., maps, fact sheets, herbarium specimens) with searchable, possibly hierarchical, identifers (e.g., species, watershed, habitat type) that define the semantics of the network. RDF allows the community to specify and search the relationships among these information types – defining the ontologies of the network. These tools represent open standards, meaning that free tools are available to resource-poor partners, yet they are widely used by the commercial software community, so that off-the-shelf applications, programming and technical support can be widely available. The approach taken by these projects parallels, and can be merged with, the taxonomic name (ITIS) and distributed species range modeling (Species Analyst) technologies also supported by CEC.

The social issue of agreeing on shared language for interchanging invasive species information may be more challenging than the technical requirements to develop standards-based software. Essential vocabularies for invasive species data include general environmental keywords (candidate thesauri include Library of Congress, Infoterra, and GEMET keywords), species nomenclature (ITIS), habitats and vegetation types (perhaps IUCN vegetation classes), disturbance types, threat impact types and levels, organization names and types, geographic place names, and eradication or control methods. Of these, only species names and place names are sufficiently standardized to adopt now.

These same technologies also underlie emerging models to predict the present range and future spread of invaders, and tools for fieldworkers. In the next year, decision-tree and Kriging models will join GARP (as ways for analysts to infer the geography of invasions from the necessarily spotty observational data. The emergence of wireless technologies and web-based data structures will allow field workers to interactively access images and identification keys for weeds, and to have entries into electronic field forms made instantly available to other users over the network. Together, these technologies will permit biologists, regulators, and the interested public to better detect, identify and combat invasive species before it is too late.

Risk Analysis to Prevent the Introduction of Invasive Species

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Mexico is a biologically megadiverse country and the centre of globally important crops. Therefore, the introduction of exotic species into the environment can represent a severe risk to biodiversity. At present Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) is starting an invasive species program, whose principal aims are: 1) to compile existing information concerning invasive species (plants, fishes, amphibians, reptiles and mammals) for terrestrial and marine environments, 2) to obtain species checklists that define priority species in order to finance specific ecological studies, 3) to determine the geographic distribution of invasive and target species, and 4) to discuss strategies to control and eradicate these species with the decision makers of the Secretariat of Environment and Natural Resources (SEMARNAT) and the Secretariat of Agriculture, Husbandry, Rural Development, Fisheries and Food (SAGARPA).

At present we have a checklist of 877 species of invasive plants and we are currently gathering ecological information for 30 species of birds, 70 species of mammals, 8 species of amphibians and reptiles, and 36 species of exotic fishes.

In this work a specific methodology to assess the risk to biodiversity due to the introduction of exotic species is presented. The methodology is based on the label information included in the voucher specimens of biological collections, as well as in a spatial analysis based on the localities where these specimens were collected. The spatial analysis is done by generating potential geographic distributions of the concerned species through spatial models. Ecologically similar areas (ESA) are obtained using models like Floramap or using genetic algorithms like GARP (Genetic Algorithm Rule-Set Production). Both programs include diverse environmental variables to generate the ESA. The resulting maps are reviewed by experts and based on their opinion can be redesigned according to other digital covers, like biogeographical regions, ecoregions, altitudinal ranges, land use and vegetation maps, etc.

Two case studies were presented during the meeting. The first one was for the moth *Cactoblastis cactorum*. This moth is a native species of Argentina and a parasite, during its larval stage, of several species of Platyopuntia. This species has been moving North from Argentina to some islands of the Caribbean Region and it has been recently recorded in Florida, U.S.A. The ESA were obtained for *C. cactorum* for the entire American continent, with special emphasis on Mexico. Subsequently, the ESA were generated for the 57 native species of Opuntia that grow in Mexico. The maps of the prickly pear species were added to obtain a map of hot spots showing the areas with the highest number of species of Opuntia. The resultant map was overlaid with that of the moth to determine the areas of higher risks of plausible introduction of the moth. The results of these analyses were presented to the concerned authorities (SAGARPA and SEMARNAT) to prevent the month's introduction to Mexico, since several prickly pear species are of great economic importance as a food resource.

The second case study was presented for *Bombus terrestris*. This bumblebee is a native species of Israel and is frequently used to pollinate tomato crops. A European company submitted a proposal to the SAGARPA looking for an authorization to introduce the bee to the Peninsula of Baja California. In Mexico, more than 1,589 species of bees exist—for the genus Bombus 21 species have been described. Baja California has 197 species (57 endemic ones). *B. terrestris* competes with the native species of bees and hybridizes with other species of the genus Bombus. Thus, its introduction may also include a risk of introduction of exotic parasites. In order to give a recommendation to the SAGARPA and SEMARNAT, the ESA were obtained for the 13 native species of Bombus using GARP. All the resulting ESA of the native species were added to obtain a map of hot spots showing the areas bearing the highest number of Bombus native species. The same

was done for 16 genera of the Megachilidae family. The resulting maps of the Bombus species were overlaid with those resulting from the genera of the Megachilidae family to obtain a map of distribution patterns. Based on these results, several recommendations were made to the involved Secretariats. The principal one was to avoid importing *B. terrestris* to Mexico. The United States Department of Agriculture and the Food Inspection Agency from Canada expressed their desire to avoid the introduction of an exotic species in North America as well. CONABIO suggested that the company look for alternative pollinators native to Mexico, like *B. ephippiatus*, or some species of Anthophora, as well as to develop technology to generate breeding areas for species that can only be used in nurseries or confined areas.

We have only just started to obtain checklists and some geo-referred locations for aquatic invasive species. The major aquatic invasive species recorded in Mexico occur in inland waters and they are more abundant in the northern states of the country. Chihuahua, Baja California, and Coahuila are the states harboring the greatest number of invasives. The same methodology described for the above case studies could be applied to generate ESA for the aquatic invasives; although, more information would be required in digital formats. The major information needs would be the species databases that must include geographically referred localities of collected specimens and an experts network. Likewise, country maps (Mexico and source countries) and the ocean currents, major watersheds, rivers, and freshwater ponds would also be required in a digital format for the spatial analysis. Additional information needs to obtain the ESA for aquatic species include ground waters, salinity, oxygen, water temperatures, and turbidity among other variables. Obtaining this information should be a priority in order to begin modeling the spatial models of the potential spread of aquatic invasive species so as to prevent their introduction.

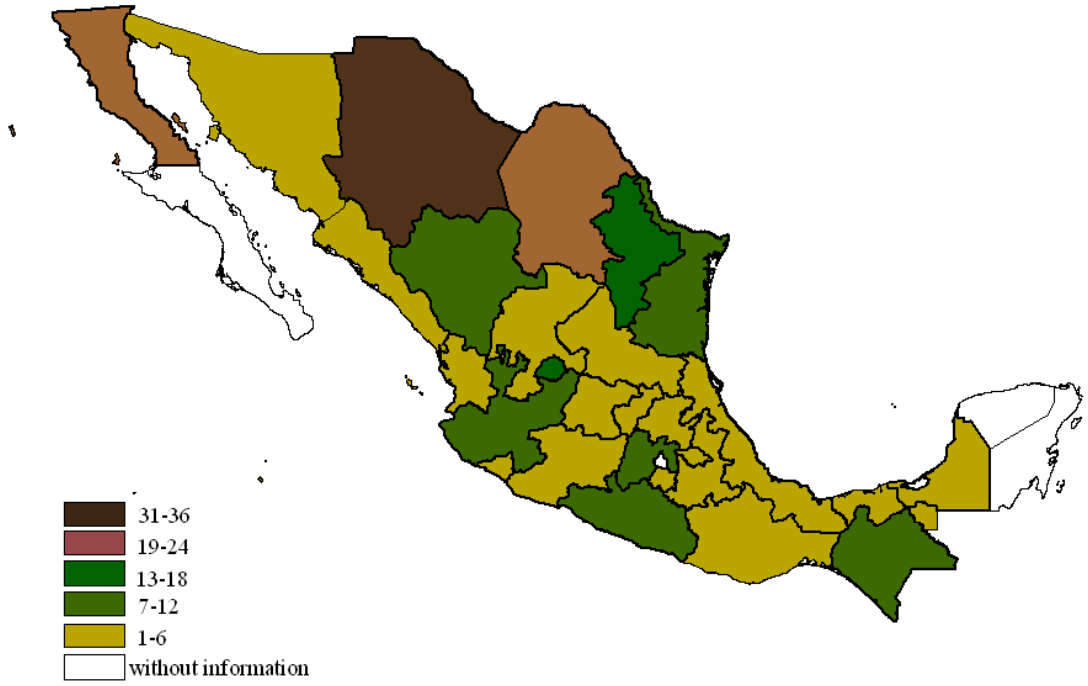

Figure 1. Number of aquatic invasive species recorded per state in Mexico.

Invasive and Colonizer Fishes and Other Aquatic Organisms in Continental México

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The fish of Mexico and other aquatic biodiversity have been affected by the expansion of invasive species that comprise introductions (stocked by Mexico and the USA) and colonizers (opportunistic invasive life forms arriving due to induced environmental changes). North American countries have introduced fish for different purposes. The study of these countrywide invaders has been the subject of several papers. From Meek (1904) to Alvarez (1950; 1970) only 6 introductions and approximately 71 colonizer fish were recognised. In 1984 Contreras-B. & Escalante reported 54 introduced fish, later increasing to 94 (Contreras-B., 2000). In 1993 Espinoza et al., recognised 36 introduced, listing 21 as native with introduced areas (5 of them not really native, but US species), plus only 32 colonizer fish, citing Contreras & Escalante, plus Arredondo-F. & Guzmán (1985) and Mújica-Cruz (1987) as references. In 1972 Castro Aguirre reported 294 colonizer fish, later expanded to 508 (Castro Aguirre et al., 1999). These species colonize continental waters due to increased salinity and water loss in rivers. Other aquatic biota reported are Hobbs (1962) on the crayfish Procambarus clarki and Campos & Contreras (1985) for Orconectes virilis, and Contreras-A., & Contreras-B. (2000) for the aquarium snail Thiara tuberculata. The source of these invaders have been sports 9 (10%), live bait 5 (5.6%), forage 15 (16.7%), food 38 (42.4%), and ornamental 11 (12.2%), adding to 78 (86.9%) resulting from aquacultural activities. Some have been accidentals mixed with intended stockings 23 (25.6%), biological control 2 (2.2%), and conservation 3 (3.3%). The sum for fishes has been 106 species. The crustaceans have remained in 3 crayfish, 1 snail and 1 mussel, as far as documented. No or very scanty information was collected for other animals (hydroids or freshwater medusae: Guajardo et al. 1987) or for aquatic weeds (Eichhornia, Hydrilla, etc.) (Contreras et al. 1973). The damages have been described as threats to endemic native species, extirpation, hybridization of stocks, reduction of local fisheries, and cultural changes especially in native peoples. The case of the substitution of pescado blanco de Chapala by tilapia/carp resulted in an increase in meat tonnage but with a loss of both biodiversity and profits, which impacted tourism. The recommended course of action to diminish colonizing by marine and brackish water species is the domestication and culture of native species, the avoidance of future introductions, and the controlling of water uses and pollution.

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Current Country Programs and Strategies

Mexico's Perspective on Aquatic Invasive Species

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Institutional Arrangement and Legal Instruments

The Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA.) is empowered by the Fisheries Law that deals with the use of aquatic species or promotion of aquatic activities such as aquaculture, the introduction of aquatic species, use of exotic species, movement of species within the country for aquaculture purposes, ornamental fish, sanitary regulations and procedures, and scientific collection. The Fisheries Law Regulation (amended Sept. 1999) has very specific instruments and procedures to deal with the introduction of aquatic species into federal waters, such as controlling the introduction of aquatic species and encouraging the authorities to promote aquaculture development; and provide an authorization procedure for sanitary requirements; the introduction of species; the prohibition upon the introduction of species which are likely to destroy native species; and the obligation to restock. It also deals with the revocation, and cancellation of concessions, violations and breaches and related sanctions and procedures.

Derived from the Fisheries Law Regulation (1999), Mexico has the National Fisheries Chart (DOF, 17/08/00) (CNP) that provides a new legal tool that refers to the management of fisheries resources, aquaculture, inventory and status of freshwater ichthyofauna, and protected species among other important issues. It provides specific guidelines, strategies and provisions for the conservation, protection, restoration and management of aquatic resources and activities that could affect their habitat and ecosystems. This CNP Chart includes a compilation of technical data sheets for each fishery or cultured resource and aquatic provinces for freshwater fish. In many cases, it provides specific notes and recommendations to avoid the use of exotic species, disincentives for the movement of aquatic organisms, and incentives for restocking with native species. It also encourages scientific research that moves towards developing new culture techniques for native species, and updating their status.

In addition to the above, the Ministry of Environment and Natural Resources (SEMARNAT) deals with all aspects of natural resources protection and conservation including law enforcement and surveillance through its Federal Attorney for Environmental Protection (PROFEPA). The task of the National Institute of Ecology (INE) is to update all data bases and regulations that deal with the status of aquatic endangered, or protected species (NOM–059–ECOL–1994), and the National Commission for Biodiversity (CONABIO) that develops new tools for monitoring the current status of aquatic biodiversity in Mexico. The General Law for ecological balance and environmental protection LEGEEPA) also deals with introductions and has a regulation in regard to Environmental Impact Assessment (EIA) which specifies the need to submit an EIA study ensuring that native local species will not be harmed with any request to introduce aquatic species into federal waters and for farming purposes.

Among important official standards dealing with aquaculture sanitary requirements, aquaculture and biodiversity conservation are: *NOM–010–PESC–1993* (DOF 16/06/94), which deals with sanitary requirements, the introduction of live aquatic organisms for aquaculture and ornament; *NOM–011–PESC–1993* (DOF 16/06/94), which deals with quarantine procedures, prevents the introduction and dispersion of certifiable and notifiable diseases (import of live aquatic organisms for aquaculture and ornament; *NOM–059–ECOL–1994*, which provides a list of protected species, and reflects the status of aquatic species at risk, endangered or extinct; *NOM–EM–003–PESC–2000* (DOF 25/04/2000), determines viral disease in crustaceans, their products or sub-products,

introduced into the country and their movement within it. All regulations are built following international standards and joint group participation of federal and state government, academia and stakeholders. In addition to these official standards, the government has supported the development of codes of best practices and management in aquaculture and the establishment of biosafety protocols in shrimp farms. There are other efforts to create new culture techniques that will avoid and reduce the need to introduce exotic species. Where some commercial farms carried out different experimental aquaculture projects using native species in the Gulf of Mexico in a joint venture with research institutions.

Cultured Species and Its Social Benefits

The species contributing to aquaculture production are mostly exotic species, such as carp and tilapia, followed by native shrimp production that has reached above 30 thousand metric tons in the year 2000. Aquaculture activities have a long history of introducing at least two main species: carp and trout, and most recently the introduction of tilapia, which has been very successful economically and socially speaking. These introductions followed international recommendations regarding new sources of protein for the poorest communities in developing countries. Considering that Mexico had a similar program named "Mexican Alimentary System Program" in the 80´s and most recently the "National Program for Rural Aquaculture" that has the same aim of a huge social benefit reaching about 46 thousand families in 1999. The Mexican government has also encouraged the extension of aquaculture facilities, fish farms, hatcheries and culture centers to make this new source of protein available to help relieve poverty and promote regional development, among other goals. Today Mexico has reached a level of progress that understands the importance of the sustainable development that SEMARNAT has been involved in for the past six years; development that includes a policy that considers food security, poverty alleviation, biodiversity conservation, ecosystem approach, as well as holistic management.

Cooperation Efforts in North America

In order to face the challenge of aquatic invasive species at the international, regional and national level it is necessary to double our efforts in the following areas:

1. Diagnostic, basic research:
    - enhance efforts to update the actual situation of exotic aquatic species
    - scientific understanding of all introductions (old and new)
    - continue studies to update aquatic species inventory (CNP)
    - fully identify all social and educational benefits derived from aquatic native species use
    - conduct studies and research on marine species
2. Development of native species culture techniques:
    - enhance national research capacity towards native culture spp.
    - increase culture technological development of native aquatic resources
    - develop biosafety protocols in aquaculture
3. Public participation:
    - maintain and improve actual regulations
    - continue and increase participation of stakeholders
    - sustain sound conservation and management of aquatic resources

- promote programs to generate public consciousness

4. International cooperation:
    - increase and improve international cooperation and coordination
    - transfer of technology in order to increase capacity building to avoid and/or mitigate the impact of exotics species
    - develop regional exchange mechanisms of technical and scientific information (clearing house)

Aquatic Nuisance Species—A Canadian Great Lakes Overview

Tom Morris
Marine Safety Transport Canada (AMSEE)

Introduction

Non-native aquatic organisms have established themselves in waters throughout the world, often with unfortunate results; for example, the Great Lakes have suffered significant damage as a result of this phenomenon. Because many of these introductions have been attributed to the discharge of ballast water from ships, demands have been made for ballast water discharge controls. In response to concerns expressed by the Great Lakes Fisheries Commission, Transport Canada introduced voluntary guidelines for mid-ocean ballast water exchange in April 1989 for ships destined to the Great Lakes.

Since 1989, the Canadian guidelines have been expanded and now cover all waters under Canadian jurisdiction. Mandatory US regulations have also been implemented for the Great Lakes, and international ballast water management regulations are under development by the International Maritime Organization.

Guidelines and Regulations

The implementation of mandatory regulations was not considered appropriate in 1989 due to the lack of legislative authority, the lack of scientific data supporting the effectiveness of the recommended treatment (i.e., the exchange of ballast at sea), the lack of alternatives for cases where ships could not or did not exchange their ballast, and the fact that there were concerns regarding the safety of ships that were not designed to exchange ballast at sea.

Over the last twelve years, many developments have addressed these issues. The statutory authority to replace the Canadian guidelines by regulations was provided through an amendment to the *Canada Shipping Act* that came into force in October 1998. Research has been conducted into the effectiveness, safety and alternatives to ballast water exchange. However, regulations have not yet been developed by Canada for the Great Lakes principally due to the fact that the US regulations introduced in 1993 apply to all ships entering the Great Lakes whether headed to a Canadian or US port; thus, the introduction of Canadian regulations becomes a lower priority item.

The length of time taken to develop national and international regulations has frustrated many concerned about protecting our environment. Also, for areas such as the Great Lakes, new introductions have taken place despite the presence of US regulations—causing some to question the effectiveness of that program. Because of this, legislation has been introduced or proposed in several US states, such as Michigan, and the Province of Ontario. It is felt that the only feasible solution to this problem is a regional solution—not different programs for individual states, provinces or ports.

In light of increased concerns over introduction of harmful aquatic organisms and pathogens to the Great Lakes region, Transport Canada is proposing to introduce Canadian ballast water management regulations (hopefully by the spring of 2002) that will initially be limited to the Great Lakes region. To better facilitate the preparation of Canadian regulations reflecting a joint US-Canadian approach for the Great Lakes, the Great Lakes Regional Waterways Management Forum, which is binational in membership, charter and leadership, established a Ballast Water Subcommittee that will provide operational recommendations to both the Great Lakes Panel on Aquatic Nuisance Species and the Canadian Marine Advisory Council on issues of aquatic nuisance species control from ballast water. This Subcommittee's first priority will be to make recommendations to harmonize the US and Canadian ballast water exchange regimes on the Great Lakes.

Although it is agreed that our goal is to produce a regulation that is harmonized with US regulations, there are still many issues and options that need to be discussed and decided upon; for instance, how to implement the regulations in the St. Lawrence River where larger ships sail, how to deal with new or alternative treatment methods, and how to coordinate enforcement with the US Coast Guard. In order to achieve a workable harmonized regime, the challenges of addressing issues such as the effectiveness of current requirements and sediment in ships that carry no ballast must also be met.

Ballast Water Controls

The process of developing a regime that is practical, effective, environmentally friendly, enforceable, reasonable and safe has been going on for many years and there still remains work to be done. Variations in the type of ship, ballast tank arrangements, voyages, and quantities of ballast carried make it obvious that treatment capabilities and the risks associated with introducing new species vary greatly.

It is important to understand that regulating alien organisms or pathogens in ballast water is different from our current practices for regulating pollutants such as oil, chemicals, garbage, and sewage, which are well-defined and listed in existing regulations. Determining whether preventive measures are required or proving that a violation has occurred for one of these pollutants simply involves concluding whether it is present or is present in restricted concentrations. For alien species in ballast water, creating one list of species is impossible as the list will vary from area to area, depending on the species present and the species that could prove harmful if introduced. Specific lists of targeted, unwanted species presently exist for only a few select areas. Even if lists were available for all areas, finding a method to quickly and effectively determine whether a species is present in a ship's ballast water tanks may not be possible. Control and enforcement actions, such as requiring ballast water management practices to be followed or prosecuting when ballast is discharged without following proper practices, must be available in cases where the risk of introducing an unwanted species exists, not just in cases where the presence of such a species is proven. Discharge standards and ballast testing standards are therefore an important part of the ballast water program.

International Regulations

In order to effectively reduce the risk of introductions of harmful aquatic nuisance species globally, the greatest future challenge is to develop and implement suitable international regulations for ballast water management. It will still be several years before the regulations being developed by the International Maritime Organization are brought into force, but it is hoped that the result will be a global regime that addresses both ship design and ballast water management procedures. Although the provisions for the Great Lakes may not necessarily be identical to the international provisions, it is recognized that the implementation of a global program will go a long way towards making the Great Lakes program more practical, effective and enforceable.

Aquatic Invasive Species Activities in the United States

Cathleen I. Short
US Fish and Wildlife Service

Introduction

Non-indigenous species are recognized as one of the most significant threats to fish and wildlife, second only to the loss of habitat. The United States is concerned about aquatic invaders from a resource perspective, but also because of their adverse impacts on human health and economic factors. Many of the most disastrous invaders in the United States came from outside the North American continent. An increase in trade over the last decade has caused the invasive species problem to accelerate to the point where it has become a global problem and a major threat to natural resources in many countries. Because of the increase in global trade, the pathways of aquatic nuisance species introduction, both intentional and unintentional, have increased significantly and become more complex. Invasive species can originate from practically any point on the planet. This problem has increased to the point where we are ever more concerned about both economic and ecological impacts. These complexities influence what species get imported and exported, what species are tolerated or even sought in a particular area, and the occasional conflict between positive and negative economic impacts of some non-native species. In addition, views held by animal rights enthusiasts that value all species and are opposed to lethal means of eradication and control further complicate decisions on how invasives can be controlled or eradicated.

Whether aquatic nuisance species (ANS) are introduced intentionally or unintentionally influences their management and solutions to the problems they create. Intentional introduction of aquatic species that become established in the wild can occur through a variety of mechanisms such as: aquarium releases, live food imports, bait bucket releases/imported bait, sportfish stocking, and biological control. Ballast water, aquaculture, range expansion after introduction and ship hull fouling are the pathways that have been identified as significant for unintentionally transporting aquatic invasive species into and throughout the United States.

Today, there is widespread recognition that ANS concerns in the United States are much larger than zebra mussels and have greater impacts that just on the industrial use of water. In addition to the more obvious environmental impacts, there are both direct and indirect impacts on various businesses and other sectors from both the invasive species and actions taken to prevent or control them.

Authorities and Policies

The US government is keenly aware of the scope and significance of invasive species problems and is doing a number of things to respond to the threat of ANS. There are a number of authorities and policies that guide us from the aquatic perspective recognizing that there are parallel efforts to address terrestrial invasives. The Plant Protection Act and the Injurious Wildlife Provision of the Lacey Act provide the US government with the authority to identify potentially harmful invasive species and prevent them from being imported into the United States. The process to list species as harmful is somewhat time consuming, but it is viable and is ideally used from a proactive, prevention perspective.

One of the more comprehensive efforts in the United States to address aquatic invasive species are the activities that fall under the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 (as amended, National Invasive Species Act of 1996). The primary goal of the Act is to help focus efforts in three key areas: 1) preventing the introduction of new ANS; 2) ensuring prompt detection of and monitoring changes in existing ANS; and 3) controlling established ANS in an environmentally sound manner. The Act also established the ANS Task Force to coordinate the

multitude of Federal efforts that relate to ANS. It laid the groundwork for the development of the Aquatic Nuisance Species Program that has provided the framework within which federal agencies focus their activities. The Act focuses on ballast water as a major pathway. Building on Canadian actions, it mandated US regulations for the Great Lakes on ballast water management. Two of the most important parts of the Act were the establishment of regional panels to help coordinate and prioritize regional issues, and the development and funding of state/interstate ANS management plans. These two components of the Act have helped to mobilize state efforts to address various aquatic nuisance species issues.

ANS Task Force

The ANS Task Force was established in 1991. Its role is to develop and implement the ANS Program and reduce the risk of aquatic nuisance species through prevention, detection and monitoring, and control. The basic premise was that agencies with the responsibility to address resource issues must work together and coordinate their activities with state and private entities in order to be successful in combating invasive species problems. The Task Force is comprised of seven Federal agencies, with National Oceanic and Atmospheric Administration and the US Fish and Wildlife Service serving as the co-chairs. Other governmental entities are also represented on the ANS Task Force as ex-officio members. The ex-officio members help to keep discussions balanced as many of these members are either affected by aquatic nuisance species or by actions taken to address these species. The ANS Task Force is a coordinating entity dependent on funding and commitment from individual agency members to carry out actions to implement its activities. Several committees that bring affected entities together to deal with common problems, such as control and prevention plans or outreach and education efforts support the Task Force. State and Regional participation is important to the ANS Task Force to address aquatic nuisance species issues.

Aquatic Nuisance Species Program

The core elements of the ANS Task Force program are prevention, detection and monitoring, and control. Support elements of the programs include research, education, technical assistance and the zebra mussel demonstration program. All these elements are critical in addressing invasive species problems. Prevention has always been a major focus for the ANS Task Force as its first line of defense for invasive species. The most cost-effective approach to combating invasive species is to keep them from becoming established in the first place. Prevention is the key to a successful program, especially in aquatic habitats because once they have become established the battle is largely lost or we are committed to indefinite control. Control of sea lamprey (*Petromyzon marinus*) is a good example. Control is a successful program supported by both the Canadian and US governments, but at a cost of $14 million dollars per year. Key components of prevention are early detection and monitoring, and the development of a rapid response program. The rapid spread of zebra mussels in the United States provides a good example of the need for state and federal partnerships to address the rapid spread of invasive species. Introduced into the Great Lakes in the late 1980s through ballast water, the zebra mussel is now in almost every waterway east of the Rockies. As the zebra mussels continued their spread in the mid–1990s, many people became concerned about their impact if they reached the western US. As a result, agencies within the ANS Task Force cooperatively developed the 100th Meridian Initiative to work with the states to take a proactive approach to preventing the dispersal of the zebra mussel and other ANS west of the continental divide. This effort focuses on trailered boats as the primary pathway of spread and includes voluntary efforts to inspect trailered boats conducted by some of the states involved. Education and outreach is a significant component of the initiative, as is technical assistance provided to states and local governments. This effort will also focus on the Lewis and Clark Bicentennial Commemoration in 2003 as a potential pathway. Millions of people will be tracing the

footsteps of Lewis and Clark and it is necessary to make sure that adequate precautions are taken to ensure that the boats do not carry any unwelcome visitors on their western trek.

The ANS Task Force also developed voluntary guidelines for preventing the spread of ANS associated with recreational activities. These are actions the public can take to minimize or avoid the transport of aquatic invasive species through water-related activities, such as boating, scuba diving, waterfowl hunting, and other activities. The ANS Task Force is now addressing many invasive species being spread through interconnected waterways including the round goby, a fish that was introduced into the Great Lakes around 1990 and that has spread through southern Lake Huron, all of Lake Erie, and lower Lake Michigan. There has been great concern that the goby would move out of Lake Michigan, through the Illinois waterway, and into the Mississippi River basin. The ANS Task Force organized an effort, led by the US Army Corps of Engineers and the USFWS, to look at options to address the issue. It was determined that the best long-term plan to control the movement of gobies and other ANS was to install an electrical barrier in the canal.

Detection and monitoring efforts, coupled with making the information readily available are also critical to ANS activities. The Florida Caribbean Science Center of the US Geological Survey, was established as a central repository for spatially referenced biogeographic accounts of non-indigenous aquatic species in the US Scientific reports, online/real-time queries, spatial data sets, regional contact lists, and general information on ANS are available to biologists, interagency groups, and the general public. The Science Center has developed links with states and academia to report new species and the expansion of established species. The Center works cooperatively with the Smithsonian Environmental Research Center, which compiles data on estuarine and marine species. The Task Force also helps coordinate the collection of biological and ecological data on ANS, primarily focusing on trying to determine the effectiveness of ballast water management techniques in preventing the introduction of new species. This baseline data is critical to the success of detection, as well as control and management efforts.

The Task Force also establishes collaborative committees to develop control and management plans, with the participation of states and regional entities. These control plans undergo public review before they are finalized. Examples of completed plans include the ruffe and brown tree snake control plans. Additional control plans are currently being developed for the green crab, Chinese mitten crab and Asian swamp eel.

The ANS Task Force encourages the formation of regional panels to better integrate national and regional activities; these panels are critical to the success of dealing effectively with ANS. The panels establish regional priorities, coordinate regional activities, and develop and implement action plans. The regional coordination efforts have been very successful in pulling states in a geographic area together to address common problems. Panels that are currently established include the Great Lakes Regional Panel, Western Regional Panel, and Gulf of Mexico Regional Panel. A panel for the Northeastern region is under development (established July 2001) and the Task Force is in discussion with several other regions in an effort to form additional regional panels. These panels can include representation from neighboring countries. For example, the Great Lakes and Western Regional Panels both have Canadian representation and the Northeastern panel most likely will as well. The Task Force also encourages the development of state/interstate ANS management plans. The development of these plans has been instrumental in state resource agencies garnering the support they need within their state organization to establish formal aquatic invasive species programs. Eight state/interstate entities currently have plans approved by the ANS Task Force. Several more are expected to submit plans to the Task Force for approval in the next few months.

Effective communication, education, and outreach activities are of critical importance in addressing ANS. We must be able to make the invasive species issue relevant to the general public, as well as to governmental decision makers. The public must believe there is a problem that needs to be addressed, that they should be concerned, and be part of the solution. We must also keep our

efforts focused enough to be effective, otherwise, the problem will quickly seem beyond our ability to address. As part of our celebration of the 10th anniversary of the ANS Task Force this year, we are beginning a public awareness campaign to make people more aware of ANS problems and what they can do to help. It will focus on three audiences: the general public, policy makers and water-based recreational users. A workshop held during National Fishing and Boating Week in June 2001 highlighted the recreational activity guidelines developed by the Task Force and identified specific activities that related to recreational fishing and boating activities.

On a broader scale, the US government has established an Invasive Species Council that addresses invasive species activities across all agencies and taxa. The Council came about as the result of an Executive Order issued in February 1999. The Executive Order also set up an Advisory Committee of non-federal members with invasive species expertise or interest to provide advice to the Council. The Council has developed a management plan outlining most important activities dealing with invasive species issues. The ANS Task Force works with the Council to help carry out the actions in the management plan focused on aquatic invasive species.

Summary

The ANS issue holds significant promise for increased cooperation among our three countries. We have many common concerns and objectives and a multi-nation approach is needed to find solutions. While dialogue is an important first step, a commitment to action needs to follow. US expectations from the meeting include: 1) increased cooperation, including ensuring that we are addressing similar priorities and not working at cross-purposes, 2) opportunities to learn from each other and share expertise and experiences, 3) harmonization in cross-border activities, 4) identification of ways to increase information exchange, 5) identification and encouragement of priority research, 6) sharing of resources to work cooperatively on priority problems, 7) commitment to taking identified actions, 8) determining measures of success, and 9) continued dialogue and exchange.

International Perspective for Cooperation

International Imperatives

The Global Invasive Species Programme: A Forum for Regional Cooperation

Jamie K. Reaser
National Invasive Species Council

Today, no country is self-sustaining; we all depend on goods and services from afar. Increasingly, global markets are not only driven by our needs, but also by our wants. We desire nearly every imaginable good and service, especially those we perceive to be "new," "better," "different," and "exotic."

The resulting globalization of trade, transport, and travel has functionally made everyone, everyone else's neighbor. And, while this globalization has brought social and economic benefits to many, it has also brought new challenges. Invasive species are one of these challenges.

In 1996, concern that invasive species might be one of the most significant "negative externalities" of globalization brought 78 countries and numerous international and intergovernmental organizations together at the "Trondheim Conference." This meeting, sponsored by Norway and the United Nations, was the first global effort to assess the impact of invasive species on the environment. Participants concluded that:

1. The impact of invasive species is "immense, insidious, increasing, and irreversible." In other words, every country has been impacted by invasive species, the patterns and trends follow that of globalization, and as long as we engage in international trade, travel, and transport we'll need to manage this problem;
2. Aside from climate change, invasive species are the most significant threat to the environment worldwide. Developing countries will be severely impacted, particularly Small Island Developing States (SIDS); and
3. A global plan and strategy is urgently needed to address the problem.

In 1997, three international organizations came together with a commitment to share their expertise and other resources in order to address the scientific and technical aspects of the problems identified in Trondheim. The World Conservation Union (IUCN), CAB International (CABI), and the Scientific Committee on Problems of the Environment (SCOPE) formed the Global Invasive Species Programme (GISP). GISP is a coalition of scientific and technical experts in a wide variety of disciplines relevant to minimizing the spread and impact of invasive species.

In the fall of 2000, in Cape Town, South Africa, GISP presented the findings from its first phase of work to an audience of more than 100 representatives of governments, international organizations, industries, and other bodies. They also asked participants to provide input on GISP's future program of work.

The results of GISP "Phase I" are voluminous. Working groups published books on economics, human dimensions, global change, and legal frameworks, as well as a pilot database of the 100 worst invasive species. They also produced a toolkit of best management practices and a global strategy for addressing the problem. A popular press book by Yvonne Baskin is due to be released by Island Press at the end of 2001.

The Global Strategy is GISP's response to the call from Trondheim for a global strategy and action plan. In 10 program areas, it recommends actions to be taken by governments, international organizations, and others to effectively manage invasive species. In March, 2001, GISP released a

Call to Action, urging governments and organizations to implement the Global Strategy and actively participate in GISP's second phase, a program to implement scientific and technical projects in six areas derived from the Global Strategy.

GISP invited governments and other organizations to join in the GISP Partnership Network, thus expanding the scientific and technical expertise and other programmatic resources. GISP Partners now include more than 45 governments, as well as conventions, industries, international organizations, and other bodies.

Since GISP's founding, the Convention on Biological Diversity (CBD) has been one of its most significant partners, as well as one of its most significant beneficiaries. At a recent meeting of the CBD's scientific body, the Subsidiary Body on Science, Technology, and Technical Assistance (SBSTTA), SBSTTA decided to recommend to the Conference of Parties name GISP as a thematic focal point on invasive species and ask it to implement several key decisions.

There are numerous opportunities for Commission for Environmental Cooperation (CEC) to contribute to the GISP Partnership Network. These include efforts to:

1. Work with industries to develop codes of conduct (given the focus of this meeting, the bait and aquaculture industries might be a good place to start);
2. Facilitate the development and implementation of a North American strategy on invasive species;
3. Collect regional information on invasive species through the North American Biodiversity Information Network (NABIM), link it into GISP's Global Invasive Species Information Network; and
4. Adopt a "sister" regional organization in an area where North America has many trading partners, helping to forge opportunities to share information with and build capacity within that region.

II. Developing a North American Vision Framework for Cooperation

Informatics, Modeling and Prediction Breakout Group

Issue 1: Shared Vocabularies for Indexing and Accessing Information on Aquatic Invasive Species

Action Items:

Promote the use of shared vocabularies for indexing and accessing information on invasive species:

- CEC should endorse the use of ITIS as the taxonomic reference standard for names and codes ("taxonomic serial numbers") of invasive species.
    - This should include data from all around the world, not only from North America.
    - ITIS must be able to rapidly add new invasive species to the database. This will probably require some new resources.
- Emerging trilateral standard for Geo-location (i.e., FGDC, NBII Biological metadata profile) should be endorsed as standard usage for invasive species.
- Establish or promote consultative processes for standardizing other vocabulary types, such as subject references (examples, GEMET, IUCN, and Library of Congress thematic references), methods, legal status, and best practices, to have a common framework and the same terminology for North America.
    - note: CONABIO is going to organize a workshop in Mexico that will include experts from different sectors, with emphasis on access to information from taxonomists and encourage government officials to use them.
- Promote multilingual user interfaces.

Notes on Current Status:

In Mexico the metadata is not standardized. CONABIO has not developed a metadata system for general use, nor can they provide the service due to the lack of resources to satisfy the user demand for information.

Issue 2: Increase Taxonomic Capacity

Guiding Principle:

Correct and timely identification of invasive species is essential to any information system supporting their detection, assessment and control. Improved taxonomic services are urgently needed to support applications to aquatic invasive species.

Action Items:

- endorse the Davis Declaration, which calls for an increase support for taxonomic services;
- encourage the support of electronic inventories of existing museum collections to make them available, in cooperation with other initiatives (both global and regional, for example, the NABIN Species Analyst project, IABIN, Species 2000, and GBIF), and continue North American leadership in these efforts; and
- highlight awareness of (economic, scientific, cultural) importance of taxonomic capacity and its predicaments.

Issue 3: Lack of Timely and Accessible Use of Information

Guiding Principle:

Given the economic and ecological importance of introduced species, there should be free and open access to information on the identity, occurrences, spread, and risks associated with aquatic invasive species.

Action Items:

Encourage Canada, Mexico and the United States contribute data to the invasive species node network envisioned by GISP and IABIN. Shared information services supported by these nodes include:

- Lists of species considered invasives by countries and partner organizations, including name, status, and risk category. This service may also include "clean lists", when available.
- Expert participation on species identification.
- Invasive species research and control projects, including assessments of what methods have been more or less locally successful in meeting the invasive species challenge.
- Registries of databases and other information resources on invasive species.
- Encourage expansion and interoperability in lists providing access to experts.
- Promote North American early warning systems. Multiple systems are needed, and are under development. Because of the diversity of users, policy issues need to be addressed for target species and habitats. The informatics challenge is to provide standardized on-line information for use by the multiple systems. Successful early warning systems must include:
    - rapid detection
    - rapid identification
    - rapid risk assessment
    - timely control action

Non-informatics Discussion:

- A framework is needed to develop an assessment process for economic impacts of introduced species – including their effects on industry, competitiveness, the provision of environmental services, and their costs in terms of non-market environmental values.
- A comparable framework is needed to develop a synthetic assessment process for sociocultural impacts.
- Genetics and genomics. Short-term informatic priorities mostly concern species-based impacts of aquatic invasive species. However in the long run, species-based information systems will have to connect or be merged with genetic and genomic information systems to address such issues as genetics-based taxonomy, identification of source populations, evolution and adaptation of invasive species, and spread of hybrids, genetically modified organisms, and suborganismal genetic entities such as viruses and transposable elements.
- Information transmission in the community (whether it is adequately provided to communities). An adequate information infrastructure requires support of technical capacity and network infrastructure, including education, training, and technical support services, as well as the standards elements addressed above.
- Appropriate terminology for addressing invasive species issues in North America needs to be carefully considered, and where possible, standardized. The workgroup discussed distinctions

among invasive, non-indigenous, and aquatic nuisance species as labels for CEC policy discussions.

- The group noted that "aquatic invasive species" as boundaries for a policy process may be too narrow, since the genetic structure of invading populations may be important (particularly with the increasing presence of genetically modified organisms). Some important sub-specific processes include evolution of invasives to adapt and spread in novel environments, hybridization and introgression, and spread of viruses and transposable elements both within invasive populations and between invasives and native species. It is possible that redefining the policy universe in terms of "invasive biotas", which would include genetic entities as well as full species, would be appropriate for some policy issues.
- A workshop was proposed with key players to enhance cooperation on shared information, also to address issues of copyright and liability to foster free exchange of information. Mexico has some policy concerns on how this issue is treated.
- The group explored the desirability of establishing a new listserve specific for North American aquatic invasive species. Other existing listserves (IUCN, CPA, GISP, NABIN, CPMAN) partially address this issue. The meeting participants as a whole were interested in the possibility, with approximately a third saying that they would subscribe to such a service.

Participants:

Laura Arriaga, Barbara Bauldock, Renata Claudi, Kristy Ciruna, Salvador Contreras Balderas, Yves DeLafontaine, Ronald Dermott, Pam Fuller, William P. Gregg, Sergio A. Guzman del Proo, Glen Jamieson, Roger Mann Arthur J. Niimi, Townsend Peterson, James F. Quinn, Anthony Ricciardi, Victor Sanchez Cordero, Marcos Silva, Edwin A. Theriot, David Vieglais, Miller A. Whitman

Chair: Ed Theriot

Facilitators/Rapporteurs: Carlos Valdes, Jurgen Hoth, Lourdes Juarez

Prevention and Control Mechanisms: Regulatory Measures Breakout Group

Objective 1: Directory of North American government agencies and other institutions dealing with invasive species

- CEC to form a steering committee
- The directory would support government efforts by providing a basic information tool in the form of an inventory of people in Canada, Mexico and the United States working on species, vectors and pathways
- The process to create the directory could follow the model used to create the forensics wildlife laboratories directory (questionnaire sent to various agencies, compiling answers into a data base that would organize the information under different categories (country, state, vector species etc.)
- The directory would include a list of regulations regarding invasive species in each country/state/province

Time line: twelve months June 2001→ June 2002

Objective 2: Understand regulatory frameworks, identify gaps and share lessons learned

Action Item: Workshop on Regulatory Systems in the Three Countries

- exchange information about standards and regulatory frameworks in the three countries, the experience of government agencies to date. Include case studies, successful tools, control lists, criteria and regulated species, etc.
- establish science-based framework (data base, web links, etc) for information exchange on invasive species of common concern
- framework should distinguish between intentional and unintentional introductions of species
- bring workshop to the attention of NAWEG (meeting in 2002)

Time line: begin once the directory is finished, allow approximately 6 months to organize June 2002→ Jan. 2003

Objective 3: Attract government attention

Action Items: Identify Invasive Species of Common Concern

- organize workshops about vectors and invasive species of common concern. (CEC)
- work on North American list of invasive species of common concern: agree on methodology and criteria to include species in the list

Time line: 2002–2003

Objective 4: Identify North American Priorities for Vectors and Pathways (e.g., ships, aquaculture, live bait, etc.)

Action Items:

- Recommendations of the three governments to highlight priority vectors, engage national discussion on invasive species, identify priorities, establish national priority vectors.

- Participants stated that an internal dialogue should take place in each of the countries to define what areas of concern can be discussed in a bilateral or trilateral forum.
- Recommendation for national discussion to highlight each country's priorities on what invasive species areas and pathways should be addressed.
- Identify value-added of trilateral cooperation.

Time line: 2002–2003

Objective 5: Organize Regional Workshops using GISP Framework as a model

Action Items:

- identify regional actions required to heighten awareness of invasive species problem
- discussion to highlight opportunities for trilateral action and programs

Time line: 2003–2004

Participants:

Luis Ernesto Aguilar Rosas, Porfirio Alvarez Torres, Richard Charette, David Antonio Fuentes Montalvo, Pamela F. Hall, Eileen Henniger, Jim Houston, Tom Morris, Fredrika Moser, Marshall Myers, Steve Oberholtzer, Oscar Ramirez Flores, Marie-Jose Ribeyron, Daniel Robledo, Mark Sherfy, Cathleen Short, Paul Zajicek

Chair: Chris Wiley

Facilitators/Rapporteurs: Darlene Pearson, Ignacio Gonzalez, Lourdes Juarez

Prevention and Control Mechanisms: Voluntary Measures Breakout Group

Goal:

- improve management practices and consumer behavior
- minimize the probability of the establishment of exotic species at minimal cost

Needed to Measure Success:

- Establish a baseline (survey) including:
  - research on codes of conduct, the number of those in the industry that use them, the number of consumers who know about codes of conduct, etc.
  - research on how many consumers and government official know about the problems of invasives
  - repetition of surveys in the medium and long-term to understand how behavior/knowledge of players has changed

Partners:

- industries associated with the four main invasive pathways or vectors
- partner with agencies to gather existing polls/surveys and to conduct new ones to fill the gaps
- e.g., DFO, SAGARPA, NABIN, GISP, NOAA Sea Grant

Obstacles to Overcome:

- lack of appropriate technology (those required for codes of conduct)
- (in the past) there was a need for cheap protein (MX)
- market demand for exotic species
- public awareness
- cultural biodiversity
- transboundary nature of the problem and the lack of cooperation among the three countries
- lack of financial resources

Available Resources:

- some technologies already exist or are on the way to being developed
- information on biodiversity, invasive species, pathways (e.g., databases)
- experts and expertise in Canada, Mexico and the United States
- codes of conduct and best practices already exist

Additional Resources Needed:

- funds for research (R&D)
- political sensitivity about the invasives issue

- collaboration among the three countries
- network of excellence (NEC) to increase cooperation among continental universities

Action Items (to facilitate cooperation among experts, institutions and industry):

- prepare a standardized PowerPoint presentation ready to be downloaded and adapted to local purposes,
- present information on invasives and codes of conduct, regulations, and public behavioral guidelines, etc. at the trade shows of the 4 pathway industries or vectors (shipping, aquaculture, aquarium, live bait),
- contact the industry associations of the 4 pathways,
- CEC as a clearinghouse for information (e.g., through a listserve),
- convince the big wholesalers to host some of this information on their web sites (e.g., codes of conduct),
- compile industry specific codes of conduct and regulatory experiences, and store these in an online database,
- compile routes of dispersion by pathway of distribution,
- compile poster/pamphlet material and put on web site
- conduct baseline and follow-up surveys of industry and the public regarding its knowledge and use of codes of conducts
- identify economic incentives to encourage public and industry participation
- measure compliance costs and competitiveness effects of each economic incentive identified

Participants:

Juan Jose Alfaro, Edward Black, Ron Dermott, Sharon Gross, Hector Espinosa, Edwin Grosholz, Darrell L. Harris, Roberto Eduardo Mendoza Alfaro, Marshall Myers, Kathy Short,

Chair: Sergio F. Monroy

Facilitators/Rapporteurs: Chantal Line Carpentier, Zachary Patterson

Public Awareness Development Breakout Group

Goal:

Raise public awareness concerning the threats and consequences (both ecological and economic) of aquatic invasive species, and the potential actions that can be taken to change the attitudes and behaviors of society.

Guiding Principles:

Actions should develop a coherent message based upon best available scientific information taking into account the regional context of the situation.

Funding Agencies

- elected officials
- policy makers
- nongovernmental organizations
- general public
- private sector
- mass media

Objective 1: Coordinate a mass media campaign to help change society's attitudes and actions

Action Items:

- develop a common and accurate message of the issue and its potential solutions by gathering a pool of scientific writers, editors, heads, association of writers to;
- build on existing resources (e.g., SeaWeb) to develop the media's ability to get an accurate message out to the public. (This could be done by way of a resource base for the media);
- target economic reporters to bring to the forefront the actual and potential financial and socio-economic consequences associated with aquatic invasive species;
- gather nongovenmental organizations, academics, specialists, and communication experts to develop: mass media messages targeted to the characteristics of the three countries; communication tools (e.g., brochures, comic books, posters) related to common trinational challenges and issues;
- ensure adequate media involvement in the release of agreements, resolutions, and manifestos concerning aquatic invasive species; and
- identify champions to spearhead public awareness and educational efforts.

Objective 2: Develop and strengthen networks of stakeholders involved in and concerned about the aquatic invasive species issue

Action Items:

- organize workshops, list serves etc. to facilitate communication and the exchange of information within and between the sectors
- create an action directory.

Objective 3: Encourage public participation and involvement in actions to prevent, control and eradicate aquatic invasive species

Action Items:

- share the lessons learned from successful projects
- encourage the funding of student exchange programs

Potential Catalytic Areas for Collaboration:

- community involvement (NAFEC)
- clearing house mechanisms
- cross-sectoral think tanks

Recommendations for Informatics, Prediction and Modeling:

- develop priorities for species and pathways of concern related to aquatic invasive species

Participants:

Gabriela Chavarria, Maurice Crawford, Gretchen Fitzgerald, Monica Herzig-Zurcher, Roberto Gallardo Alaniz, Patricia Gallaugher, Jennifer Nalbone, Charles R. O'Neill Jr.

Chair: Francine MacDonald

Facilitators/Rapporteurs: Janice Astbury, Tara Wilkinson, Karen Schmidt

III. Call to Action and Workshop Recommendations to the CEC

Call to Action and Workshop Recommendations

No country is self-sustaining. We all depend on goods and services from afar. While the globalization of trade, travel, and transport has certainly brought social and economic benefits to many, it has also brought new challenges. Invasive species are one of these challenges.

Invasive species are non-native species whose introduction does or is likely to cause economic or environmental harm or harm human health.

One study indicates that invasive species already cost the United States more than $100 billion a year. However, the costs to the society worldwide are measured not just in currency, but also in unemployment, damaged goods and equipment, power failures, food and water shortages, environmental degradation, loss of biodiversity, increased rates and severity of natural disasters, disease epidemics, and even lost lives.

The prevention and control of invasive species presents scientific, political, and ethical challenges. The process of invasion is often complex, resulting in considerable scientific uncertainty. Invasive species are in part a symptom of land use and climate change, as well a result of increasing trade, travel, and transport. Implementing effective prevention and control measures will be costly and require new approaches, as well as significant advances in ecological knowledge and natural resource management.

The three countries of North America all consider invasive species a substantial concern. However, they are at different stages in their efforts to address the problem, apply relevant laws differently, and do not have the same technical capacities or level of financial resources. A trilateral approach to the prevention and control of invasive species could enable all three countries to make the issue a significant priority, develop mutually supportive legal and policy frameworks, share information and technical capacity, and use limited resources efficiently. Through trilateral cooperation, the region could address current problems and develop strategies to prevent new ones in a more timely manner. Because invasive species can spread quickly, the ability to respond rapidly to new invasions is often the key to successful eradication and cost minimization.

As a trinational organization that deals with both the public and private sectors, the CEC is well poised to facilitate the development and implementation of a regional approach to addressing the invasive species problem. Established to steward the implementation of the side accord to the North American Free Trade Agreement – the North American Agreement on Environmental Cooperation – the role of the CEC is to foster cooperation among the three NAFTA partners in responding to the challenges and seizing the opportunities that the continent-wide open market presents to the job of protecting the North American environment.

On 28–30 March 2001 the CEC convened in Montreal, Quebec, the first North American workshop to identify cooperative opportunities on "Preventing the Introduction and Spread of Aquatic Invasive Species in North America." This workshop primarily addressed intentional introductions, aquaculture and live bait, and benefited from the participation of experts and decision-makers from government agencies, industry, NGO's and academia.

Based on the results of this workshop, the CEC recommends five priority areas for cooperation in North America on invasive species:

1. Develop a North American Invasive Species Information Network and create a North American hub for the Global Invasive Species Information Network (GISP);
2. Create a regional directory of legal and institutional frameworks relevant to the prevention and control of invasive species. This directory will cover both regulatory and voluntary measures (e.g., codes of conduct), and include a list of invasive species already regulated by one of more of the three countries;

3. Identify invasive species and invasion pathways that are a concern of two or more countries and determine priorities for bi- or tri-lateral cooperation;
4. Develop and distribute tools for raising awareness of the issue and empowering policy makers, environmental educators, science writers, resource managers, and other audiences to address it; and
5. Identify tools to provide economic incentives to industries and other private stakeholders that voluntary take actions to prevent the introduction and minimize the spread of invasive species.

In order to fully implement these priorities, the CEC will need to immediately begin to link invasives into CEC's other program areas, expand the capacity of the North American Biodiversity Information Network (NABIN) to serve as the backbone for the North American Invasive Species Information Network, develop strong relationships with other regional organizations relevant to invasive species issues, and develop and strengthen relationships with intergovernmental bodies and international organizations addressing invasive species on a more global level.

Background

The CEC's Baseline Report, *Securing the Continent's Biological Wealth: Towards effective biodiversity conservation in North America*, has identified invasive species as an urgent problem of particular concern. It recommended the CEC focus on invasive species that are likely to have a direct effect in all three countries, or affect migratory species that move between the three nations (Recommendation 6). Other recommendations by the CEC's stakeholders support processes through which invasive species problems can be addressed.

Last March (28–30), CEC cooperated with the Canadian Department of Fisheries and Oceans (DFO), The Secretariat of Environment and Natural Resources (SEMARNAT), Transport Canada, and the US National Oceanic and Atmospheric Administration (NOAA) to hold a workshop on aquatic invasive species, with a particular emphasis on preventing the movement of invasives along trade pathways.

Action Item 5.7 of the draft, *The CEC Strategy for the Conservation of Biodiversity in North America*, (hereafter, Strategy) calls for the CEC to promote the development of concerted efforts to combat invasive species in North America. Furthermore, all 14 ecological regions identified in the Strategy as areas for priority cooperation have been impacted by invasive species.

Introduction

Problem Definition

The world is crisscrossed with an increasingly expanding network of "pathways." By air, sea, and land, people are moving themselves and their products further and faster than ever before.

People purposely transport plants, animals, and other organisms internationally for a variety of reasons. For example, animals serve as food or pets. Plants provide new crop varieties, timber for housing, and ornamentals for gardening. Microbes are used to combat disease, drugs, and agricultural pests.

People also unintentionally move living organisms that unwittingly become "hitch hikers" and "stowaways." For example, insects sometimes infest wood packaging materials, barnacles attach to the hulls of inter-continental ships, and microbes might live in the dirt stuck to the bottom of a tourist's shoes. Anytime someone travels internationally or purchases something that originated overseas, there is a chance that they helped give a living organism a "free ride" from one place to another.

Free rides? Not really. The long-term costs society pays for relocating certain plants, animals, and other organisms around the world—purposefully and unintentionally—have the potential to outweigh the direct economic benefits derived from a specific commodity's trade and transport.

Most of the organisms purposely moved around the world are meant for domestic uses—agriculture, livestock, gardening, pets, etc. Some of these organisms "escape" captivity or are carelessly released into the environment. In most cases, these organisms and those that are unintentionally imported (esp., animals) probably don't survive long because they are ill adapted to their new locations. Typically, those that do survive don't cause serious problems.

However, about 1 out of every 1000 organisms introduced into a new environment thrive. They reproduce, spread, and cause serious harm. These organisms are collectively known as "invasive species."

Invasive species are organisms (plants, animals, or other organisms) that have been moved from their native habitat to a new location where they cause significant harm to (or significantly threaten) economic systems, the environment, or human health.

Pathways are the means of transport and routes by which an invasive species is moved from one location to another.

Impacts of Invasive Species

Society pays a great price for invasive species—costs measured not just in currency, but also unemployment, damaged goods and equipment, power failures, food and water shortages, environmental degradation, loss of biodiversity, increased rates and severity of natural disasters, disease epidemics, and lost lives.

Invasive species are one of the most significant drivers of environmental change globally. Even the best-protected natural areas are not immune to the invasion of non-native species. Approximately 50 per cent of the species listed as Threatened or Endangered under the US Endangered Species Act have been negatively impacted by invasive species.

Invasive species can also take a heavy economic toll on governments, industries, and private citizens. A recent study estimates that invasive species already cost the United States more than $100 billion a year. The control of a single species can carry a price tag in the millions. For example, the United States and Canada are spending $14 million a year to control sea lampreys in the Great Lakes. The Formosan termite costs an estimated $300 million in property damage annually in the city of New Orleans, Louisiana.

Costs from invasive species are also incurred when specific commodities or transport systems are affected. The spread of invasive species increases the probability that countries will not be able to:

- sell certain food products because their trade and transport may spread destructive pests and highly infectious diseases that kill agricultural crops, livestock, or people;
- sell certain types of other commodities (e.g., horticultural products, seeds, and pets) because countries fear that they will escape into the environment, causing irreversible harm and requiring expensive, long-term control; or
- use certain types of shipping containers because their trading partners fear that, upon arrival, they will inadvertently release pests that will destroy agricultural, forestry, or fisheries systems or the natural environment.

Invasive species can impact the health of humans and domestic animals. Pathogens and parasites may themselves be invasive species or may be introduced by invasive vectors. Bubonic plague, spread by non-native rats carrying infected fleas, is a well-known historic example. Recently, foot-

and-mouth disease has become a significant concern in many regions of the world. Cholera and some of the microorganisms that can cause harmful algal blooms in North America and other areas are relocated and released in the ballast water carried by large ships. Imported red fire ants cause painful and potentially deadly stings to humans, livestock, and pets in the southern United States.

Challenges and Opportunities

The prevention and control of invasive species presents scientific, political, and ethical challenges. The process of invasion is often complex, resulting in considerable scientific uncertainty. Invasive species are in part a symptom of land use and climate change, as well a result of increasing trade, travel, and transport. Implementing effective prevention and control measures will be costly and require new approaches, as well as significant advances in ecological knowledge and natural resource management.

Because every country is an exporter and importer of goods and services, every country is also a facilitator and victim of the invasion of non-native species. Furthermore, today's marketing mottos include words like "new," "more," and "better." Exotic things and exotic places are "in." We are adding more lanes to and raising the speed limits on the invasive species "pathways." As demands for international trade, tourism, and travel increase, minimizing the spread and impact of invasive species will become more challenging.

Invasive species are not only moved, they move themselves. They can hop, fly, or swim across jurisdictional boundaries. Thus, once invasive species become established within one country, they pose a threat to an entire region, as well as trading partners and every country along a trading pathway.

Few countries have invested in the development of well-coordinated policies and programs to address the problem. Developing countries that recognize the gravity of the situation and want to take immediate action are hampered by a lack of scientific, technological, and financial resources. Efforts of most governments to address invasive species problems are poorly coordinated. Neighboring countries are often unaware of each other's policies and practices.

Methods to limit the spread of invasive species can be controversial on ethical grounds. Some animal rights groups oppose the eradication of invasive species, especially large mammals. Human health concerns arise over the application of certain pesticides, such as the use of DDT to control mosquitoes in malaria-infested regions. Some scientists and environmental groups worry that biological control agents (living organisms imported to control pests) pose risks that may exceed those of the invasive species already in place.

Country Perspectives

North American countries have only recently begun to realize the broad scope and significant impact of the invasive species problem. They are just beginning to take concerted steps to prevent and control invasive species in a strategic and holistic manner. These steps are not yet adequate as many new outbreaks of invasive species are discovered within their borders every year. The associated environmental, economic, and human health costs continue to rise.

Mexico

In a recent report to the Convention on Biological Diversity, the Mexican Government, through the National Commission on Biodiversity (CONABIO), stated that invasive species are an important problem for Mexico, but the government faces several challenges in addressing the issue. These challenges include: 1) a very restricted budget to cope with the threat; 2) limited knowledge of invasive species, mainly restricted to those species of special concern; 3) risk assessments are

limited to a few invasive species of particular concern; and 4) infrastructure and technical capacity not sufficient to effectively deal with the problem. The authority that deals with the invasive species issues is the National Commission of Agricultural and Animal Health (CONASAG); its main focus has been on diseases and plagues affecting the agricultural sector. The role of CONABIO has increased, particularly as it develops a national clearinghouse of invasive species, and as an important partner of the North American Biodiversity Information Network (NABIN). CONABIO is the Mexican agency currently engaged in international environmental forums dealing with invasive species.

United States

In 1993, a study released by the US Office of Technology Assessment (OTA) concluded that invasive species are a major environmental and economic burden for the United States and that there are significant gaps in the federal laws to regulate invasive species.

Over the next few years, hundreds of scientists, resource managers, State officials, private interest groups, ranchers, and many others wrote to federal officials, urging the United States government to consider invasive species a priority and to develop a coordinated national effort to address the problem. In 1999, the United States responded with the Executive Order on Invasive Species (13112), creating an interagency coordination body (The National Invasive Species Council, NISC) and a non-Federal stakeholders group (The Invasive Species Advisory Committee). The Executive Order calls for the United States to release a national invasive species management plan every two years. The first Plan ("Meeting the Invasive Species Challenge") was released on 18 January 2001 and strongly emphasizes the need for international cooperation and capacity building. The 10 governmental Departments currently comprising the Council are in the process of implementing the Plan's 57 action items.

Canada

Invasive species are also a significant concern for the government of Canada. Currently, various ministries and agencies manage domestic and international invasive species issues in Canada, depending on the type of invasive species and the sector they impact. However, Canada is currently trying to gain support and explore mechanisms for uniting the various provincial and federal agencies working on invasive species. In order to raise awareness of the problem and the need for a well-coordinated response, Environment Canada is in the process of developing an invasive species fact booklet that will be available to all levels of Canadian government. Canadian officials recently informed the United States that they intend to post the US Plan on their website and solicit online feedback from federal and provisional agencies involved with invasives species on how it could: 1) be tailored to Canadian interests, 2) be developed into a bilateral document, or 3) provide a Canada-United States framework for a multinational effort.

Urgent Need for a Regional Approach

Like many environmental problems, the impacts of invasive species can have a cascading or ripple effect that is first felt locally, then nationally, and ultimately regionally. However, unlike many other environmental problems, invasive species have the ability to move themselves. They can spread rapidly and often in unpredictable patterns. They do not respect jurisdictional boundaries.

Thus, once invasive species become established within one country, they pose a threat to an entire region, as well as trading partners and every country along a trading pathway. The ability of one country to prevent new invasions depends greatly upon the capability of other countries to effectively manage invasive species and invasion pathways domestically.

Clearly, no country will be able to succeed in addressing its domestic invasive species problems, unless it activity engages in international cooperation and invests in strategies that raise the capacity of other nations to manage invasive species.

The three countries of North America all consider invasive species a significant concern. However, they are at different stages in their efforts to address the problem, apply relevant laws differently, and do not have the same technical capacities or level of financial resources. A trilateral approach to the prevention and control of invasive species could enable all three countries to make the issue a significant priority, develop mutually supportive legal and policy frameworks, share information and technical capacity, and use limited resources efficiently. Through trilateral cooperation, the region could address current problems and develop strategies to prevent new ones in a timelier manner. Because invasive species can spread rapidly, the ability to respond quickly to new invasions is often the key to successful eradication and cost minimization.

Recognizing the needs and opportunities for a regional approach to the problem, the US Plan calls for the development of a North American Strategy on Invasive Species:

"By December 2001, the Council will outline an approach to a North American invasive species strategy, to be built upon existing tripartite agreements and regional organizations, and initiate discussions with Canada and Mexico for further development and adoption."

Under the Plan, the United States has also committed to fund and coordinate seven regional workshops on invasive species in other parts of the world. These workshops are being conducted in cooperation with local government co-hosts and the Global Invasive Species Programme (GISP). Each of these workshops will provide the foundation for development of a regional strategy on invasive species. Workshops have already been held for the Nordic-Baltic region (May 2001) and Mesoamerica and the Caribbean (June 2001). The remainder will take place in South America (Oct 2001), Southern Africa (2002), the Austral-Pacific (2002), Western Africa (2002), and South-Southeast Asia (2002).

The CEC Strategy concludes that "Since invasive species already exact a large toll on North American biodiversity, and because effective measures to control potential future invasions are not yet adequate, a (regional) strategy to effectively address major threats to biodiversity must include steps to prevent and combat such introductions. Continental-wide screening, detection and monitoring, early warning systems, joint emergency responses, and quarantine measures need to be developed. Furthermore, the role of travel and North American trade in the spread of invasives must be thoroughly investigated."

It is important that a North American strategy on invasive species not only address the issues of prevention and control within and among the three countries, but that it also reflects the need for the countries of North America to work closely with other regions of the world. There are three primary reasons why external linkages must be a fundamental component of the North American strategy:

- North America's worst invasive species originate in other regions of the world and the solutions to address the problem may thus lie elsewhere.
- Organisms native to North America have the potential to, and occasionally have, become invasive in other regions. Clearly, there is a need for us to share our information and expertise.
- Despite intentions to be helpful, we have inadvertently facilitated the introduction of invasive species to other regions through development assistance programs, military operations, famine relief projects, and international financing. Therefore, we have a responsibility to ensure that our international programs do "more good than harm."

The CEC Role

As a trinational organization that deals with both the public and private sectors, the CEC is well poised to deal with the invasive species issue. Established to steward the implementation of the side accord to the North American Free Trade Agreement—the North American Agreement on Environmental Cooperation—the role of the CEC is to foster cooperation among the three NAFTA partners in responding to the challenges and seizing the opportunities that the continent-wide open market presents to the job of protecting the North American environment.

The CEC has implemented a number of trinational biodiversity initiatives that could incorporate invasive species projects or on which invasive species projects could be built. These initiatives include the North American Biodiversity Information Network (NABIN), the Ecological Regions of North America, the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities in the Gulf of Maine and the Bight of California, and the North American Bird Conservation Initiative (NABCI). In each of these initiatives, the CEC has collaborated with a wide range of partners in order to make available essential information, coordinate efforts, and develop regional strategies. The CEC has consistently played an important role in exploring the links between biodiversity conservation and economic benefits.

The CEC also has the ability to support biodiversity conservation, including projects relevant to invasive species through the North American Fund for Environmental Cooperation (NAFEC).

North American Invasive Species: CEC's Priorities on Aquatic Invasive Species

Workshop on Aquatic Invasives

The CEC recently laid the foundation for a trilateral strategy to address the problem by bringing representatives of the three countries together for a meeting on aquatic invasive species. In coordination with the Canadian Department of Fisheries and Oceans (DFO), SEMARNAT, Transport Canada, and NOAA, the CEC held the meeting on 28–30 March 2001, in Montreal, Canada. The purpose of the workshop was to identify opportunities that the governments in the region could take to prevent and control the spread of invasive species into and within North America's aquatic environments.

Aquatic invasive species were chosen as the initial theme for the CEC's work because wetlands are among the most precious and threatened habitats in North America, the CEC is well-recognized for its work in the freshwater and marine conservation, and there are already a variety of disparate activities within North America to address aquatic invasives, but the programs are not well-coordinated across the region.

Reflecting the particular role and unique mandate of the CEC, the workshop presented the aquatic invasive species challenge as it relates to North American free markets. The fundamental need for regional cooperation to solve the invasive species issue was a key theme of the workshop. The scope and importance of the aquatic invasive species issue, existing capacities and mechanisms to prevent and control aquatic invasions that enter North America via trade-related pathways (e.g., intentional introductions, aquaculture, live bait, shipping, etc.), and case studies from distinct geographical regions of the continent were presented. The main opportunities were discussed under the following categories: 1) Informatics, Prediction, and Modeling; 2) Prevention and Control Measures: Regulatory Mechanisms; 3) Prevention and Control Mechanisms: Voluntary Measures and Engaging the Private Sector; and 4) Public Awareness Development.

Priority Areas for Cooperation

Action Item 5.7 of the CEC Strategy calls for the CEC to promote the development of concerted efforts to combat invasive species in North America. Potential areas for work are identified as: planning efforts; screening; detection and monitoring mechanisms; early warning systems; joint emergency response; information systems; quarantine requirements; methodologies; and technical assistance in order to prevent or control the introduction, movement, and impact of invasive species; as well as assessing the role of travel and trade in the introduction and spread of invasive species.

Participants in the workshop identified a wide variety of actions that could be taken to address the problem of invasive species. The CEC has selected five high priority recommendations for its future work. Initially, these priorities will focus on aquatic invasive species and pathways. In order to become a priority, the recommendations had to:

- fall within the CEC's unique role and mandate;
- provide a clear opportunity to facilitate cooperation, increase capacity, and raise awareness of the problem throughout North America;
- engage public and private stakeholders;
- be catalytic in nature and lay the foundation for other priorities to be accomplished;
- build upon previous CEC projects;
- build upon other existing frameworks and projects within the region;
- draw upon technical expertise within the CEC network; and
- have the potential to build upon and contribute to the work of the Global Invasive Species Programme or other international bodies

Priority 1: Develop a North American Invasive Species Information Network and create a North American hub for the Global Invasive Species Information Network (GISP).

Rationale: All three countries have identified the need to enhance the collection, sharing, analysis, and distribution of data and other information sources. As one of its three top priorities for immediate action, the CEC Strategy aims to ensure accessible information on biodiversity within the region, with NABIN serving as the backbone for this effort. Action 3.4 of the Strategy calls for the development of a North American biodiversity clearinghouse mechanism for issues of common concern.

GISP has already recognized Mexico as a potential hub for the Global Invasive Species Information Network and the US government is granting CONABIO $20K as "seed funds" toward the establishment of this hub.

Priority 2: Create regional directory of legal and institutional frameworks relevant to the prevention and control of invasive species. This directory will cover both regulatory and voluntary measures (e.g., codes of conduct), and include a list of invasive species already regulated by one of more of the three countries.

Rationale: Action Item 5.5 of the Strategy, requires the CEC to promote the compatibility of laws and policies at a continental level concerning the conservation and sustainable use of biodiversity. Action Item 5.6 calls on the CEC to promote the effective implementation of these laws.

The GISP has published a directory of legal and institutional frameworks relevant to invasive species on the global scale. The US Plan requires the National Invasive Species Council to conduct an evaluation of current US legal and regulatory authorities relevant to invasive species.

Priority 3: Identify invasive species and invasion pathways that are a concern of two or more countries and determine priorities for bi- or tri-lateral cooperation

Rationale: Under Action Item 3.1 of the Strategy, the CEC is to foster the development of a regular series of reports that take stock of the condition of the North American environment. Action Item 4.2 calls for the CEC to identify priorities for organizations involved in the management and conservation of biodiversity.

Under its Management Plan, the United States is already implementing projects that address plant propagative material and international assistance as invasion pathways of particular concern.

Priority 4: Develop and distribute tools for raising awareness of the issue and empowering policy makers, environmental educators, science writers, resource managers, and other audiences to address it

Rationale: Under Action Item 3.5 of the Strategy, the CEC will promote public awareness campaigns based on its assessment of environmental conditions in North America. Action Item 4.2 calls for the CEC to design and deliver joint regional initiatives for capacity building and training. Action Item 4.6. states that the CEC is to increase public awareness of biodiversity issues by sharing models and best practices used for public education and outreach.

The GISP has already published a Global Strategy on Invasive Species, a Toolkit of Best Management Practices, a Guide to International Legal and Institutional Frameworks relevant to invasive species, and other products that the CEC could immediately begin to make widely available throughout North America.

Under the US Plan, the National Invasive Species Council is developing both domestic and international education and outreach campaigns. All three governments and some nongovernmental organizations have already developed education/outreach materials that could be utilized and distributed by CEC.

Priority 5: Identify tools to provide economic incentives to industries and other private stakeholders who voluntarily take actions to prevent the introduction and minimize the spread of invasive species

Rationale: Under Action Item 6.5, the CEC is to work with governments to identify the role of incentives in the conservation and sustainable use of biodiversity.

Near-term Opportunities and Challenges

In order to fully implement these priorities, the CEC will need to begin the following processes as soon as possible:

- take action to link invasives into CEC's other program areas thematically and regionally (e.g., marine protected areas, grasslands, law and policy);
- expand the capacity of NABIN to serve as the backbone for the North American Invasive Species Information Network and to provide the capacity to predict and provide rapid reports on new invasions;
- develop strong relationships with other regional organizations relevant to invasive species issues, such as the North American Plant Protection Organization (NAPPO); and
- develop and strengthen relationships with intergovernmental bodies and international organizations addressing invasive species on a more global level (e.g., GISP, CBD, IPPC, RAMSAR, CITES).

Appendices

Workshop Agenda

Aquatic ecosystems around the world are being transformed and degraded by invasive species—plants and animals, including predators, competitors or pathogens, that evolved elsewhere and can consequently invade new areas and outcompete other species. The impacts of these invasive species can be severe, damaging ecosystems and undermining the local economies they support. The increase in global trade raises the risk of aquatic invasive species introductions to the NAFTA countries of Canada, Mexico and the United States. *The purpose of this workshop is to identify North American cooperative opportunities, which will help to prevent and control the spread of aquatic invasive species into and within North America.*

Given the particular role and unique mandate of CEC, the workshop will present the aquatic invasive species challenge as it relates to North American free markets. Regional cooperation and its fundamental role to solving the invasive species issue will be a key theme of the workshop. The scope and importance of the aquatic invasive species issue, existing capacities and mechanisms to prevent and control aquatic invasions which enter North America via trade-related pathways (e.g., intentional introductions, aquaculture, live bait, etc.), and case studies from distinct geographical regions of the continent will be presented. Based on these presentations, information gaps, cooperative opportunities and the role of CEC in those opportunities will be identified.

Goal

The goal of this workshop is to establish a common perspective on issues concerning aquatic invasive species, and to identify areas of cooperation by which Canada, Mexico and the United States can address pathways of introduction of aquatic invasive species into coastal and freshwater ecosystems. Trade-related pathways, with an emphasis on intentional introductions, aquaculture and live bait, the importance of regional cooperation and the added value that CEC can bring in that cooperation will be the main themes of the workshop.

Objectives

- discuss the current status as well as identify gaps in scientific knowledge, monitoring and assessment, prevention and control, as well as education and outreach efforts concerning aquatic invasive species;
- facilitate communication and cooperation among the three governments and other entities affected by aquatic invasive species issues, focusing on trade-related pathways and cooperation in the North America;
- identify what CEC can do to bring added value to the ongoing activities related to aquatic invasive species in North America, in particular with respect to intentional introductions, live bait, aquaculture etc.;
- bring the scope and importance of the aquatic invasive species challenge to the attention of more public and private decision makers; and
- develop recommendations to the three governments, industry, and the public as well as discuss possible priorities for cooperation and that will facilitate action to reduce the rate of introduction of aquatic species.

When and Where: **28–30 March 2001**
Intercontinental Hotel
360 St. Antoine Ouest
Montreal, Quebec
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Tel.: 514.987.9900
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Product:

- A publication that communicates the results of the working groups: Framework for Trinational Cooperation (i.e. Workshop Conclusions and Recommendations)

Agenda

DAY 1, 28 MARCH 2001

19:00 to 21:30 Evening reception, including

Welcome(s)

Introductions and a short presentation by CEC expressing their goals/hopes for the workshop.
Janine Ferretti (CEC)

Keynote: Pathways and Impacts of Aquatic Invasive Species
Compelling description of the threat of Aquatic Invasive Species in North America, including related pathways, economic and ecological impacts.
Clifford Lincoln, Member of Parliament, Government of Canada
Salvador Contreras-Balderas, Universidad Autonoma de Nuevo Leon

DAY 2, 29 March 2001
PLENARY SESSIONS[1]

State of the Aquatic Invasive Species Situation in North America

8:30 ***Priority Species and Spaces in North America***
Case studies describing the hardest hit regions, as well as the most destructive aquatic invasive species in North America.
8:30 *Glen Jamieson (DFO)*
8:50 *Pam Fuller (USGS)*

9:10 *Questions*

9:20 ***Engaging Industry: Examples from Aquaculture, Live Bait and Shipping***
This section shall cover in detail the present and potential threats of and actions being taken in the prevention and control of invasive species as they relate to industry.
9:20 *Edward Black (DFO)*
9:40 *Roberto Mendoza (Universidad de Nuevo Leon)*

[1] All presentations are 20 minutes in length, unless otherwise noted.

DAY 2, 29 March 2001 (cont.)

10:00 *Questions*

10:10 Break

10:30 ***Engaging Industry — continued***
10:30 *Ivan Lantz (Shipping Federation of Canada)*
10:50 *Mark Sherfy (US Fish and Wildlife Service)*

11:10 *Questions*

11:20 ***"Informatics, Modeling and Prediction" and aquatic invasive species***
The role of database networks, such as IABIN, FishBase, NODC and NABIN, in aquatic invasive species monitoring, evaluation and predictive modeling. The discussion will also include the use of these tools in public outreach and education, species taxonomy, research and monitoring, as well as prediction.
11:20 *Anthony Ricciardi (Dalhousie University)*
11:40 *Jim Quinn (University of California, Davis)*
12:00 *Laura Arriaga (CONABIO)*

12:20 *Questions*

12:35 Preparation for working lunch

Current Country Programs and Strategies[2]

12:50 ***Prevention, control and management of aquatic invasive species in the three countries***
This section consists of country program and strategy presentations, and will cover topics such as the roles of regulation, voluntary action, management strategies, communication and outreach.
12:50 *Mexican presentation: Porfirio Alvarez (SEMARNAT)*
13:20 *Canadian presentation: Chris Willey (DFO) and Tom Morris (Transport Canada)*
13:50 *US presentation: Cathy Short (USFWS, Co-chair ANSTF)*

14:20 *Questions*

International Perspective for Cooperation

14:40 ***International Imperatives***
This section will describe the history of, as well as need and potential for international cooperation in addressing aquatic invasive species. This will include a description of existing international cooperation efforts working on aquatic invasive species both within and outside North America.
14:40 *Jamie Reaser (NISC), Global Strategy on Invasive Alien Species*

15:00 *Questions*

15:10 Break

[2] 30 minute presentations

DAY 2, 29 March 2001 (cont.)

WORKING GROUP SESSIONS—Part I
Developing a North American Vision: Framework for Cooperation

In this section Working Groups shall be charged with the task of identifying North American regional priorities and opportunities to address the aquatic invasive species threat. A set of questions will guide the discussions in each group.

Working groups convene with a particular area of responsibility:

	Group 1	**Informatics, Prediction and Modeling** *Chair: Ed Theriot (US Army Corps of Engineers)* *Facilitator: Carlos Valdes (CEC)* *Rapporteur: Jurgen Hoth (CEC)*
	Group 2	**Prevention and Control Mechanisms: Regulatory Measures** *Chair: Chris Wiley (DFO)* *Facilitator: Darlene Pearson (CEC)* *Rapporteur: Ignacio Gonzalez (CEC)*
	Group 3	**Prevention and Control Mechanisms: Voluntary Measures and Engaging the Private Sector** *Chair: Sergio Monroy (CANAIPESCA)* *Facilitator: Chantal Line Carpentier (CEC)* *Rapporteur: Zachary Patterson (CEC)*
	Group 4	**Public Awareness Development** *Chair: Francine MacDonald (Ontario Federation of Anglers and Hunters)* *Facilitator: Janice Astbury/Hans Herrmann (CEC)* *Rapporteur: Tara Wilkinson (CEC)*
15:30	Working Groups react to what was covered (or not covered) in keynote presentations as well as to the questions presented. Working Groups start to identify priorities.	
18:00	Adjourn	

DAY 3, 30 MARCH 2001
WORKING GROUP SESSIONS CONTINUED—Part II
Developing a North American Vision: Framework for Cooperation

8:30	Working Groups report to Plenary
9:00	Working Groups develop a strategy that will address the priorities identified from the previous day.
10:30	Break
10:45	Continuation of Regional Action Development
12:00	Working Groups report back to Plenary
13:00	Preparation for working lunch
13:30	Working Lunch ***"Informatics, modeling and prediction" and aquatic invasive species*** *Townsend Peterson (University of Kansas)*
14:00	Wrap-up, conclusions and next steps
15:30	Adjourn

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28–30 March 2001
Intercontinental Hotel, Montreal, Quebec

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