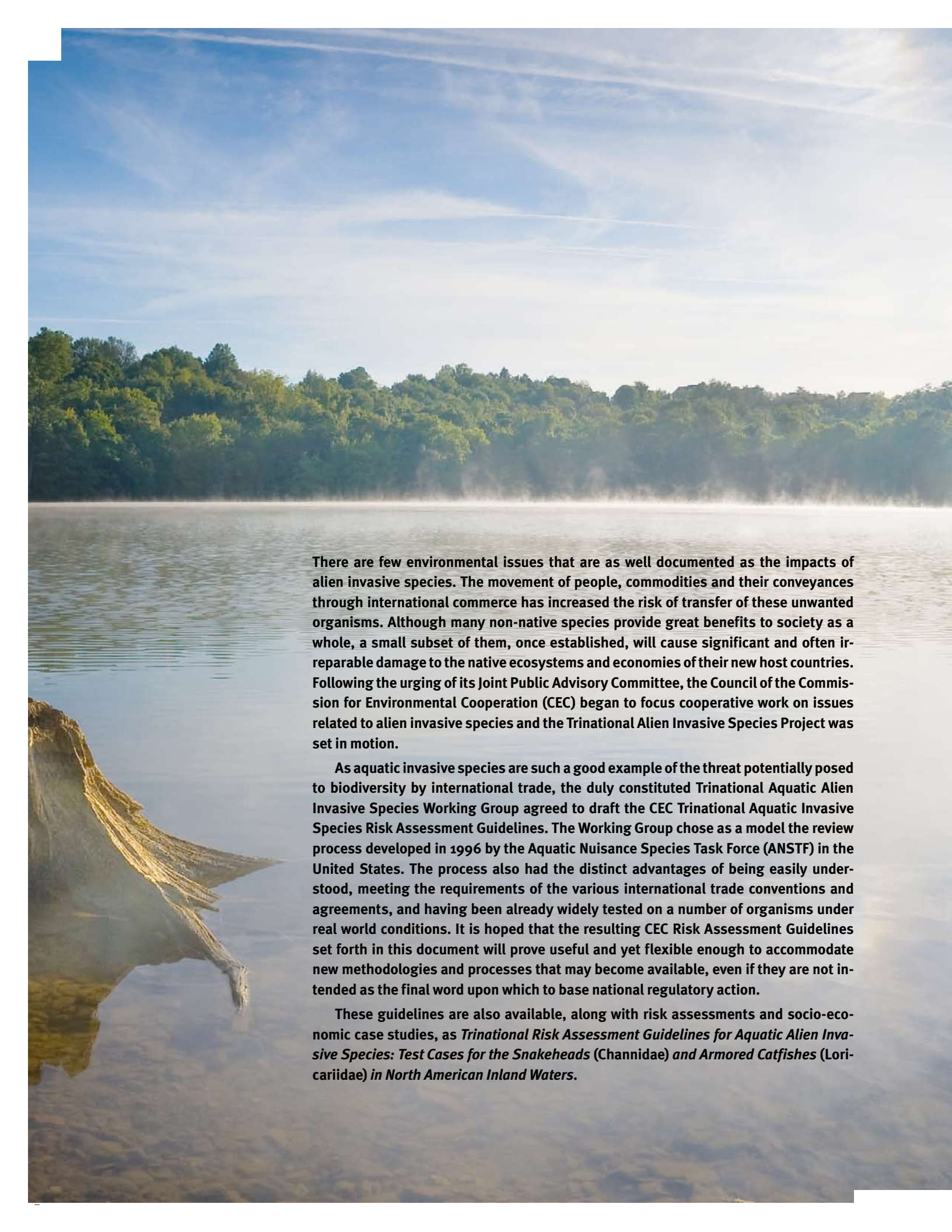




Trinational Risk Assessment Guidelines for Aquatic Alien Invasive Species



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There are few environmental issues that are as well documented as the impacts of alien invasive species. The movement of people, commodities and their conveyances through international commerce has increased the risk of transfer of these unwanted organisms. Although many non-native species provide great benefits to society as a whole, a small subset of them, once established, will cause significant and often irreparable damage to the native ecosystems and economies of their new host countries. Following the urging of its Joint Public Advisory Committee, the Council of the Commission for Environmental Cooperation (CEC) began to focus cooperative work on issues related to alien invasive species and the Trinational Alien Invasive Species Project was set in motion.

As aquatic invasive species are such a good example of the threat potentially posed to biodiversity by international trade, the duly constituted Trinational Aquatic Alien Invasive Species Working Group agreed to draft the CEC Trinational Aquatic Invasive Species Risk Assessment Guidelines. The Working Group chose as a model the review process developed in 1996 by the Aquatic Nuisance Species Task Force (ANSTF) in the United States. The process also had the distinct advantages of being easily understood, meeting the requirements of the various international trade conventions and agreements, and having been already widely tested on a number of organisms under real world conditions. It is hoped that the resulting CEC Risk Assessment Guidelines set forth in this document will prove useful and yet flexible enough to accommodate new methodologies and processes that may become available, even if they are not intended as the final word upon which to base national regulatory action.

These guidelines are also available, along with risk assessments and socio-economic case studies, as *Trinational Risk Assessment Guidelines for Aquatic Alien Invasive Species: Test Cases for the Snakeheads (Channidae) and Armored Catfishes (Loricariidae) in North American Inland Waters*.

Trinational Risk Assessment Guidelines for Aquatic Alien Invasive Species

Richard Orr (1) and Jeffrey P. Fisher (2)*

INTRODUCTION

In 1993, Canada, Mexico and the United States signed the North American Agreement on Environmental Cooperation (NAAEC) as a side agreement to the North American Free Trade Agreement (NAFTA). The NAAEC established the Commission for Environmental Cooperation (CEC) to help the Parties ensure that improved economic efficiency occurred simultaneously with trinational environmental cooperation. The NAAEC highlighted biodiversity as a key area for trinational cooperation. In 2001, the CEC adopted a resolution (Council Resolution 01-03), which created the Biodiversity Conservation Working Group (BCWG), a working group of high-level policy makers from Canada, Mexico and the United States. In 2003, the BCWG produced the “Strategic Plan for North American Cooperation in the Conservation of Biodiversity.” This strategy identified responding to threats, such as invasive species, as a priority action area. In 2004, the BCWG, recognizing the importance of prevention in addressing invasive species, agreed to work together to develop the draft CEC Risk Assessment Guidelines for Aquatic Alien Invasive Species (hereafter referred to as the Guidelines). These Guidelines will serve as a tool to North American resource managers who are evaluating whether or not to introduce a non-native species into a new ecosystem. Through this collaborative process, the BCWG has begun to implement its strategy as well as address an important trade and environment issue. With increased trade comes an increase in the potential for economic growth as well as biological invasion, by working to minimize the potential adverse impacts from trade, the CEC Parties are working to maximize the gains from trade while minimizing the environmental costs.

Objectives of the Guidelines

The objective of the Guidelines is to provide a standardized process for evaluating the risk to biodiversity of introducing aquatic non-indigenous organisms into a new environment.

The Guidelines provide a framework where scientific, technical, and other relevant information can be organized into a format that is understandable and useful to managers and decision makers. The Guidelines were developed to function as an open process with early and continuous input from the appropriate scientific and technical experts.

The Guidelines were designed to be flexible and dynamic enough to accommodate a variety of approaches in evaluating the invasive potential of introduced aquatic species depending on the available resources, accessibility of the biological information, and the risk assessment methods available at the time of the assessment. The Guidelines may be used as a purely subjective evaluation, or be quantified to the extent possible or necessary, depending on the needs of the analysis. Therefore, the process will accommodate a full range of methodologies from a simple and quick professional judgmental process to an analysis requiring extensive research and sophisticated technologies.

The importance of conducting a high-quality risk assessment is that it can provide a solid foundation for justifying corrective action. The specific function of the Guidelines is to present a process that can be used to: (1) evaluate recently established non-indigenous organisms, and (2) evaluate the risk associated with individual pathways (e.g., ballast, aquaculture, aquarium trade, fish stocking, hull fouling, live bait).

The History and Development of the Guidelines

These Guidelines were modified from the US Aquatic Nuisance Species Task Force’s Generic Non-indigenous Aquatic Organisms Risk Analysis Review Process in 1996. The development of these Guidelines have been synchronous with, and functionally tied to, the development of various ecological risk assessments and with the international trade agreements and their associated risk standards. The applicability of these guidelines was recently reviewed (Leung and Dudgeon 2008).

In addition to the above projects and numerous other pertinent works, the following quality criteria (modified from Fischhoff *et al.* 1981) were used in designing the Guidelines:

- **Comprehensive** – The assessment should review the subject in detail and identify sources of uncertainty in data extrapolation and measurement errors. The assessment should evaluate the quality of its own conclusions. The assessment should be flexible to accommodate new information.
- **Logically Sound** – The risk assessment should be up-to-date and rational, reliable, justifiable, unbiased, and sensitive to different aspects of the problem.
- **Practical** – A risk assessment should be commensurate with the available resources.
- **Conducive to Learning** – The risk assessment should have a scope sufficiently broad to carry over value for similar assessments. The risk assessment should serve as a model or template for future assessments.
- **Open to Evaluation** – The risk assessment should be recorded in sufficient detail and be transparent enough in its approach that it can be reviewed and challenged by qualified independent reviewers.

* 1-National Invasive Species Council, Washington, DC; and 2-ENVIRON International Corporation, Seattle, WA

Risk Analysis Philosophy

The risk assessment process allows for analyzing, identifying and estimating the dimension, characteristics and type of risk. By applying analytical methodologies, the process allows the assessors to utilize qualitative and quantitative data in a systematic and consistent fashion.

The ultimate goal of the process is to produce quality risk assessments on specific aquatic invasive organisms, or to evaluate those non-indigenous organisms identified as being associated with specific pathways. The assessments should strive for theoretical accuracy while remaining comprehensible and manageable, and the scientific and other data should be collected, organized and recorded in a formal and systematic manner.

The assessment should be able to provide a reasonable estimation of the overall risk. All assessments should communicate effectively the relative amount of uncertainty involved and, if appropriate, provide recommendations for mitigation measures to reduce the risk.

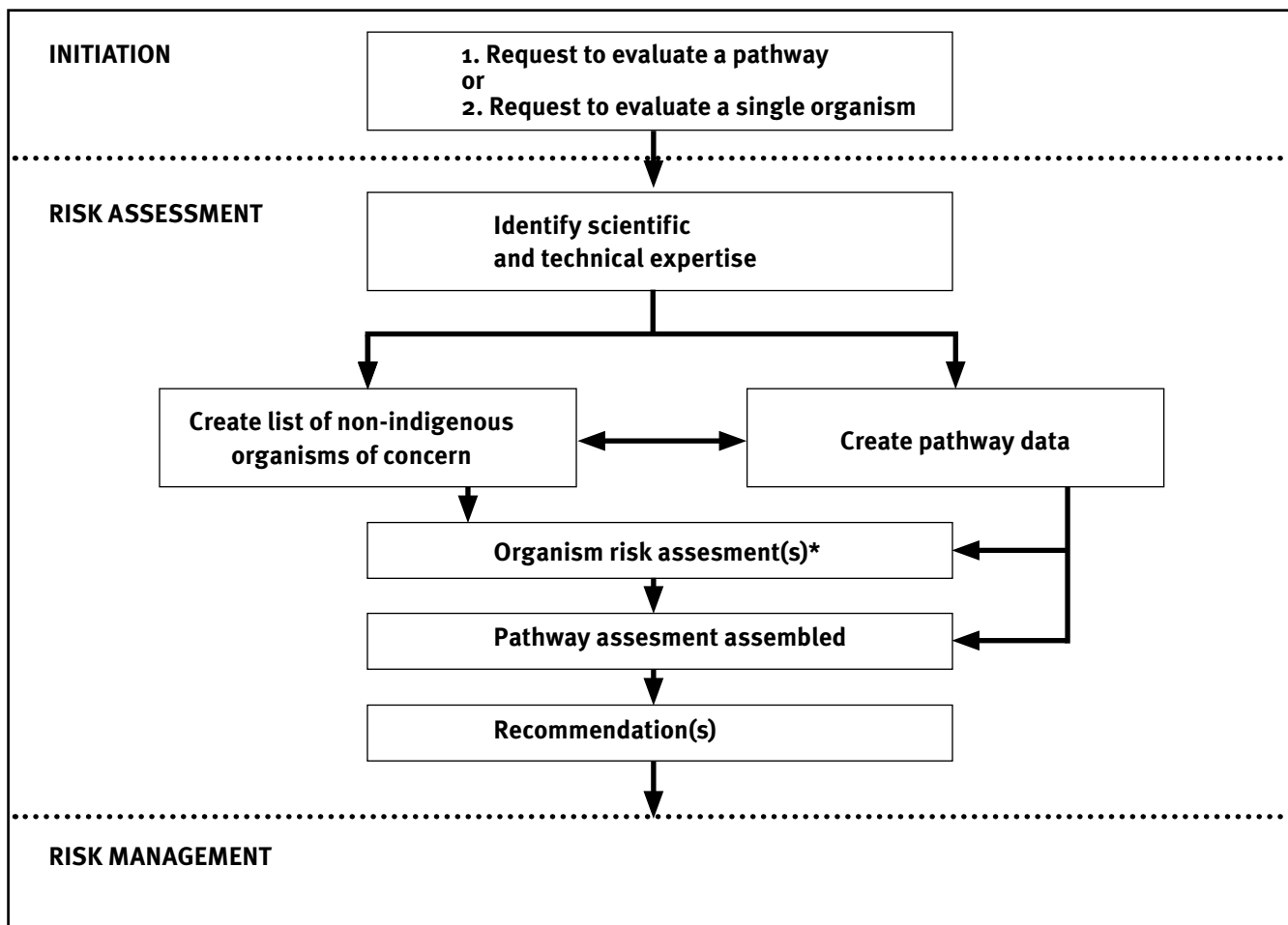
Caution is required to ensure that the process clearly explains the uncertainties inherent in the process and to avoid design and implementation of a process that reflects a predetermined result. Quantitative risk assessments can provide valuable insight and understanding; however, such assessments can never capture all the variables. Quantitative and qualitative risk assessments should always be buffered with careful professional judgment. Goals that cannot be obtained from a risk assessment are:

1. A risk assessment cannot determine the acceptable risk level. What risk, or how much risk, is acceptable depends on how a person, agency, or country perceives that risk. Risk levels are value judgments that are characterized by variables beyond the systematic evaluation of information. Under existing international law each country has the right to set its own acceptable risk level as long as they maintain a degree of consistency in their risk decisions.

2. It is not possible to determine precisely whether, when, or how a particular introduced organism will become established. It is equally impossible to determine what specific impact an introduced organism will have. The best that can be achieved is to estimate the likelihood that an organism may be introduced and estimate its potential to do damage under favorable host/environmental conditions.

The ability of an introduced organism to become established involves a mixture of the characteristics of the organism and the environment in which it is being introduced. The interaction between the organism and receiving environment largely determines whether it fails or succeeds at invading, establishing and/or spreading. These factors cannot necessarily be predicted in advance by general statements based only on the biology of the organism. In addition, even if extensive information exists on a non-indigenous organism, many scientists believe that ecological dynamics are so turbulent and chaotic that future ecological events cannot be accurately predicted.

Figure 1. Risk Analysis Framework



* For details on the Organism Risk Assessment see Figure 2 "Risk Assessment Model." Pathways that show a high potential for introducing non-indigenous organisms should trigger detailed risk analyses.

If all were certain, there would not be a need for risk assessment. Uncertainty, as it relates to the individual risk assessment, can be divided into three distinct types:

- a) uncertainty of the process – (methodology)
- b) uncertainty of the assessor(s) – (human error)
- c) uncertainty about the organism – (biological and environmental unknowns)

Each one of these presents its own set of problems. All three types of uncertainty will continue to exist regardless of future developments. The goal is to succeed in reducing the uncertainty in each of these groups as much as possible.

The “uncertainty of the process” requires that the risk methodologies involved with the Guidelines never become static or routine but continue to be modified when procedural errors are detected and/or new risk methodologies are developed.

“Uncertainty of the assessor(s)” is best handled by having the most qualified and conscientious persons available conduct the assessments. The quality of the risk assessments will, to some extent, always reflect the quality of the individual assessor(s).

It is the most difficult to respond to the “uncertainty about the organism.” Indeed, it is the biological uncertainty more than anything else that initiated the need for a risk process. Common sense dictates that the caliber of a risk assessment is related to the quality of data available for the organism and ecosystem that will be invaded. Those organisms for which copious amounts of high-quality research have been conducted are the most easily assessed. Conversely, an organism for which very little is known cannot be easily assessed.

A high degree of biological uncertainty, in itself, does not demonstrate a significant degree of risk. However, those organisms that demonstrate a high degree of biological uncertainty do represent a real risk. The risk of importing a damaging non-indigenous organism (for which little information is known) is probably small for any single organism but the risk becomes much higher when one considers the vast number of these organisms that must be considered. It is not possible to identify which of the “unknowns” will create problems—only to assume that some will.

The paucity of data does not mean that the organism will have no negative impact, but it also does not mean that it will. Demonstrating that a pathway has a “heavy” concentration of non-indigenous organisms for which little information is present may, in some cases (based on the “type” of pathway and the “type” of organisms), warrant concern. However, great care should be taken by the assessor(s) to explain why a particular non-indigenous organism load poses a significant risk.

This need to balance risks with uncertainty can lead assessors to concentrate more on the uncertainty than on known facts that may affect impact potential. Risks identified for alien invasive species in other regions often provide the justification in applying management measures to reduce risks in other regions where the species have not yet been introduced. Thus, risk assessments should concentrate on evaluating potential risk.

Some of the information used in performing a risk assessment is scientifically defensible, some of it may be anecdotal or based on experience, and all of it is subject to the filter of perception. However, we must provide an estimation of risk based on the best information available and use that estimation in deciding whether to allow the proposed activity involving the non-indigenous organism and, if so, under what conditions.

Assessments should evaluate risk in order to determine the management actions that are commensurate with the identified risks. Estimations of risk are used to restrict, modify or prohibit, high risk pathways, with the goal of preventing the introduction of invasive species.

The following quote is taken from the NRC (1983) Red Book, entitled *Risk Assessment in the Federal Government: Managing the Process*:

We recommend that regulatory agencies take steps to establish and maintain a clear conceptual distinction between assessment of risks and consideration of risk management alternatives; that is, the scientific findings and policy judgments embodied in risk assessments should be explicitly distinguished from the political, economic, and technical considerations that influence the design and choice of regulatory strategies.

This can be translated to mean that risk assessments should not be policy-driven. However, the Red Book then proceeded with a caveat:

The importance of distinguishing between risk assessment and risk management does not imply that they should be isolated from each other; in practice, they interact, and communication in both directions is desirable and should not be disrupted.

This can be translated to mean that the risk assessment, even though it must not be policy-driven, must be policy-relevant. These truths continue to be valid (NRC 1993).

The Guidelines for Conducting Pathway Assessment and Organism Risk Assessments

The need for a risk assessment starts either with the request for opening a new pathway that might harbor aquatic invasive organisms, or the identification of an existing pathway that may be of significant risk. All pathways showing a potential for non-indigenous organism introduction should receive some degree of risk evaluation. Those pathways that show a high potential for introducing non-indigenous organisms should trigger an in-depth risk assessment.

Continuous open communication between the risk managers and the risk assessors is important throughout the writing of the risk assessment. This is necessary to ensure that the assessment will be policy relevant when completed. Risk managers should be able to provide detailed written questions that they need answered to the risk assessors before the risk assessment is started. This will allow the assessors to focus the scientific information relevant to the questions (issues) that the risk managers will need to address.

The following details of the Guidelines focus on evaluating the risk of non-indigenous organisms associated with an identified pathway. Figure 1 outlines the flow of a pathway analysis, dividing the process into initiation, risk assessment, and risk management. Specific organisms needing evaluation which are not tied to a pathway assessment would proceed directly to the “Organism Risk Assessments” box in Figure 1 and the “Organism Risk Assessments” section.

Collecting Pathway Data

Specific information about the pathway must be collected. This information, coupled with additional data would fulfill the “Collect Pathway Data” element in Figure 1.

Specific information needed about the pathway will vary with the “type” of pathway (e.g., ballast water, aquaculture, aquarium trade,

Table 1. Screening Tool

Category	Organism Characteristics	Concern
1a	species non-indigenous, not present in country	yes
1b	species non-indigenous, in country and capable of further expansion	yes
1c	species non-indigenous, in country and reached probable limits of range, but genetically different enough to warrant concern and/or able to harbor another non-indigenous pest and/or introduce risk of hybridization	yes
1d	species non-indigenous, in country and reached probable limits of range and not exhibiting any of the other characteristics of 1c	no
2a	species indigenous, but genetically different enough to warrant concern and/or able to harbor another non-indigenous pest, and/or capable of further expansion and/or introduce risk of hybridization	yes
2b	species indigenous and not exhibiting any of the characteristics of 2a	no

fish stocking). The following generalized list of information has been useful in other non-indigenous risk assessments:

- 1) Determine exact origin(s) of organisms associated with the pathway.
- 2) Determine the numbers of organisms traveling within the pathway.
- 3) Determine intended use, or disposition, of pathway.
- 4) Determine mechanism and history of pathway.
- 5) Review history of past experiences and previous risk assessments (including foreign countries) on pathway or related pathways.
- 6) Review past and present mitigating actions related to the pathway.

Creating a List of Aquatic Invasive Organisms of Concern

One element identified in Figure 1 is the need to “Create List of Non-indigenous Organisms of Concern.” To create such a list, the following generalized process is recommended:

- 1) Determine what organisms are associated with the pathway.
- 2) Determine which of these organisms qualify for further evaluation using the table below.
- 3) Produce a list of the organisms of concern from (step 2) categories 1a, 1b, 1c, and 2a. Taxonomic confusion or uncertainty should also be noted on the list.
- 4) Conduct organism risk assessments from the list of organisms developed in step 3.

Based on the number of organisms identified and the available resources, it may be necessary to focus on fewer organisms than those identified using the above table. When this is necessary, it is desirable that the organisms chosen for complete risk assessments be representative of all of the organisms identified. A standard method is not available because the risk assessment process is often site or species specific. Therefore, professional judgment by scientists familiar with the aquatic organisms of concern is often the best tool to determine which organisms are necessary for effective screening. This screening can be done using alternative approaches. Different approaches can be found in each of the three log commodity risk assessments (USDA Forest Service 1991, 1992, 1993).

Organism Risk Assessment

The Organism Risk Assessment element in Figure 1 is the most important component of the Guidelines used in evaluating and determining the risk associated with a pathway. The Organism Risk Assessment can be independent of a pathway assessment if a particular non-indigenous organism needs to be evaluated. Figure 2 represents the Risk Model that drives the Organism Risk Assessment.

The Risk Assessment Model is divided into two major components: “Probability of Establishment” and the “Consequence of Establishment.” This division reflects how one can evaluate a non-indigenous organism (e.g. more restrictive measures are used to lower the probability of a particular non-indigenous organism establishing itself when the consequences of that establishment are greater).

The Risk Assessment Model is a working model that represents a simplified version of the real world. In reality, the specific elements of the Risk Model are not static or constant, but are dynamic showing distinct temporal and spatial relationships. Additionally, the elements are not equal in weighing the risk, nor are they necessarily independent. The weight of the various elements will never be static because they are strongly dependent upon the non-indigenous organism and its environment at the time of introduction.

The two major components of the Risk Assessment Model are divided into seven basic elements that serve to focus scientific, technical, and other relevant information into the assessment. Each of these seven basic elements is represented on the Organism Risk Assessment Form (Appendix A) as probability or impact estimates. The individual elements may be determined using quantitative or subjective methods.

The strength of the assessment is that the information gathered by the assessor(s) can be organized under the seven elements. The cumulative information under each element provides the data to assess the risk for that element. Whether the method used in determining the risk for that element is quantitative, qualitative or a combination of both, the information associated with the element (along with its references) will function as the information source. Placing the information in order of descending risk under each element will further communicate to reviewers the thought process of the assessor(s).

Adequate documentation of the information sources makes the Guidelines transparent to reviewers and helps to identify information gaps. This transparency facilitates discussion if scientific or technical

disagreement on an element-rating occurs. For example, if a reviewer disagrees with the rating that the assessor assigns an element, the reviewer can point to the information used in determining that specific element-rating and show what information is missing, misleading, or in need of further explanation. Focusing on information to resolve disagreements will often reduce the danger of emotion or a preconceived outcome from diluting the quality of the element-rating by either the assessors or the reviewers.

The specific questions and rationale for each of the Risk Assessment Model elements addressed are listed below. Note: when evaluating an organism that is not associated with a pathway, or an organism recently introduced, the answer to the first two Group 1 questions below would automatically be rated as “high” because entry into the new environment is either assumed or has already occurred.

A. Elements - Group 1: Assess Probability of Organism Establishment

1. Aquatic Non-indigenous Organisms Associated with Pathway (At Origin) – Estimate probability of the organism being on, with, or in the pathway.

The major question inherent to this calculation is: does the organism show a convincing temporal and/or spatial association with the pathway? For example, hull fouling of recreational boats has been shown to provide a viable pathway for the introduction of the zebra mussel into uncolonized waters of North America from the lower Great Lakes, although a different pathway (ballast water) is recognized as re-

sponsible for their initial introduction into the Great Lakes.

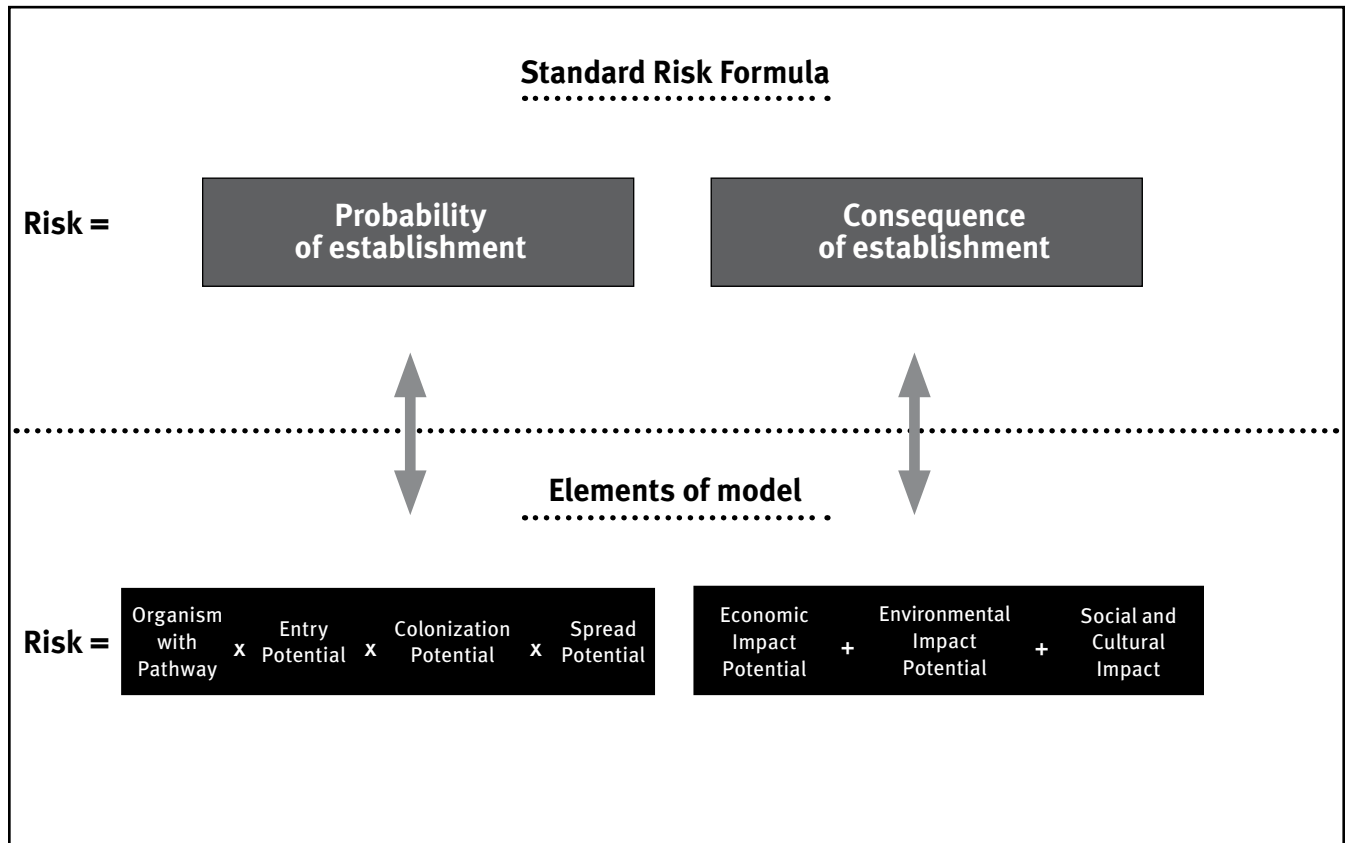
2. Entry Potential – Estimate probability of the organism surviving in transit.

The entry potential considers the probability of that the organism in the pathway could enter (i.e., be released) into the environment of concern. Some of the characteristics of this element include: the organism’s hitchhiking ability in commerce; its ability to survive during transit; the stage of life cycle of the organism during transit; the number of individuals expected to be associated with the pathway; and/or whether it is deliberately introduced (e.g., as a biocontrol agent or for fish stocking). For many species that would be evaluated under these guidelines, the probability of entry would be considered “1” (i.e., 100%). Typical examples would include species released for biological control or sport fishing opportunities such as mosquito fish (*Gambusia spp.*) for mosquito control, and smallmouth bass for recreational fisheries into waters west of the continental divide. In other cases, a species may be intentionally brought into a region where it is not indigenous through commerce, but its probability of entry into the environment is less than 100%. The importation of snakehead fishes in the live food trade represents a typical example of this case.

3. Colonization Potential – Estimate probability of the organism colonizing and establishing a reproductively viable population.

Some of the characteristics that should be considered in this analysis include: the potential for the organism to obtain adequate

Figure 2. Risk Assessment Model



For model simplification, the various elements are depicted as being independent of one another. That is, the order of the elements in the model does not necessarily reflect the order of calculation.

food resources; abiotic and biotic environmental resistance factors (e.g., geographical and temporal associations); propagule pressure—the number of individuals likely to be introduced via the pathway; and, the ability to reproduce or hybridize in the new environment. This qualitative estimation must consider whether the environmental factors, such as water quality, climate, and physical habitat components like temperature, structure, and flow, are within the environmental tolerance limits of the organism to permit a self-reproducing population to be established.

4. Spread Potential – Estimate probability of the organism spreading beyond the colonized area.

Some of the characteristics of this element include: ability for natural dispersal, ability to use human activity for dispersal, ability to readily develop races or strains, and the estimated range of probable spread based on the availability of suitable habitat conditions. For example, Genetic Algorithm for Rule-Set Projection (GARP) modeling considers a variety of climatic variables in the native range of an organism and applies that information to evaluate the potential spread of an organism, or class of organisms, in new environments that may share those climatic conditions. (see Peterson and Viegals 2001, Kolar 2004, and Herborg *et al.* 2007).

B. Elements – Group 2: Assess Consequence of Establishment

1. Economic Impact Potential – Estimate economic impact if established.

Some of the characteristics of this element of the guidelines include: economic importance of hosts, damage to crop or natural resources, effects to subsidiary industries, exports, lost ecological services, and direct control and management costs. Economic impacts may be calculated from direct monetary expenditures that result from the damage caused by the species, such as the costs required to clean water intake lines of zebra mussels. A monetary assessment of the loss of ecosystem goods and services may also be calculated but the uncertainty with these estimates will likely be higher.

2. Environmental Impact Potential – Estimate environmental impact if established.

Some of the characteristics of this element include: ecosystem destabilization or modification or degradation, reduction in native biodiversity from the loss or reduction in quality of preferred habitats, reduction or elimination of keystone species, reduction or elimination of endangered/threatened species, loss or reduction in quality of preferred habitat conditions for native species, and impacts of future control actions. If appropriate, impacts on the human environment (e.g., human parasites or pathogens) would also be captured under this element.

3. Social and Cultural Influences – Estimate impact to social and cultural practices.

Some of the characteristics of this element include: impacts to aboriginal cultures and other cultures of national and regional importance, and social impacts that are not easily captured under the economics elements.

The elements considered in the “Consequences of establishment” box in Figure 2 can also be used to record positive impacts that a non-indigenous organism might have, e.g., its importance as a biocontrol agent, pet, sport fish, scientific research organism, or its use in aquaculture. The elements in the case of deliberate introductions would record information that will be useful in determining the element-rating that provide a balance between the cost, the benefit, and the risk of introducing the non-indigenous organism.

The Organism Risk Assessment Form (Appendix A) should be flexible. Each non-indigenous organism is unique and the assessor needs to have the freedom to modify the form to best represent the risk associated with that particular organism. However, the seven elements need to be retained to estimate the risk. If the assessor feels additional information, ideas, or recommendations would be useful, they should be included in the assessment. The assessor can combine “like” organisms into a single assessment if their biology is similar (e.g., tropical aquarium fish destined for temperate North America).

The number of risk assessments to be completed from the list of non-indigenous organisms in a particular pathway (Figure 1) depends on several factors. These include the amount of information on the organism, the available resources, and the assessor’s professional judgment concerning whether the completed assessments effectively represent the pathways’ non-indigenous organism risk.

The source of the information under each element and the degree of uncertainty the assessor associated with each element needs to be recorded in the Risk Assessment. The use of the Reference Codes at the end of each statement, coupled with the use of the Uncertainty Codes for each element, fulfill these requirements. (Reference Codes and Uncertainty Codes are described in Appendix A.)

Summarizing Organism and Pathway Risk

An estimate of risk is made at three levels in the Guidelines. The first level places a risk estimate on each of the seven elements within the Risk Assessment (element-rating). The second level combines the seven risk element estimates into an Organism Risk Potential (ORP), which represents the overall risk of the organism being assessed. The third level links the various ORPs into a Pathway Risk Potential (PRP), which will represent the combined risk associated with the pathway.

The most difficult steps in a risk assessment are assigning quantitative or qualitative estimates to an individual element, determining how the specific elements in the model are related, and deciding how the estimates should be combined. There is no “correct” formula for completing these steps. Various methods such as geographical information systems, climate and ecological models, decision-making software, expert systems, and graphical displays of uncertainty, may potentially increase the precision of one or more elements in the Risk Assessment Model. Indeed, risk assessments should never become so static and routine that new methods cannot be tested and incorporated.

When evaluating new approaches, it is important to keep in mind that the elements of the Risk Assessment Model are dynamic, and not equal in value. New approaches appropriate for assessing one organism may be immaterial or even misleading in evaluating another organism.

The strength of the Guidelines is that the biological statements under each of the elements provide the raw material for testing various approaches. Therefore, the risk assessment will not need to be re-done to test new methods for calculating or summarizing the ORP and PRP.

On risk issues of high visibility, examination of the draft assessment should be completed by pertinent reviewers not associated with the outcome of the assessment. This is particularly appropriate when the risk assessments are produced by the same agency, professional society, or organization responsible for the management of that risk.

Components of the Final Assessment

- Introduction
- Pathway information
- A complete list of the organisms of concern
- The individual Organism Risk Assessments
- Response to specific questions requested by risk managers
- Summation of the methodology used in determining the ORPs and PRPs
- Summation and responses to outside reviewers

APPENDIX A

Organism Risk Assessment Form

ORGANISM RISK ASSESSMENT FORM

(With Uncertainty and Reference Codes)

ORGANISM _____ FILE NO. _____

ASSESSOR _____ DATE _____

PATHWAY ORIGIN _____ ORIGIN _____

I. LITERATURE REVIEW AND BACKGROUND INFORMATION (summary of life cycle, distribution, and natural history):

II. PATHWAY INFORMATION (include references):

III. RATING ELEMENTS: Rate statements as low, medium, or high. Place specific biological information in descending order of risk with reference(s) under each element that relates to your estimation of probability or impact. Use the reference codes at the end of the biological statement where appropriate and the Uncertainty Codes after each element rating.

PROBABILITY OF ESTABLISHMENT

Element Rating (L,M,H)	Uncertainty Code (VC - VU)	ELEMENTS
_____	_____	Estimate probability of the non-indigenous organism being on, with, or in the pathway. (Supporting Data with reference codes)
_____	_____	Estimate probability of the organism surviving in transit. (Supporting Data with reference codes)
_____	_____	Estimate probability of the organism successfully colonizing and maintaining a population where introduced. (Supporting Data with reference codes)
_____	_____	Estimate probability of the organism to spread beyond the colonized area. (Supporting Data with reference codes)

CONSEQUENCE OF ESTABLISHMENT

Element Rating (L,M,H)	Uncertainty Code (VC - VU)	ELEMENTS
_____	_____	Estimate economic impact if established. (Supporting Data with reference codes)
_____	_____	Estimate environmental impact if established. (Supporting Data with reference codes)
_____	_____	Estimate impact from social and/or cultural influences. (Supporting Data with reference codes)

I. ORGANISM/PATHWAY RISK POTENTIAL: (ORP/PRP) _____

Probability of Establishment Consequence of Establishment = ORP/PRP RISK

II. SPECIFIC MANAGEMENT QUESTIONS**III. RECOMMENDATIONS****IV. MAJOR REFERENCES****REFERENCE CODES TO ANSWERED QUESTIONS**

Reference	CodeReference Type
(G)	General Knowledge, no specific source
(J)	Professional Judgment
(E)	Extrapolation; information specific to pest not available; however, information available on similar organisms applied
(Author, Year)	Literature Cited

UNCERTAINTY CODES TO INDIVIDUAL ELEMENTS

(based as much as possible on peer-reviewed science)

Uncertainty Code	Symbol	Description
Very Certain	VC	As certain as I am going to be
Reasonably Certain	RC	Reasonably certain
Moderately Certain	MC	More certain than not
Reasonably Uncertain	RU	Reasonably uncertain
Very Uncertain	VU	An educated guess

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Commission for Environmental Cooperation

393, rue St-Jacques Ouest, Bureau 200
Montréal (Québec) Canada H2Y 1N9
t (514) 350-4300 f (514) 350-4314
info@cec.org / www.cec.org