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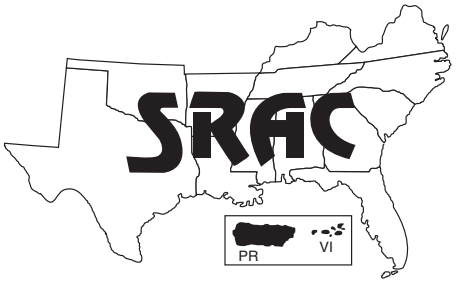


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# Risk Analysis for Non-Native Species in Aquaculture

Jeffrey E. Hill[1]

Many non-native aquatic species have been introduced into the United States. Some benefit society by providing food, recreational opportunities, and the associated socio-economic activity. But some introduced species that have escaped or been released are undesirable additions to aquatic ecosystems because they cause ecological or economic harm or are dangerous to human health. These are called invasive species. Although only a small minority of introduced aquatic species cause serious problems, it is often difficult to predict which species will become problematic. Therefore, the introduction of species outside their native ranges always carries some element of risk.

The risk of culturing a non-native species depends primarily on the probability that individuals will escape and establish in the new region, and on the consequences that would have for native species, ecosystems or humans.

Risk analysis evaluates the risks associated with various human activities, including the risks of introducing non-native species. Although methods differ, the risk analysis process includes assessing, managing and communicating risk. All parts of the process are important, although risk assessment often receives more attention and resources than the other components. Indeed, many agencies tend to concentrate on risk assessment to the detriment of risk management or the communication of risk to affected stakeholders. All three components should be part of a transparent process, because risk analysis deals with exceedingly complex ecological, economic, legal, political and social issues.

This publication examines risk analysis as it relates to aquaculture. For more information on the issue of non-native species in aquaculture; definitions of terms associated with species introductions and their status; and the process of introduction, survival, reproduction and establishment, see SRAC Publication No. 4303, *Introduction to Non-Native Species in Aquaculture.*

## Risk Assessment

Risk assessments usually evaluate risk as a function of the probability that a species will survive, reproduce and successfully establish, and the consequences of that happening. Usually biological information on the species is compiled—including life history, physiology and ecology data—and gaps in knowledge are identified. Information about the climate, habitat and biotic communities of the region into which a non-native may be introduced is also gathered. And likely pathways of introduction are determined.

There can be risk even where a species fails to establish. For example, some species may persist for a long time because of continual releases, or they may be long-lived and survive for years after a single introduction. Although some risk assessment methods do not consider such cases, it is important to consider them.

There are both qualitative and quantitative methods for risk assessment; both are useful and have their place. Although natural resource agencies and scientists favor quantitative methods as being objective and "scientific," most risk assessments are qualitative. Quantitative methods require considerable data on the species and regions of interest, and are therefore time-consuming and expensive. Moreover, there is subjectivity in defining model parameters and in interpreting quantitative methods. Both quantitative and qualitative methods are more effective in modeling the potential for species establishment than in predicting the ecological effects of a given species. Therefore, scientific uncertainty is inherent to all risk assessments. In general, qualitative methods provide considerable insight into risk, while quantitative methods clarify spe-

[1] University of Florida/IFAS Tropical Aquaculture Laboratory

cific questions such as predicting the expansion of a population from an introduction site or identifying characteristics of species that may become invasive.

The most common risk assessment method used for aquatic species in the United States is contained in the *Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process* (hereafter, Generic Analysis; RAM Committee, 1996) developed by the Risk Assessment and Management Committee of the Federal Aquatic Nuisance Species Task Force. Hill and Zajicek (2007) recently reviewed the implementation of this process with some species of interest in aquaculture (e.g., Asian carps). Many management practices have been based on the seven risk assessments described in the paper, including tightened state culture regulations and the federal listing of species as injurious wildlife. Although listing a species as injurious wildlife does not ban its culture, it does make it illegal to import the species into the U.S. or transport it across state lines.

The Generic Analysis risk assessment model is qualitative and considers seven risk elements organized under the probability of establishment (four elements) and the consequences of establishment (three elements) (Figure 1). Each element is assigned a qualitative estimate of risk (low, medium or high) and an estimate of certainty (very certain, reasonably certain, moderately certain, reasonably uncertain and very uncertain). The risk ratings are used to estimate overall risk, but the certainty ratings are included as a qualitative measure of the magnitude and distribution of the scientific uncertainty in the estimates. In practice, certainty ratings are most scrutinized when there is a conclusion of low risk.

To estimate the probability of establishment, it is necessary to estimate the probability of the species 1) being within a pathway of introduction, 2) surviving transit and successfully entering the region, 3) successfully colonizing and maintaining a self-sustaining population, and 4) spreading beyond the initial introduction site. Because each step in the process depends on the success of each preceding step, the overall probability is a conditional probability. A conditional probability is obtained by multiplying the probabilities for individual steps. The calculated value is, therefore, less than that of the lowest probability step. However, the Generic Analysis conservatively assigns the lowest of the four ratings as the overall probability estimate.

The consequences of establishment are based on estimates of 5) economic impact, 6) environmental impact and 7) perceived impacts (i.e., social or political). Because economic and environmental effects were considered most important, the overall rating for the consequences of establishment is primarily based on these two elements. To be conservative, the higher of these two risk ratings is used. Perceived impacts influence the outcome only if economic and environmental risks are both low.

The final output of the risk assessment model is an Overall Risk Potential (ORP), which is the average of the risk ratings for establishment probability and its consequences. To be conservative, these qualitative averages are rounded up (e.g., a low and a medium yields a medium ORP). Medium and high-risk ORP values are considered to require the implementation of risk management programs.

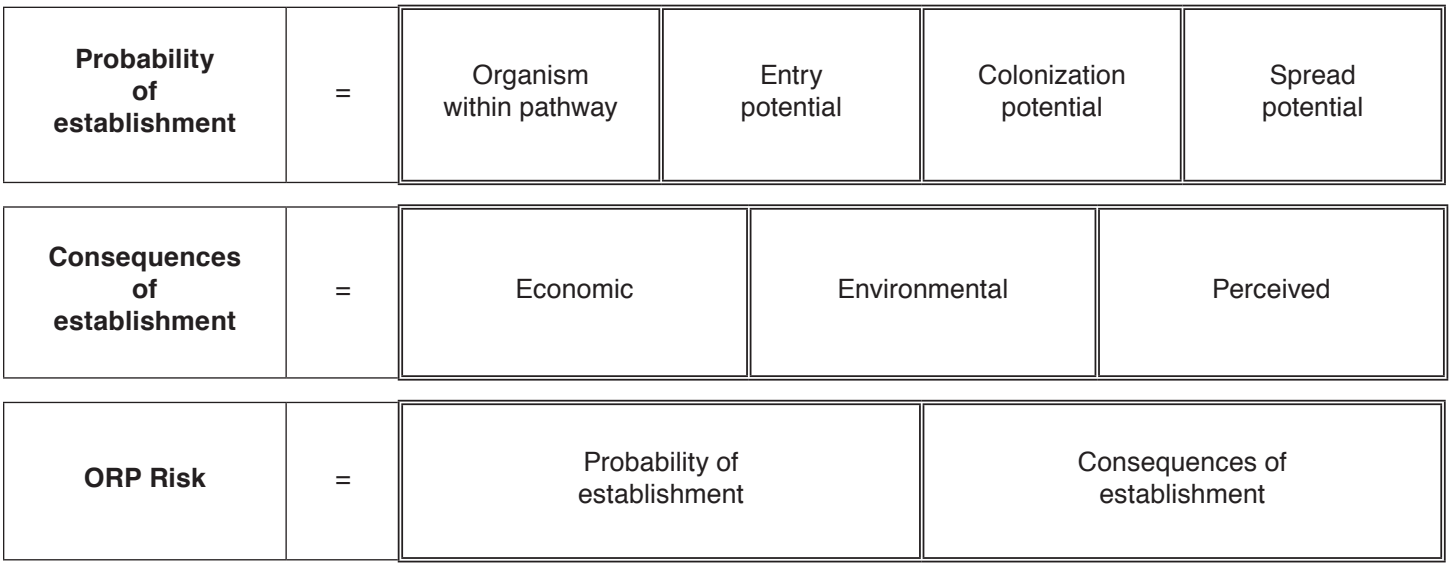


**Figure 1.** Outline of the Generic Analysis risk assessment method. The probability of establishment is the lowest ranking of the four rated elements. The consequences of establishment is the higher of the rankings for economic and environmental impacts; perceived impacts influence the outcome only if economic and environmental risks are low. The Overall Risk Potential (ORP) of an introduced organism is based on the qualitative average of the two main components of the model—probability of establishment and consequences of establishment.

## Risk Management

Once risks are identified, it is important to try to manage them. Management may take many forms, but in aquaculture the most common actions are the tightening of regulations or some form of prohibition. For example, regulation may restrict the type of culture facility used to reduce the probability of escape (e.g., requiring indoor, tank culture). Or, aquaculturists may be required to add reproduction safeguards (e.g., triploidy) to prevent establishment if a species escapes or is released. On the other hand, it might be determined that existing regulations are adequate for managing risk. At the federal level, various risk management plans have been or are being developed for natural resource agencies to use with species of concern; some of these are also of interest to aquaculture (e.g., Asian carps).

Besides adhering to proscriptive requirements, aquaculturists also can be proactive by adopting practices that reduce the risk that non-native cultured species will escape or be released. Aquaculture Best Management Practices (BMPs) generally allow wide latitude for managers at individual facilities to tailor specific features and practices for non-native species containment (e.g., FDACS, 2007). General provisions include using redundant barriers to escape, such as perimeter levees; bird netting; effluents draining through screens, filters, gravel or sand; or retention/detention systems (often stocked with native predatory fish). Human security provisions include fences with locked gates, supervised public visitation, or on-site security. Under BMPs, the producer must comply with all regulations but the overall philosophy is goal-oriented rather than process-oriented. That is, the desired outcome of the regulatory agency is to prevent, or in some cases reduce, introductions of non-native species from a particular facility rather than to mandate specific safeguards. However, agencies may require specific conditions for permitting the culture of some species (e.g., indoor culture only).

**Definitions associated with risk.**

- **Precautionary principle:** A concept whereby uncertainty regarding consequences leads to a decision to forego an activity, even one with benefits, if the consequences might be serious or irreversible.
- **Risk:** The potential for harm to occur. Risk is a function of the probability that an event will occur and the consequences of the event.
- **Risk analysis:** A comprehensive process that includes risk assessment, risk management and risk communication.
- **Risk assessment:** A process for determining the nature, severity and probability of risks.
- **Risk aversion:** The unwillingness to bear or accept risk.
- **Risk communication:** An interactive process of exchanging information among assessors, regulators and stakeholders concerning the nature, severity and probability of risks and options for managing those risks.
- **Risk management:** A process for determining options for managing risks identified by risk assessment.

Hazard Analysis Critical Control Point (HACCP) planning is one approach that shows promise. It clearly links activities on and around the aquaculture facility with the potential for species introduction. This tool was developed for food safety but has been widely applied to prevent the introduction and spread of non-native species. The process identifies critical points where introductions can occur and develops standard procedures for reducing the chance of introduction. For example, if a producer moves live fish from one facility to another, an HACCP plan would address the transport truck, the transfer of fish to and from the truck, and the clean-up of the truck and equipment after transport. The U.S. Fish and Wildlife Service (USFWS) has instituted a program in which hatchery facilities develop and implement HACCP plans. The process is straight-forward and logical, and there are tools and sample plans available on-line at a USFWS-sponsored Web site (*http://www.haccp-nrm.org*). The Michigan and Minnesota Sea Grant Programs have training materials and programs specifically for the aquaculture and baitfish industries that assist in implementing Aquatic Invasive Species-HACCP programs (Gunderson and Kinnunen, 2006).

A goal of risk analysis is to balance the potential risks of an activity against its potential benefits. Risk assessment identifies and estimates risk, but the risk management component is where much of the balancing of risks occurs. Risk management at its best is an interactive process involving not only agencies and scientists but a broad range of stakeholder groups. Indeed, the acceptability of risk is a societal question rather than a scientific question, and therefore requires stakeholder input.

Risk aversion (or sensitivity to risk) is an important factor in determining how to manage risk. As a matter of policy, many agencies subscribe to the precautionary principle, whereby scientific uncertainty about the possibility of risk frequently overrides any consideration of ecological, economic or societal benefit. The application of this principle produces high aversion to risk and, if taken to its logical conclusion, precludes most or all activities involving the introduction or potential introduction of non-native species. This is a concern for aquaculture, given that some broad definitions of introduction include individuals maintained in captivity or under culture. Moreover, it is commonly

claimed that any species in culture will escape captivity, and that the culture of non-native species is synonymous with an authorization to stock these species into the environment. This philosophy severely limits the use of mitigation strategies to reduce risk to an acceptable level because it considers any level of risk unacceptable. For example, several states prohibit triploid grass carp (*Ctenopharyngodon idella*) and the U.S. Fish and Wildlife Service did not accept triploidy as a risk mitigation measure for black carp (*Mylopharyngodon piceus*) because the induction of triploids is not 100 percent effective.

## Risk Communication

When there is open and continuous communication among assessors of risk, managers of risk, regulators and affected stakeholders, risk analysis will be more effective. Some risk analysis schemes do not have a separate component for risk communication but incorporate it into activities carried out under assessment and management. However it is done, obtaining the participation of a broad group of experts and interested parties early in the risk assessment process aids in identifying and describing risks and is vital in subsequently prioritizing and managing risks. Regulation compliance and many other risk mitigation strategies require the education and participation of the public and various stakeholder groups. Outreach and education programs can be important communication components of an effective risk analysis process.

## Summary

Risk analysis is a method of evaluating the risks associated with introduced species, including non-native species used in aquaculture. Most emphasis is placed on risk assessment, which is generally conducted by scientists, but risk management and risk communication are equally important components of risk analysis. Aquaculture research and Extension faculty and industry stakeholders must understand risk analysis and, if possible, participate in the process. These groups can help ecologists and fisheries biologists identify risks and are vital in the development, communication and implementation of risk management options.

## References and Additional Resources


FDACS (Florida Department of Agriculture and Consumer Services). 2007. Aquaculture Best Management Practices Rule. Division of Aquaculture, Florida Department of Agriculture and Consumer Services, Tallahassee, Florida. Available at: *http://www.floridaaquaculture.com/publications/P-01499-booklet-07_BMP_RULE.pdf*

Gunderson, J. L. and R. E. Kinnunen. 2006. AIS-HACCP: Aquatic Invasive Species–Hazard Analysis and Critical Control Point Training Curriculum, 2nd edition. Michigan Sea Grant Publication Number MSG-00-400 and Minnesota Sea Grant Publication Number MN SG-F11. Available at: *http://seagrant.umn.edu/downloads/ais-haccp_manual.pdf*

Hill, J. E. and P. Zajicek. 2007. National aquatic species risk analysis: a call for improved implementation. *Fisheries* 32(11):530-538.

Minnesota Sea Grant AIS-HACCP Web site. *http://www.seagrant.umn.edu/ais/haccp*

RAM Committee (Risk Assessment and Management Committee). 1996. Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process. Aquatic Nuisance Species Task Force, Washington, D.C. Available at: *http://www.anstaskforce.gov/Documents/ANSTF_Risk_Analysis.pdf*

USFWS (U.S. Fish and Wildlife Service). 2004. HACCP Planning for Natural Resource Pathways: Hazard Analysis & Critical Control Point Planning. Available at: *http://training.fws.gov/EC/Resources/pdf/HACCP%20Manual.pdf*



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