The HACCP Approach To Prevent The Spread Of Aquatic Nuisance Species By Aquaculture And Baitfish Operations

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ABSTRACT

The potential exists for aquatic nuisance species (ANS) to spread to uninfested waters through the transport of wild harvested baitfish and aquacultured fish. Baitfish and aquaculture industries are, however, diverse and complex, as are their risks of spreading ANS. Most industry segments pose no or very low risk of spreading ANS. To deal effectively and fairly with this potential vector, it is important to characterize the industry according to their risks of spreading ANS. Without adequate risk assessment of individual operations, regulations could be imposed which would unnecessarily negatively impact the economy of these industries and still not effectively reduce the risk of spreading ANS. One approach to this problem is to apply the Hazard Analysis and Critical Control Point (HACCP) concept similar to that used by the seafood industry to minimize seafood consumption health risks. The advantages of this system are that it can effectively deal with a diverse industry, it has proven to be a good partnership between industry and government regulators, and, if properly applied, it is effective. The HACCP approach concentrates on the points in the process that are critical to the safety of the product, minimizes risks, and stresses communication between regulators and the industry.

INTRODUCTION

Baitfish wild harvest and aquaculture have been identified as vectors for the spread of ANS (Litvak and Mandrak 1993; Ludwig and Leitch1996; Litvak and Mandrak 1999; Goodchild 1999). In fact, some management agencies have closed ANS infested areas to harvest and culture, some states have banned the importation of live bait, and others only allow certified ANS-free bait into their state (Kinnunen 1994). Other regulations restricting the economic viability of the baitfish and aquaculture industries have been proposed. The baitfish industry and aquaculture industries are extremely diverse in the species produced, the market forms of the species, the production systems used, and the water source used (Gunderson and Tucker 2000, U.S. Department of Agriculture 2000). Most industry segments pose no or very low risk of spreading ANS. To deal effectively and fairly with this potential vector, it is important to characterize the industry according to their risks of spreading ANS. Without adequate risk assessment of individual operations, regulations could be imposed which would unnecessarily negatively impact the economy of these industries and still not effectively reduce the risk of spreading ANS. One approach to this problem is to apply the Hazard Analysis and Critical Control Point (HACCP – pronounced has-sip) concept similar to that used by the seafood industry to minimize seafood consumption human health risks.

In December 1995, the Food and Drug Administration (FDA) issued seafood regulations based on the principles of HACCP (National Seafood HACCP Alliance 1997). The FDA issued these regulations to ensure safe processing and importing of fish and fishery products. These regulations specify that someone trained in HACCP perform certain critical jobs in seafood processing. Just as HACCP is used to ensure safe seafood, it can be applied to other business processes to ensure product safety. The Seafood HACCP approach was modified to address the risk that wild harvested baitfish and private and public cultured fish could spread ANS.

The goal of the ANS-HACCP approach is to prevent the spread of ANS while maintaining viable baitfish and aquaculture industries. The ANS-HACCP approach can also be used to certify ANS-free products for those businesses that choose to seek this certification.

Because industry pioneered the HACCP approach and it stresses communication between the industry and resource managers, the approach attempts to strike a balance between overregulation and ignoring the potential for moving ANS. For the ANS-HACCP concept to be adopted as a tool, it must be accepted by both the industry and resource management agencies.

METHODS: THE HACCP APPROACH

HACCP is neither a new term nor a new concept. The Pillsbury Co. pioneered the application of the HACCP concept to food production during its efforts to supply food for the U.S. space program in the early 1960s. Pillsbury decided that their existing quality control techniques did not provide adequate assurance against contamination during food production. The company found that end-product testing necessary to provide such assurance would be so extensive that little food would be available for space flights. The only way to ensure safety, Pillsbury concluded, would be to develop a preventive system that kept hazards from occurring during production. Since then, Pillsbury's system has been recognized worldwide as an effective hazard control. It is not a zero risk system, but it is designed to minimize the risk of hazards (National Seafood HACCP Alliance 1997).

The seven HACCP principles have since been developed and include:

1) Conduct a hazard analysis. Prepare a list of steps in the process where significant hazards occur and describe the control measures.
2) Identify the critical control points (CCP) in the process.
3) Establish controls for each CCP identified.
4) Establish CCP monitoring requirements. Establish procedures for using monitoring results to adjust the process and maintain control.
5) Establish corrective actions to be taken when monitoring indicates that there is a deviation from an established critical limit.

6) Establish procedures to verify that the HACCP system is working correctly.

7) Establish effective record-keeping procedures that document the HACCP system.

The ANS-HACCP concept, if adopted by the industry and resource management agencies, can be used to focus attention on the segments of the baitfish and aquaculture processes that are most likely to pose a risk of spreading ANS. The HACCP approach allows regulators to assess what happens in various baitfish/aquaculture operations and evaluate how potential hazards are being handled. With HACCP, the emphasis is to understand the entire process. This requires the regulator and industry to communicate and work with one another. HACCP is most effective when regulators take the opportunity to review the HACCP plan and evaluate if critical hazards have been properly identified and that individual businesses are consistently controlling these hazards. It is therefore, a shared responsibility of the baitfish/aquaculture businesses and the resource management agencies to develop and implement ANS-HACCP plans.

Hazard Analysis ? Principle 1

To perform a hazard analysis for the development of an ANS-HACCP plan, baitfish harvesters and fish farmers must gain a working knowledge of potential hazards. The ANS-HACCP plan is designed to control all reasonable ANS hazards. Such hazards are categorized into three classes: 1) plants, 2) invertebrates, and 3) fish and other aquatic vertebrates.

Species considered ANS will vary from state to state. Consult with state resource management agencies to determine which species are considered ANS hazards. Aquatic nuisance plant hazards may include plants such as Eurasian watermilfoil (*Myriophyllum spicatum*), water chestnut (*Trapa natans*), hydrilla (*Hydrilla verticillata*), curly leaf pondweed (*Potamogeton crispus*), and purple loosestrife (*Lythrum salicaria*).

Aquatic nuisance invertebrate hazards may include zebra (*Dreissena polymorpha*) and quagga (*Dreissena bugensis*) mussels, Asiatic clam (*Corbicula fluminea*), spiny (*Bythotrephes cederstroemi*) and fishhook (*Cercopagis pengoi*) waterfleas, lumholtzi waterflea (*Daphnia lumholtzi),* rusty crayfish (*Orconectes rusticus*), Chinese mitten crab (*Eriocheir sinensis*), and green crab (*Carcinus maenas*).

Aquatic nuisance fish hazards may include ruffe (*Gymnocephalus cernuus*), round goby (*Neogobius melanostomus*), white perch (*Morone americana*), rudd (*Scardinius erythrophthalamus*), threespine and fourspine stickleback (*Gasterosteus aculeatus* and *Apeltes quadracus*), smelt (*Osmerus mordax*), and Asian carps – black (*Mylopharyngodon piceus*), grass (*Ctenopharyngodon idella)*, silver (*Hypophthalmichthys molitrix)*, and bighead (*Hypophthalmicthys nobilis*). Other aquatic vertebrates could include amphibians or reptiles that may be identified as nuisance species.

Each ANS has a unique life history and characteristics that cause them to be an environmental and economic concern and determines how they can be spread via baitfish and fish raised for stocking. These unique life histories and characteristics must be considered when developing control strategies. The following is a brief description of some of these unique characteristics of plants, invertebrates, and fish that must be considered.

When live fish are harvested from infested waters, there is a risk that ANS can be moved to uninfested waters. These hazards can be transported with the fish, the water, or cling to equipment used in infested waters. Many aquatic nuisance plant species reproduce by plant fragmentation. Small pieces of the plant can settle to the bottom, take root and grow even after being out of water for many days or even weeks in moist, cool conditions. Care must be taken to prevent the transport of viable plant fragments to uninfested waters. In addition, many plants can produce seeds or tubers that can survive long periods before germinating. Movement of dredged material could move viable seeds, tubers, zhizomes, or turions.

Some aquatic invertebrates can produce resting eggs that are resistant to freezing and drying (i.e. spiny and fish hook waterfleas) or produce eggs and larvae that are too small to see without aid of a microscope (i.e., zebra and quagga mussels). Other invertebrates, like zebra and quagga mussels, can attach to boats, equipment, and vegetation and survive out of the water long enough to be moved to other waters. Female crayfish may be able to establish a population even without the presence of a male, because they can carry viable sperm for many months before fertilizing eggs. As a result of these characteristics, aquatic nuisance invertebrates present different challenges for preventing their spread from infested waters.

ANS fish may be found in the waters where other fish are harvested or ANS fish may be cultured. Separating fish or other vertebrate ANS after harvest is difficult and is best accomplished by preventing an infestation in your ponds or facility. Other options include harvesting during times of the year or times of the day when the ANS fish or other vertebrates are spatially segregated. Because fish and other vertebrates may have different body shapes or sizes than targeted species, grading or sorting techniques may be able to reduce the risk of contamination to acceptable levels. ANS fish that are cultured for food (or other purposes) must be contained in the culture environment and prevented from escaping into the wild.

The hazard-analysis step is fundamental to the ANS-HACCP system. To establish a plan that effectively prevents the spread of ANS, it is crucial that all significant ANS hazards and the measures to control them be identified. During hazard analysis, the potential significance of each hazard should be assessed by considering risk (likelihood of occurrence) and severity of environmental impact. Estimation of risk is usually based upon a combination of experience, ANS infestation data, state policies, and information from the technical literature. Severity is the seriousness of a hazard. Assessment of ANS risk and severity will require close communication with resource management agencies and university experts.

It is important to remember that ANS-HACCP should focus solely on significant hazards that are reasonably likely to occur and may result in an unacceptable movement to new waterbodies. Without this focus, it would be tempting to try to control too much and lose sight of the truly relevant hazards. First-time HACCP plan writers, more often than not, identify too many hazards! This is a problem because it can dilute your ability to focus efforts and control the truly significant hazards. The dilemma is finding out and deciding what is significant. A hazard must be controlled if it is: 1) reasonably likely to occur **and** 2) if not properly controlled, it is likely to result in an unacceptable risk of spreading ANS to new waterbodies.

Before beginning the hazard analysis, a flow diagram (Appendix A) must be completed that shows the steps required to grow, harvest, handle, and distribute live baitfish or aquaculture products. This step provides an important visual tool that the ANS-HACCP team can use to complete the remaining steps of the ANS-HACCP plan. The flow diagram should be clear and complete enough so that people unfamiliar with the process can quickly comprehend the operational procedures. Since the accuracy of the flow diagram is critical to conduct a hazard analysis, the steps outlined in the flow diagram must be verified for the baitfish/aquaculture operation. If a step is missed, a significant hazard may not be addressed.

A hazard-analysis worksheet (Appendix B) can be used to organize and document the considerations in identifying ANS hazards. Each step in the process flow diagram should be first listed in column 1. Results of the hazard identification process are recorded in column 2. The risk assessment should be recorded in column 3, with the justification for accepting or rejecting the listed potential hazards stated in column 4. In column 5, list any control measures that can be applied to prevent the significant hazards. Control measures are actions and strategies that can be used to prevent or eliminate an ANS hazard or reduce it to an acceptable level.

An important difference between seafood HACCP and this program is that there are few science-based controls currently available. As a result, control measures are best determined with the help of resource management agencies, Sea Grant, university, college, or other local experts.

Critical Control Points ? Principle 2

For every significant hazard identified during the hazard analysis there must be one or more critical control points (CCPs) where the hazard is controlled. CCPs are points in the process where HACCP control activities will occur. A CCP should be a specific point in the process where application of a control measure effectively prevents, eliminates, or reduces the hazard to an acceptable level. It may not be possible to fully eliminate or prevent a hazard. In some cases and with some ANS hazards, minimization may be the only reasonable goal of the ANS-HACCP plan. Although hazard minimization is acceptable in some instances, it is unacceptable in others. It is important that all ANS hazards be addressed and that any limitations of the ANS-HACCP plan to control those hazards be understood by resource management agencies and the fish farmer or baitfish harvester. When ANS-HACCP plans cannot satisfactorily control ANS hazards, other approaches to prevent the spread will be required.

Many points in the flow diagram not identified as CCPs may be considered control points. A HACCP plan can lose focus if points are unnecessarily identified as CCPs. Only points at which significant ANS hazards can be controlled are considered CCPs. A CCP should be limited to that point or those points at which control of the significant hazards can best be achieved. For example, an ANS plant fragment hazard may be controlled by attempting to avoid infested areas of the lake, by trying to pick each fragment off of a net before leaving the lake, by using equipment only in the infested waters, or by freezing the net for 48 hours before going to uninfested waters. However, trying to avoid infested areas, trying to pick off plant fragments, or freezing the net for 48 hours would not necessarily be considered CCPs if using equipment only in the infested waters best controlled the hazard. Differentiating between CCPs and control points will vary from business to business and depend on their unique operation. When designating CCPs, it is important to consider any applicable state statutes or rules that may dictate the identification of a CCP. For example, if it is illegal to transport an ANS overland, then CCPs must be developed to comply.

Establish Controls — Principle *3*

Controls must be established for each CCP identified in the hazard analysis on the ANS-HACCP plan form (Appendix C). A control represents the boundaries that are used to ensure that a baitfish or aquaculture operation produces ANS-free products. Each CCP must have one or more controls for each significant ANS hazard. When the process deviates from the control limits, corrective action must be taken to ensure an ANS-free product. Examples of controls might be a minimum flow rate and time that baitfish are held in the holding tank to ensure that aquatic nuisance plant fragments are trapped in the outlet filters. In this case, a minimum flow rate and time must be adhered to in order to control the aquatic plant hazard.

In many cases, the appropriate control may not be readily apparent or available. Tests may need to be conducted or information gathered from sources such as scientific publications, regulatory guidelines, experts, or experimental studies. If the information needed to define controls is not available, a conservative value should be selected. The rationale and reference material used to establish controls should become part of the support documentation for the ANS-HACCP plan.

Monitoring — Principle 4

Monitoring is important to ensure that the controls designed to eliminate or minimize ANS hazards are consistently met. Monitoring is the process that the operator relies upon to maintain control at a CCP. Accurate monitoring indicates when there is a loss of control at a CCP and a deviation from a control limit. When a control limit is compromised, a corrective action is needed. Reviewing the monitoring records and finding the last recorded value that meets the control limit can determine the extent of the problem needing correction. Monitoring also provides a record that products were in compliance with the HACCP plan.

Control measures are intended to control the hazards at each CCP. Monitoring procedures are used to determine if the control measures are being enacted and the control limits are being met. Monitoring procedures must identify:

1) What will be monitored (Appendix C, column 4)

2) How the control limits and preventive measures will be monitored (Appendix C, column 5)

3) How frequently monitoring will be performed (Appendix C, column 6)

4) Who will perform the monitoring (Appendix C, column 7)

Monitoring must be designed to provide rapid results. There is no time for lengthy analytical testing because control limit failures must be detected quickly and an appropriate corrective action instituted before distribution occurs.

Physical and chemical measurements are preferred monitoring methods because testing can be done rapidly. Physical measurements (e.g., time, flow, current speed, temperature, and direct observation) can often be applied to ANS control. Examples of physical measurement monitoring at a CCP are:

1) Time and temperature: This combination of measurements is often used to monitor the effectiveness for destroying or controlling ANS contamination of traps, nets, and other equipment. For example, nets used in Eurasian watermilfoil-infested waters in Minnesota must be frozen for 48 hours or dried for 10 days before using in other waters.

2) Water flow rate: Because plant fragments, eggs, and many invertebrates cannot swim against water currents, holding fish in flowing water to separate them from ANS is one way to control the hazard. Measuring flow rate, current speed, and the time it takes for one complete water exchange are examples of physical measurements that may be monitored.

3) Sensory examination: Observations for the presence of ANS contamination in baitfish or fish for stocking or continued observation for the establishment of ANS in waters considered to be uninfested is one way to monitor ANS hazards.

Monitoring instruments that produce a continuous record of the measured value will not control the hazard on their own. Continuous records need to be observed periodically and action taken when needed. The length of time between checks will directly affect the amount of product loss when a critical limit deviation is found. In all cases, the checks must be performed in time to ensure that the contaminated product is isolated before shipment. When it is not possible to monitor a CCP on a continuous basis, it is necessary for the monitoring interval to be short enough to detect possible deviations from control limits.

Corrective Action — Principle 5

Corrective actions must be taken when controls at a CCP have been compromised. These actions must be predetermined when developing the HACCP plan. When controls are violated at a CCP, the predetermined, documented corrective actions should be immediately instituted. There are two components of corrective actions. First, corrective actions should state procedures to restore control at the CCP and second, they must determine the appropriate disposition of the affected product.

Corrective action options include: 1) isolating and holding fish for safety evaluation, 2) diverting the affected fish to another use where ANS contamination would not be considered critical, 3) using some method to separate ANS from the fish, 4) rejecting fish, or 5) destroying fish. Corrective actions are implemented when monitoring results indicate a deviation from control limits. Effective corrective actions depend heavily on an adequate monitoring program.

All corrective actions taken should be documented. Documentation will assist in identifying recurring problems so that the ANS-HACCP plan can be modified. Additionally, corrective action records provide proof of product disposition.

Verification — Principle 6

The purpose of verification is to provide a level of confidence that the plan is based on solid scientific principles, is adequate to control the hazards associated with producing and selling the harvested or cultured product, and is being followed.

There are several elements associated with this principle, including validation and reviews. Confusion sometime arises because the HACCP plan must include verification procedures for individual CCPs **and** for the overall plan.

Validation is an essential component of verification and requires substantiation that the HACCP plan, if implemented effectively, is sufficient to control the ANS hazards that are likely to occur. Validation of the plan occurs before the plan is actually implemented. The purpose of validation is to provide objective evidence that all essential elements of the plan have a scientific basis and represent a valid approach to controlling the ANS hazards associated with baitfish harvest and fish culture. There are several approaches to validating the HACCP plan; among them are incorporation of fundamental scientific principles, use of scientific data, reliance on expert opinion, or conducting specific observations or tests.

Actual components of the ANS-HACCP plan should be validated before relying on it and when factors warrant such as: 1) harvesting fish from a new lake, 2) changing the harvest techniques or culture methods, 3) new scientific information about potential hazards or their control, or 4) infestation of new ANS. Validation involves a scientific and technical review of the rationale behind each part of the HACCP plan from hazard analysis through each CCP verification strategy.

Verification activities developed for CCPs are essential to ensure that the control procedures used are properly functioning and that they are operating and calibrated within appropriate ranges for ANS control. CCP verification may also include targeted sampling and testing. Calibration is conducted to provide assurance that monitoring results are accurate.

In addition to the verification activities for CCPs, strategies should be developed for scheduled verification of the complete HACCP system. The frequency of the system-wide verification should be yearly or whenever there is a system failure or a significant change in the product or process. Systematic verification activities include on-site observations and record reviews. An unbiased person who is not responsible for performing the monitoring activities should perform reviews.

Until the ANS-HACCP approach is accepted and used by industry and resource management agencies, there is no official role of the resource management agencies in reviewing ANS-HACCP plans. The major role of resource management agencies in an ANS-HACCP system can be to verify that the plans are effective and are being followed. Verification normally will occur at the facility or at the water body that is being harvested.

ANS-HACCP plan reviewers must have access to records that pertain to CCPs, deviations, corrective actions, and other information pertinent to the HACCP plan that may be needed for verification. Because plans may contain proprietary information, the regulatory agency or other plan reviewers must appropriately protect them.

ANS-HACCP Records — Principle 7

Accurate record keeping is an essential part of a successful HACCP program. Records provide documentation that control limits have been met or that appropriate corrective actions were taken when limits were exceeded. Likewise, they provide a means of monitoring so that adjustments can be made to prevent ANS contamination. The four types of records needed are described below.

1) ANS-HACCP Plan and Support Documents:

   It is advisable to maintain ANS-HACCP plan supporting documentation. ANS-HACCP support documents include the information and data used to develop the plan. This includes written hazard-analysis worksheets, records of any information used in performing the hazard analyses, and information used to establish controls actions and strategies.

   Support documents may include the current geographic range of ANS infestation or sufficient data used to establish the adequacy of any barriers to prevent ANS release. In addition to data, support documents may also include correspondence with resource management agency personnel, consultants, or other experts.

2) Monitoring Records:

   ANS-HACCP monitoring records are primarily kept to demonstrate control at CCPs. ANS-HACCP records provide a useful way to determine if control limits have been violated. Timely record review by a management representative ensures that the CCPs are being controlled in accordance with the ANS-HACCP plan. Monitoring records also provide a means by which regulators can determine whether a firm is in compliance with its HACCP plan.

3) Corrective Action Records:

Corrective action records are important to document procedures used to restore control if critical control measures were violated and to document the appropriate disposition of the affected product.

4) Verification Records:

Verification records should include modifications to the HACCP plan, operator records verifying supplier compliance with guarantees or certifications, verification of the accuracy and calibration of all monitoring equipment, results of on-site inspections, and results of equipment evaluation tests.

All records should be signed or initialed and dated by the reviewer.

RESULTS AND DISCUSSION

The ANS-HACCP approach has been designed for three primary purposes. The first is to restrict the spread of ANS via the culture or transfer of live fish while maintaining the economic viability of baitfish and aquaculture industries. Many organizations and resource management agencies have recommended that baitfish/aquaculture operations be eliminated if they use ANS infested waters or are raising ANS. This is certainly the most effective approach to prevent the spread of ANS, but it is also potentially unnecessarily restrictive to important segments of the baitfish/aquaculture industry. It may also be short sighted. ANS may continue to spread despite our best efforts, and by eliminating businesses lake-by-lake and river-by-river as ANS continue their spread, there may not be a significant short-term impact, but cumulatively over many years it may have a large negative economic impact. We should anticipate the possibility of continued ANS spread and attempt to minimize the cumulative impact on the industry, while protecting the environment, by initiating an ANS-HACCP approach soon.

Of course, if the risk and economic damage caused by the baitfish/aquaculture industry is significant, then shutting down segments of the industry or preventing the culture of ANS is appropriate. The risk, however, is often small and depends on the ANS and the control strategies used. The risk is especially small compared to the risk associated with recreational boating and commercial shipping. Because of the relatively small size of the impacted baitfish/aquaculture industry, they are frequently held to a zero risk standard, while the extremely large and powerful recreational boating and commercial shipping industries are not held to that same standard. The fact that the baitfish/aquaculture industry is rather small is advantageous because less effort is needed to encourage them to change their behavior to reduce the risk of spreading ANS than is needed to change the behavior of recreational boaters or commercial shippers. The ANS-HACCP approach is one way in which resource management agencies can work with the baitfish/aquaculture industries to change, monitor, record, and verify their efforts to reduce the risk of spreading ANS.

The second purpose of the ANS-HACCP approach is to provide state and federal hatcheries with a means to satisfy public concerns regarding their role in the spread of ANS. State and federal hatcheries must also change their behavior for raising and stocking fish to ensure that they are not responsible for the spread of unwanted species when the waters they use become ANS infested. Public hatcheries have been implicated in the unintentional spread of fish. An example is the U.S. Fish and Wildlife Service Inks Dam, Texas hatchery, which was identified as the source of a gizzard shad introduction to Morgan Lake, New Mexico via a shipment of largemouth bass. Gizzard shad have subsequently appeared to move downstream into the San Juan arm of Lake Powell, Utah (Bob Pitman, U.S. FWS, Albuquerque, NM pers. com.). Gizzard shad are not native to this region. State and federal hatcheries have a responsibility to instill confidence in the public that they are addressing ANS risks when they raise and stock fish. The ANS-HACCP approach provides a mechanism by which state and federal hatcheries can assure the public that they are conducting their fish stocking efforts in an environmentally responsible manner.

The third purpose for developing the ANS-HACCP approach is to provide a mechanism by which private aquaculturists can certify their product as ANS-free. Some states and watersheds require certified ANS-free bait. In addition, some organizations, agencies, and private buyers would like to purchase certified ANS-free fish for stocking. Currently, there is no certification program available. The ANS-HACCP approach could serve this purpose.

The ANS-HACCP approach has been pilot tested with the Michigan Wholesale Bait Association and the U.S. Fish and Wildlife Service hatchery managers and ecological services personnel in the southwest region. During these two training sessions, each were taught the basic principles of ANS-HACCP, how the principles apply to preventing the spread of aquatic nuisance species with the movement of live fish, and the development specific ANS-HACCP plans. These ANS-HACCP plans were developed in both training sessions by dividing participants into small working groups that focused on real situations involving the transfer of live fish from areas that contained ANS. Results of these pilot tests were very positive. Both groups appropriately applied the principles of ANS-HACCP, and each felt that the approach was workable from a business/public hatchery management perspective and that it could significantly reduce the risk of spreading ANS. Pilot project participants also provided suggestions to modify the draft manual. Comments from agency, industry, and university reviewers were also incorporated into the training manual (Gunderson and Kinnunen 2001).

SUMMARY

The ANS-HACCP approach has many advantages. It can effectively deal with a diverse industry and diverse risk factors associated with a variety of plant, invertebrate, and vertebrate ANS. If it develops as it has in the seafood industry, it should prove to be a good partnership between industry and government regulators. It can help avoid overly restrictive regulations, and, if properly applied, can be effective at reducing the risk of spreading ANS via baitfish and fish stocking.

The HACCP approach concentrates on the points in the process that are critical to the environmental safety of the product, minimizes risks, and stresses communication between regulators and the industry. With proper cooperation between industry representatives, resource management agencies, and other ANS experts, the ANS-HACCP approach will reduce the risk that ANS will be established in new locations while maintaining the economic viability of the baitfish and aquaculture industries. It can provide a mechanism for ANS-free certification, and it can instill confidence in the public that state and federal fish stocking programs are conducting their activities in an environmentally responsible manner.

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Appendix A. Example of a Flow Diagram – Shiner Wild Harvest

Step 1	**Shiners are seined in the fall from Lake XXX.**
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Step 2	**Harvested shiners are dip-netted from the seine and moved to the transport truck in 5 gallon buckets with lake water.**
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Step 3	**Buckets of shiners and lake water are dumped into transport truck. Truck also contains well water from facility to which salt has been added.**
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Step 4	**Shiners are transported to holding facility where the water and shiners are drained from the truck directly into holding tanks.**
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Step 5	**Shiners at the holding facility are held in flow through, aerated well water until sold.**
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Step 6	**More shiners are brought into the facility periodically for holding.**
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Step 7	**Shiners for sale to retail bait shops are put into 5 gallon buckets and loaded onto trucks and delivered in salted, aerated, well water.**
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Step 8	**Shiners are dip-netted from the truck and placed in 5 gallon buckets filled with well water for measuring volume and for moving them into the retail bait shop.**
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Step 9	**Shiners for sale to another wholesaler are dip-netted from tanks, placed in 5 gallon buckets to measure volume, and then loaded onto trucks containing salted, aerated, well water.**
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Step 10	**The whole truckload of water and shiners is drained directly into a wholesaler's holding tanks.**

Appendix B. Hazard Analysis Worksheet

(1) Harvest or Aquaculture Step	(2) Identify potential ANS hazards introduced or controlled at this step (1)	(3) Are any potential ANS hazards significant? (Yes/No)	(4) Justify your decisions for column 3.	(5) What control measures can be applied to prevent the significant hazards ?	(6) Is this step a critical control point? (Yes/No)
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Appendix C. HACCP Plan Form

HACCP Plan Form									
			Monitoring						
(1) Critical Control Point (CCP)	(2) Significant Hazard(s)	(3) Limits for each Control Measure	(4) What	(5) How	(6) Frequency	(7) Who	(8) Corrective Action(s)	(9) Records	(10) Verifi-cation