HACCP Planning for Natural Resource Pathways

Hazard Analysis
&
Critical Control Point Planning

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Table of Contents

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The Fish and Wildlife Service, the State of Arizona Game and Fish Department, and the State of Wyoming Game and Fish Department developed *HACCP Planning for Natural Resource Pathways*. The manual identifies some pathways in natural resource work through which non-target species of plants, animals, and biologics can be transferred to habitats where they could become future invasive problems. It is keyed to the operations and activities associated with natural resource management and aquatic resource propagation.

The Development Team included the following participants:

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The cover photo of tidal wetlands showing the invasive/non-native plant *Phragmites australis* at the Supawna Meadows National Wildlife Refuge, Pennsville, New Jersey provided by Gene Nieminen, U.S. Fish & Wildlife Service.

All other photos within this manual involving Inks Dam National Fish Hatchery operations were provided by Bob Pitman and Robert Lindsey, hatchery manager, Inks Dam National Fish Hatchery, both U.S. Fish & Wildlife Service.

Introduction to Hazard Analysis & Critical Control Point Planning (HACCP)

Across the country, natural resource management agencies work with species and their supporting habitats, collecting data to define species health and population trends. Biologists and technicians routinely sample populations and evaluate habitats to establish reference benchmarks for agency direction and management decisions. Their work is at the center of professional biology, research, and resource management. While management activities are essential, they are not without risks to species and habitats.

Managers recognized that hitchhiking non-target species could become invasive species management problems, but biologists lacked a comprehensive planning tool to identify risks and document preventative measures. Without a planning method, the approach to this natural resource issue has been subjective and inconsistent. An effective planning tool brings consistency to solve this management problem. While a plan is just a plan, ***planning is everything***. This is an appropriate consideration for natural resource work. The planning process points out research needs and identifies where better procedures are needed to prevent species spread. *This manual presents a planning process from industry that has been modified for natural resource work*.

The Pillsbury Company pioneered the HACCP concept in food production, supplying food for the U.S. space program in the early 1960s. Since then, HACCP has become recognized and used around the world as a proactive method to ensure product purity. HACCP planning is widely used and accepted by industry for good reason. It works! In a similar manner, HACCP planning for natural resource pathways will remove or reduce to an acceptable limit non-target species of plants and animals (hazards) before they are introduced to new locations.

The same HACCP process used by industry is followed throughout the manual, except for slight changes to fit natural resource work. Like all good planning systems, the HACCP model developed by industry has a few basic principles that must be observed. Industry formed HACCP planning teams to describe the production process, identify hazards (risks), determine where hazards can be controlled, and describe procedures to remove the hazards identified. Teams set acceptable limits for activity tasks and develop documentation with the ability to verify that specified procedures were followed.

HACCP plans record the important elements: *who*, *what*, *where*, *when*, *how,* and *why*. Plans help management target problems and improve best management practices. Industry was able to improve production purity and eliminate contaminants by relying on records of what worked and modifying or eliminating procedures that did not work. Processes and methods based on documented records evolved. Implementing a HACCP concept to manage natural resource pathways could create a similar evolution of best management practices to prevent spread of non-target species.

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Chapter 1:
Why HACCP Is Important

HACCP planning as a pathway management tool provides a comprehensive method to identify risks and focus procedures to prevent spread of species through natural resource pathways. Natural resource work could unintentionally spread non-target (potentially invasive) species to new habitats. These non-targets could hitchhike on field or farm equipment, or be included in shipments of species relocated to restore range, or moved into or out of a refugium. Species monitoring, collections, natural resource surveys, and fish stockings are also potential pathways.

On a larger scale, shipping and importation have provided pathways by which non-indigenous species have arrived in the United States. Invasive species move through human-assisted pathways to new habitats and may impact native plants, animals, and economies. For example, it is widely accepted that zebra mussels *Dreissena polymorpha* were introduced to the Great Lakes through international shipping traffic and ballast water discharge. Shippers did not intend to move zebra mussels; they just intended to use ballast water to safely cross the ocean. Once ships enter U.S. ports in the Great Lakes, the ballast water is discharged and cargo loaded. Unfortunately, many species can survive transoceanic trips in ballast water, hitchhiking to new waters as non-target species and biological contaminants. Likewise, the horticultural industry has provided pathways by which numerous plants, or hitchhikers on plants, have been imported into the United States and now cause major problems in agricultural, rangeland, riparian, and other natural areas. Some of our worst insect invaders, such as the Formosan termite *Coptotermes formosanus* Shiraki, arrived in packing and crating materials. Understanding pathways and developing plans to remove non-target species and prevent biological contamination is necessary to prevent unintended spread of species.

The invasion of zebra mussels in the mid-1980s caused a surge of invasive species awareness and prompted federal legislation in the form of the Non-indigenous Aquatic Nuisance Protection and Control Act of 1990, amended in 1996. In February 1999, the Presidential Executive Order 13112 created the National Invasive Species Council and the Invasive Species Advisory Committee.

Introductions of hitchhiking species of plants, animals, and biologics, such as parasites and disease-causing pathogens, are unintentional, like the zebra mussel spread to North America. However, these introductions should not be considered “accidental.” Understanding pathways and developing plans to remove hitchhiking species are necessary to prevent unintended spread. Considerable research is underway to develop effective blocks for the difficult ballast water exchange pathway.

Hazard Analysis and Critical Control Point planning is widely known by its acronym, HACCP (pronounced "hassip"). It has become an industry standard ensuring food purity by removing hazards (contaminants) at critical control points throughout production rather than by more costly end-point testing. The key to understanding natural resource-modified HACCP is to view non-target species of plants, animals, diseases, pathogens, and parasites as hitchhikers or hazards (industry contaminants) throughout the planning process. The target is whatever is being moved from place to place. It could be a plant, animal, piece of equipment, sampling gear, or even you. Many plant parts and seeds are moved from place to place attached to socks or entangled in sampling equipment or nets.

Natural Resource Pathway Management

Planning is nothing new for biologists and managers, but applying HACCP planning to natural resource work is a new concept. Without appropriate planning, the management work that takes biologists, technicians, and their equipment to many different habitats could be pathways for species spread. HACCP planning identifies high-risk activities and focuses attention on those actions needed to close open pathways. Plans documenting risks, as well as methods used to remove non-target species, give managers the opportunity to weigh risks for species spread against benefits from natural resource actions. For some pathways, the risks outweigh resource benefits until better procedures to remove non-target species are identified. HACCP planning provides a systematic method to make consistent decisions based on identified risks. HACCP plans create a reference source documenting best management practices and procedures that can be shared with other offices, agencies, and the private sector to reduce risks of species spread through pathways with similar characteristics.

"Planning Is Everything"

First-time natural resource HACCP planners tend to pick well-known invasives as non-target species to remove from pathways. While these species deserve increased attention, biologists recognize that many local species could become invasive if introduced outside their native range. HACCP planning for natural resource pathways intends to remove all non-targets. Information and reference sources on species that have gained national recognition are included in Chapter 7. The examples of non-target species spread used in this manual show how natural resource pathway planning can help prevent similar types of spread.

Before learning the mechanics of HACCP planning, you must recognize one important point. Creating a HACCP plan is a small part of applying the HACCP concept for natural resource work. The values of HACCP planning are many. Using an onion as an example, planners will find new layers of questions, learning that natural resource management has increased in complexity rather than decreased. Sorry! HACCP planning will not make your life easier, but it will make you a better biologist, and our natural resources will be better protected from invasive species.

This manual uses a species that has spread through natural resource pathways as a model for HACCP planning. However, for clarification, it should be noted that non-native species introduced for management reasons are not considered in this discussion. Significant evaluation, research, and multiple-agency review precedes the introduction of non-native species for management needs.

Chapter 2 includes the narrative description of the case history of the Inks Dam National Fish Hatchery, which is also used throughout the manual to illustrate HACCP planning.

Fine mesh synthetic filters attached to water inlets prevent other species from entering fish rearing ponds.

Bob Pitman & Robert Lindsey/USFWS

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Chapter 2:
Case History of Inks Dam National Fish Hatchery

Inks Dam National Fish Hatchery (NFH) is located about 60 miles northwest of Austin, Texas, in the hill country next to the Colorado River. Established by authority of the Public Works Administration Grant, in conjunction with the construction of Buchanan and Inks Dams on the Colorado River, the facilities became operational in 1940. Originally, the hatchery raised and stocked recreational fish, such as largemouth bass *Micropterus salmoides* and channel catfish *Ictalurus punctatus*, into the chain of reservoirs created by five new dams on the Colorado River. In the 1960s and 1970s, the hatchery provided fish for farm ponds. In the 1980s and 1990s, channel catfish and largemouth bass were produced for angling on Native American lands and throughout the Southwest. Striped bass and paddlefish are also reared in the 27 earthen ponds at this warmwater hatchery.

Inks Dam Hatchery is situated on a 160-acre parcel of which 25 surface acres are in ponds ranging in size from 0.2 to 1.5 acres in size. The pond alignment is not systematic as over the past 60+ years the ponds have been resized many times. Production features include a raceway and a holding building with 14 indoor tanks. Hatchery water supply originates from Inks Lake with an intake tube 15 feet below normal surface elevation. The water is carried 0.25 miles through pipe to the hatchery and can travel as far as another 0.5 miles to the last pond. Water quality can be an issue during the months of June through September with oxygen levels as low as 0.25 ppm and hydrogen sulfide being present. Both of these are lethal to fish without remediation.

Inks Dam National Fish Hatchery located 60 miles northwest of Austin, Texas.

Bob Pitman & Robert Lindsey/USFWS

Many species of fish, amphibians, plants, and invertebrates from Inks Dam Lake also enter hatchery waters through this pipeline. The hatchery is bordered with a 1200-acre state park that essentially serves as a wildlife refuge. Other species crawl, hop, fly, or slither into these productive rearing ponds to feed and reproduce.

There are three primary species cultured; channel catfish, largemouth bass, and striped bass. The catfish spawn in June, eggs are incubated in the hatch house, and fry are returned and raised in ponds to harvest size. Catfish are produced year-round with major harvest and shipping occurring with young of year (6") during October and November and yearling fish (9") during May. Largemouth bass production begins with pond spawning in April; fry are collected 17 days after spawn, and then moved to grow out ponds. After 3 weeks the fingerlings are harvested at 1.5 inches and distributed. The striped bass are imported as fry and raised in ponds for 35 days, harvested, trained to take artificial diets in tanks, and stocked back in ponds till December. They are then harvested as an 8" fish and distributed.

Fine-mesh, synthetic filtering bags or "socks" are placed over inlet pipes when ponds are filling to keep non-target species out. This filtering method requires continual monitoring to prevent clogging and blowout or breakage. Sorting and examination during pond harvest and when fish are in holding tanks provide a final opportunity to remove these non-target hitchhikers before fish are loaded for distribution. *Separating non-target hitchhikers is not easy*. During periods when water quality issues occur, the water must be passed through packed columns (tanks) or paddle wheels used on the ponds. If the water is not conditioned many or all fish might die if netting, sorting, and "handling" are not done carefully when fish are prepared and loaded onto the fish-hauling unit. Some mortality would be quickly obvious, but other stress-related deaths may not occur until after fish are stocked. After all this effort and expense, everything could be lost and the management need unmet. The distribution unit is capable of carrying 4,000 pounds of fish (depending on size and species). A well-constructed HACCP plan ensures that shipments of healthy fish free of all non-target species arrive at the stocking site.

The problem of non-target species spread through routine fish stockings has most likely occurred since operations began at Inks Dam. Receiving biologists have reported the following non-target species included in shipments of channel catfish or largemouth bass from Inks Dam: Guadalupe bass *Micropterus treculi*, logperch *Percina caprodes*, gizzard shad *Dorosoma cepedianum*, white bass *Morone chrysops*, bluegill *Lepomis macrochirus*, sunfish *Lepomis marginatus,* and other non-target hitchhikers. The invasion of zebra mussels raised awareness and focused the attention of agencies and individuals on the problem of unintended species spread and the resulting impact on species and habitats. The fact that natural resource pathways may contribute to the unintentional spread of species needs to be addressed with an appropriate management response. HACCP planning and the comprehensive planning process it involves can bring consistency to removal of non-targets and concentrate efforts on high-risk problem areas and related critical control points. The problem of non-target exclusion at Inks Dam is complex, with no easy fixes. HACCP planning identifies and helps prioritize facility and equipment improvements needed to comply with new levels of concern for unintended species spread.

Morgan Lake, Navajo Nation — Northwest New Mexico

Morgan Lake is a power plant reservoir in northwestern New Mexico managed for recreational fishing by the Navajo Nation. Management biologists from the New Mexico Fishery Resources Office (USFWS) and the Navajo Nation periodically survey the reservoir to determine growth rates and overall species health. Routine stocking requests for fingerling largemouth bass are submitted by the Fishery Resources Office to maintain a recreational fishery. This request is provided to Inks Dam NFH, the only Region 2 fish hatchery producing northern strain largemouth bass.

Stocking fish from Inks Dam National Fish Hatchery.

Bob Pitman & Robert Lindsey/USFWS

Fishery surveys in 1999 found 108 gizzard shad ranging in size from 85 to 335 mm. Similar surveys in 1994 and 1997 did not collect gizzard shad. It is suspected that this species was introduced to Morgan Lake with a stocking of largemouth bass fingerlings in May 1998. It would be difficult to detect small numbers of gizzard shad hitchhiking with the largemouth bass fingerlings. In 2000, biologists working in the San Juan arm of Lake Powell collected a single adult gizzard shad. It is likely that this fish represents gizzard shad emigrants discharged from Morgan Lake into Chaco Wash where they entered the San Juan River near Shiprock, New Mexico, and moved from there into Lake Powell. Six adults were collected from Lake Powell in August 2002 by Utah biologists.

An article from *The Salt Lake Tribune*, August 2002, included in Chapter 7, is one consequence of this unintended spread. The Inks Dam NFH example is followed throughout this manual to illustrate HACCP planning as a pathway management tool.

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Chapter 3: HACCP Planning

A successful HACCP program depends on creating a firm foundation, which includes management commitment, HACCP training, and assembly of an effective HACCP team. Failure to provide these will likely lead to ineffective design, implementation, and management of the HACCP plan.

Management Commitment - For a HACCP plan to work, it is extremely important to have the support of everyone in the agency, from the Director to the biological technicians in the field. Without it, the plan will not become an agency priority or be effectively implemented.

HACCP Training - Education and training are important elements in developing and implementing a HACCP program. Employees who will be responsible for the HACCP program must be adequately trained in its fundamentals. This course is designed to meet that need.

HACCP Team Assembly - Assembling a team is an important step in building a HACCP program. Although one person may be able to analyze hazards and develop a plan successfully, many agencies find it helpful to build a team. When only one person develops the HACCP plan, some key points can be missed or misunderstood in the process. The team approach minimizes this risk. It also encourages ownership of the plan, builds agency/program involvement, and brings in different areas of expertise. Teams can also include people from state or federal resource management agencies, universities or community colleges, or local experts.

5 Steps to HACCP Planning

There are five steps to HACCP planning.

1. Describing the activity.
2. Identifying potential hazards.
3. Diagramming the flow of steps for the activity.
4. Filling out a hazard analysis worksheet.
5. Completing the HACCP plan form.

Each step corresponds to a specific form in the HACCP planning process. Forms are included in Chapter 5.

HACCP Step 1 – Activity Description

<table>
<tr><th colspan="2">Activity Description</th></tr>
<tr><td>Facility:</td><td>Site:</td></tr>
<tr><td>Project Coordinator:</td><td rowspan="4">Activity/Management Objective:</td></tr>
<tr><td>Site Manager:</td></tr>
<tr><td>Address:</td></tr>
<tr><td>Phone:</td></tr>
</table>

Project Description i.e. Who; What; Where; When; How; Why

Step 1 - Activity Description

Once a HACCP team is established, the members first describe the activity, the method of accomplishing the activity, and the intended purpose and need for the activity.

Examples of activities include the following:

- Natural resource management (agricultural and aquatic)
- Raising and/or stocking of fish
- Importing of fish/plants
- Surveys (aquatic and terrestrial)
- Restorations (habitat and native species) and bringing in species and outside construction materials
- Research field work
- Fire control
- Law enforcement
- Navigational aids
- Road construction and maintenance
- Recreation activities
- Biocontrol → intentional introductions
- Pet trade
- Nursery stock: soil → fire ants

The project description should be a narrative description that includes such information as who, what, when, where, how, and why. The description should offer a historical, working reference to facilitate communication with the facility staff and other resource management agency personnel.

Here is a sample showing how Inks Dam NFH filled out Step 1 of the form.

HACCP Step 1 – Activity Description

Activity Description	
Facility: Inks Dam National Fish Hatchery	Site:
Project Coordinator: Robert Lindsey	Activity/Management Objective: Rearing and distribution of largemouth bass free of non-targets.
Site Manager: Robert Lindsey	
Address: 345 County Road 117 Burnet, TX	
Phone: 512-793-2474	

Project Description i.e. Who; What; Where; When; How; Why
Fishery Resource Offices request northern strain largemouth bass a year before production begins at the Inks Dam National Fish Hatchery. Requests are submitted to the Regional Office for prioritization with other production and fishery needs. After review a production and stocking request is provided to the hatchery prior to the fish rearing season. The Hatchery Manager and Assistant Manager direct the harvest of broodstock from holding ponds in early March to begin the rearing cycle. Four-year-old broodstock are harvested by draining the pond and moved to flow-through raceways. In two to three weeks, depending on temperature patterns, fish are sorted by sex and 50 pair are stocked into a spawning pond. Most fish will spawn in three days. About seventeen days after brood fish are stocked fry collection begins. Schools of fry are collected with seines and moved in 20-gallon tubs to filled and fertilized rearing ponds. Fry usually are kept in these rearing ponds for three weeks when they are harvested as 1.5 inch fingerlings and moved to holding tanks to be trained on artificial feed. After four weeks of feeding these fish are moved to small rearing ponds where artificial feeding on pellets continues throughout the rest of the rearing cycle. The 6-8 inch fish are usually equipped with oxygen and easy loading/unloading access. The yearling fish are graded, sorted, weighed, and treated, if needed, before they are loaded for distribution in two to three days. Larger fish are easier to separate from non-targets and some species have matured and left the rearing pond. Fish are then distributed to receiving waters in the southwest. Requesting Fishery Resources Offices meet the delivery truck to assist with stocking.

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HACCP Step 2 – Identify Potential Hazards

(to be transferred to column 2 of HACCP Step 4 – Hazard Analysis Worksheet)

Hazards: Species or Contaminants Which May Potentially Be Moved/Introduced
Vertebrates:
Invertebrates:
Plants:
Other Biologics (e.g. genetics, disease, pathogen, parasite, or non-pathogens):
Others (non-biological contaminants e.g. pesticide residue, oil products, etc. or harborage via packing or construction materials, etc.):

Step 2 - Potential Hazards

Hazards are species or contaminants that may be moved or introduced, causing ecological damage and furthering the spread of unwanted species to new habitats. They may include vertebrates, invertebrates, plants, other biologics (e.g., diseases, pathogens, and parasites), or other contaminants (e.g. pesticides, engine oil etc.).

To perform a hazard analysis for the development of a HACCP plan, managers must gain a working knowledge of potential hazards. The HACCP plan is designed to control all reasonable hazards. Such hazards are categorized into five classes: vertebrates, invertebrates, plants, other biologics, and others. Species considered hazards vary from state to state, agency to agency, and biologist to biologist. Consulting with multiple resource management agencies is necessary to determine which species are considered hazards. Group discussions here help focus planning objectives and establish the basic foundation for each HACCP plan. After completing Step 4, the Hazard Analysis Worksheet, the HACCP planning process will further sharpen the focus on non-targets that need to be removed from the pathway being reviewed.

Here is a sample showing how Inks Dam NFH filled out Step 2 of the form.

HACCP Step 2 – Identify Potential Hazards

(to be transferred to column 2 of HACCP Step 4 – Hazard Analysis Worksheet)

Hazards: Species or Contaminants Which May Potentially Be Moved/Introduced
Vertebrates: Guadalupe bass (*Micropterus treculi*), logperch (*Percina caprodes*), gizzard shad (*Dorosoma cepedianum*), white bass (*Morone chrysops*), bluegill (*Lepomis macrochirus*), warmouth (*Lepomis gulosus*), green sunfish, common carp, smallmouth buffalo, redbreast sunfish, bullfrogs, tadpoles, gulf coast toad, aquatic snakes
Invertebrates: miscellaneous aquatic insects, Asian clam (*Corbicula spp*), crayfish
Plants: Hydrilla, Eurasian watermilfoil, water star thistle, water hyacinth, brushy pond week, various algae (*Chara, Pithophora, Hydrodicton*)
Other Biologics (e.g. genetics, disease, pathogen, parasite, or non-pathogens): Largemouth bass virus
Others (non-biological contaminants e.g. pesticide residue, oil products, etc. or harborage via packing or construction materials, etc.): None

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HACCP Step 3 – Flow Diagram

Flow Diagram Outlining Sequential Tasks to Complete Activity/Project
Described in HACCP Step 1 – Activity Description
(to be transferred to column 1 of the HACCP Step 4 – Hazard Analysis Worksheet)

Task 1	
	⇓
Task 2	
	⇓
Task 3	
	⇓
Task 4	
	⇓
Task 5	
	⇓
Task 6	
	⇓
Task 7	
	⇓
Task 8	
	⇓
Task 9	
	⇓
Task 10	

Step 3 - Flow Diagram

A flow diagram shows in simple block or symbol form the tasks required to accomplish the activity. This step provides an important visual tool that the HACCP team can use to complete the remaining steps of the plan. Only a clear, simple, and complete description of the process is needed. Information is taken from the Activity Description box in HACCP Step 1. It is important to include all the tasks within the activity. The flow diagram should be clear and complete enough so that people unfamiliar with the activity/process can quickly comprehend your operations and/or activity. If a task is missed, a significant hazard may not be addressed. The HACCP team should evaluate the entire activity/operation and make any changes required in the flow diagram. The evaluation allows each team member to gain an overall picture of how the activity is conducted.

Here is a sample showing how Inks Dam NFH filled out Step 3 of the form.

HACCP Step 3 – Flow Diagram

Flow Diagram Outlining Sequential Tasks to Complete Activity/Project
Described in HACCP Step 1 – Activity Description
(to be transferred to column 1 of the HACCP Step 4 – Hazard Analysis Worksheet)

Task 1	Harvest brood fish from holding ponds & transfer to raceways. Hold fish for 2-3 weeks in raceways. Sort, grade, sex brood stock (50 pair) for spawning.
	⇓
Task 2	Fill spawning ponds with Lake Buchanan water through gravity feed water line.
	⇓
Task 3	Transfer broodstock (50 pair) to spawning pond.
	⇓
Task 4	Harvest fry 17 days after brood fish are stocked out to spawn and move to rearing pond for 3 week phase I rearing.
	⇓
Task 5	Harvest phase I fingerlings (1.5 inches) and move to confined rearing tanks with flow-through water and begin 4 weeks of feeding artificial diet.
	⇓
Task 6	Harvest pre-phase II fish and move to small rearing ponds. Continue feeding until harvest in November as phase II (6-8 inch fish).
	⇓
Task 7	Harvest phase II LMB and move to flow-through raceway for grading, sorting, counting, weighing, and examination.
	⇓
Task 8	Fill Regional Distribution Unit with well water or filtered raw water from Inks Dam. Load phase II largemouth and haul to stocking sites.
	⇓
Task 9	Fishery staff meet distribution unit and net fish directly or send them through the quick discharge tube into lakes or ponds.
	⇓
Task 10	

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HACCP Step 4 – Hazard Analysis Worksheet

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task 1	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				
Task 2	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				

HACCP Step 4 – Hazard Analysis Worksheet (continued)

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task #	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				
Task #	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				

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Step 4 - Hazard Analysis Worksheet

The Hazard Analysis Worksheet can be used to organize and document the considerations in identifying hazards. Each task listed in the Step 3 flow diagram is listed in column 1 of the worksheet. Potential hazards identified in HACCP Step 2 are recorded in column 2. Results of the risk assessment should be recorded in column 3, with the justification for accepting or rejecting the listed potential hazards stated in column 4. Control measures are listed in column 5. Column 6 answers whether this task is a critical control point.

Analyze the Hazard

The hazard analysis is fundamental to HACCP planning. To establish a plan that effectively prevents the movement of hitchhikers, it is crucial to identify significant hazards and measures to control them. During the hazard analysis, the significance of each potential hazard should be assessed by considering risk (probability of occurrence) and severity. The estimate of risk is usually based on a combination of experience and biological knowledge of the pathway. Severity is the seriousness of a hazard. This assessment requires close communication with biologists, resource management agency personnel, and other experts. For some field biologists, the expertise necessary to properly assess the risk of non-target spread is available within the agency. However, others may need outside assistance to address this issue correctly.

The HACCP team has the initial responsibility to decide which hazards are significant and must be addressed by the HACCP plan. Keep in mind that there may be differences of opinion, even among experts, as to the significance of a hazard. The HACCP team may rely on available guidance materials and the opinions of experts who assist in the development of HACCP plans. One approach to hazard analysis divides it into two activities: brainstorming and risk assessment. Brainstorming should result in a list of potential hazards at each operational step.

After hazard identification, the team conducts an analysis of the risks and severity of each of the hazards to determine the significance of potentially moving hitchhikers or contaminants to new habitats. However, the HACCP process focuses solely on significant hazards that are reasonably likely to occur.

Control Measures - Actions that can be used to control and remove identified hazards (sometimes referred to as a preventive measure).

Control measures are actions and strategies that can be used to prevent or eliminate a hazard or reduce it to an acceptable level. In practice, control measures encompass a wide array of actions (note the probably potential hazards that are identified for Inks Dam NFH on page 21).

As Inks Dam NFH analyzed its process, it identified the harvest and holding steps as times to remove any plant material that may have been collected with the largemouth bass (in column 6).

Filtering "sock" on pond water supply line.

Bob Pitman & Robert Lindsey/USFWS

Identifying too many hazards can be a problem because it can dilute your ability to focus efforts and control the truly significant hazards. Accordingly, it is essential that only significant hazards be identified and controlled with the HACCP plan. The dilemma is deciding what is significant. A hazard must be controlled if 1) it is reasonably likely to occur, *and* 2) if not properly controlled, it is likely to result in an unacceptable risk of introducing non-targets to new locations.

Determine the Critical Control Points

For every significant hazard identified during the hazard analysis, there must be one or more critical control points (CCPs) where the hazard is controlled. The CCPs are the points in the activity where HACCP control actions occur.

Critical Control Point - The best point, step, or procedure at which significant hazards can be prevented or reduced to minimum risk.

Points may be identified as CCPs when hazards can be prevented. In the Inks Dam NFH example, the following may be true:

- Raw surface water containing hazards should be avoided.
- Hazards can be eliminated by filtering raw-intake water.
- Hazards can be eliminated during harvest by rearing species to a larger size.
- Hazards can be separated from harvested fish for stocking during grading procedures.
- Hazards can be separated manually from larger fish in small quantity shipments.
- Hazards can be eliminated by distributing contaminated shipments to already infested public waters.

It may not be possible to fully eliminate or prevent a hazard. In some cases and with some hazards, minimization may be the only reasonable goal of the HACCP plan. Although hazard minimization is acceptable in some instances, it is important that all hazards be addressed. Any limitations of the HACCP plan to control those hazards should also be understood by resource management agencies and their partners. When HACCP plans cannot satisfactorily control hazards, other approaches to prevent the spread are required.

Control Point - Any step at which potential hazards can be controlled**.**

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 hazards can be controlled* are considered CCPs. A tendency exists to control too much and designate too many 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, a plant fragment hazard can be controlled by attempting to avoid infested areas of the lake, by trying to pick each fragment off a net before leaving the lake, or by freezing the net for 48 hours before going into uninfested waters. However, trying to avoid infested areas or pick off plant fragments would not necessarily be considered CCPs if freezing the net for 48 hours best controlled the hazard.

Differentiating between CCPs and control points varies from activity to activity and depends on the unique operation. When designating CCPs, you must also consider any applicable state statutes or rules that may dictate the identification of a CCP. For example, it is illegal to transport non-targets overland in some states, and CCPs that comply must be developed.

During hazard analysis in the previous section, you learned how to determine where hazards enter an operation/activity. Often, the best place to control a hazard is at the point of entry. But this is not always true. The CCP can be several steps away from the point at which the significant hazard is introduced.

A series of four questions can help you identify CCPs for a process. The questions, discussed below and shown in Figure 1, are referred to as the CCP decision tree and are asked at each process step identified as having a significant hazard during the hazard analysis. Properly used, the CCP decision tree can be a helpful tool in identifying CCPs, but it is not a perfect one.

Question 1 — *Does a control measure (Do control measures) exist at this step or subsequent steps for the identified hazard?*

If "yes," ask question 2.

If "no" because you cannot identify a control measure, ask, "Is control at this step necessary to prevent or minimize the hazard?"

> If "no," the step is not a CCP for the hazard.
>
> If "yes," you have identified a significant hazard that is not being controlled. The step, process, or product must be redesigned to include a control measure. Sometimes there is no reasonable control measure available. In such cases, HACCP does not provide assurance that the activity is hazard- or hitchhiker-free.

Question 2 — *Does this step eliminate or reduce the likely occurrence of a significant hazard to an acceptable level?*

Consider whether this is the best step at which to control the hazard.

If "yes," the step is a CCP. Move to the next significant hazard.

If "no," ask question 3.

Question 3 — *Could contamination* with *an identified hazard or hazards occur, or increase at this step?*

For example, if you continue to add fish harvested from infested waters to holding tanks, you may be adding non-target species that had already been removed from the system.

If "yes," ask question 4.

If "no," the step is not a CCP for the hazard.

Question 4 — *Will a subsequent step eliminate the identified hazard or hazards or reduce the likely occurrence to an acceptable level?*

If "yes," this step is not a CCP for the hazard. Be sure the hazard is controlled by a subsequent processing step.

If "no," this step is a CCP.

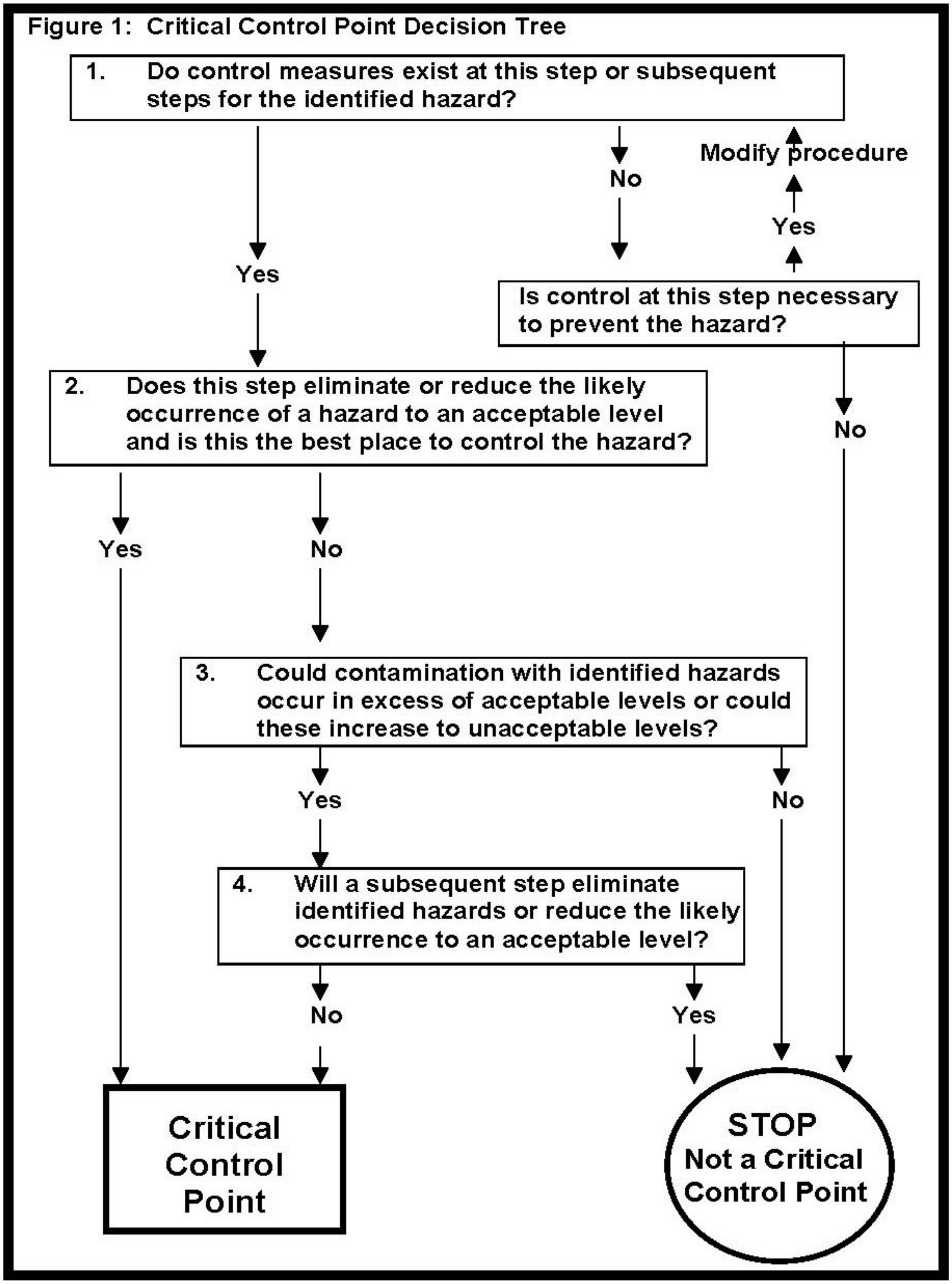

Figure 1. Critical Control Point Decision Tree

Establish Controls

Controls must be established for each CCP identified in the hazard analysis. A control represents the boundaries that are used to ensure that an activity is free of non-targets. Each CCP must have one or more controls for each significant hazard. When the process deviates from the control limits, corrective action must be taken to ensure that non-targets have not slipped through the control point. Examples of controls might be a minimum flow rate and time during which fish are held in the holding tank to ensure that aquatic nuisance plant fragments are trapped in the outlet filters. In this case, adhering to a minimum flow rate and time controls 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 unavailable, a conservative value should be selected. The rationale and reference material used to establish controls should become part of the support documentation for the HACCP plan.

Control Limit - A criterion that must be met for each control measure associated with a critical control point. Often a variety of options exist for controlling a particular hazard. Selection of the best control option and the best control limit is often driven by practicality and experience.

Control - (a) (verb) To manage the conditions of an operation to maintain compliance with established criteria. (b) (noun) The state in which correct procedures are being followed and criteria are being met.

Establish Operating Limits

If monitoring shows a trend toward lack of control at a CCP, managers should take action before the control limit is exceeded. The point at which managers take such an action is called the operating limit. Operating limits should not be confused with control limits. Operating limits are established at a level that would be reached before the control limit was violated.

The activity should be adjusted when the operating limit is exceeded to avoid violating critical limits. Biologists and technicians should make these adjustments to avoid loss of control and the need to take corrective action. Spotting a trend toward loss of control early and acting on it can reduce the risk of spreading non-target species with minimal stress on target species subjected to HACCP procedures used to separate non-targets. Corrective action is only required when the control limit is exceeded.

Operating Limit - Criteria that are more stringent than critical limits and that are used to reduce the risk of non-target contamination. For example, if a certain chemical concentration is required to control a non-target hazard, the operating limit is generally set above the minimum concentration needed to ensure effective treatment.

Operating limits may be selected for various reasons:

- For quality (e.g., separating fish by species and size).
- To avoid exceeding a control limit (e.g., a flow rate in holding tanks could be higher than the control limit to ensure that any aquatic plant fragments are trapped in the outlet filter or a disinfectant solution could be stronger than needed to ensure control).

Here is a sample showing how Inks Dam NFH filled out the Step 4 form. Not all of the tasks are shown in this sample. See Chapter 4 for the full documentation for Step 4.

HACCP Step 4 – Hazard Analysis Worksheet

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task # 1 Harvest brood fish from holding ponds & transfer to raceways. Hold fish for 2-3 weeks in raceways. Sort, grade, sex brood stock (50 pair) for spawning.	Vertebrates Other fish species	No	Fish are large and easily separated.		
	Invertebrates Miscellaneous aquatic insects	No	Adult fish handpicked & moved.		
	Plants Hydrilla, water star thistle	No	Adult fish handpicked & moved.		
	Other Biologics None				
	Others None				
Task # 2 Fill spawning ponds with Lake Buchanan water through gravity feed water line.	Vertebrates Other fish species	Yes	Fish easily travel with water into ponds.	Filters need to be used.	No
	Invertebrates Miscellaneous aquatic insects	Yes	Insects travel with water into ponds.	Filters need to be used.	No
	Plants Watermilfoil, hydrilla, water star thistle	Yes	Plants travel with water into ponds.	Filters need to be used.	No
	Other Biologics None				
	Others None				

HACCP Step 5 – HACCP Plan Form

HACCP Plan Form (all CCPs or "yeses" from column 6 of HACCP Step 4 – Hazard Analysis Worksheet)	
(1) Critical Control Point:	
Significant Hazard(s):	
Limits for Each Control Measure:	
Monitoring	What:
	How:
	Frequency:
	Who:
Evaluation & Corrective Action(s) (if needed):	
Supporting Documents (if any):	
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<	
(2) Critical Control Point:	
Significant Hazard(s):	
Limits for Each Control Measure:	
Monitoring	What:
	How:
	Frequency:
	Who:
Evaluation & Corrective Action(s) (if needed):	
Supporting Documents (if any):	
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<	
(3) Critical Control Point:	
Significant Hazard(s):	
Limits for Each Control Measure:	
Monitoring	What:
	How:
	Frequency:
	Who:
Evaluation & Corrective Action(s) (if needed):	
Supporting Documents (if any):	
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<	
Facility:	**Activity/Management Objective:**
Address:	
Signature: **HACCP Plan was followed.**	**Date:**

Step 5 - HACCP Plan Form

Find the tasks that you have identified as CCPs in column 6 of the Hazard Analysis Worksheet (Step 4). If you do not have any significant hazards and CCPs, then you do not need to complete the HACCP Plan Form. If you do have CCPs identified from your Hazard Analysis Worksheet, then record in order each task in block 1 of the CCP segments in the HACCP Plan Form. For each task identified, enter the hazard(s) in block 2 of the HACCP Plan Form. This information can be found in column 2 of the Hazard Analysis Worksheet.

Complete the HACCP Plan Form by designing techniques, methods, and treatments to deal with each of the significant hazards that you entered in block 2 of the HACCP Plan Form. Complete the HACCP Plan Form for each of the CCPs you identified in your hazard analysis. These steps involve setting the controls (block 3), establishing monitoring procedures (block 4 with its four monitoring cells), establishing evaluation and corrective action procedures (block 5), and establishing a verification and record-keeping system as supporting documentation, as needed (block 6).

Establishing controls is a difficult task because little research has been conducted on natural resource pathways and prevention or removal of hitchhikers or contaminants. Therefore, it is important for resource management agencies, university researchers, and the private sector to work together to identify effective procedures to separate non-targets from shipments, collections, surveying, sampling, monitoring, and the equipment used for this work. Once acceptable controls are identified, they must be monitored by a planned sequence of observations or measurements to assess whether the CCP is under control. If monitoring reveals that control limits are not met, then there must be a corrective action that has been written into the plan that identifies procedures to follow to ensure that the hazard has been controlled.

Verifying that all procedures and protocols are effectively controlling hazards is important. Accurate records must be kept to ensure that the HACCP plan is being followed. When you have finished these steps for all of the CCPs that relate to your activity, you will have a completed HACCP plan.

After completing a HACCP Plan Form, you should sign and date the first page of the form. The signature must be that of the most responsible individual on site during the controlled activity signifying that the HACCP plan has been implemented by your agency or organization.

Here is a sample showing how Inks Dam NFH filled out Step 5 of the form.

HACCP Step 5 – HACCP Plan Form

HACCP Plan Form (all CCPs or "yeses" from column 6 of HACCP Step 4 – Hazard Analysis Worksheet)		
(1) Critical Control Point:		**Task # 7 – Harvest phase II LMB and move to flow-through raceway for grading, sorting, counting, weighing, and examination.**
Significant Hazard(s):		Plants could be collected and moved.
Limits for Each Control Measure:		Water flows fast enough to move plants through raceways.
Monitoring	What:	Water flow rates.
	How:	Visual check.
	Frequency:	Twice a day.
	Who:	Staff.
Evaluation & Corrective Action(s) (if needed):		Increase flow if plants have not been removed. Retain fish until all plants are removed.
Supporting Documents (if any):		
>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<		
(2) Critical Control Point:		**Task # 8 – Fill Regional Distribution Unit with well water or filtered raw water from Inks Dam. Load phase II largemouth and haul to stocking sites.**
Significant Hazard(s):		Plants and animals could be moved with fish.
Limits for Each Control Measure:		Filters will be used to fill tanks, large mesh nets to load adult fish, net loads visually inspected to remove non-targets.
Monitoring	What:	Filter in place, nets of proper size.
	How:	Check that filters are in place and working, examine nets.
	Frequency:	When fish are loaded.
	Who:	Staff.
Evaluation & Corrective Action(s) (if needed):		Determine that controls are in place and working. Find alternatives for fish if controls have not worked.
Supporting Documents (if any):		
>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<		
(3) Critical Control Point:		**Task # 9 – Fishery staff meet distribution unit and net fish directly or send them through the quick discharge tube into lakes or ponds.**
Significant Hazard(s):		Non-targets could have passed through control points.
Limits for Each Control Measure:		Statistically valid samples will be used on each tank of LMB.
Monitoring	What:	Insure sample examinations are performed according to established methods.
	How:	Observation and participation.
	Frequency:	At each stocking site.
	Who:	Onsite Management Biologist.
Evaluation & Corrective Action(s) (if needed):		Management alternative for loads found to be contaminated will be identified before the distribution trip is started.
Supporting Documents (if any):		
>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<		

Facility: Inks Dam National Fish Hatchery **Address:** 345 County Road 117, Burnet, TX	**Activity/Management Objective:** Rearing and distribution of largemouth bass free of non-targets.
Signature: **HACCP Plan was followed.**	**Date:**

Monitoring Critical Control Points

Monitoring is important to ensure that the controls designed to eliminate or minimize hazards are consistently met.

Monitor - To conduct a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.

Purpose for Monitoring

There are three purposes for monitoring:

- To identify trends that may require improvements or research to ensure hazards are controlled.
- To identify when there is a loss of control (a deviation occurring at a CCP).
- To provide written documentation of the hazard control system.

Monitoring is the process that the manager relies upon to maintain control at a CCP. Accurate monitoring indicates when there is a loss of control at a CCP. When controls are not adequate, corrective actions are needed. Reviewing the monitoring records can determine the extent of the problem and the corrective action. Monitoring also provides that activities from the HACCP plan were followed. This information is useful in verifying the HACCP plan, as discussed in a later section ("Supporting Documentation"), starting on page 28.

Design of a Monitoring System

The preventive measures discussed earlier regarding hazard analysis and the control limits are intended to control the hazards at each CCP. Monitoring procedures are used to determine whether the preventive measures are being enacted and control limits are being followed.

Monitoring procedures must identify the following:

- *What* will be monitored – usually a measurement or observation to assess whether the CCP is operating within the control limit.
- *How* the control limits and preventive measures will be monitored – usually physical or chemical measurements or observations.
- How *frequently* monitoring will be performed – continuously or intermittently.
- *Who* will perform the monitoring – someone trained to perform the monitoring task.

Each of these factors is discussed in more detail below.

What Is Monitored?

Monitoring may mean measuring a characteristic of the activity or protocol to determine compliance with a control limit. Examples include the following:

- Measurement of water flow rate or tank water exchange rate.
- Measurement of freezer temperature when freezing nets to kill hazards.
- Observations of the presence/absence of hazards.
- Measurements of any chemical concentrations for treatments used to kill hazards.

Monitoring may also involve observing whether a preventive measure at a CCP is being performed. Examples include checking with management agencies for lists of infested waters or checking to see that fish coming from other facilities did not come from infested waters.

How Will Control Limits and Preventive Measures Be Monitored?

Monitoring must be designed to provide rapid (real-time) results. There is no time for lengthy analytical testing because control limit failures must be detected quickly and appropriate corrective actions instituted before transfers, distributions, and releases occur.

Physical and chemical measurements are preferred monitoring methods because testing can be done rapidly. Physical measurements (e.g., time, temperature, and direct observation) can often be related to hazard control. Physical measurements include the following:

- *Time and temperature -* This combination of measurements is often used to monitor the effectiveness of procedures used to destroy or control hazard contamination of collection gear, nets, and other natural resource survey equipment and materials. An example would be the drying or freezing of equipment for a specific time to kill a contaminant.
- *Water flow rate -* Since plant fragments, eggs, and many invertebrates cannot swim against the current, holding fish in flowing water to separate them from hitchhikers is one way to control the hazard. Measuring flow rate and the time it takes for one complete water exchange is an example of physical measurements that may need to be monitored.
- *Visual examination -* Observations for the presence of hazard contamination of equipment - such as firefighting equipment, agricultural implements, sample nets, species collection gear, and boats and trailers - is one way to monitor for non-target hazards.

How Frequently Will Monitoring Be Performed?

Monitoring can be continuous or intermittent. Where possible, monitor continuously. Continuous monitoring is possible for many types of physical and chemical parameters.

A monitoring instrument that produces a continuous record does not control the hazard on its own, it needs to be observed periodically and action taken when needed. This too is a component of monitoring. The length of time between checks directly affects the amount of corrective action when a critical limit deviation is found. The frequency of intermittent monitoring should be determined from historical knowledge of the activity and pathway.

Who Will Monitor?

Assignment of the responsibility for monitoring is an important consideration when developing an HACCP plan. The individual assigned to CCP monitoring could be the manager, biologist, or technician.

Including all personnel in HACCP planning builds a broad base of understanding and commitment to the program. All unusual occurrences and deviations from controls should be reported immediately to make sure that adjustments and corrective actions are timely. All records and documents associated with CCP monitoring must be signed or initialed by the person doing the monitoring.

Who will perform the monitoring is recorded in the HACCP plan form. In the Inks Dam example, monitoring responsibility ranges from the hatchery staff to field management biologists depending on the CCP.

Corrective Actions

Corrective Action - Procedures followed when a deviation from a critical limit occurs at a critical control point.

When controls are violated at a CCP, the predetermined, documented corrective actions should be instituted immediately.

Corrective actions are implemented when monitoring results indicate a deviation from control limits. Effective corrective actions depend heavily on an adequate monitoring program. The primary objective is to establish a HACCP plan that permits rapid identification of deviations from a control limit. The sooner the deviation is identified, the more easily corrective actions can be taken and the greater the potential for minimizing the risk of spread. An individual who has a thorough understanding of the activity, pathway, and HACCP plan and who has the authority to make decisions needs to be assigned the responsibility of making corrective actions.

All corrective actions taken should be documented. Documentation will assist the facility managers in identifying recurring problems so that the HACCP plan can be modified.

Corrective action options for Inks Dam NFH may include the following:

- Isolating and holding fish for safety evaluation.
- Diverting the affected fish to another use where aquatic hazard contamination would not be considered critical.
- Separating non-targets from the fish.
- Rejecting fish.
- Destroying fish.

Implementing Corrective Actions

Corrective actions must bring the CCP back under control. A corrective action should take care of the immediate (short-term) problem as well as provide long-term solutions. The objective is to implement a short-term fix so that control can be re-established as soon as possible without further deviations. An unanticipated or recurring control limit failure necessitates a re-evaluation of the HACCP plan.

A permanent solution to eliminating or minimizing the initial cause or causes for the deviation should be implemented if necessary. Specific instructions for corrective actions must be available to all workers in the operation and should be part of the documented HACCP plan. Corrective actions are usually written in an “if/then” format; the “if” part of the corrective action describes the condition, and the “then” part describes the action taken.

Documenting Corrective Action

Predetermined corrective actions are written into the HACCP plan. When control limits are exceeded and a corrective action occurs, it is recorded in the HACCP Plan Form under the corrective action block. A separate corrective action report is helpful as supporting documentation and should contain the following:

- Activity/pathway.
- Description of the deviation.
- Corrective action taken.
- Name of the individual responsible for taking the corrective action.
- Results of any evaluations.

In the Inks Dam case, corrective actions ranged from finding alternative stocking sites for contaminated stocks to destroying the shipment or lot.

Supporting Documentation

The HACCP Plan Form has a section (block 6) to note where supporting documentation regarding verification and records can be found.

Verification Procedures

Verification - The use of methods, procedures, or tests, in addition to those used in monitoring, that determine whether the HACCP system is in compliance with the HACCP plan and/or whether the plan needs modification.

One of the more complex principles of HACCP is *verification*. Although it is complex, the proper development and implementation of the verification principle is fundamental to the successful execution of the HACCP plan. HACCP has spawned a new adage—"trust what you can verify," which speaks to the heart of the verification principle. 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 the pathway, 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. The following are elements of verification:

- Validation
- CCP verification activities
- Calibration of monitoring devices
- Calibration record review
- Targeted sampling and testing
- CCP record review
- HACCP system verification
- Observation and reviews
- Regulatory agencies

Validation - The element of verification focused on collecting and evaluating scientific and technical information to determine whether the HACCP plan, when properly implemented, *effectively* controls identified pathway hazards.

Validation is an essential component of verification and requires substantiation that the HACCP plan, if implemented effectively, is sufficient to control the pathway 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 pathway hazards. There are several approaches to validating the HACCP plan, among them incorporation of fundamental scientific principles, use of scientific data, reliance on expert opinion, or conducting of specific observations or tests.

Validation can be performed by the HACCP team or by an individual qualified by training or experience. Validation activities may be similar in scope and time commitment to the original HACCP plan development. Actual components of the plan should be validated before relying on the HACCP plan or and when factors warrant. These factors could include: changes in the pathway; using new or different techniques; new scientific information about potential hazards or their control; or new infestations of invasives. 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 of CCPs

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 to eliminate non-target species. Additionally, CCP verification includes supervisory review of CCP calibration, monitoring, and corrective action records to confirm compliance with the HACCP plan. CCP verification may also include targeted sampling and testing.

Calibration of Monitoring Device - Verification includes calibration of monitoring devices or review of calibration records to ensure the accuracy of measurements. Regular review of CCP strategies and monitoring methods is important. If the strategies in the plan are not updated regularly to incorporate new techniques and ideas, there is a higher risk that non-target species will be spread.

Methods Record Review - Reviewing the methods and equipment specified in the planning process records involves checking the methods that will be used to remove non-targets to make sure that these methods actually remove hitchhikers. Reviews become a part of reference data that contribute to HACCP success.

Targeted Sampling and Testing - Verification may also include targeted sampling, testing, and other periodic activities. If you rely on others to verify through compliance records that the pathway is free of non-target species, you may want to check targeted samples to verify their claims. Typically, when a monitoring procedure is not as stringent as desired, it should be coupled with a strong verification strategy.

CCP Record Review - At least two types of records are generated at each CCP: monitoring and corrective action. These records are valuable management tools, providing documentation that CCPs are operating within established safety parameters and deviations are handled in an appropriate manner. However, records alone are meaningless unless someone in a supervisory capacity reviews them periodically to verify that the HACCP plan is being followed.

HACCP System Verification

In addition to the verification activities for CCPs, strategies should be developed for scheduled verification of the complete HACCP system. The frequency of the systemwide verification should be yearly or whenever there is a system failure or significant change in the product or process. The HACCP team is responsible for ensuring that this verification is performed.

System Verification Activities - Systematic verification activities include on-site observations and record reviews. An unbiased person who is not responsible for performing the monitoring activities usually performs reviews.

System verification should occur at a frequency that ensures the HACCP plan is routinely being followed. This frequency depends on a number of conditions, such as the variability of the process and the natural resources pathway.

Regulatory Agencies and HACCP Planning For Natural Resource Pathways

The HACCP approach could be used by resource management agencies to control and manage natural resource pathways in agencies and industry. A quick review of HACCP plans required for approved actions would show possible invasive non-targets that may be introduced along with the action. For example, many states receive recreation species to meet management needs from businesses or other agencies that are many states away. Management agencies could require and review HACCP plans *before* delivery of these transfers. Review of HACCP plans for effectiveness and to see that the plan is being followed provides an additional level of security.

Natural resource HACCP plans are unique documents prepared to prevent non-target species spread through natural resource pathways. HACCP plan reviewers must have access to records that pertain to CCPs, deviations, corrective actions, and other information pertinent to the plan that may be needed for verification. The plans could provide an important information resource that others can review to find expert methods to remove non-targets.

Record-Keeping Procedures

Accurate record keeping is an essential part of a successful HACCP program. Records provide documentation that the control limits have been met or appropriate corrective actions taken when the limits were exceeded. Likewise, they provide a means of monitoring so that adjustments can be made to prevent non-target contamination.

Types of Records Needed

Several types of records are needed:

- HACCP plan and support documents.
- Monitoring records.
- Corrective action records.
- Verification records.

Each of these types of records is discussed below.

HACCP Plan and Support Documents - It is advisable to maintain HACCP plan supporting documentation described in this chapter. HACCP support documents include information and data used to develop the plan. This includes the written Hazard Analysis Worksheet and records of any information used in performing the hazard analysis and establishing the controls.

Support documents may include information about the current geographic range of non-targets that may get into the pathway and sufficient data used to establish the adequacy of any barriers to this contamination. In addition to data, support documents may also include correspondence with consultants or other experts.

Support documents should also include a list of the HACCP team, each member's responsibilities, and a summary of the preliminary steps taken in the development of the HACCP plan.

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

By tracking the values recorded on monitoring records, an operator or manager can determine whether a process is approaching its control limit. Trends can be identified through record review to make necessary adjustments. If timely adjustments are made before the control limit is violated, managers can prevent nonreversible species introductions.

Examples of CCP monitoring records may include the following:

- Number of samples or examinations made to check for non-targets
- Frequency of filter checks and how often they failed or needed replacement

Corrective Action Records - Corrective action records were discussed earlier in this chapter (see page 27).

Verification Records - Verification records should include the following:

- Modifications to the HACCP plan (e.g., changes in handling and distribution).
- Management records verifying supplier compliance with HACCP plans and associated guarantees or certifications.
- Verification of the accuracy and calibration of all monitoring equipment.
- Results of in-house, on-site inspections.
- Results of equipment evaluation tests.

Record Monitoring Information

Monitoring information should be recorded at the time the observation is made. False or inaccurate records filled out before the operation takes place or those that are completed later are inappropriate for a HACCP system.

Record Review

The HACCP Plan, Step 5, monitoring section records information on CCPs and any control deviations that occur. This critical data should be reviewed in a timely manner by management, and all records should be signed or initialed and dated by the reviewer.

Using the Inks Dam example, monitoring records should be included for each of the activities identified (What, How, Frequency and Who) of the HACCP plan. The identification and location of these records should be entered in block 5 of the form so they can easily be found for follow-up review or corrective actions. Any corrective actions taken should be noted in block 6 for each CCP.

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Chapter 4: Examples

HACCP Step 1 – Activity Description

Activity Description	
Facility: Inks Dam National Fish Hatchery	Site:
Project Coordinator: Robert Lindsey	Activity/Management Objective: Rearing and distribution of largemouth bass free of non-targets.
Site Manager: Robert Lindsey	
Address: 345 County Road 117 Burnet, TX	
Phone: 512-793-2474	

Project Description i.e. Who; What; Where; When; How; Why
Fishery Resource Offices request northern strain largemouth bass a year before production begins at the Inks Dam National Fish Hatchery. Requests are submitted to the Regional Office for prioritization with other production and fishery needs. After review a production and stocking request is provided to the hatchery prior to the fish rearing season. The Hatchery Manager and Assistant Manager direct the harvest of broodstock from holding ponds in early March to begin the rearing cycle. Four-year-old broodstock are harvested by draining the pond and moved to flow-through raceways. In two to three weeks, depending on temperature patterns, fish are sorted by sex and 50 pair are stocked into a spawning pond. Most fish will spawn in three days. About seventeen days after brood fish are stocked fry collection begins. Schools of fry are collected with seines and moved in 20-gallon tubs to filled and fertilized rearing ponds. Fry usually are kept in these rearing ponds for three weeks when they are harvested as 1.5 inch fingerlings and moved to holding tanks to be trained on artificial feed. After four weeks of feeding these fish are moved to small rearing ponds where artificial feeding on pellets continues throughout the rest of the rearing cycle. The 6-8 inch fish are usually equipped with oxygen and easy loading/unloading access. The yearling fish are graded, sorted, weighed, and treated, if needed, before they are loaded for distribution in two to three days. Larger fish are easier to separate from non-targets and some species have matured and left the rearing pond. Fish are then distributed to receiving waters in the southwest. Requesting Fishery Resources Offices meet the delivery truck to assist with stocking.

HACCP Step 2 – Identify Potential Hazards

(to be transferred to column 2 of HACCP Step 4 – Hazard Analysis Worksheet)

Hazards: Species or Contaminants Which May Potentially Be Moved/Introduced
Vertebrates: Guadalupe bass (*Micropterus treculi*), logperch (*Percina caprodes*), gizzard shad (*Dorosoma cepedianum*), white bass (*Morone chrysops*), bluegill (*Lepomis macrochirus*), warmouth (*Lepomis gulosus*), green sunfish, common carp, smallmouth buffalo, redbreast sunfish, bullfrogs, tadpoles, gulf coast toad, aquatic snakes
Invertebrates: miscellaneous aquatic insects, Asian clam (*Corbicula spp*), crayfish
Plants: Hydrilla, Eurasian watermilfoil, water star thistle, water hyacinth, brushy pond week, various algae (*Chara, Pithophora, Hydrodicton*)
Other Biologics (e.g. genetics, disease, pathogen, parasite, or non-pathogens): Largemouth bass virus
Others (non-biological contaminants e.g. pesticide residue, oil products, etc. or harborage via packing or construction materials, etc.): None

HACCP Step 3 – Flow Diagram

Flow Diagram Outlining Sequential Tasks to Complete Activity/Project
Described in HACCP Step 1 – Activity Description
(to be transferred to column 1 of the HACCP Step 4 – Hazard Analysis Worksheet)

Task 1	Harvest brood fish from holding ponds & transfer to raceways. Hold fish for 2-3 weeks in raceways. Sort, grade, sex brood stock (50 pair) for spawning.
	⇓
Task 2	Fill spawning ponds with Lake Buchanan water through gravity feed water line.
	⇓
Task 3	Transfer broodstock (50 pair) to spawning pond.
	⇓
Task 4	Harvest fry 17 days after brood fish are stocked out to spawn and move to rearing pond for 3 week phase I rearing.
	⇓
Task 5	Harvest phase I fingerlings (1.5 inches) and move to confined rearing tanks with flow-through water and begin 4 weeks of feeding artificial diet.
	⇓
Task 6	Harvest pre-phase II fish and move to small rearing ponds. Continue feeding until harvest in November as phase II (6-8 inch fish).
	⇓
Task 7	Harvest phase II LMB and move to flow-through raceway for grading, sorting, counting, weighing, and examination.
	⇓
Task 8	Fill Regional Distribution Unit with well water or filtered raw water from Inks Dam. Load phase II largemouth and haul to stocking sites.
	⇓
Task 9	Fishery staff meet distribution unit and net fish directly or send them through the quick discharge tube into lakes or ponds.
	⇓
Task 10	

HACCP Step 4 – Hazard Analysis Worksheet

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task # 1 Harvest brood fish from holding ponds & transfer to raceways. Hold fish for 2-3 weeks in raceways. Sort, grade, sex brood stock (50 pair) for spawning.	Vertebrates Other fish species	No	Fish are large and easily separated.		
	Invertebrates Miscellaneous aquatic insects	No	Adult fish handpicked & moved.		
	Plants Hydrilla, water star thistle	No	Adult fish handpicked & moved.		
	Other Biologics None				
	Others None				
Task # 2 Fill spawning ponds with Lake Buchanan water through gravity feed water line.	Vertebrates Other fish species	Yes	Fish easily travel with water into ponds.	Filters need to be used.	No
	Invertebrates Miscellaneous aquatic insects	Yes	Insects travel with water into ponds.	Filters need to be used.	No
	Plants Watermilfoil, hydrilla, water star thistle	Yes	Plants travel with water into ponds.	Filters need to be used.	No
	Other Biologics None				
	Others None				

HACCP Step 4 – Hazard Analysis Worksheet (continued)

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task # 3 Transfer broodstock (50 pair) to spawning pond.	Vertebrates Other fish species	No	Large broodstock easily separated from non-targets.		
	Invertebrates Miscellaneous aquatic insects	No	Large mesh nets will not collect insects.		
	Plants Watermilfoil, hydrilla, water star thistle	No	Plants will be flushed out by water flow.		
	Other Biologics None				
	Others None				
Task # 4 Harvest fry 17 days after brood fish are stocked out to spawn and move to rearing pond for 3 week phase I rearing.	Vertebrates Other fish, bullfrogs, tadpoles, toads	Yes	Other species could be in the pond and collected in seine.	Visually examine tubs and remove non-targets by hand.	No
	Invertebrates Miscellaneous aquatic insects	Yes	Species could be collected in seine.	Visually examine tubs and remove non-targets by hand.	No
	Plants Watermilfoil, hydrilla, water star thistle, water hyacinth	Yes	Could be collected in seine.	Visually examine tubs and remove non-targets by hand.	No
	Other Biologics None				
	Others None				

HACCP Step 4 – Hazard Analysis Worksheet (continued)

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task # 5 Harvest phase I fingerlings (1.5 inches) and move to confined rearing tanks with flow-through water and begin 4 weeks of feeding artificial diet.	Vertebrates Other fish, bullfrogs, tadpoles, toads	Yes	Non-targets impossible to separate during harvest.	Visually separate larger non-targets. Use siphon to remove bottom-hugging tadpoles.	No
	Invertebrates Miscellaneous aquatic insects	Yes	Non-targets impossible to separate during harvest.	Visually remove insects.	No
	Plants Watermilfoil, hydrilla, water star thistle, water hyacinth	Yes	Non-targets impossible to separate during harvest.	Visually pick out plant fragments.	No
	Other Biologics None				
	Others None				
Task # 6 Harvest pre-phase II fish and move to small rearing ponds. Continue feeding until harvest in November as phase II (6-8 inch fish).	Vertebrates Other fish, bullfrogs, tadpoles, toads	No	Species removed during confinement.		
	Invertebrates Miscellaneous aquatic insects	No	Removed by feeding LMB.		
	Plants Watermilfoil, hydrilla, water star thistle, water hyacinth	No	Removed by water flow.		
	Other Biologics None				
	Others None				

HACCP Step 4 – Hazard Analysis Worksheet (continued)

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task # 7 Harvest phase II LMB and move to flow-through raceway for grading, sorting, counting, weighing, and examination.	Vertebrates Other fish, bullfrogs, tadpoles, toads	No	Fish harvested with large mesh net and non-targets will be separated.		
	Invertebrates Miscellaneous aquatic insects	No	Fish harvested with large mesh net and non-targets will be separated.		
	Plants Watermilfoil, hydrilla, water star thistle, water hyacinth	Yes	Fish harvested with large mesh net, plants will be rinsed through mesh and removed by hand.	Water flow in raceways will remove plants after 24 hours.	Yes
	Other Biologics None				
	Others None				
Task # 8 Fill Regional Distribution Unit with well water or filtered raw water from Inks Dam. Load phase II largemouth and haul to stocking sites.	Vertebrates Other fish, bullfrogs, tadpoles, toads	Yes	Species could enter with water delivery.	Raw water should be filtered.	Yes
	Invertebrates Miscellaneous aquatic insects	Yes	Species could enter with water delivery.	Raw water should be filtered.	Yes
	Plants Watermilfoil, hydrilla, water star thistle, water hyacinth	Yes	Species could enter with water delivery.	Raw water should be filtered.	Yes
	Other Biologics None				
	Others None				

HACCP Step 4 – Hazard Analysis Worksheet (continued)

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task # 9 Fishery staff meet distribution unit and net fish directly or send them through the quick discharge tube into lakes or ponds.	Vertebrates Other fish, bullfrogs, tadpoles, toads	Yes	Non-targets could have been passed through other control points.	Visual inspection using random samples.	Yes
	Invertebrates Miscellaneous aquatic insects	Yes	Non-targets could have been passed through other control points.	Visual inspection using random samples.	Yes
	Plants Watermilfoil, hydrilla, water star thistle, water hyacinth	Yes	Non-targets could have been passed through other control points.	Visual inspection using random samples.	Yes
	Other Biologics None				
	Others None				

HACCP Step 5 – HACCP Plan Form

HACCP Plan Form (all CCPs or "yeses" from column 6 of HACCP Step 4 – Hazard Analysis Worksheet)		
(1) Critical Control Point:		**Task # 7 – Harvest phase II LMB and move to flow-through raceway for grading, sorting, counting, weighing, and examination.**
Significant Hazard(s):		Plants could be collected and moved.
Limits for Each Control Measure:		Water flows fast enough to move plants through raceways.
Monitoring	What:	Water flow rates.
	How:	Visual check.
	Frequency:	Twice a day.
	Who:	Staff.
Evaluation & Corrective Action(s) (if needed):		Increase flow if plants have not been removed. Retain fish until all plants are removed.
Supporting Documents (if any):		
>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<		
(2) Critical Control Point:		**Task # 8 – Fill Regional Distribution Unit with well water or filtered raw water from Inks Dam. Load phase II largemouth and haul to stocking sites.**
Significant Hazard(s):		Plants and animals could be moved with fish.
Limits for Each Control Measure:		Filters will be used to fill tanks, large mesh nets to load adult fish, net loads visually inspected to remove non-targets.
Monitoring	What:	Filter in place, nets of proper size.
	How:	Check that filters are in place and working, examine nets.
	Frequency:	When fish are loaded.
	Who:	Staff.
Evaluation & Corrective Action(s) (if needed):		Determine that controls are in place and working. Find alternatives for fish if controls have not worked.
Supporting Documents (if any):		
>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<		
(3) Critical Control Point:		**Task # 9 – Fishery staff meet distribution unit and net fish directly or send them through the quick discharge tube into lakes or ponds.**
Significant Hazard(s):		Non-targets could have passed through control points.
Limits for Each Control Measure:		Statistically valid samples will be used on each tank of LMB.
Monitoring	What:	Insure sample examinations are performed according to established methods.
	How:	Observation and participation.
	Frequency:	At each stocking site.
	Who:	Onsite Management Biologist.
Evaluation & Corrective Action(s) (if needed):		Management alternative for loads found to be contaminated will be identified before the distribution trip is started.
Supporting Documents (if any):		
>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<		

Facility: Inks Dam National Fish Hatchery **Address:** 345 County Road 117, Burnet, TX	**Activity/Management Objective:** Rearing and distribution of largemouth bass free of non-targets.
Signature: **HACCP Plan was followed.**	**Date:**

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Chapter 5:
Blank Forms

HACCP Step 1 – Activity Description

<table>
<tr><th colspan="2">Activity Description</th></tr>
<tr><td>Facility:</td><td>Site:</td></tr>
<tr><td>Project Coordinator:</td><td rowspan="4">Activity/Management Objective:</td></tr>
<tr><td>Site Manager:</td></tr>
<tr><td>Address:</td></tr>
<tr><td>Phone:</td></tr>
</table>

Project Description i.e. Who; What; Where; When; How; Why

HACCP Step 2 – Identify Potential Hazards

(to be transferred to column 2 of HACCP Step 4 – Hazard Analysis Worksheet)

Hazards: Species or Contaminants Which May Potentially Be Moved/Introduced
Vertebrates:
Invertebrates:
Plants:
Other Biologics (e.g. genetics, disease, pathogen, parasite, or non-pathogens):
Others (non-biological contaminants e.g. pesticide residue, oil products, etc. or harborage via packing or construction materials, etc.):

HACCP Step 3 – Flow Diagram

Flow Diagram Outlining Sequential Tasks to Complete Activity/Project
Described in HACCP Step 1 – Activity Description
(to be transferred to column 1 of the HACCP Step 4 – Hazard Analysis Worksheet)

Task 1	
	⇓
Task 2	
	⇓
Task 3	
	⇓
Task 4	
	⇓
Task 5	
	⇓
Task 6	
	⇓
Task 7	
	⇓
Task 8	
	⇓
Task 9	
	⇓
Task 10	

HACCP Step 4 – Hazard Analysis Worksheet

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task 1	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				
Task 2	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				

HACCP Step 4 – Hazard Analysis Worksheet (continued)

1 Tasks (from HACCP Step 3 - Flow Diagram)	2 Potential hazards identified in HACCP Step 2	3 Are any potential hazards significant? (yes/no)	4 Justify evaluation for column 3	5 What control measures can be applied to prevent undesirable results?	6 Is this task a critical control point? (yes/no)
Task #	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				
Task #	Vertebrates				
	Invertebrates				
	Plants				
	Other Biologics				
	Others				

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HACCP Step 5 – HACCP Plan Form

HACCP Plan Form (all CCPs or "yeses" from column 6 of HACCP Step 4 – Hazard Analysis Worksheet)	
(1) Critical Control Point:	
Significant Hazard(s):	
Limits for Each Control Measure:	
Monitoring	What:
	How:
	Frequency:
	Who:
Evaluation & Corrective Action(s) (if needed):	
Supporting Documents (if any):	
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<	
(2) Critical Control Point:	
Significant Hazard(s):	
Limits for Each Control Measure:	
Monitoring	What:
	How:
	Frequency:
	Who:
Evaluation & Corrective Action(s) (if needed):	
Supporting Documents (if any):	
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<	
(3) Critical Control Point:	
Significant Hazard(s):	
Limits for Each Control Measure:	
Monitoring	What:
	How:
	Frequency:
	Who:
Evaluation & Corrective Action(s) (if needed):	
Supporting Documents (if any):	
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>><<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<	
Facility:	**Activity/Management Objective:**
Address:	
Signature: **HACCP Plan was followed.**	**Date:**

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Chapter 6:
Glossary

alien — see non-indigenous.

aquarium release — a type of intentional introduction whereby a captive or pet fish, aquarium plants, and contaminated water are released into open waters by an aquarium hobbyist.

aquatic nuisance species (ANS) — a non-indigenous species that threatens the diversity or abundance of native species; the ecological stability of infested waters; or commercial, agricultural, aquacultural, or recreational activities dependent on such waters.

bait bucket introduction — a type of introduction involving fish (usually small minnows) or invertebrates, used or intended to be used as bait, that are released or escape into open waters as a result of fishing activities.

contaminant introduction — see stock contaminant.

control — (a) (verb) to manage the conditions of an operation to maintain compliance with established criteria. (b) (noun) the state in which correct procedures are being followed and criteria are being met.

control limit — a criterion that must be met for each control measure associated with a critical control point.

control measures — actions that can be used to control a potential hazard (sometimes referred to as a preventive measure).

control point — any step at which potential hazards can be controlled.

corrective action — procedures followed when a deviation from a critical limit occurs at a critical control point.

critical control point (CCP) — the best point, step, or procedure at which significant hazards can be prevented or reduced to minimum risk.

deviation — failure to meet a critical limit.

endemic — a species or any other taxonomic group that is native to a limited geographic area (such as a lake, drainage system, biogeographic region, or country).

escape	a type of unintentional introduction whereby a non-target species escapes into open water from captive conditions such as an aquaculture facility, research facility, hatchery, ornamental fish farm, or zoological park.
established	an introduced organism with one or more reproducing or breeding populations.
exotic	see non-indigenous.
hazard	a non-target species of plant or animal that is reasonably likely to be transported through natural resource work and become established with negative impacts to native species and their habitats.
indigenous	occurring or found naturally in a particular area or ecosystem; historically occurring in a geographic range previous to the arrival of the first European settlers in North America; a species that is a member of the native natural community.
intentional stocking or relocation	an introduction for specific natural resource management purposes.
introduced	an organism moved by humans (or by human actions) to an ecosystem or region where it was not found historically due to human actions (i.e., is, an individual, group, or population of organisms that occur in a particular locale because of human actions).
locally established	an introduced organism with one or more naturally reproducing populations but with a very restricted distribution and no evidence of natural range expansion (in general, limited to a relatively confined area, such as a small lake).
monitoring	conducting a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.
native	see indigenous.
naturalized	see established.

non-indigenous	an individual, group, or population of a species that is introduced into an area or ecosystem outside its historic or native geographic range. In this manual, the term includes both foreign (i.e., exotic) and transplanted species, and is used synonymously with “alien,” “non-native” and “introduced.”
non-native	see non-indigenous.
non-target species (NTS)	any species of plant, animal, disease, pathogen, or parasite that may be present in the action area but is not the species for which an action was initiated; synonymous with hazards in the industry’s application of HACCP planning.
open water	in this manual, includes all lakes, rivers, streams, and springs; also any water bodies, such as reservoirs, ponds, canals, and drainage ditches, considered to be outside the boundaries or control of captive conditions (e.g. aquaculture facility, research facility, hatchery, ornamental fish farm, or zoological park). An open water may have either a permanent, temporary, or intermittent water connection (e.g. via flooding) with other aquatic systems.
operating limits	criteria that are more stringent than critical limits used to reduce the risk of contamination by non-target species. For example, if a certain chemical concentration is required to control a non-target hazard, then the operating limit is generally set above the minimum concentration needed to ensure effective treatment.
pathway	an identified activity or process through which a species is transferred to a new location where it could become established and become invasive.
pathway management	the act of identifying control points through process mapping of an action and incorporating systems to reduce or eliminate non-target biologics.
pests	species that do not threaten: the diversity or abundance of native species; the ecological stability of infested waters; or commercial, agricultural, aquacultural, or recreational activities dependent on such waters but are considered to be undesirable.

reintroduction	the intentional release by humans of a species into a drainage, or portion of a drainage, in which it was indigenous in historic times but where it subsequently became locally extinct.
restocking	the deliberate release by humans of a species into an area where it already occurs, usually with the intention of augmenting the existing population.
reported	refers to an introduced species that has been recorded (i.e., collected, stocked, or observed) from open waters but is not as yet known to be established.
risk	an estimate of the likely occurrence of a hazard.
severity	the seriousness of a hazard (if not properly controlled).
stock contaminant	fish unintentionally stocked with, or instead of, another species or taxa (e.g., green sunfish mistakenly mixed with, or misidentified as, bluegill during stocking); fish released into open waters because one or a few individuals were inadvertently mixed in with a larger shipment of fish or fishes intended for stocking.
target	whatever is being moved from place to place. Examples of natural resource activities where the term could be applied include stocking of a species of fish for recreation or restoration, collection of a species for captive breeding or relocation, and movement from location to location by a biologist or scientist collecting habitat data or moving equipment from area to area, region to region.
taxon	group of organisms of any taxonomic rank. Plural is taxa.
transplant	an organism moved outside its native geographic range but within a country where it occurs naturally (i.e., one whose native range includes at least a portion of the country where it is found); a species moved by humans, either deliberately or accidentally, from an area where it is native, to another area outside its native distribution but within the same national geographic range.
unsuccessful introduction	an introduced species that has failed to establish a self-sustaining or reproducing population.

validation — the element of verification focused on collecting and evaluating scientific and technical information to determine whether the HACCP plan, when properly implemented, *effectively* controls identified pathway hazards.

vector — a biological pathway for a disease or parasite (i.e., an organism that transmits pathogens to various hosts).

verification — the use of methods, procedures, or tests, in addition to those used in monitoring, that determine whether the HACCP system is in compliance with the HACCP plan and/or whether the plan needs modification.

Sources for the above definitions include:

Fuller, P.L., L.G. Nico, and J.D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, MD.

Gunderson, J.L., and R.E. Kinnunen, eds. 2001. Aquatic Nuisance Species – Hazard Analysis and Critical Control Point Training Curriculum. Minnesota Sea Grant, Duluth, MN and Michigan Sea Grant, Ann Arbor, MI.

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Chapter 7: References

This chapter includes references to websites, government publications, books, and videos. The full text of two relevant articles has also been included.

Related Websites

http://bluegoose.arw.r9.fws.gov/resources/weeds.html—invasive species resources—links from the U.S. Fish and Wildlife Service invasives webpage

http://www.invasivespecies.gov/faq/main.shtml—National Invasive Species Council—frequently asked questions

http://www.nps.gov/plants/alien/index.htm—Plant Conservation Alliance's Alien Plant Working Group—additional information on invasive plants (including specific species)

http://nas.er.usgs.gov/—Non-indigenous Aquatic Species—information resource for the Florida Caribbean Science Center of the USGS—huge list of non-indigenous species website links

http://tncweeds.ucdavis.edu/

http://www.weedcenter.org/—Center for Invasive Plant Management

http://www.anstaskforce.gov/—Aquatic Nuisance Species Task Force

http:/biology.usgs.gov/cro/invasive.htm—USGS, BRD, Central Region

http://www.issg.org/—Invasive Species Specialist Group—also a list of "100 of the World's Worst Invasive Species"

http://www.sgnis.org/—Sea Grant Non-indigenous Species

http://www.seagrant.umn.edu/pubs/freeorder.html—Minnesota Sea Grant exotic species publications

http://www.100thmeridian.org/

http://www.northeastans.org/imagelinks.htm—Northeast ANS Panel—links to plant & animal ANS images

http://www.protectyourwaters.net/prevention/prevention_user.php

http://contaminants.fws.gov/Issues/InvasiveSpecies.cfm—FWS Division of Environmental Quality Invasive Species webpage

http://www.aquanic.org—AquaNIC (Aquaculture Network Information Center)

http://www.entryway.com/seagrant/—National Aquatic Nuisance Species Clearinghouse

Government Publications Available on the Internet

http://www.wws.princeton.edu/~ota/disk1/1993/9325_n.html—U.S. Congress, Office of Technology Assessment. *Harmful Non-Indigenous Species in the United States*. OTA-F-565 (Washington, DC: U.S. Government Printing Office, September 1993).

http://www.cnie.org/nle/biodv-26.html—Corn, L., et al. *Harmful Non-Native Species: Issues for Congress*. CRS Issue Brief for Congress. The National Council for Science and the Environment.

http://www.denix.osd.mil/denix/Public/ES-Programs/Conservation/Invasive/intro.html—Westbrooks, R. *Invasive Plants, Changing the Landscape of America: Fact Book*. Washington, DC: Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), 1998.

Books and Publications

Bright, C. and L. Starke. 1998. Life out of bounds: bioinvasion in a borderless world. Worldwatch Institute. W.W. Norton and Company, New York, NY. ISBN: 0393318141.

Cox, G.W. 1999 Alien species in North America and Hawaii: impacts on natural ecosystems. Island Press. ISBN: 1-55963-680-7.

Devine, R.S. 1998. Alien invasion: America's battle with non-native animals and plants. National Geographic Society. ISBN: 0792274490.

Fuller, P.L., L.G. Nico, and J.D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, MD.

Mooney, H.A., and R.J. Hobbs. 2000. Invasive species in a changing world. Island Press. ISBN: 1555963782X.

Simberloff et al. 1997. Strangers in paradise: impact and management of non-indigenous species in Florida. Island Press. ISBN: 1559634308.

Van Driesche, J., and R. Van Driesche. 2000. Nature out of place: biological invasions in the global age. Island Press. ISBN: 1559637579.

Williamson, M. 1996. Biological invasions. Chapman and Hall. ISBN: 0412591901.

Videos

MN Sea Grant video. "Stop Exotics, Clean Your Boat."

MN Sea Grant video. "From Net to Sale: Controlling ANS with the HACCP Approach for Baitfish and Aquaculture Industries"

Information Television Videos:

- "Aquatic Invaders"
- "Plants Out of Place"

Articles

Articles are included below.

Fish and Wildlife Blunders in Lake Powell

By Skip Knowles, *The Salt Lake Tribune*, Tuesday, August 27, 2002

After years of telling Utah biologists to forget about stocking gizzard shad in Lake Powell because of concern for sensitive species, the U.S. Fish and Wildlife Service accidentally did just that.

“We considered it years ago and Fish and Wildlife said absolutely not,” said southern region biologist Dale Hepworth. “Now they did it by mistake. That’s kind of comical.”

Gizzard shad, and as many as eight other species, were accidentally stocked several years ago in Morgan Lake near Shiprock, N.M., along with a load of largemouth bass intended for the lake.

The lake periodically overflows down Chaco Wash into the San Juan River, a major tributary to Powell. Biologists, though, are unsure when the first gizzards made it to Powell.

Powell biologist Wayne Gustaveson calls the accident bleak for downriver species but a great thing for Powell.

Called “stink shad” in their native southeastern United States, gizzards are not a catchable game fish. But as a forage fish, they could bring back the days of screaming fishing rod reels and huge striped bass.

Gustaveson estimates that at least 2,000 gizzards exist in Powell based on the six specimens netted in the San Juan River arm of Powell this month. They indicate a breeding population Gustaveson predicts will spread throughout the lake in two to five years.

The intruders are bad news for endangered humpback chubs downstream from Powell. Gizzards will not eat the chubs if they spread downriver, but they could out-compete them for plankton and biomass.

The Little Colorado River, 100 miles downstream from Glen Canyon Dam, which forms Lake Powell, is home to the largest known population of endangered humpback chubs.

Non-native threadfin shad currently live in Powell but have never spread far upriver or downriver. But gizzards are a much larger, more robust and faster breeding variety that love muddy water.

Threadfins take two years to reach 3–4 inches in length. Gizzards grow that large in two months, Gustaveson said.

Powell’s once-famous “striper” fishery collapsed in the mid-‘80s when striped bass wiped out the threadfin shad planted there as forage. Periodically, the threadfins bounce back, but it is a short-lived boom.

Don’t count your trophy stripers before they hatch, says Gordon Mueller, an ecologist with U.S. Geological Survey. He will be surprised if stripers can wrap their lips around dinner-plate shaped adult shad.

He caught the first gizzard shad in the Powell system in June of 2000 during a project that sampled 40,000 fish.

In a “finny” foreshadowing, the 14-inch gizzard showed up in the net with three endangered razorback suckers, caught in the muddy mouth of the San Juan.

“It’s not good news. It may have repercussions for not only the endangered fish but for the recreation fishery,” Mueller said.

The greedy gizzards will gobble up plankton, a food source for all young fish.

“There’s another chair at the table,” Mueller said.

And unlike the threadfin that is always small enough for predators to eat, the gizzard gets up to 18 inches.

Too much of Powell’s productivity is already tied up in large carp, Mueller says, and gizzards may just be another big fish that predators can’t eat.

“It’s very unfortunate that they’re there,” Mueller said. “Our ability to create change is a lot better than our ability to direct it.”

Nothing can be done about the gizzards without harming other aquatic life, said USFWS spokesman Tom Bauer, in Albuquerque. And what of the USFWS hand in the accidental introduction?

“I’m not going to get into that name-calling game,” Bauer said.

And what of those other mystery fished dumped in that New Mexico lake?

Nobody knows, but scientists have not caught them in Powell yet.

The largemouth bass initially came from Inks Dam National Fish Hatchery in south-central Texas in 1998, where gizzard shad are abundant.

Subsequent loads of bass transported to Morgan Lake from the hatchery were found to have as many as nine different species besides largemouth bass.

Guadalupe bass, logperch, gizzard shad, white bass, bluegill and dollar sunfish, to name a few.

Gizzard shad exist in Utah in shallow Willard Bay as a boon to the walleye and wiper fishery there, but are periodically killed off in droves by cold temperatures.

Gizzard Shad Found in Lake Powell

News Release

During routine fish sampling in August on Lake Powell's upper San Juan arm six gizzard shad were collected. This forage species is new to Lake Powell and the main-stem Colorado River drainage. Shad averaged 4 inches and were suspected to be naturally reproduced within the lake. Ramifications of a new species of fish range from good to bad.

Gizzard shad grow quickly and attain a much larger size than threadfin which, to this point, were the only shad in Lake Powell. The rapid growth means that largemouth and smallmouth bass are able to eat shad for only a short time each spring. Then shad and young bass may actually compete for the same limited planktonic food.

Striped bass are the dominant predator in Lake Powell and have for decades decimated threadfin shad from the open water. In other years, shad numbers have been cropped as newly hatched shad are eaten almost as fast as they enter open water in search of food. Gizzard shad will grow large enough to provide a bigger ration of food for stripers for a longer period of time. It may be that striped bass size and condition will increase as the gizzard shad become widespread and fully established.

The unknown element is how fast gizzard shad will colonize Lake Powell and where they will reside. Gizzard shad prefer mud-stained water and have been shown to lose the competitive battle with threadfin for food in open, clear water. Gizzard shad are more adept at bottom-feeding on algae while threadfin are better adapted to feeding on free-swimming zooplankton. It may be that both shad species will be limited to productive inflow areas that now exclusively harbor threadfin. Or gizzard shad may populate the open water and proliferate there due to their larger body size and greater fecundity. The outcome is unknown and will be the subject of close scientific scrutiny by the Utah Division of Wildlife Resources during the new species colonization period. The outcome will likely be determined by striped bass as they feed on both gizzard and threadfin shad.

While the origin of the new species in Powell is unknown it has been reported by U.S. Fish and Wildlife Service that gizzard shad were accidentally introduced into Morgan Lake near Shiprock, NM with a shipment of largemouth bass in 1998. The bass came from Inks Dam National Fish Hatchery in south-central Texas in the Rio Colorado drainage where gizzard shad are abundant in the surface water used at the hatchery. Subsequent loads of bass transported to Morgan Lake from the hatchery were found to have as many as 9 different species besides largemouth bass (fish species included Guadalupe bass, logperch, gizzard shad, white bass, bluegill, and dollar sunfish). These shipments were refused but gizzard shad were already firmly established in Morgan Lake. Logistics prevent shad from being chemically removed from Morgan Lake which is an important largemouth bass sport fishery on the Navajo Reservation. The 1200-acre lake provides water to the APS power plant near Shiprock. Lowering the lake would require the power plant to be shut down for an extended period. Poisoning fish without lowering the lake would block intakes with dead fish and effectively shut down the power plant as well.

One single adult gizzard shad was collected from Lake Powell in 2000 near the San Juan inflow. This fish was suspected to be a downstream migrant from Morgan Lake. No gizzard shad were found in Lake Powell during 2001. Now it appears that enough adult gizzard shad have taken up residence in Lake Powell to produce a year-class of young in the huge reservoir. The development of the gizzard shad population in all of Lake Powell may take only 2 years or may be delayed for decades.

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