Slide 1

Biosecurity for Aquaculture Facilities

Today's presentation will discuss some basic principles of biosecurity for aquaculture. While many of these measures are applicable for viral hemorrhagic septicemia (our focus today), they can also be effective for preventing other infectious diseases of fish as well as the introduction of many aquatic invasive species.

Slide 2

Biosecurity

- Practices, procedures and policies to prevent introduction and spread
  - Infectious diseases
    - Microorganisms
      - Bacteria, viruses, fungi
    - Parasites
  - Aquatic invasive species
    - Zebra mussels, rusty crayfish

So what exactly is biosecurity?
Biosecurity involves the practices, procedures and policies used to prevent the introduction and spread of disease causing organisms (e.g., bacteria, viruses, fungi, parasites) as well as many aquatic invasive species (e.g., zebra mussels, rusty crayfish). Fish diseases continue to be one of the greatest causes of economic loss for the industry, accounting for million of dollars in annual losses to U.S. fish producers. While some fish pathogens are well known problems, other diseases are emerging or spreading to previously unaffected areas. Outbreaks can happen rapidly and spread quickly, often resulting in high mortalities. It is difficult to predict when disease might occur, however the routine use of biosecurity measures can reduce the risk of introduction and economic impact of these diseases. Top Photo: Gizzard shad with external hemorrhages from VHS. Courtesy of Paul Bowser, Aquatic Animal Health Program, Cornell University, College of Veterinary Medicine; Bottom Photo: Crayfish covered with zebra mussels. From Ontario Ministry of Natural Resources.

Slide 3

Use of Biosecurity

- Reduce risk of disease introduction
- Minimize spread on-farm or to new areas
- Promote fish health
- Protect economic investment
  - Reputation
- Protect against new diseases
  - Viral hemorrhagic septicemia
- Protect human health
  - Zoonoses, Food safety

Why is biosecurity important? The most obvious reason is to reduce the risk of disease introduction or spread on your farm. The concentration of large number of animals within production settings can lead to the rapid spread of disease. High stocking densities also increase stress, making fish more susceptible to disease. Since treatment options are limited for most aquaculture diseases, prevention remains the best line of defense for the aquaculture producer.

Biosecurity measures can also help promote fish health and protect your economic investment. There are a number of regulations and trade requirements for fish, as well as a growing demand for specific pathogen free (SPF) fish. Many times these requirements involve the implementation and documentation of biosecurity procedures on the farm. Maintaining healthy fish and acquiring pathogen free status can improve or ensure a producer's reputation for providing high quality product.

Biosecurity measures can also protect stocks against new and emerging diseases, such as VHS. Prior to 2005, VHS was considered a disease of salmonids. However, in 2005, the a new strain of the virus was discovered in a number of important freshwater commercial and sport fish. While at this point, VHS has not entered aquaculture establishments, other "new" diseases have had an impact on the industry, including spring viremia of carp or koi herpes virus.

One final reason for implementing biosecurity measures is the protection of human health. While most zoonotic diseases (diseases of animals/fish that can affect people) of fish are food safety issues, there are a number of fish pathogens that can cause illness in humans in contact with infected fish. Examples include *Mycobacterium marinum, Edwardsiella ictaluri.*

Slide 4

Biosecurity Plans

- No "one-size-fits-all" solution
  - Varies with type of operation, species, life stage reared
- Range
  - Simple and quickly implemented
    - Foot dips; disinfection; signs
  - Others economic investment or effort
    - Dedicated quarantine equipment or facilities
- Cost-Benefit

The needed biosecurity measures for a farm will depend on a number of factors, including the type of facility, the purpose of the facility (e.g., stocking, food fish), as well as the species and life stages reared. Therefore, there is no "one-size-fits-all" solution. Determining the biosecurity measures needed will involve identifying risk areas for your facility and determining the necessary preventive measures to obtain the greatest cost-benefit. Most preventive measures are inexpensive when compared to the potential loss that can occur from fish deaths, decreased production or the need for depopulation following a disease outbreak. Many are also quickly implemented procedures (e.g., foot dips, disinfection); while others may involve variable levels of economic investment or effort (e.g., dedicated quarantine equipment or facilities). Work with your veterinarian or fish health specialist to identify risk factors and develop an effective biosecurity plan for your operation. Once determined, make sure these measures are communicated to others involved with your farm (e.g., employees delivery personnel, visitors).

Photos: Indoor recirculating system from http://www.usbr.gov/pmts/fish/Capabilities.html; Pond from http://www.umass.edu/aquaculture/aquaculturetour_000.htm; Raceway from Auburn University Fisheries and Allied Aquaculture Image Gallery

Slide 5

Biosecurity Principles

- Identify Hazards
  - Understand disease transmission
  - What are the risk factors for your farm
- Assess Risks
  - Impacts to your farm
- Determine biosecurity measures needed
  - Prioritize

Assessing your farm for the needed biosecurity measures first requires an basic understanding of how diseases can be spread on your farm and the various risk factors for transmission. This will help you to identify, assess and prioritize the specific risk areas for your farm are and determine what measures will help reduce those risks. This is what today's workshop involves.

Slide 6

Disease Transmission in Fish

- Direct contact between fish
  - Vertical or horizontal
  - Entry through skin, open wounds, gills
- Ingestion (oral)
  - Infected live or frozen fish
  - Cannibalism of dead or dying fish
  - Contaminated feed

Understanding how fish diseases are spread, helps to identify necessary biosecurity measures. Fish diseases can be spread between fish by direct contact, ingestion (oral), water sources, fomites, and vectors. Not all pathogens are transmitted by all routes; some may be spread by multiple routes. Thinking about diseases (and subsequent prevention) in this manner can help to prevent and protect for a number of diseases versus addressing each disease individually.

Direct contact is one of the most common routes of disease transmission in aquaculture. This involves the transfer of disease causing agents through contact with infected fish. Entry may occur through the skin, open wounds, mucous membranes, or gills. Infectious microorganisms can be found on the mucus layer of fish as well as occur from seeping lesions. Some pathogens are spread from female fish to her eggs (vertical transmission). Entry into the susceptible fish can occur through the skin, open wounds or gills.

Disease pathogens can also be transmitted **orally** by consumption of contaminated feed, infected live or frozen fish, or cannibalism of dead or dying fish from the same unit. The ingestion of intermediate hosts for some pathogens (e.g., snails infected with parasitic organisms) can lead to the oral transmission of fish pathogens. Ingestion of water contaminated with waste products from infected fish may also serve as a transmission route.

Slide 7

Disease Transmission in Fish

- Water Sources
  - Inputs, transfer
  - Including aerosols
    - Spray or splashes between tanks
- Fomites: Inanimate objects
  - Equipment: Nets, buckets, siphon hoses
  - Footwear, clothing, vehicles

Water sources can serve to transfer of disease causing organisms. Infected fish can contaminate the water sources they are living in. Contamination occurs from the urine, feces, reproductive fluids and mucus of infected fish. Movement of this contaminated water during the transport of fish can spread pathogens to new locations. A few fish pathogens (e.g., *Ichthyophthirius multifiliis* (ICH)) have been found to spread via aerosols, sprays or splashes between tanks. This is less common and typically requires close proximity of sources

Fomites are inanimate objects that can transfer pathogens between rearing areas or production sites. These items become contaminated following contact with infected fish or contaminated water sources. Examples include equipment, such as nets, buckets, siphon hoses, any equipment that comes in contact with fish (especially sick fish). Fomites also include footwear or clothing worn by fish handlers, or vehicles (e.g., hauling trucks/tanks) that may be used to transport potentially infected fish or contaminated water.

Slide 8

Disease Transmission in Fish

- Vectors: Living creatures
  - Predatory birds, wildlife
  - Pets
  - People
- Zoonotic: affects people
  - Bacterial agents
    - *Mycobacterium*
    - *Edwardsiella*
    - *Erysipelothrix*
    - *Klebsiella*

Less commonly, fish diseases may be spread by vectors. **Vectors** are living creatures, such as fish-preying birds, that can spread disease pathogens. These animals may transfer fish diseases between locations by carrying the pathogen on their body or feet, or by dropping fish or fish parts at other locations. Rodents may also carry fish pathogens on their body or in their feces or urine, contaminating the environment or fish feeds. Domestic animals (such as pets running around the farm) may also serve as cross-contamination mechanisms for some pathogens. People can serve as vectors by transferring pathogens to fish during handling (e.g., hands). While not a route of transmission to fish, **zoonotic diseases** are those diseases of fish that can be spread to humans, to cause illness. Examples include a number of bacterial organisms – *Mycobacterium, Erysipelothrix, Klebsiella, Edwardsiella*. Biosecurity measures should also address any zoonotic risks to you or your employees as well as the risk to your fish stocks.

Slide 9

Disease Introduction Risk Factors

- Fish Movement
  - Incoming Fish, Eggs
- Water Sources
- Fish Health
- Equipment and Vehicles
- Vectors (Animal and Human)

Now that we have a basic understanding of how the organisms can be spread, let's look at some of the risk factor for disease introduction onto fish farms. As we discuss these risk factors/areas, see if you can identify how the disease transmission can occur. This will help you identify prevention measures to use to reduce the risk (they will also be discussed for each risk factor)

The main risk factors for disease introduction onto an aquaculture facility are fish movement, water sources, factors impacting fish health, contaminated equipment and vehicles and vector transmission.

Slide 10

Risk: Fish Movement

- New or returning fish
  - Broodstock
  - Eggs
  - Grow out
  - Restocking
- Prevention
  - Purchase healthy fish
  - Quarantine new arrivals

The movement of fish onto, within or off the farm is the greatest risk factor for disease introduction and spread in aquaculture. New fish brought to the farm for breeding, grow out or restocking may introduce pathogens to resident fish. This may include purchased fish (if not inspected) or eggs (if not disinfected), as well as wild stocks. Fish that have been taken off-farm and then returned may also pose a disease risk, especially if they have been co-mingled with other fish. Keep in mind that for some diseases, fish may be infected without showing signs of illness. These "carrier" fish can then serve as potential sources of infection to other fish.

Photos of fish stocking from http://www.dpi.vic.gov.au/DPI/nrenfaq.nsf/LinkView/50E6069BC86D0677CA256C77001E54F4B43DB2A1BECEB2A04A256812001DD817 and http://muskokaoutdoors.ca/blog/2006/03/15/mnr-ont-fish-stocking-summary/

Slide 11

Prevention: Fish Movement

- Purchase Healthy Fish
  - Known or trusted suppliers
  - Inspected, health certification, tested free of important diseases
  - Specific pathogen free (SPF) broodstock
  - Limit number of sources
  - Limit frequency of purchases
  - Vaccinate newly acquired fish

Purchase healthy fish. To prevent disease introduction onto your farm, purchase fish from known and trusted suppliers. These fish should be inspected and found free of important diseases. Limit the number of sources fish are purchased from and the frequency and number of new introductions onto your farm. When possible, purchase eggs or fish from certified disease-free broodstock. (This may not be applicable for all fish species cultured). Eggs should be disinfected upon arrival. When appropriate, vaccinate newly acquired fish for diseases.

Slide 12

Prevention: Incoming Fish

- Quarantine new or returning fish
  - Time varies - 4-6 weeks
  - Maintain quarantine area separate from rest of farm, including
    - Water sources or flow circuits
    - Equipment
    - Effluents
  - Care for quarantined fish LAST or by a designated employee

Quarantine new arrivals. Once fish are brought to your farm, minimize the transfer of disease to resident fish by isolating new arrivals before adding them to your current stock. This includes fish recently purchased as well as fish returned to the farm. The length of quarantine is variable and depends on the disease of concern; four to six weeks is commonly suggested. Keep in mind some diseases are also temperature related (e.g., spring viremia of carp is seen most commonly when water temperatures are 17^{o}C (63^{o}F) or below) and signs may not be seen until optimal water temperature occur.

The quarantine area should be located away from resident fish and should have a separate water source or flow circuit and any water effluent, on or off the farm, from the quarantine area should be managed to avoid contaminating water sources or fish production areas. Dedicated equipment should be used in the for the quarantine area to avoid fomite transfer to resident fish. Care of fish in the quarantine area (e.g., feeding, cleaning) should occur after resident fish, or by an employee assigned solely to the care and handling of the quarantined fish.

Slide 13

Risk Factor: Water Sources

- Surface water greatest risk
  - Variable water quality, fish pathogens
- Ground water sources less risk
  - Well water, springs
- Municipal sources

Water Sources Many disease causing organisms can be transferred through water sources (e.g., surface water sources). Use pathogen-free water sources, such as well, springs, or other groundwater sources when possible. Surface water sources should be avoided as they have a greater potential for carrying fish pathogens.

Slide 14

Prevention: Water Sources

- Disinfection of water supply
  - Ozonation, ultraviolet irradiation
- Filtration
  - Exclusion of aquatic species

If the use of pathogen-free sources, is not possible, disinfection of the water supply by ozonation or ultraviolet radiation may be needed. Filtration of water sources can help exclude the introduction of unwanted aquatic species from your water source.

Slide 15

Risk Factor: Fish Health

- Disease
  - Direct loss: deaths, illness
  - Indirect loss: decreased production
    - Reduced growth rates
    - Reduced feed conversion efficiency
    - Reduced product quality
- Optimum health of fish
  - Improves ability to fight off infection

The impact of fish diseases may result in the direct losses due to illness or mortalities; however, effects may be more indirect such as a decrease in production (e.g., reduced growth rates, feed conversion efficiency, or product quality). Optimum health of your fish is essential and greatly improves their ability to fight off infection. This is achieved by minimizing stress, maintaining appropriate water quality parameters and proper nutrition, removing potential infectious disease sources, and monitoring and maintaining fish production and health records.
Photo: fish mortality from Auburn University Fisheries and Allied Aquaculture Image Gallery

Slide 16

Prevention: Fish Health

- Minimize stress
  - Acceptable stocking densities
  - Minimize frequent transfers between units or farms
  - Use gentle fish handling methods

Minimize stress. The susceptibility of fish to disease is greatly influenced by stress. A number of parameters in aquaculture can increase stress in fish, including high stocking densities, improper water quality parameters and poor nutrition. Minimize stress in your fish by keeping stocking densities within acceptable parameters. Limit transfers of fish between units or locations when possible. When moving fish, use gentle crowding and fish handling methods.

Slide 17

Prevention: Fish Health

- Maintain optimum water quality
  - Avoid fluctuation
  - Can predispose or compound disease
- Monitor temperature
  - Avoid fluctuations
  - Lower temps affect fish immune systems
  - Some pathogens have optimum temperature range

Maintain optimum water quality. Fluctuations or improper maintenance of water quality parameters can predispose fish to disease. This includes temperature, as many fish pathogens have an optimum temperature range for infectivity and fish immune systems are influenced by water temperature (less effective at lower temperatures).
Photo from Geoff Wallat, Ohio State University.

Slide 18

Prevention: Fish Health

- Provide proper nutrition
  - Avoid nutrient deterioration
    - Store feed in cool, dry place
    - Use within 3-6 months
  - Keep vectors out of feed
    - Store in secured area
    - Clean up spilled feed
  - Obtain live feed from reliable sources

Provide proper nutrition. Store feed in a cool, dry place and use within 3 to 6 months. This serves to maintain vitamin and mineral stability in the feed as well as reduce the potential for moldy feed. Keep feed in areas secured from vectors (e.g., rodents, birds). Clean up any spilled feed to avoid attraction of birds or rodents. If live fish are used as feed, be sure to obtain healthy fish from reliable sources.

Slide 19

Prevention: Fish Health

- Monitor fish frequently
- Remove dead or dying fish
  - Humanely euthanize
  - Dispose
  - Prevent predator access
- Remove and isolate ill fish
  - Separate isolation facilities
  - Handle after resident fish or assign employee
- Diagnostic testing
  - Contact your veterinarian or fish health specialist

Remove dead or dying fish. Monitor fish frequently for disease. Employees should know the major signs of illness in fish and who to contact when these are noted. Early identification of fish diseases can help minimize its spread and impact on your farm.
Ill or dead fish should be removed immediately as they can serve as potential diseases sources to the remaining stock. Dying fish should be promptly and humanely euthanized. Disposal should be in accordance with local and state laws and in a manner that predators or wild birds cannot access carcasses and further spread the disease.
Ill fish should be removed and placed in an isolated area away from current

fish stocks. This area, similar to quarantine, should have dedicated equipment and water sources. Care or treatment of these fish should occur after healthy resident fish or by an employee solely dedicated to this area. When signs of illness are noticed, contact your aquatic veterinarian or fish health specialist immediately. Necropsy and testing of ill fish can help identify a potentially infectious disease before it becomes widespread on your farm.

Slide 20

Prevention: Fish Health

- Keep accurate records
  - Fish illness, death
  - Growth
  - Feed conversion ratios
    - Helps detect subtle or sudden changes
  - All introductions, fish sources, fish movements on or off farm
    - Identify potential disease entry points
  - Treatments or vaccinations
  - Prior disease situations

Keep accurate records. Maintenance and monitoring of fish production and health records can help to detect disease problems and highlight their severity (e.g. sudden versus gradual increases in death rate) and often provides clues for disease diagnoses. Maintain accurate records of fish illnesses or deaths. Keep records on fish production parameters, such as growth and feed conversion ratios to aid in detecting subclinical disease problems. Record all new introductions or returning fish, their sources, and movements on or off the farm. This can help identify potential disease entry points in the event of a disease outbreak. Maintain records of any treatments or vaccinations or prior disease situations.

Slide 21

Fomites: Equipment

- Pathogens can survive in the environment
  - Variable time
- Movement of contaminated equipment
  - Nets, buckets, hoses
  - Boots, waders
  - Tanks, raceways

Many disease causing agents can survive in the environment for variable amounts of time. For this reason, any equipment (e.g., nets, buckets, scales, boots, waders) or even vehicles used to work with or move fish can serve as a potential source of disease transfer between facilities or units. Photo: Seine net from the Auburn University Fisheries and Allied Aquaculture Image Gallery. Photo: Waders drying from Geoff Wallat, Ohio State University Extension.

Slide 22

Fomites: Vehicles

- Cleaning and disinfection
  - Include wheel wells, tires, and undercarriage
- Do not share between sites
- Remove residual water or debris

Vehicles and equipment should not be shared between sites; if possible dedicated equipment or vehicles should be used. If this is not possible, these items should be cleaned and disinfected between fish lots or farms. Any residual water or debris should be removed; bilge water from boats should be removed and disinfected. Vehicle cleaning should include the wheel wells, tires and undercarriage. Wash stations should be provided on-site away from animal production areas. Photo: Fish transport truck (top) fish/fingerling transport vehicles from Auburn University Fisheries and Allied Aquaculture Image Gallery.

Slide 23

Fomites: Prevention

- Cleaning and disinfection
  - Approved products
  - Fish and environment safety
  - Allow proper contact time
- Thorough drying
  - Sunlight (UV)
- Avoid using wood

Any equipment used at aquaculture facilities should be cleaned and thoroughly dried (preferably in direct sunlight) or chemically disinfected before being used in another location. Fish production tanks, raceways and ponds should be disinfected between each lot of fish. Construction materials should be non-porous and easy to clean and disinfect. Avoid the use of wood, as it is hard to disinfect completely; if used it should be limited to temporary structures and should never be transferred to another site. Photo used with permission from Dr. Andy Goodwin, University of Arkansas.

Slide 24

Prevention: Fomites

- Foot dips
  - Near entrance
  - Used prior to and after leaving area
  - Change solution daily or when visibly soiled
- Boots/waders
  - Submerse and clean
  - Allow necessary contact time

Foot dips should be placed near the entrance to animal areas. Boots/waders should be cleaned and submersed for an appropriate period of time (see disinfectant product label) prior to and after leaving the area. Foot dip solutions should be changed daily or when visibly soiled with debris.Photo used with permission from Dr. Andy Goodwin, University of Arkansas.

Slide 25

Proper Cleaning Protocol

- Remove all visible debris
  - Inactivates many disinfectants
  - Microorganisms can "hide"
- Wash (soap and water) and Rinse
- Dry
- Apply disinfectant solution
  - Use appropriate concentration
  - Allow appropriate contact time
- Rinse and/or neutralize
  - Sodium thiosulfate for chlorine products

Cleaning and disinfection of equipment and vehicles is an important disease prevention measure for aquaculture facilities. One of the most overlooked and most important steps is the removal of visible debris (e.g., mucus, waste products, aquatic plants and algae, uneaten feed). This is important because many disinfectants are less effective and often inactivated in the presence of organic matter and debris. Another ofent overlooked step is to allow ample contact time for the disinfectant to work.

Many disinfectants can be lethal to fish, so thorough ***rinsing*** (away from production areas) and/or ***neutralization*** (e.g., sodium thiosulfate for chlorine products) are necessary to remove any toxic residues. If possible, allow the item to ***thoroughly dry*** before re-using them with fish or at different locations. Drying, especially in direct sunlight, can also be effective at destroying a number of fish pathogens.

Slide 26

Select Disinfectants for Aquaculture

Product	Concentration*	Uses and Precautions
Virkon® Aquatic	1:100 (1%) to 1:200 (0.5%) for 1 minute	Equipment, pumps, protective clothing, foot dips, bilges, bins, buckets, harvesting equipment, vehicles
Sodium hypochlorite (bleach)	200-500 ppm	Nets, boots, clothing. Surfaces must be clean; easily inactivated by organic debris. May be corrosive. Highly toxic for aquatic animals. Allow to inactivate for several days or neutralize with sodium thiosulfate after 3 hours. Note: Bleach is 5.25% sodium hypochlorite solution.
Iodine (iodophors)	200 ppm for a few seconds	Nets, boots, clothing. Surfaces must be clean; product is easily inactivated by organic debris. Highly toxic for aquatic animals
Benzalkonium chloride	250 ppm	Plastic surfaces - *can be toxic to fish, so use with caution in fish areas
Alcohol (ethanol)	70%	Hand santizing

There are a number of chemical disinfectants available that are effective against fish pathogens. Some can be toxic to fish, so should be used with caution or in areas away from live fish.

References: World Organization for Animal Health (OIE). Chapter 1.1.5. Methods for disinfection of aquaculture establishments. In: Manual of diagnostic tests for aquatic animals, 2006.

Slide 27

Risk Factor: Vectors

- Wild fish
- Predators
  - Birds and wildlife
- Rodents
- Domestic animals
  - Dogs and cats traveling between farms
- People
  - Employees, Visitors

Vectors. As previously mentioned, living creatures, such as fish-preying birds or other wildlife predators or vermin can spread disease agents. This may occur by carrying the pathogen on their body or feet, or by dropping fish or fish parts at other locations; this also includes domestic animals that may travel between farms. Pathogen transfer between farm and wild fish populations is an equally important consideration. People can also serve as vectors transferring pathogens during handling or on their feet or clothing. This includes visitors to the farm, (e.g., delivery personnel, transport personnel, salesmen, or the general public) or employees.
Photos from Geoff Wallat, Ohio State University.

Slide 28

Prevention: Vectors (Animals)

- Limit contact
- Minimize bird nesting sites
- Implement predator and rodent management programs

Limit contact between your fish and other animals that may present a risk of disease introduction. This includes wild fish stock, predators, domestic animals (e.g., dogs and cats), and wildlife traveling between farms. Implement predator management and rodent control programs. Contact USDA-APHIS or your local extension office for legal control measures. Biosecurity measures must protect cultured fish from contact with wild species, as well as prevent the escape of infected cultured fish or run-off of contaminated water sources or effluents.
Photo from http://www.umass.edu/aquaculture/aquaculturetour_000.htm

Slide 29

Prevention: Vectors (People)

Farm Visitors
- Post signs
- Maintain a visitor log
- Use foot dips/baths for shoes
- Accompanied by farm personnel
- Avoid animal areas

Visitors to the farm, especially those coming from areas where they may have been exposed to fish diseases (e.g. other farms or areas with known disease outbreaks), may serve as vectors for the introduction of disease. These individuals should take measures to minimize the potential risk of disease transfer. This includes wearing clean coveralls and disposable or disinfected rubber boots while on the farm. Maintain a log of visitors to your farm. All visitors on your farm should be accompanied by farm personnel during their visit. When possible, these individuals should avoid animal areas and be restricted from contacting and handling your fish (unless absolutely necessary).
Employees should wear clean clothing/coveralls and footwear when working with fish and wash or sanitize their hands when moving between areas. Foot dips for disinfecting footwear should also be used between these areas. Employees should perform tasks in areas from lowest risk to highest risk (e.g, inside tanks to outside tanks), from most susceptible to least susceptible populations (e.g., fry or fingerlings to adult). Personnel should save quarantine/isolation work for last. Access to egg incubation and fry facilities should be restricted to a minimum number of well-trained individuals.
Photo: fish mortality from Auburn University Fisheries and Allied Aquaculture Image Gallery

Slide 30

Prevention: Vectors (People)

- Employees
  - Wear clean clothing or coveralls
  - Use foot dips
  - Wash or sanitize hands before and after contact with fish
  - Work for areas of lowest risk to highest risk
  - Limit access to egg or fry facilities

Visitors to the farm, especially those coming from areas where they may have been exposed to fish diseases (e.g. other farms or areas with known disease outbreaks), may serve as vectors for the introduction of disease. These individuals should take measures to minimize the potential risk of disease transfer. This includes wearing clean coveralls and disposable or disinfected rubber boots while on the farm. Maintain a log of visitors to your farm. All visitors on your farm should be accompanied by farm personnel during their visit. When possible, these individuals should avoid animal areas and be restricted from contacting and handling your fish (unless absolutely necessary).
Employees should wear clean clothing/coveralls and footwear when working with fish and wash or sanitize their hands when moving between areas. Foot dips for disinfecting footwear should also be used between these areas. Employees should perform tasks in areas from lowest risk to highest risk (e.g, inside tanks to outside tanks), from most susceptible to least susceptible populations (e.g., fry or fingerlings to adult). Personnel should save quarantine/isolation work for last. Access to egg incubation and fry facilities should be restricted to a minimum number of well-trained individuals.
Photo: fish mortality from Auburn University Fisheries and Allied Aquaculture Image Gallery

Slide 31

Implementation

- Communication
  - Discuss plan with employees and visitors to the farm
- Written plan
  - Becoming more common requirement
  - Ensures all have access to procedures
- Reassessment
  - What is working, what is not

Once you have determined the biosecurity measures you will implement on your farm, it is important to communicate this to employees and visitors to your farm. Having a written plan ensures those affected will have access to the necessary procedures, and in many cases is becoming a requirement for the inspection process or for transport requirements. Once biosecurity measures are implemented, it is also important to assess how they are working.

Slide 32

Conclusions

- Threat of infectious diseases to aquaculture will continue
- Use of biosecurity measures
  - Help to prevent disease introduction and spread
  - Protects your fish, your farm and your investment

As the aquaculture industry continues to grow, the threat of infectious diseases to fish production facilities will continue. New disease pathogens are being discovered or are emerging to new locations. While the risk of disease in production settings cannot be completely eliminated, the use of biosecurity measures on the farm can help you to prevent disease introductions and spread and protect your fish, your farm and your investment.

Slide 33

Additional Resources

- Goodwin A. 2002. Biosecurity protection for fish operations. University of Arkansas Cooperative Extension Service. http://www.aragriculture.org/disaster/biosecurity/protection_fish_operations.pdf.
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- Malison JA, Hartleb CF. 2005. Best management practices for aquaculture in Wisconsin and the Great Lakes Region. http://aqua.wisc.edu/publications/ProductDetails.aspx?productID=485

Slide 34

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Slide 35

AIS-HACCP

A **Aquatic**
I **Invasive**
S **Species**

H **Hazard**
A **Analysis**
C **Critical**
C **Control**
P **Point**

Slide 36

Why AIS-HACCP?

- **Public hatcheries, fish farmers, bait harvesters, resource managers, researchers, and enforcement officers have been identified as vectors for AIS spread**
- **These operations / activities are extremely diverse**
- **Risks posed by each vary considerably**
- **Some operations / activities are at risk of being shut down (maybe needlessly)**
- **Can provide a mechanism for AIS-free certification**