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Biosecurity in Aquaculture, Part 3: Ponds

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This SRAC publication is Part 3 of a three-part "Biosecurity in Aquaculture" series. It should be read after SRAC Publication No. 4707, *Biosecurity in Aquaculture, Part 1: An Overview*. SRAC Publication No. 4708, *Biosecurity in Aquaculture, Part 2: Recirculating Aquaculture Systems* covers biosecurity considerations specific to recirculating aquaculture systems (RAS). This fact sheet, Part 3 of the series, highlights important aspects of biosecurity in ponds and provides a practical guide for designing a facility-specific biosecurity plan. Although concentrating primarily on finfish, the principles described also hold for other species groups.

Biosecurity in aquaculture consists of practices that minimize the risk of introduction and spread of an infectious disease among the animals at a facility and the risk that diseased animals or infectious agents will leave a facility and spread to other sites and susceptible species. Good biosecurity also includes reducing stressful conditions that can make fish more susceptible to disease. General biosecurity principles are the same regardless of production system. Good biosecurity includes obtaining healthy stocks and optimizing their health and immunity through good husbandry (animal management); preventing, reducing, or eliminating disease-causing organisms and their spread (pathogen management); and educating and managing staff and visitors on good biosecurity practices (people management).

Pond culture remains one of the most common and cost-effective forms of aquaculture production in the U.S. and world-wide, primarily because the natural environment provides many of the necessary resources that, in closed recirculating aquaculture systems, would otherwise incur significant costs. However, it is this close interaction with nature that also makes biosecurity in ponds much more challenging than it is for recirculating aquaculture systems.

Outdoor pond aquaculture challenges include:

- differences in geology and topography
- water source
- prepared and live food; species and density
- exposure to pests, predators, and other animals
- disinfection options and limitations, and
- more complex disease management.

Differing biosecurity levels in different areas within a single facility are often necessary. Disinfection and isolation, for logistical reasons, will be more difficult for outdoor pond aquaculture than for indoor tank culture.

Pond Types

Ponds vary greatly with regard to infrastructure, inputs, and purpose. These differences must be taken into consideration when designing a biosecurity program.

Factors that determine pond type include water source, topography, geology, ground /bank plant cover, drainage, construction materials and methods, soil type, watershed characteristics, and access to utilities, including roads and electricity.

Common pond types include levee ponds, watershed ponds, and water table ponds. Levee ponds, a staple of the channel catfish industry in western Mississippi, eastern Arkansas, and northeastern Louisiana's delta regions, are ideal for areas with flat topography and clay-type soils. Levee ponds are partially excavated and surrounded by an embankment, or levee, which also helps to hold in water (see SRAC Publication No. 101, *Construction of Levee-Type Ponds for Fish Production).* Levee ponds are relatively large (acres in size), often use groundwater from wells, and can be drained (Fig. 1).

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Figure 1. Levee ponds from a catfish farm in Mississippi. Photo credit: Matt Griffin, NWAC, Mississippi State University

Watershed ponds are common in areas with rolling terrain, including parts of Mississippi, Tennessee, Alabama, Georgia, and Illinois. Watershed ponds rely heavily on stored rainwater utilizing dams built across valleys to form reservoirs (see SRAC Publication No. 102, *Watershed Fish Production Ponds: Site Selection and Construction).* Soil type can vary, and in some areas, clay must be added to prevent ponds from leaking (see SRAC Publication No. 105, *Renovating Leaky Ponds).*

In Florida, water table ponds are fed by aquifers which are relatively shallow in much of the central and southern portions of the state. When the aquifer is charged, excavation of soil (in central Florida) or limestone/bedrock (in south Florida) results in ponds filling up on their own directly from the groundwater. Water table ponds, except during periods of drought, cannot be dried completely (Fig. 2).

Aquaculture ponds also differ with regard to purpose, including:

- broodstock holding ponds
- breeding ponds
- nursery (fry) ponds
- growout ponds

Figure 2. Water table pond beginning to fill, at an ornamental fish farm in Florida.

Each purpose will likewise have its own biosecurity challenges, and not all recommendations described in this publication will be feasible for every situation.

Broodstock holding ponds are managed to promote more rapid conditioning and maturation of gonads for current breeding cycles, or to hold and further grow-out adult fish for the next breeding season. Broodstock holding ponds may not be stocked with numbers as high as for growout, but fish are larger and so may be more susceptible to lower dissolved oxygen concentrations. Feeding rates can be heavy to promote maturation.

Breeding ponds are used when more controlled indoor settings for spawning are either more difficult or economically or logistically problematic. In the ornamental fish industry in Florida, live-bearers (swordtails, guppies, platies, variatus, and mollies) and some cichlid species are often bred in ponds. Biosecurity considerations are more challenging because these ponds contain mixed age classes.

Nursery (fry) and growout ponds hold younger life stages, which are more susceptible to infections than older age classes. Fertilized hatchery pond management (see SRAC Publication No. 469, *Fertilization of Fish Fry Ponds)* is often used to prepare ponds for these youngest life stages. For smaller ornamental fish farm ponds, after harvesting, ponds are drained of water (or, for groundwater ponds, water is pumped out) and the remaining excess organic debris is removed. Ponds may or may not be disinfected prior to fertilization, and when water quality, phytoplankton, and zooplankton (live foods) are acceptable, fry or fingerlings are stocked. For other species and regions, ponds may be harvested and re-stocked without cleaning for multiple production cycles.

In order to develop the best biosecurity plan for one's facility, one must be familiar with general biosecurity principles, infectious diseases which may affect one's fish, and regulatory considerations prior to determining acceptable risks and worst-case scenarios. The more specific biosecurity recommendations one can incorporate, the more biosecure the facility and ponds will be.

Pond culture: specific biosecurity considerations

General biosecurity considerations (e.g., fish and water sources) are discussed in SRAC Publication No. 4707, *Biosecurity in Aquaculture, Part 1: An Overview,* and those should be reviewed for additional information.

Ponds have more specific challenges based on size, infrastructure, management, and exposure, including:

- size and visibility constraints
- detritus/organic build up
- use of large-scale equipment /vehicles (e.g., seine nets, trucks)
- live foods and commercial feeds
- interactions with pests and predators, and
- personnel.

Size and visibility constraints

Although some very large indoor RAS tanks are used on some facilities, in general ponds are much greater in size. Poor visibility due to turbidity, managed phytoplankton, and size make assessment of the general population—apart from feeding (which remains a critical tool for health observations)—more difficult during the early stages of a disease outbreak. Small numbers of sick and dead fish are much less obvious in ponds than they are in tanks, especially if they are not at the surface.

Detritus/organic buildup

Buildup of organic materials (detritus) from feces, uneaten food, and dead and decaying organisms will serve as a reservoir for bacteria and other microorganisms that can cause disease. This organic load also increases oxygen demand and decreases dissolved oxygen levels in the pond. Disease-causing organisms that thrive in higher organic systems include bacteria, such as *Aeromonas* (see SRAC Publication No. 0478, *Aeromonas Bacterial Infections - Motile Aeromonad Septicemia)* and *Flavobacterium columnare* (see SRAC Publication No. 0479b, *Columnaris Disease: Flavobacterium Columnare),* which causes columnaris disease; parasites, including the ciliates *Tetrahymena, Trichodina, and Epistylis* (see SRAC Publication No. 4701, *Protozoan Parasites);* and *Saprolegnia* and other fungi (see SRAC Publication No. 4700, *Saprolegniasis (Winter Fungus) and Branchiomycosis of Commercially Cultured Channel Catfish).*

Large-scale equipment and vehicles

Large seine nets, paddle-wheel aerators, vehicles, and other large pieces of aquaculture equipment can harbor and carry infectious disease agents from one pond area to another, either through transport of infected water, dirt/substrate, plant material, fish or fish tissues, or intermediate hosts of parasites, such as snails.

Live foods and commercial feed quality and storage

Live, natural foods, a common component of pond production systems, are a good supplemental source of nutrition but can potentially spread or transmit disease-causing organisms. Good quality commercial feeds are critical for overall health and immunity, but improper storage and use past expiration dates can result in nutrient breakdown and contamination. The quantities of commercial feeds required for pond culture are measured by the pallet or tonnage. Although it is often more cost effective to buy large quantities, if feeds are used after their recommended expiration date or have not been stored properly, they will be of poorer overall nutritional quality.

Pests, predators, and domestic animals

Pond pests and predators not only eat fish and/or compete for food and other resources, but can also spread and transmit diseases. Often the extent of impact by a pest or predator is not observed until a significant proportion of fish are already affected. Invertebrates such as water scorpions, predaceous diving beetles, oligochaete worms, snails, and insect larvae, and vertebrates such as otters, aquatic birds, reptiles, amphibians, and unwanted fish species are all potential health and biosecurity risks. Animals which come in contact with, or enter ponds, can also spread disease. Livestock, such as cattle and goats, are used in some operations to graze on vegetation, and dogs may be used to help control bird populations, but their usefulness for these functions must be properly weighed against their potential to spread disease.

Animals can spread disease-causing organisms (bacteria, viruses, parasites, fungi) mechanically, on their skin or in their feces, or they may be a necessary part of a parasite life-cycle. Oligochaete worms (Fig. 3)

Figure 3. The oligochaete worm *Dero digitata,* commonly found in the bottom of catfish ponds, is an intermediate host for a myxozoan parasite that causes proliferative gill disease in channel catfish. Photo credit: Graham Rosser, NWAC, Mississippi State University

are an intermediate host for several parasites including myxozoans (one species of which causes proliferative gill disease in channel catfish (see SRAC Publication No. 475 *Proliferative Gill Disease (Hamburger Gill Disease))* and roundworms *(Eustrongylides* is a problem in aquarium fish pond aquaculture). *Eustrongylides* (Fig. 4) and *Sebekia* (a pentastomid parasite) (Fig. 5) life stages have been found in otters. Aquatic reptiles—turtles, snakes, and alligators—are final hosts for pentastomids, which can infect fish as the juvenile (nymph) stage. Snails are an intermediate host for digenean trematodes ("grubs"), and fish-eating birds can serve as final hosts, carrying adult "grubs." Fish-eating, aquatic birds (Fig. 6 and Fig. 7) not only can spread pathogens mechanically, but can also move fish around and act as hosts for digenean trematodes (grubs), including *Bolbophorus confusus* (a digenean

Figure 6. White pelicans are an important part of the *Bolbophorus* (a grub parasite) life cycle. They can also spread other disease organisms from one pond to another on their bodies or on fish they may be carrying. Photo credit: Jimmy Avery, NWAC, Mississippi State University

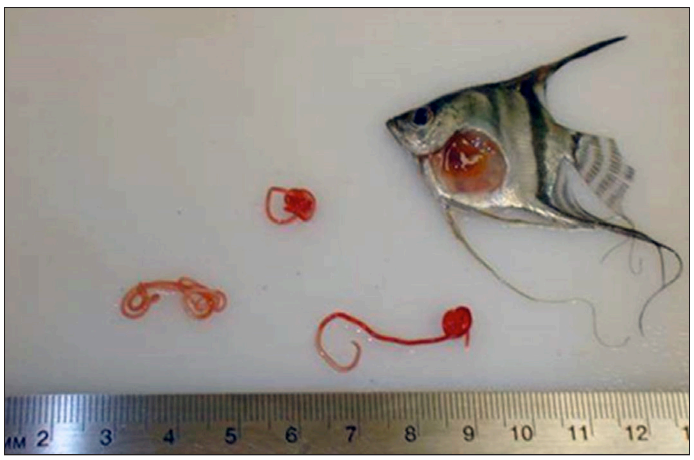

Figure 4. Larval *Eustrongylides* roundworms found in the body cavity of an angelfish. *Eustrongylides* adults are found primarily in wading, fish-eating birds. Other life stages may be found in oligochaete worms in the pond bottom.

Figure 5. Nymph stages of *Sebekia,* a pentastome parasite, completely fill a female swordtail. Adult life stages are found in aquatic turtles, snakes, and alligators.

Figure 7. Great blue herons and other wading birds contain life stages of digeneans ("grubs") and can spread a variety of other disease-causing organisms. Photo credit: Les Torrans, USDA-ARS, NWAC

affecting channel catfish) (see SRAC Publication No. 1801, *Infestations of the Trematode Bolbophorus sp. in Channel Catfish)* (Fig. 8) and *Centrocestus* (a digenean ("grub") that can infect the gills of many different species of fish) (Fig. 9). Unwanted fish species (including sunfish and mosquitofish) can act as predators or directly transmit fish pathogens. In addition, some of these animals, such as crayfish, muskrats, and armored suckermouth catfish species can damage pond banks.

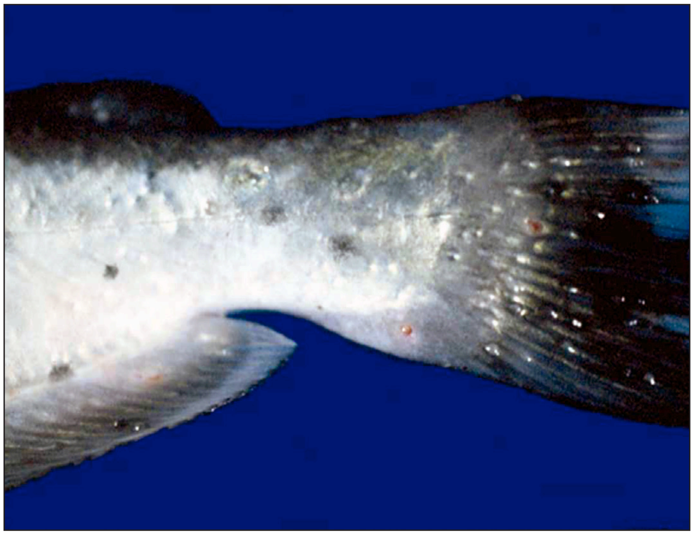

Figure 8. The tail end of a channel catfish infected with numerous *Bolbophorus,* a digenean parasite ("grub"). Photo credit: Lester Khoo, NWAC, Mississippi State University

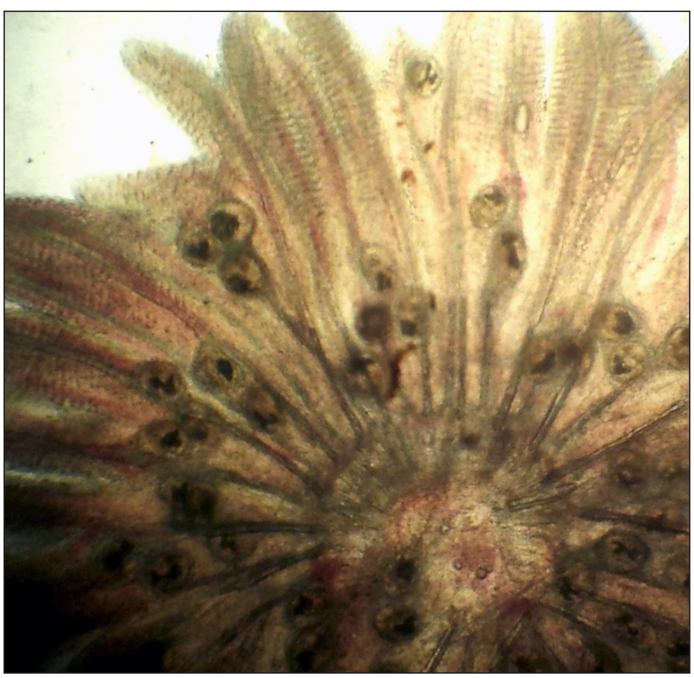

Figure 9. Moderate infestation of the digenean (grub) *Centrocestus* in the gill of this fish.

Personnel

Aquaculture personnel must periodically enter a pond as part of routine management, for example, to collect dead, to apply chemicals, to add or fix aeration, and/or to harvest. These personnel may carry infectious disease organisms on their skin or clothing from one pond to another if proper biosecurity precautions are not followed, and therefore protocols, such as showering and changing clothes and shoes should be considered when working ponds with fish of different health status.

Optimizing biosecurity for ponds

Good husbandry practices, including optimal water quality, nutrition, and stocking density, are important not only for promoting good growth rates and body condition but also to strengthen an animal's immune system and minimize risk of infection. In addition to the general aquaculture biosecurity considerations described in SRAC Publication No. 4707, *Biosecurity in Aquaculture, Part 1: An Overview,* the following recommendations for pond producers will help reduce their biosecurity risks.

Because aquaculture species and pond production systems differ from one farm to another, producers should contact an aquaculture health specialist and production specialist for more facility-specific biosecurity recommendations. Reasonable safety precautions should always be followed, including use of personal protective equipment when handling disinfectants, drugs, pesticides, and other chemicals.

Water source, quality, and daily observations

Water quality parameters should be tested regularly for optimal health. Dissolved oxygen should be checked daily when at its lowest point (early, pre-dawn). Other parameters, including total ammonia, temperature, nitrite, and pH may require daily testing, initially, until values stabilize. Alkalinity and hardness may not fluctuate as widely and so may require less frequent testing. Stocked ponds should be observed at least once or twice a day during feeding for changes in appetite, behavior, and appearance. Feeding may be the only time that fish are at the surface and visible. Periodic sampling of fish from each pond by the facility health manager or consultant will help identify disease issues before a major outbreak occurs.

Pond maintenance and cleaning

Ponds should be designed (or renovated, if necessary) to make drainage and periodic cleaning easier. Pond cleaning methods will vary depending upon pond location and type, condition, size, amount of organics, and disease concerns. Drainage and drying of the pond bottom; use of heavy machinery, e.g., backhoes and bulldozers, to remove organics; or spraying banks and pumping out of organics, as is done routinely in smaller, groundwater ponds, can be very effective cleaning methods; however, if cleaned to vigorously, removal or damage to the clay layer may result in pond leakage.

Removal of organics will improve water quality and reduce reservoirs for disease-causing organisms including bacteria, fungi, viruses, and parasites. Periodic cleaning will also allow removal—or at least reduction—of snail numbers and predators, such as aquatic reptiles, both groups of which can carry and spread diseases.

For larger levee and watershed ponds, logistics, economics, disease incidence and severity, and owner perceptions will ultimately determine how often producers will renovate, drain, and clean ponds, but the easier the process of cleaning, the more likely it will occur. If possible, periodic fallowing or drying is helpful.

In ornamental fish aquaculture in Florida, water table (groundwater) ponds should be pumped down, excess organics removed, and ponds washed after each harvest, or at least twice a year. Groundwater ponds cannot be dried (except during major droughts when groundwater levels drop).

Pond disinfection

Regular pond cleaning will greatly reduce the numbers of disease-causing organisms. However, pond disinfection efforts may be necessary after cleaning (harvest, drainage, and removal of organics), especially after an infectious disease outbreak.

Pond disinfection is more challenging than tank disinfection because of differences in size and scale, as well as the presence of soil (with organics) as the primary substrate. The soil/organics combination will decrease the effectiveness of common disinfectants, and size makes costs even more critical. Pond disinfection on a regular basis further reduces the numbers of disease-causing organisms that may infect younger stages or naïve populations of fish. Pond disinfection may also be mandatory after outbreaks with some diseases that are regulated by local agencies, the state, USDA-APHIS, or the international community. Personnel must follow proper safety precautions and wear personal protective equipment.

One common disinfection method is use of quick lime (CaO) or hydrated (slaked) lime ($Ca[OH]_2$) which is spread evenly over a freshly cleaned pond bottom (Fig. 10). Quick lime or hydrated lime is not the same as agricultural limestone and dolomite limestone, which

Figure 10. Quick lime spread over the bottom of this water table pond increases the soil and water pH and helps to kill some disease causing organisms.

are used for a different purpose. Quick or hydrated lime rapidly increases soil and water pH and, if held to a pH of 11 or above for at least one hour, can kill many disease-causing organisms including some bacteria and viruses. If quick lime is applied to dried pond beds, organics will undergo dessication /dehydration. Ideal application rates will vary depending upon initial soil and water pH, but commonly recommended rates range from 500 to 1,300 pounds per acre. After an outbreak of a reportable disease such as spring viremia of carp, pH levels should be measured and additional lime added as necessary to maintain pH >11.

For reportable disease outbreaks, the World Organization for Animal Health (OIE) suggests application of quicklime to dried pond beds at the rate of 3,560 to 4,550 pounds per acre. After application, the pond is allowed to stay dry for one week or until the soil cracks to a depth of 4 inches (10 cm). Then the pond is filled and the quicklime raises the water pH, completing disinfection. Levels of pH should be 11 or more.

Drying and plowing is another method that can provide some level of pond disinfection. This method may only be possible during the dry season, or may not be possible at all in areas with year-round high groundwater or heavy rainfall. The pond is first allowed to dry for a week or until the surface has cracked to a depth of 4 inches (10 cm). After this occurs, the soil should be broken up to a depth of approximately 8 inches (20 cm) with a plow or tiller and allowed to dry for an additional week, prior to preparation, refilling, and stocking. This process helps disinfect through a combination of microbial degradation, sunlight /UV exposure, aeration, and desiccation.

Pests, predators, and domestic animals

Pests and predators are important health and biosecurity risks. Animals such as aquatic birds that can move readily from one pond to another on the same facility or between aquaculture facilities can easily spread infectious disease organisms. Good pond management includes mowing of pond banks and levees and control of aquatic weeds. These practices will help reduce potential hiding places for predators, including snakes. Routine pond cleaning and disinfection will help reduce numbers of unwanted pests and predators. In addition, proper use of pesticides, deterrent methods, and pond nets and covers (for smaller ponds) will help reduce the numbers of unwanted animals near or in the ponds.

As discussed previously, domestic animals including dogs, which often serve to control bird populations, and cattle and goats, which control grass and vegetation present a significant risk and means for diseases to spread. Cattle and goats are more problematic especially if they routinely enter and exit ponds. For farms with a significant bird population, the ability for well-trained dogs to reduce the number of birds on-site may well outweigh their potential to spread disease; of course, other options for bird control, e.g., noise (cannons) or visual deterrents should be considered. Producers should be familiar with local, state, and federal regulations regarding use of pesticides and control of nuisance wildlife. Consult with a local extension specialist and USDA-APHIS Wildlife Services representative for more information. Also consult with a fish health specialist who can help you more accurately determine risk/benefit.

Commercial feed

Feed considerations for pond production facilities are of particular concern because very large quantities are required for many operations. Feeds should be of good quality, appropriate for the species, fresh (used prior to expiration date), and properly stored in a cool (potentially refrigerated), dry, well-ventilated area that excludes vermin (e.g., rats, mice, and cockroaches) and other animals. Improperly stored feeds will have reduced nutritional value including breakdown of anti-oxidant vitamins and fatty acids, can grow fungi that may produce harmful toxins (e.g., aflatoxins), and can be contaminated by vermin, further reducing quality.

Personnel and visitors

Personnel can also spread disease onto, or within a facility. Proper precautions should be taken to reduce the potential for introduction or spread. Employees should not visit other aquatic facilities prior to work without showering and changing clothing. If feasible, personnel should be assigned to specific areas and not allowed into others without hand and footbath disinfection (and shower or change of clothes if necessary). If staffing does not permit separation by area, ponds should be worked, in order, from youngest to oldest fish, and from healthiest to most diseased, and equipment should be appropriate cleaned and disinfected in between ponds of unknown health status.

Disinfection of equipment and supplies

Prior to disinfection, equipment and supplies should be cleaned thoroughly of dirt and other organic matter. The pros and cons of different disinfection methods for equipment and supplies, including physical and chemical means, are described in SRAC Publication No. 4707, *Biosecurity in Aquaculture, Part 1: An Overview*. For large seine nets, drying and prolonged exposure to sunlight will help reduce pathogen loads (Fig. 11). Similarly, drying of large equipment may help reduce pathogen loading if use of disinfectant chemicals is not an option. Depending upon the disease organism, however, use of disinfectant chemicals may be necessary. Items that cannot be disinfected (e.g., wooden pallets, etc.) should be destroyed and discarded as per local regulations.

Figure 11. Drying and exposure to sunlight will help reduce pathogen loads on large pieces of equipment, such as this seine net. Photo credit: Matt Griffin, NWAC, Mississippi State University

Developing a biosecurity plan for a pond-based aquaculture facility

The biosecurity plan should take into consideration water source, culture species, production scheme, pond type, nutrition, equipment, personnel, pathogens of concern, and other facility-specific issues. The following section is intended as a guide for developing a plan for your operation. Part 1 of this series should be reviewed for more background information and a more general template.

Work with knowledgeable professionals. Consult with an experienced aquaculture health professional, production specialist, and aquaculture engineer who can help with facility design and biosecurity planning.

Know your species. Have you met your species' needs with regard to water quality, environment, and nutrition? These needs should be compatible with pond design/culture methods and overall husbandry protocols.

Know your pathogens. Prioritize and list major and minor pathogens of concern and identify the critical control points in your operation (see below) where they may enter, spread, or leave your facility.

Ponds favor the growth and spread of disease-causing organisms for many reasons:

- greater build-up of organics and potential disease reservoirs in soils, pests, and predators
- minimal flushing or dilution
- higher fish densities, and
- other underlying stressors

Understand your critical control points. Be aware of how pathogens enter, spread through, and leave the facility, and assess your risks at each point.

- ***Source of fish and preventive management.*** If you routinely receive fish, e.g., for growout or broodstock, or even as live feeders, know your fish supplier, ask questions about previous disease issues, and, ideally, purchase fish from a supplier who practices the highest level of fish health management and who can provide a health certificate with the shipment. Document all information available regarding the fish's health and testing. In many cases, the health certificate will be fairly broad in scope, but should also document testing for relevant diseases and pathogens of concern for that species. Even a small number of pathogens on or in the fish will be amplified within ponds. Work with a fish health professional. If necessary, fish should be sampled for specific pathogens and diseases of concern before they enter the facility or during quarantine. Additional preventive measures may be necessary, such as egg disinfection, vaccination, and the use of immunostimulants. If the fish are produced on site there should be physical separation and disinfection stations and/or showers and changing areas between life stages (i.e., the breeding area, the fry/ fingerling area, and the growout area).
- ***Water source.*** Protected water sources, such as deep wells, have a much lower risk of containing disease-causing organisms than unprotected water sources such as surface waters that may contain wild fish and other animals and the diseases they carry. If your facility uses surface waters, be aware of species living in that water body that may carry diseases of concern. If pathogens of regulatory concern are known to exist within surface waters used for pond culture, mechanical filtration and disinfection may be necessary prior to use. Consult a fish health specialist.
- ***Commercial Feed.*** Use good quality feed appropriate for the species and store it in a cool, potentially refrigerated, dry place (or as directed by the manufacturer) that excludes vermin and other animals; improperly stored feed will lose nutritional value and can harbor disease-causing bacteria and fungi. As discussed, live and frozen foods can carry parasites, bacteria, fungi, and viruses (many of which survive freezing). Various measures can be taken to minimize some, but not all, risks from these (see SRAC Publication No. 4707, *Biosecurity in Aquaculture, Part 1: An Overview).*
- ***Live and frozen foods.*** If live foods are fed, they should be tested for relevant pathogens prior to feeding. Other live and frozen foods should be considered potential reservoirs and tested in the event of a disease outbreak.
- ***Other animals.*** Approved methods should be used to control pests, predators, and feral animals which can transfer pathogens from one system to another or may contain life stages that can infect fish as part of the life cycle. Domestic animals are also a risk and their presence and usefulness should be weighed against their ability to spread disease.
- ***Aerosolization.*** Movement of very small particles through the air in very fine water droplets or bubbles can spread organisms from one pond to another, e.g., through use of paddlewheel aerators, degassing towers, etc. Especially during outbreaks, try to reduce potential for spread of disease-causing organisms by this route to neighboring ponds.

- ***Equipment.*** Equipment should be designated for use in a specific pond, or specific group of ponds, if possible, to limit potential spread of disease. Otherwise, equipment should be cleaned and disinfected as thoroughly as possible prior to use in another pond.
- ***Personnel.*** Employees and visitors can easily spread disease-causing organisms on their shoes, hands and arms by immersing themselves in pond water, or handling animals or equipment in one pond and failing to disinfect themselves before handling fish, water or equipment in another pond. Disinfection stations for footwear and hands and access to showers and changing areas will help limit spread of disease for personnel who work in both ponds with diseased fish and ponds with healthy fish.

Design and manage the facility to physically isolate different groups of fish and exclude pathogens

- Design ponds to facilitate cleaning.
- The "all-in-all-out" method, where one group of fish is stocked at the same time or within a narrow time frame and no others are added prior to harvest, is preferred. Mixing different groups or age classes can result not only in predation of smaller fish by larger fish, but also in exposure of previously unaffected fish to disease pathogens (see SRAC Publication No. 4707, *Biosecurity in Aquaculture, Part 1: An Overview).* If all-in-all-out is not feasible, the health of newly introduced fish and of older fish should be assessed prior to stocking. Producers should also understand that introduced and resident fish will be at increased risk of developing disease from each other.
- Use of pond covers and netting/fencing for smaller ponds will help reduce spread of pathogens via birds and other predators (Fig. 12).

Figure 12. Netting helps to reduce spread of disease and predation by birds and other animals.

- Reducing pond water levels, either by partially draining or pumping, will help prevent overflow and mixing of ponds during periods of high rainfall. This can also help reduce pathogen load in pond water.

Control animal movement and personnel and visitor flow patterns

- Develop written protocols for movement of new fish onto the facility and from one area to another to minimize potential of pathogen exposure to other groups.
- For facilities that both breed and growout fish, employees should be assigned to work only with a specific age class. If that is not possible, then on a daily basis they should work with "cleaner" or more vulnerable animals (eggs, fry, fingerlings) first, then with older animals that have a stronger immune system and finally, with "dirtier" fish (quarantined, sick) last, or should shower and change clothes if warranted.
- Showers and changing areas should be clearly visible and easily accessible from the ponds and other fish areas.
- If vehicles are used, surfaces inside should also be cleaned and disinfected regularly.
- Post concise, clear rules for personnel and visitors regarding area access and receiving locations for feed, equipment, and other essential deliveries. Signs clarify farm rules and designate areas that are off-limits or restricted.

Employee education and acceptance

Standard operating procedures (SOPs) for biosecurity. SOPs should be written out, easily understood by employees, accessible, and located near worker safety information, material safety data sheets (MSDS), emergency contact numbers, and other relevant work documents. Checklists/duty sheets for all relevant activities will help promote compliance and assist with oversight.

Education. Employees should be formally trained on the importance of biosecurity, SOPs, and compliance; training should be given regularly. Personnel should have the opportunity to provide constructive comments to improve SOPs. If protocols are difficult to follow or not understood, compliance will be poor.

Disinfection, sanitation, and disposal of dead fish

Methods. Written protocols should include standard sanitation and disinfection. A general cleaning (scrubbing and rinse to remove organics and soils) is required before disinfection. Physical and chemical disinfection methods are specific to types of equipment and areas. There should be regularly scheduled cleaning and system maintenance. Cleaning equipment and supplies should be stored appropriately in designated areas, with separate storage for chemicals.

Disposal. Dead and very sick fish should be removed at least once a day. Dead and sick fish are a major pathogen source. Local, state, and federal regulations for handling disease outbreaks (including reporting, disposal of fish killed by, or exposed to reportable diseases, and discharge of water from sick populations) should be determined and included in written SOPs.

Routine health and disease screening

In consultation with a fish health specialist, routine observation and a representative sample of populations in the facility will serve as an early warning system and help reduce the likelihood of a major disease outbreak.

Quarantine protocols. Quarantine (isolation, acclimation, and observation) of new animals is important to reduce the risk of introducing a disease into a facility. Water used should be from protected sources. The length of time for quarantine will depend upon the diseases of concern, the species, and what the animals will be used for. For future broodstock, an ideal quarantine period is 30 to 60 days. Growout fish should be stocked in a cleaned pond.

Routine observations. All fish should be observed for signs of disease including changes in feeding response, other behavioral changes, changes in physical appearance including eroded fins, changes in color, bloody areas, exophthalmia (pop-eye), bloating, scale loss, increased mucus in the system, masses, and grossly visible parasites.

Routine sampling. Throughout the production cycle, routine sampling by a fish health professional will reveal any problems before a major disease outbreak occurs. This information can then be used to modify the biosecurity plan. Initial and routine sampling of new, incoming animals should be part of the SOP to help identify presence of any diseases and/or pathogens of concern. Samples should be taken at the beginning and then periodically throughout quarantine.

Disease outbreaks and mortalities

An action plan should be established for disease outbreaks and mortalities.

Isolation and separation. Although important as a routine, this becomes even more critical in the event of an outbreak, since diseases can spread very rapidly from pond to pond. Diseased populations should be isolated. Routine maintenance and any other actions requiring contact with a diseased pond should be followed by appropriate disinfection of equipment and showering and change of personnel clothing (and/or the pond should be handled last). All employees should be alerted and appropriate signage or other means used to indicate which group(s) is affected.

Problem solving. Prior to any disease outbreak, the following issues should be discussed with a fish health professional and fish disease diagnostic laboratory: water quality, nutrition, protocols for sampling fish (numbers of animals, what tests should be run, how to ship, who to contact for results).

Cause(s). What is/are the diagnosed cause(s) of the outbreak? The following factors should all be taken into consideration: pathogen(s), husbandry-associated factors, level of risk, most probable route of entry, and reportability.

Management. Pull dead animals from the pond at least once a day. Determine if any husbandry changes (e.g., reducing feeding rate, increasing aeration, adding salt) are also necessary. Establish a chain of contacts, including a fish health professional, facility health manager, facility area managers, and relevant regulatory authorities, to determine options, drug legalities and availability, dosage rate, personnel and supply requirements, reporting to proper authorities if required, cost/benefit for various management decisions, and prevention.

Depopulation and disposal. Determine appropriate methods of depopulation, carcass collection, disposal, and disinfection according to local, state, and national regulations.

Disaster management. Although a disaster management plan is outside the scope of this series of publications on biosecurity, outdoor exposure, susceptibility to the weather, and geographic and environmental connectedness in pond-based production make development of such a plan essential.

Records are critical for all areas of production, pond and health management

General production. General production records such as broodstock fecundity, growth rates for younger life stages, numbers stocked, stocking weights, harvest numbers, and average harvest weights are ways of tracking groups and can be used to assess the effectiveness of a biosecurity plan.

Biosecurity management. Documentation (check lists) will help ensure that employees fulfill assigned tasks (such as cleaning and drying seine nets), carry out pond system and equipment checks, document feeding and observations, and remove dead and very sick fish, and that visitors are tracked and are aware of biosecurity policies. A biosecurity audit (overall review of biosecurity at the facility) by an aquatic animal health professional will help ensure that adequate precautions are being taken. During a disease outbreak, procedures and records should be thorough enough to convince authorities that good biosecurity measures were in place, that affected groups were isolated, and that no cross-contamination with other groups occurred. In the event of a reportable disease outbreak requiring depopulation, this will help ensure that other ponds were not exposed and will not have to be depopulated.

Health and disease management. Records should also document morbidity and mortality numbers, disease signs, feeding response and other general health observations, and water quality/chemistry. For diagnostic sampling, records should include sampling done by group, date sampled, numbers sampled, diagnostics run, findings, treatments and amounts of drugs used, veterinary prescriptions if required, and, finally, methods of collecting and disposing of diseased or dead animals.

Summary

Pond systems have specific biosecurity challenges because of their reliance on natural inputs, large size and observational and routine management challenges, presence of a soil substrate, and greater susceptibility to invasion by pests, predators, and other animals. Examining specific points in production when pathogens may be introduced or disease may develop will help in creating a solid, workable bio-security plan. Good biosecurity minimizes exposure and susceptibility to pathogens and reduces economic losses from mortalities, as well as losses resulting from mandatory depopulation.

Biosecurity programs for a pond facility should begin at the planning and design stage. Get help from an aquacultural engineer, a production specialist, and an aquatic animal health professional when developing your plan. Important considerations include animal and water source, species and life stage requirements, health management, intended use and system capacity, economics, personnel, overall husbandry management (pond cleaning and disinfection, harvest methods, aeration), and related logistics. Don't wait until a major catastrophe has occurred. Low level losses, over time, will also reduce revenues and can be avoided with a good plan.

Suggested Readings

Chapter 1.1.3. Methods for disinfection of aquaculture establishments. OIE (World Organization for Animal Health) Manual of Diagnostic Tests for Aquatic Animals 2013. http://www.oie.int/fileadmin/Home/eng/Health_standards/aahm/2010/1.1.03_DISINFECTION.pdf

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Yanong, R.P.E. 2002. Nematode (roundworm) infections in fish. FA91. University of Florida/IFAS Cooperative Extension Service. http://edis.ifas.ufl.edu/FA091.

USDA United States Department of Agriculture | National Institute of Food and Agriculture

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