

# PREPARING FOR AND RECOVERING FROM HURRICANES, TYPHOONS, CYCLONES AND TROPICAL STORMS IN POND-BASED FISH PRODUCTION

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Although most considerations relating to storm preparation and response boil down to simple common sense, the key to resilience lies in getting organized, putting plans down on paper and having the necessary information at hand before storms approach your facility.



Flooding inside a levee complex. This shows three separate ponds underwater. Although the fish all got mixed together, none left the facility and only a few were lost as the water was eventually pumped out.

Whether referred to as hurricanes, typhoons, cyclones or tropical storms, these weather events (referred to collectively as Tropical Cyclones) regularly pose serious threats for pond aquaculture producers throughout the world. This article focuses on day-to-day, long- and short-term recommendations for building resilience to storms in pond-based aquaculture, and key response considerations during and following storm events. Storm preparedness should be

a year-round activity throughout the life of an aquaculture facility, and the process actually begins with initial site selection.

## **I. Pre-Storm Planning – Long-term Preparedness**

**Initial Site Planning** The considerations below could be considered ideal, but they all should be taken into account when evaluating a potential pond production facility. Sites that appear suitable for pond-based aquaculture (flat land with high clay-content

soil and abundant water sources) are often particularly vulnerable to storm impacts. Unique challenges will include access, utilities, topography and infrastructural considerations as they relate to potential storm impacts.

- Search for sites above the 100 year-flood plain.
- Search for areas that are not close to water bodies that are prone to flooding when subjected to heavy rains associated with storms.
- Search for sites with surrounding topography that will allow for efficient and rapid drainage to the watershed.
- Search for areas with good road infrastructure that would allow expedient and multiple escape routes when evacuating from hurricanes, typhoons or tropical storms.
- Search for areas with resilient electrical grids. Avoid relatively isolated sites with limited access to electrical utilities.
- Search for areas where farm equipment can be easily moved to higher elevations to avoid flooding.
- Search for areas where utilities, communications and other critical infrastructure can be permanently established on higher ground to avoid equipment damage during flooding.
- If producing freshwater fish species, look for areas where saltwater intrusion during storm surge or flooding is not likely to occur. Typically, this includes sites that are 15 miles (24 km) or more from any coastline or water body with a direct connection to saltwater.

**Site Establishment** A specific site can be more or less prone to storm damage, but each site can be developed in such a way as to minimize impacts.

- Establish higher-elevation areas (at or above the 50-year flood elevation) at designated levee junctions throughout the farm, with one elevated area for every 200-300 acres (80 – 120 ha).
- Consider seasonal prevailing winds when laying out ponds. If storm related winds are parallel with the long axis of a pond, excessive wave action can damage down-wind levees during severe storms.

- Construct levees surrounding the farm and/or pond complex in areas that can potentially flood. Levees should be constructed a minimum of 24" (60 cm) above the highest recorded flood stage for the property.

- Install main drain valves or shut-offs in leveed complexes to prevent flood water intrusion from surrounding high water. Have an alternate drain line running above the protection levee elevation so water from heavy rains can be physically pumped out of the leveed complex during a flood event while avoiding water entering the facility from outside the levees.

- Install pump stations inside levee complexes to remove water that normal drainage features cannot keep up with during heavy rains.

- Ensure all pump stations are sufficiently elevated or otherwise protected from flooding and have a protected gas or diesel backup operating system in case of prolonged power outages.

- Increase the normal recommended capacity of pond and main drain lines by 40% or more when constructing in areas that could be impacted by severe storms.

- Clear the facility of large trees and any tall or unused structures that could fall into ponds, block vehicle access or damage electrical or other critical infrastructure during high winds.



An example of placing hatchery buildings on constructed earthen raised platforms well above historic flood levels. The leveed pond complex is visible in the distance, behind the building.

- Ensure well casings and caps are located a minimum of 24" (60 cm) above the surrounding grade to help prevent intrusion of floodwater containing high salinity, pesticides, or fertilizers into groundwater supplies.

- Locate all hatcheries, shop facilities, equipment buildings and feed storage facilities on higher elevation ground or place buildings on pilings or elevated pads.

- Construct all buildings and structures to a minimum 140 mph (225 km/hr) wind rating and preferably 180 mph (290 km/hr) wind ratings.

- Install gas or diesel backup generators to operate critical buildings such as hatcheries and broodstock facilities and to power supplemental aeration equipment for ponds and tanks if necessary. Generators and fuel storage tanks must all be elevated or

otherwise protected from inadvertent flooding.

### Seasonal Considerations - Outside of Storm Season

- Develop a disaster plan that identifies chain of command, with clearly defined primary/secondary roles and responsibilities of various team members. The specific actions outlined below can serve as the basis for most sections of the plan. A 5-day timeline should be included to reflect specific preparation activities leading up to the storm impact. Post-impact actions should also be programmed based on recovery priorities. Incorporate realistic expectations regarding the time involved for both storm preparation and response.

- Designate an Emergency Response Team for the facility. Members of the

**Storm preparedness** should be a year-round activity throughout the life of an aquaculture facility, and the process actually begins with initial site selection.



Low levees can be overtopped from flooding in the surrounding watershed. In this instance the pond liner and levee surface are visible, as is air bubbling up from diffusers supplied by an emergency blower located on the platform.



emergency response team should be thoroughly trained and physically capable of performing assigned duties and responsibilities. They should also be knowledgeable about the hazards found on the farm. Maps for each block of ponds and all other facilities should be prepared, including locations of electrical equipment (with shut-off options), fuel storage tanks (both above and below ground), propane tanks, compressed gas (for welding, fish transport, etc.), feed bins, chemical spill equipment and alternate entry/exit routes. The team should be trained in decision making regarding when to take actions themselves or when to wait on outside emergency responders. All team members must be trained in the use of various types of fire extinguishers, first aid (including CPR), shutdown procedures for electricity and equipment and chemical spill control.

- Download one or more of the readily available computer and cellular phone apps that model storm track predictions, send alerts, and track storm impacts.
- Purchase and maintain a stockpile of “weather-proofing” supplies on-hand at the facility, such as tarps and sand bags for buildings, pumps, generators, fuel tanks and damaged levees.
- Purchase and maintain emergency medical supplies, a drinking water supply, and a dry- and canned food sup-

**Seasonal considerations:** Develop a disaster plan that identifies chain of command, with clearly defined primary/secondary roles and responsibilities of various team members. The specific actions outlined below can serve as the basis for the most sections of the plan.



A, B. Both ponds pictured here were protected by levees constructed well above the surrounding floodplain.

ply adequate for 3 or more weeks of survival for employees that become stranded at the facility or may need to return to the facility for animal care or recovery before utility and emergency services are restored.

- Perform adequate facility infrastructure maintenance to ensure items such as loose roofing materials or improperly/inadequately grounded electrical equipment do not become much more serious issues during a storm event.
- Maintain good fish inventory, equipment inventory, and feeding records at all times. This information is critical during recovery and insurance claims. Take these records with you when evacuating for storms. Establish a procedure to store records digitally and transmit them weekly to one or more

recipients so they will exist and be retrievable on computers in other locations.

### Monthly Considerations during Storm Season

- Check short- and long term weather forecasts and radar at least once daily during storm season.
- Monitor newscasts and weather reports for potential and impending storm threats.
- Review facility infrastructure maintenance issues.
- Any equipment not in use, or equipment used primarily during other seasons (such as during spawning season) should be stored or secured in a safe location, as if a storm were already on its way. This reduces the time poten-

tially required for moving and securing equipment in the event an evacuation needs to be made.

- Evaluate the vulnerability of your feed storage facilities. Consider limiting feed purchases and supplies on hand to prevent feed loss from water damage in case of a severe storm. This is particularly true for ground-level storage facilities.

- If secure storage facilities are available on site, arrange for fuel deliveries several days prior to the expected storm impact. Consider fuel needs for tractors, generators and farm vehicles. Keep in mind that any fuel stored on site poses a contamination risk if storage tanks cannot be adequately protected from anticipated flooding.

- Go over emergency preparedness and evacuation plans with employees.

- Identify and repair potholes and low areas on levees. Identify other key points on each block of ponds where levee and road elevations will first become impassable in the event of rising water.

- Maintain effective aquatic vegetation and algal bloom control to limit oxygen demands during prolonged periods of power outages.

### **Annual Considerations**

- Conduct annual audits of fish inventory, equipment inventory, and feeding records to ensure they are correct.

- Refresh or replace all emergency medical supplies, a drinking water supply, and a dry and canned food supply.

- Service and test all generators (portable and non-portable) every two weeks.

- Develop or update the written plan of pre- and post-storm responsibilities and job descriptions for personnel.

- Contact your local utility company for guidance on how to disconnect power (or have it disconnected) in the event of downed lines.

- Develop a list of post-storm contacts: local emergency and medical services, local government agency offices, the farm's private insurance

carrier(s), emergency contact numbers for all employees, mechanics, electrical contractors and other important contacts. Make sure all members of the management team and the response team have this list.

### **II. Pre-Storm Planning – Short-term Preparedness**

#### **When a Hurricane, Typhoon, Cyclone or Tropical Storm Is Forecast to Impact Your Area (1 to 7 days before)**

- Harvest as many large fish (at or above market-size) as possible and transport to processors or buyers 4-7 days before a storm is forecast to pass through the area. Reducing inventory and creating a positive cash flow prior to the storm can be critical to recovery should the facility be flooded, severely damaged, or destroyed. This also thins out stocks so oxygen demands will not be as high during periods of prolonged power outages.

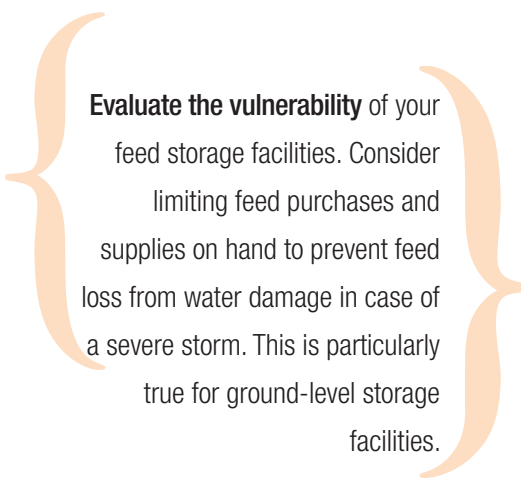
- Begin working through the step-by-step preparedness check list of tasks that must be done to secure the facility, fuel supplies, chemical supplies, fish and equipment.

- Consider thinning fish in high-density ponds/tanks and spreading them out among less dense ponds/tanks to alleviate aeration demands during prolonged periods without power. Keep in mind, however, that aeration and water exchanges may be difficult or impossible several days later when the storm impacts are greatest, and this can reduce post-transfer survival.

- Secure all feed and feed storage facilities (bins and buildings) and apply sand bags if necessary. Massive moisture-related feed losses can occur due to building damage or flooding.

- Move all non-critical equipment to higher elevations or store in secure buildings. Machinery, feed, pesticides and any other equipment and supplies not crucial to storm response should be moved to the highest elevations possible.

- To the extent possible, deploy portable aerators across the ponds, but avoid those areas that have the lowest



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elevations and would be the first to flood. Although most portable aerators are quite heavy, they should be secured to power poles or water inlet pipes, using chains or heavy duty rope, to avoid wind- or tornado-related equipment loss.

- Lower pond standpipes 12 – 18” (30 – 45 cm) below normal level, depending on projected rainfall amounts, 3-4 days before storm impact to allow sufficient time for water to drain and make room for excessive rainfall that may occur. NOTE: Be sure to raise standpipes back up to full height before significant rainfalls begin, to prevent floodwaters from entering ponds through the drains.

- Ensure all pumps and pump stations needed to remove water from the facility are working, and gas and diesel backup systems and generators are full of fuel. Protect these assets from flooding with sandbags as needed.

- Stop feeding 2 days prior to predicted storm arrival to reduce biological oxygen demand of fish and ponds. Provide additional aeration to ponds as needed in order to offset decreased photosynthesis resulting from cloud cover and to allow fish to go into the storm in the best condition possible.

#### **One Day before a Storm is Forecast to Impact Your Area**

- Unplug or shut off electrical supplies to any non-critical equipment,



**After the storm:** Do not rush back into a facility until you are sure it is safe. Drowning and electrocutions are two of the largest dangers in aquaculture production, and the danger increases several fold in the wake of a severe storm.

and disconnect power entirely to all buildings that may be flooded.

- In some states and countries, facilities that culture exotic species are required to have emergency measures in place to ensure no escapement to the wild occurs for potentially invasive species. These measures may include maintaining a supply of rotenone or other chemicals to euthanize all fish in outdoor ponds or tanks. These measures should not be taken until the storm path and rainfall projections can be determined, but with sufficient time to complete all tasks. Emergency euthanasia procedures should specify a priori the projected rainfall amounts designated for decision making purposes and consider the time requirements to allow employees to evacuate after applying (and subsequently neutralizing) treatments.

- Verify that all pond standpipes have been returned to their highest levels.
- Make sure all facility employees have evacuated to secure areas. If some staff will remain on site, confirm that they have access to structures on high ground or elevated slabs/pylons that can withstand hurricane/typhoon force winds and rain, sufficient stores of clean water and food, medical supplies, sufficient supplies of any medications they normally take, working radios or cell phones and sufficient battery or generator power.

- Those workers remaining on site should have regular cell phone communication with evacuated supervisors and colleagues, since local radio and television communications often black out for several hours as a storm passes. Local first responders may also be out of communication at the time of storm impact.

- Personnel remaining on site to monitor fish and facilities until the last moment should also closely observe water levels in low-lying and problematic areas to have sufficient warning to allow workers to exit the operation before levees and surrounding roads and highways are blocked with floodwaters.

- If the decision is made to abandon the farm, tractors and other equipment that have not already been moved to the highest ground available must be left in place.

### **III. Post-Storm Recovery Immediately After the Storm has passed**

- Do not rush back into a facility until you are sure it is safe. Drowning and electrocutions are two of the largest dangers in aquaculture production, and the danger increases several fold in the wake of a severe storm. Proceed cautiously and avoid driving

across any submerged roads or levees.

- Check on the safety of any employees that may have remained behind during the storm to care for the facility or animals.

- Check for levee breaches, flooded ponds, rising or incoming water and evidence of structural fire or damage before entering any infrastructure on the property.

- Check the entire facility for downed powerlines or other damaged utilities (such as gas pipelines) that may pose a hazard or need to be repaired.

- Inspect roofs and cover wind-damaged areas to reduce water damage inside structures.

- Start the process of water removal from the facility by pumping if necessary and if possible. Facility recovery cannot be undertaken until roads, levees, and buildings are no longer flooded.

- If ponds or tanks have become flooded and water is leaving the property and potentially carrying fish with it, seines or orange vinyl roadside fencing may be placed across shallow or slow-moving water to prevent further fish escapement. For safety reasons, do not attempt to enter, seine, or fence fast moving water that is more than ankle deep. It is better to dam the fast flowing water us-



Pond topping and mixing, due to improperly sized drains incapable of handling heavy rainfall associated with hurricane events.



Once a pond is underwater it is difficult or impossible to tell where levees and roads are.

ing heavy construction equipment if possible.

- Aeration is the first item critical to recovery that must be restored following a storm. This can be especially important for watershed ponds. Run-off from above the pond will replace algae-laden water with water carrying high levels of silt and bacteria, severely limiting natural oxygen production after the storm. After conducting the aforementioned safety checks, determine if power to stationary aerators is still functioning or has been restored. If it has, start normal aeration with electrical aerators. If it has not, begin to move portable emergency aeration equipment from secure locations to ponds with the lowest dissolved oxygen levels.

- Begin to collect, enumerate, and document dead fish, water damaged feed, and other losses as soon as possible. It may not be possible to adequately document losses later, due to scavenging and decay.

### Within a Week Following Storm Impacts

- Start the Federal and private crop insurance claims process. Accurate losses of inventory and equipment

may not be fully documented yet, but insurance claims can take months to resolve following storm events so start the paperwork now.

- Check structural soundness and document any damage to facility buildings.
- Check and document water damage to equipment and machinery.

- Continue to collect, enumerate, and document any dead fish or feed spoilage.

- Work to restore electrical and water supplies if needed.

- Maintain heavy aeration in ponds to reduce stress and associated disease of fish caused by temporary lack of aeration due to power outages or by rapid changes in water chemistry from heavy rainfall, flooding, or saltwater intrusion.

- Do not feed any portion of feed if a bag, container, or bin has been found to have water damage or spoilage. Clean out feed storage buildings, bins or other containers with spoiled feed. Thoroughly rinse them with a 10% bleach solution, and allow them to dry completely before restocking feed. Fish may die if spoiled feed is consumed.

- If structural, equipment, and operational damages are minimal, pond

inventory assessments should be started. Ponds that were flooded and ponds with visible mortality should be fully seined or partially seined and fish numbers extrapolated based on total pond volume to determine inventory losses.

- Just as critically, seining should be done to determine if undesirable wild fish species were introduced to ponds through storm surge or flooding.

### Within a Month Following Storm Impacts

- Continue and follow-up on the insurance claims process. Begin filing for any additional State or Federal disaster assistance programs for storm recovery.


- Water supply and aeration should be fully restored across the farm.

- Pond, levee, and road structural repairs should be underway.

- Drainage ditches and canals should be examined to determine to what extent, if any, they have been silted in by floodwaters or blocked by downed trees or other debris.

- Pond inventories should be continued and fish numbers extrapolated based on total pond volume to determine inventory losses. Undesirable fish species should be removed from production ponds or tanks to the extent possible.

- New feed, replacement production fish requirements, and broodfish inventories should be obtained after evaluating ponds, if necessary.

- Equipment that was flooded or inundated with water should have general and preventative maintenance done to ensure future working order. Keep all receipts for parts and labor, as well as a list of any equipment that is determined to be a total loss. 

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