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Safety on North Carolina and Kentucky Trout Farms

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Abstract. *The objective of this study was to identify and describe work-related safety hazards, injuries, and near-injury events (close calls) that occurred on trout farms in North Carolina and Kentucky. An interview instrument was used to collect information on occupational hazards, injuries, and near-injury events that resulted from work-related activities. Trout farmers reported occupational hazards including falling live tank lids, slippery surfaces on hauling trucks, lifting strains, falls from raceway walls and walkways, needlesticks while vaccinating fish, allergies, hypothermia/drowning, falls from cranes, chemical exposure, fire/explosions related to oxygen exposure, and electrical contact with overhead power lines. This study also reports solutions suggested by farm safety researchers or used by farmers to prevent the safety hazards found on trout farms.*

Keywords. Aquaculture, Fish farm, Hazards, Safety, Trout, Trout farm.

Trout propagation is one of the oldest aquacultural industries in the U.S. (NASS, 2009a). Rainbow trout (*Oncorhynchus mykiss*) is the primary species of trout produced globally and in the U.S. The USDA National Agricultural Statistics Service (NASS) reported that U.S. trout farms (n = 1,018) received $80 million in sales in 2008, an average of $78,600 per farm (NASS, 2009b). The states contributing a major share to the total revenue were Idaho, California, and North Carolina (NASS, 2009b). NASS reported that the total production of food trout in 2008 was 54,534,000 fish, down from the 2007 production of 74,286,000 fish. Farmers, including state agencies and fish clubs, also produced trout valued at $15 million for conservation and recreational purposes (Heep, 2008).

Occupational hazards among trout aquaculturists reported in the scientific literature have included diseases such as leptospirosis (Robertson et al., 1981), pfiesteria (Swinker et al., 2002; Durborow, 1999), Weil's disease (Davidson and Smith, 1936), injuries such as needlesticks (O'Neill et al., 2005), and formaldehyde exposures in hatcheries (Lee and Radtke, 1998). In one reported incident, a crane overturned into a trout pond, crushing the operator to death (NIOSH, 2003).

The objective of this study was to describe the work-related safety hazards, injuries, and near-injury events (close calls) that occurred on trout farms located in North Carolina and Kentucky. This information was obtained through on-farm visits and face-to-face interviews of trout farm owners and managers. Permission was obtained from the farmers to take photographs on their farms to illustrate potential safety hazards as well as farm-devised innovations to reduce safety risks. Solutions to the hazards developed by many of the farmers and researchers are also described.

Materials and Methods

In 2008, a total of eight trout farms located in North Carolina and Kentucky were visited during the study. The number of raceways on the eight farms ranged from 12 to 54, averaging 32 raceways per farm. Raceway sizes ranged from 7.6 to 60.9 m (25 to 200 ft) long, 0.9 to 3.0 m (3 to 10 ft) wide, and 0.6 to 1.2 m (2 to 4 ft) deep. The typical raceway was approximately 18.3 m (60 ft) long, 2.4 m (8 ft) wide, and 0.76 m (2.5 ft) deep.

An interview instrument was used to collect information on occupational hazards, injuries, and near-injury events that resulted from work-related activities, and methods developed by farmers to prevent hazards (Myers and Cole, 2009). Each interview form was assigned a case number to protect the identity of the farmers. Examples of questions from the interview instrument are shown below:

- Have you, a family member, employee, or other person been injured on your farm?
- What body part was injured?
- What was the person doing when the injury occurred?
- What have you done or plan to do to prevent similar injuries (or close calls)?
- How would you prefer to be informed or educated on safety issues?

In addition, a walk-through was conducted at each farm in which photographs were taken and

described in detail in a photo log. Photographs were used to collect visual images of the safety hazards and countermeasures implemented on each farm. Data from the interviews and photo logs were used to develop a descriptive analysis of the occupational safety hazards and countermeasures that were observed on the farms.

Results and Discussion

Among the eight trout farms surveyed, 17 incidents involving injury and 19 involving close calls were reported. Seventeen injury incidents or close calls happened to the farm owner or head manager, six occurred to a family member, eleven involved a farm employee, and one incident happened to a contractor. Only one of the eight trout farmers interviewed reported that no injuries to anyone had ever occurred on the farm. These numbers are derived from what the interview subjects remembered (and/or were willing to discuss) about past incidents at the time of the interview, so numbers of occurrences may not represent actual frequencies and cannot be used in quantitative analyses. However, the descriptive nature of the study gives us valuable information about existing trout farm safety practices and potential hazards.

This article discusses falling live tank lids, slippery surfaces on hauling trucks, lifting strains, falls from raceway walls and walkways, needlesticks while vaccinating fish, allergies, hypothermia/drowning, falls from cranes, chemical exposures, fire/explosions related to oxygen exposure, and electrical contact with overhead power lines. The safety hazards, injuries or illness events, and near-injury events reported by the trout farmers and the countermeasures implemented to eliminate safety hazards are summarized in table 1 and described in the following sections.

Table 1. Hazards, injury or illness events, and near-injury events reported by trout farmers in this study, and countermeasures to eliminate or reduce the hazard.

Exposure to Safety Hazard	Injury or Illness	Near-Injury Event	Farmer and/or Researcher Generated Countermeasures to Eliminate or Reduce Safety Hazards
1. Falling live tank lids	Severed finger, hand injury, bruises and abrasions		Hydraulic struts or locking hinges on lids. Wooden or rubber wedge to prop tank lids open. Heavy metal lids replaced by light sheet metal.
2. Slippery surfaces on hauling trucks		Head injury, bruises and abrasions	Install steps with hand rails on hauling truck. Install a non-slip surface on hauling truck surfaces. Wear shoes with sufficient traction.

3. Lifting strains	Torn knee cartilage, back injury, torn bicep, back strain		Use mechanical means to carry several feed bags. Build loading docks level with the truck bed. Use smaller pallets with fewer stacked bags. Use chutes to unload fish from hauling tanks. Use a boom truck to move net loads of fish. Use a permanent or portable pump to move water.
4. Falls from raceway walls and walkways	Shin abrasion, lacerated nose, broken wrist, bruises, injured shoulder	Strains, bruises, broken bones, drowning,	Use proper gauge metal (with traction) for walkways. Use wider walkways. Keep walkways clear of debris or tools. Secure walkways with weights.
5. Needlesticks while vaccinating fish	Rash	Anaphylactic shock, respiratory distress, rash or death	Anesthetize fish before injection. Inject fish on a corrugated table (can install a shelter around the table to avoid adverse weather).
6. Allergies	Dermatitis, respiratory irritation	Anaphylactic shock	Wear gloves, a long-sleeved shirt, and a mask. Inspect feed for mold.
7. Hypothermia and drowning	Hypothermia or drowning		Wear neoprene waders. Use adequate lighting at night. Do not work alone. Cover raceway with rigid plastic mesh in a frame.

			Install end-of-raceway barriers.
8. Falls from cranes	Cracked rib, broken leg, knee injury		Be aware of tripping hazards near vehicles. Place flags near struts to increase their visibility. Install non-slip surfaces.
9. Chemical exposures		Respiratory irritant and stains the skin	Wear gloves, masks, and eye protection.
10. Fire or explosions related to oxygen exposure		Burns and death	Place "no smoking" signs near oxygen containers. Inspect oxygen tanks and cylinders for damage. Secure oxygen cylinders with a chain.
11. Contact with overhead power lines		Electrocution, severe burns, or death	Elevate power lines to avoid contact. Bury power lines. Use a ground fault interrupter (GFI).

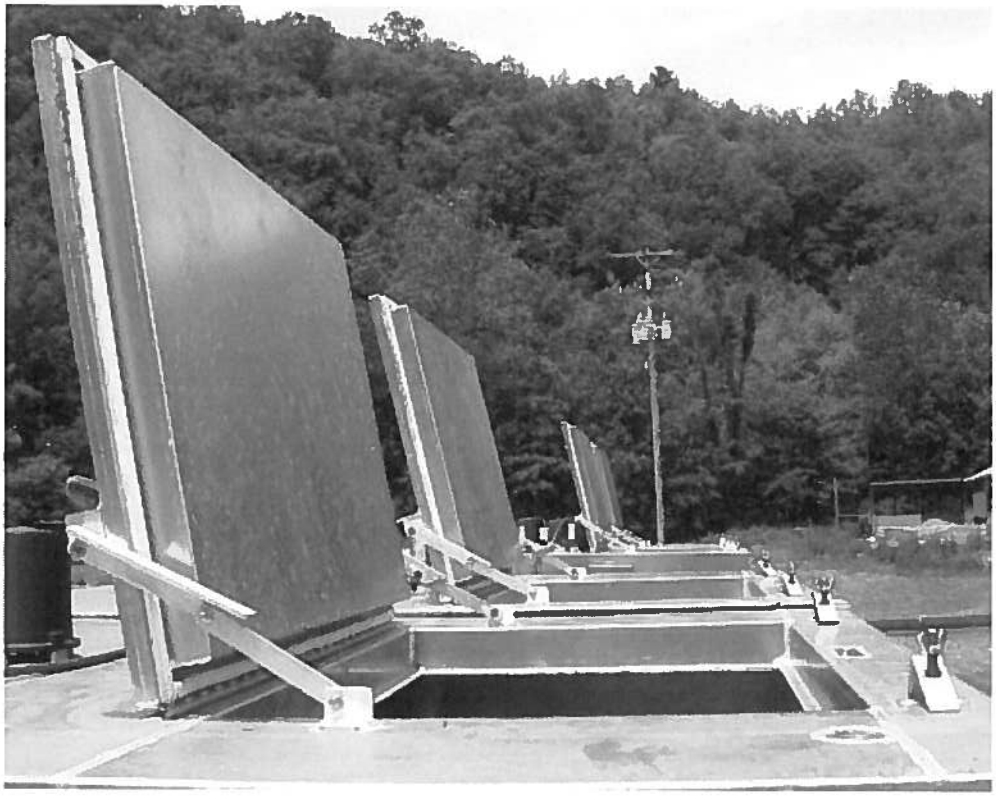

Figure 1. Locking hinges on live haul tank lids prevent the lids from falling on workers' hands.

Falling Live Tank Lids

Falling hauling tank lids can cut, bruise, or sever fingers. In one incident in North Carolina, a heavy lid fell and severed about one-half inch of a worker's finger. The severed finger was successfully reattached at a local hospital. In an incident in Kentucky, wind blew a heavy fiberglass tank lid, hitting the farmer on the back and knocking him off the live haul truck. The farmer was bruised and cut. Use of locking (or hydraulic) hinges (fig. 1), wooden or rubber wedges to block the lid in an upright position, or lightweight sheet metal lids that flip open completely (180□) are solutions to this hazard.

Slippery Surfaces on Hauling Trucks

Loading trout from the top of the hauling tanks presents the risk of falling (fig. 2), especially in wet and icy conditions. Applying a layer of non-slip coating on hauling tank tops may be a good safety practice. Tests may need to be done to assess how well such a coating would stick to the hauling tank metal; incorporating non-slip material may need to be done by the manufacturer. Trout farmers can install steps covered with a high-traction metal, such as SlipNOT □ , on the hauling truck, as shown in figure 3, to reduce slipping hazards. Non-slip surfaces strategically placed on live haul truck surfaces can help prevent falls even when the surfaces are wet. Farmers should wear shoes with sufficient traction when standing on the hauling truck.

Lifting Strains

A primary approach to avoiding muscle strain is to rely more on mechanization than on manual labor. Many of the examples of good safety practices in this section involve using machine power whenever practical. One North Carolina trout farmer reported a family member turning or twisting while carrying a feed bag, which resulted in torn cartilage in her knee. The use of feed trucks to distribute feed in raceways helps to avoid the strain of carrying bags of feed during manual feeding (fig. 4). Another North Carolina trout farm used an air blower feeding device to blow feed

Figure 2. Falls from the top of live haul tanks are more likely when water, fish mucus, and ice are introduced. When loading is done inside a building, a safety harness can be suspended from the ceiling for workers to wear.

Figure 3. Non-slip surface bolted onto the steps of this live haul truck provides good traction even when wet.

Figure 4. Feed trucks blow feed into raceways and alleviate the need to carry heavy feed bags

when feeding by hand.

Figure 5. Smaller pallets or "minis" are in the foreground with conventional large wooden pallets in the background.

from barrels into raceways. Small 4-wheelers and fork-lifts can mechanize the movement of feed bags around the farm.

Building loading docks that are level with the bed of the hauling truck makes it much more practical and safe for wheeling hand trucks with feed stacks as well as

Figure 6. The shorter stacks of feed bags (nine bags) used with minis create less risk of straining muscles versus wheeling around excessively heavy loads.

loading other items or equipment. Using smaller rubber pallets ("minis", fig. 5) with fewer feed bags (nine or ten bags per pallet, fig. 6) instead of large wooden pallets with more feed bags, about forty to fifty 18 kg (40 lb) bags per pallet, can be safer.

Using chutes (fig. 7) to unload trout from hauling tanks is much more efficient than dip netting multiple loads of fish. At the same time, less muscle exertion is required. Likewise, use of boom trucks to lift net loads of fish from raceways to hauling tanks saves a significant amount of manual lifting (fig. 8). Caution must be exercised, however, to prevent contact of the boom with overhead electrical power lines (see the Contact with Overhead Power Lines section).

Instead of filling hauling tanks by carrying buckets of water or having a line of people pass buckets of water up to the hauling tank, gas or electric powered water pumps (either portable, fig. 9, or permanent, fig. 10) are often used to reduce the muscle stress of aquaculture workers.

Figure 7. Fish quickly slide down a chute when discharged from a hauling tank, avoiding stress on the fish and strain on the farm workers.

Figure 8. Use of cranes or booms to move loads of fish can help to avoid muscle strains from repeatedly lifting loads from the raceway to the hauling tank.

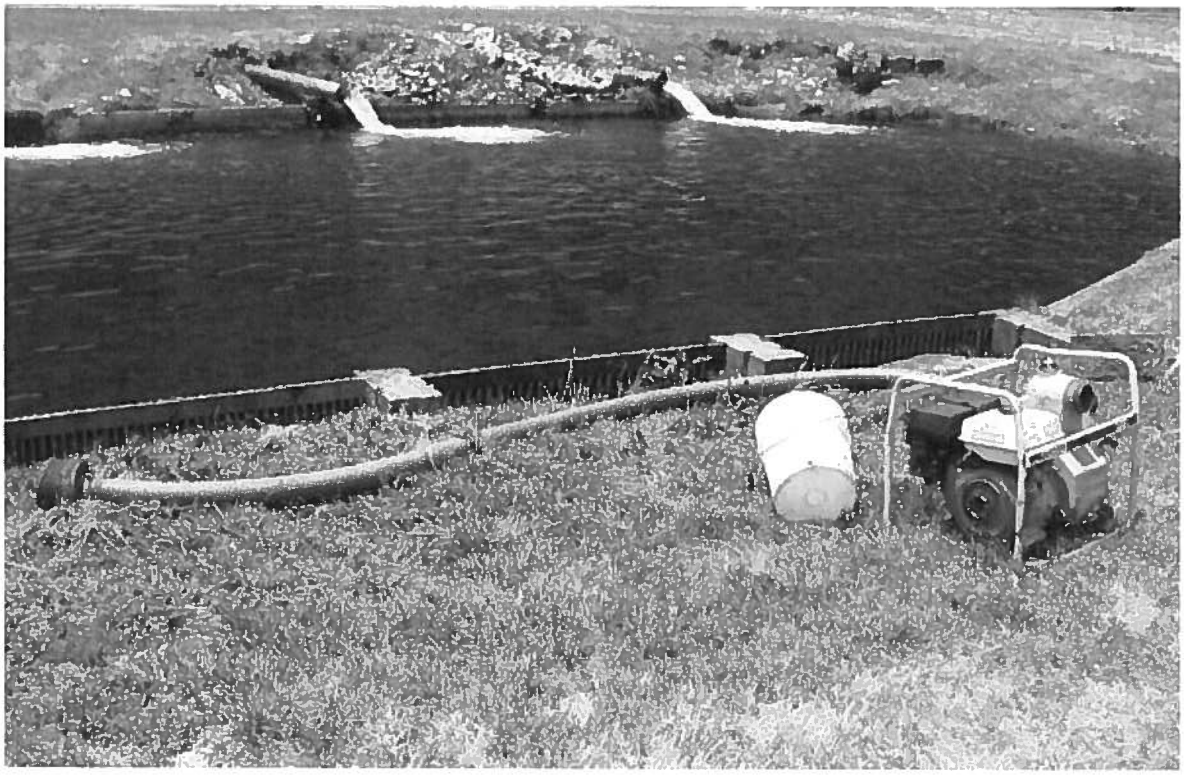

Figure 9. Portable gas-powered water pump.

A trout farmer in North Carolina uses a water volume displacement indicator on the side of his live haul tanks to calculate the weight of fish going into the tanks (fig. 11). This technique avoids the labor-intensive process and the strain of weighing each dip net load of fish. One North Carolina farm has a centralized vacuum system that can save significant labor when cleaning the quiescent zones of trout raceways (fig. 12). Most systems that reduce the amount of labor required can also be considered an addition to a farm's safety features.

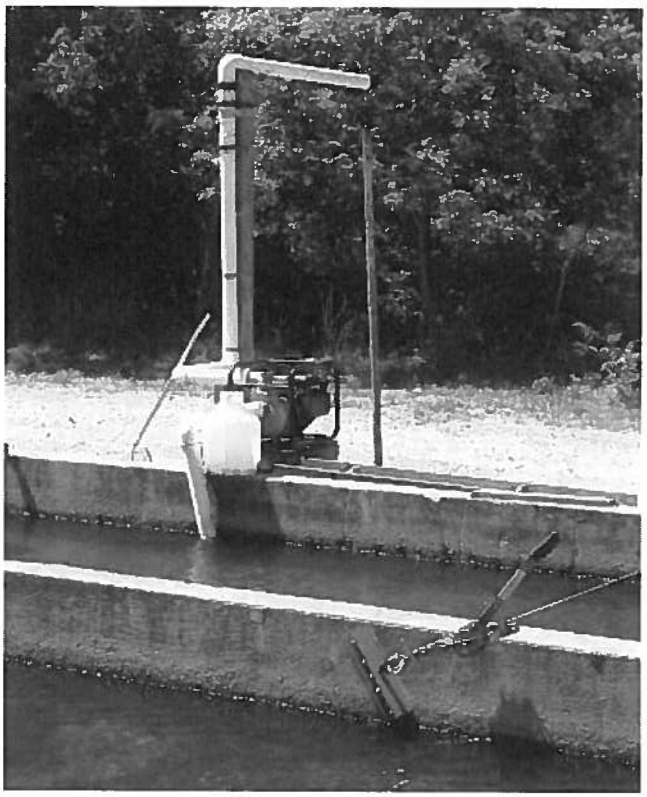

Figure 10. Live haul trucks can pull up to this permanent water pump to get filled with water.

A North Carolina trout farm worker injured a shoulder and tore a bicep muscle when lifting a pressure washer off of a truck. The farm manager felt that the truck should be equipped with a hydraulic lift. The same farm requires workers to wear back belts or braces (waist band with shoulder straps) to prevent injury when lifting heavy loads. However, there is no evidence that back belts reduce back injury or pain associated with repeated lifting, pushing, pulling, twisting, or bending. Laboratory-based research found that belt use only reduced spine bending (Giorcelli et al., 2001), and an epidemiology study found that elastic support back belt use did not reduce back injuries or pain (Wassell et al., 2000).

Falls from Raceway Walls and Walkways

Wooden plank walkways crossing over raceways and resting on the concrete raceway walls split and break over time and may be slippery when wet, especially when fish mucus is present (fig. 13). A few years ago, an elderly North Carolina farm owner was standing on the end of a wooden walkway with a heavy load of trout when someone unexpectedly removed a weight from the opposite side. The walkway flipped up and lacerated the owner's nose, requiring plastic surgery. As a result, this trout company has installed a 4-foot-wide reinforced concrete walkway across its raceways (fig. 14). Metal walkways are usually preferred but should be made of sturdy metal to prevent splaying (fig. 15), and the surface should provide traction.

Another trout farmer slipped off of an icy wooden plank and received a skin abrasion; now he avoids walking on his planks when ice is present. When ice is not pre-

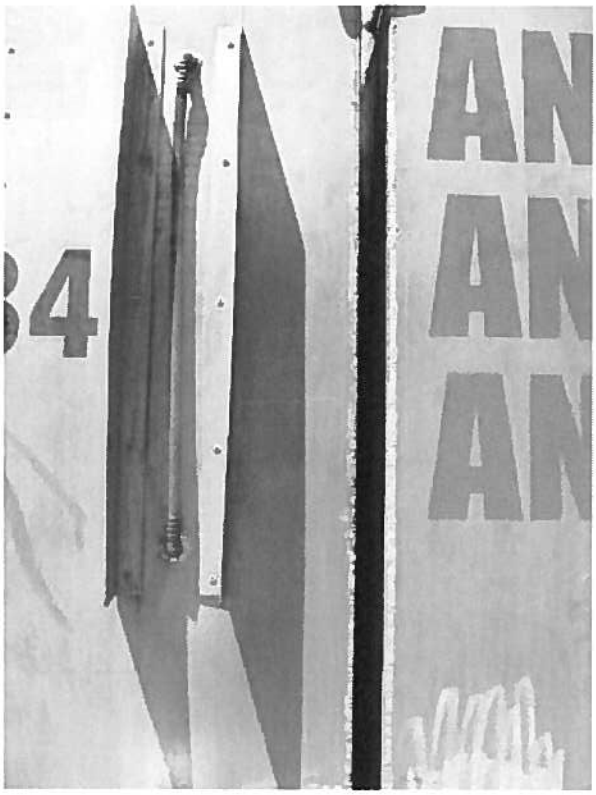

Figure 11. The clear plastic tube on the side of this live haul tank indicates the amount of water displaced when a load of trout is added to the tank.

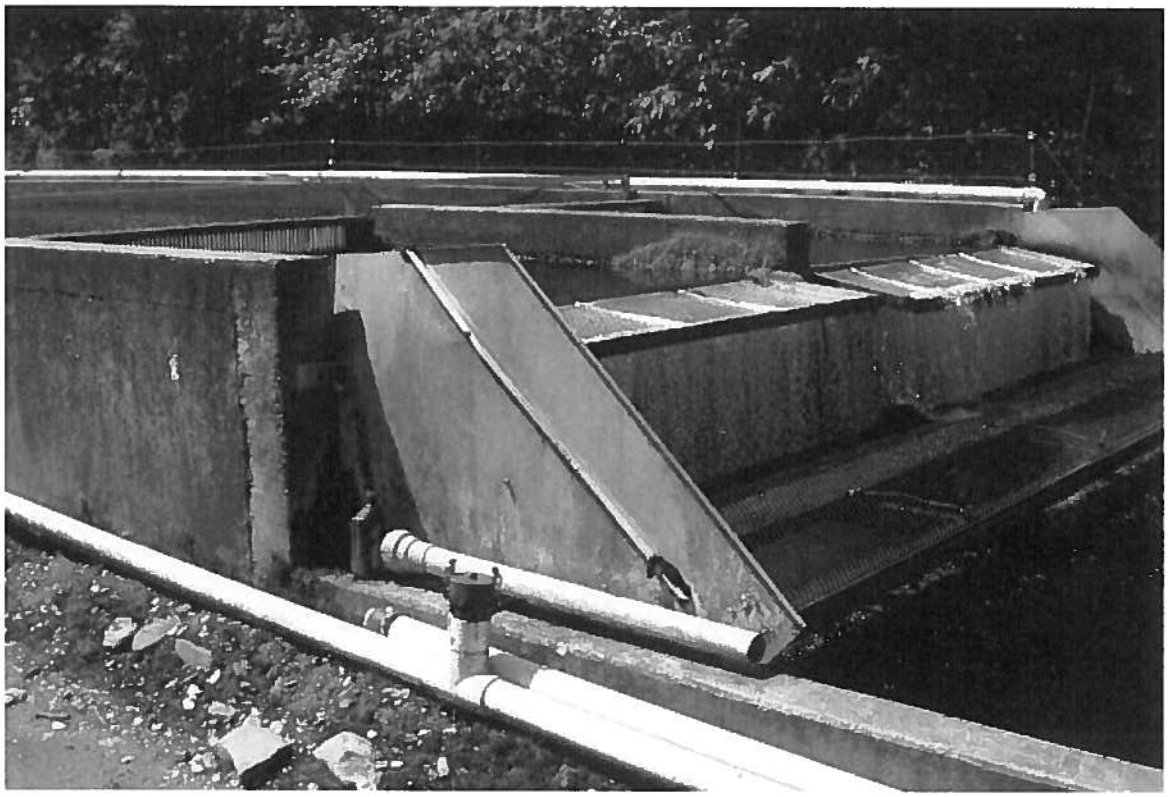

Figure 12. The white pipes in the foreground are part of a centralized vacuum system used to

clean trout raceways.

Figure 13. This farm manager is crossing on a partially split wooden plank walkway while carrying a dip net loaded with trout.

sent, he uses shoes with metal studs to walk on the planks. Yet another North Carolina farmer reported falling off of an ice-laden plank into a raceway wall covered with ice while carrying 18 kg (40 lb) nets full of trout to load onto a buyer's hauling tank. He received multiple bruises on his body that, while significant, did not require a doctor visit. This farmer felt that the small size of his farm, with annual production of 31,750 kg (70,000 lb), did not justify buying heavy equipment to move fish. From his

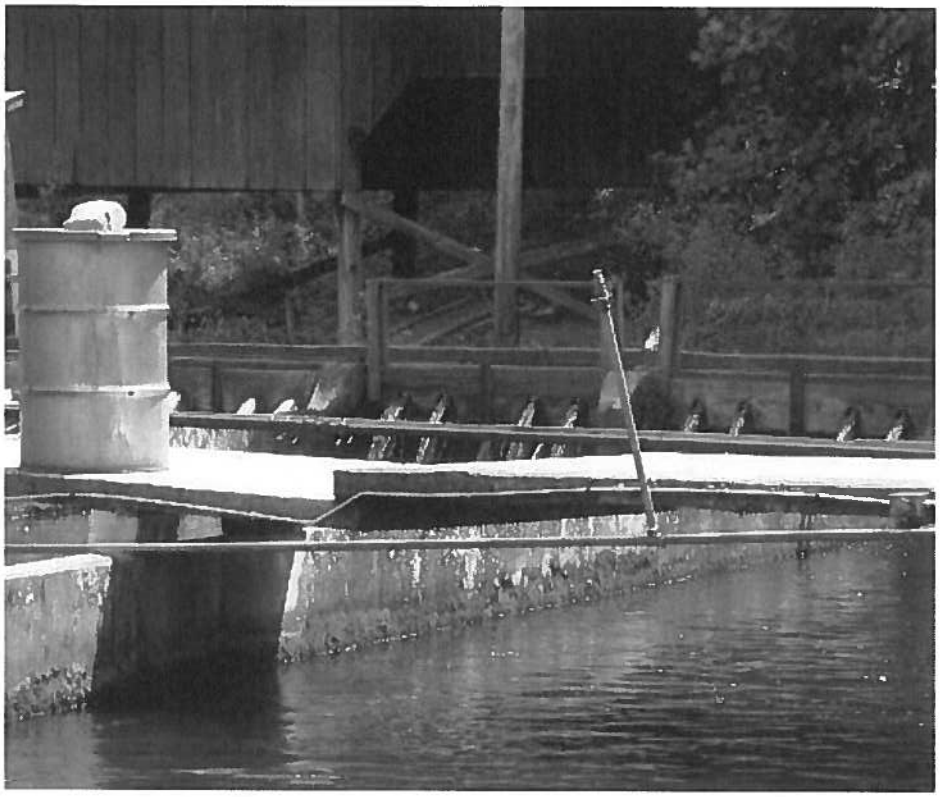

Figure 14. This 4-foot-wide reinforced concrete walkway adds to workers' safety when moving between raceways.

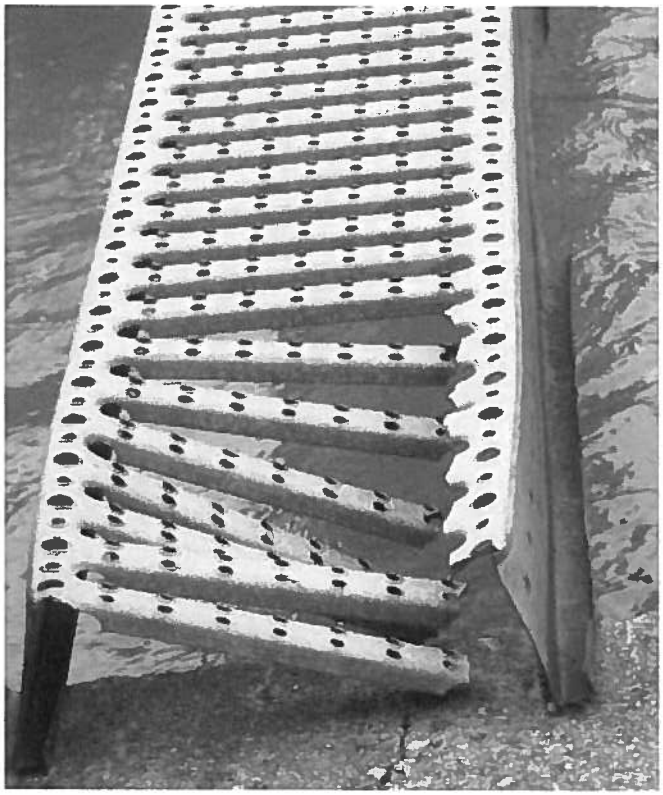

Figure 15. Splayed metal walkway.

perspective, economic constraints force him to do most jobs on the farm manually. He has a goal, however, to build a second road on the other side of his raceways. With roads on both sides, he would not need to rely as much on wooden plank walkways because he would have direct access to both sides of the raceway.

Top-of-the-line walkways are of no use if the concrete raceway walls are crumbling. Repairs using metal-reinforced concrete are necessary in these cases. A Kentucky trout farmer received a shoulder injury when he slipped on an ice-covered raceway wall while feeding his fish. A trout farm owner in North Carolina reported using large amounts of salt on raceway walls during winter to prevent ice formation. A Kentucky trout farmer reported almost falling while crossing the raceway spillway (fig. 16) and now uses plank walkways to cross raceways instead of using the spillway. One farmer broke his wrist when he tripped on a hammer that one of his employees left laying on the 20 cm (8 in.) wide raceway wall; his wrist struck the wall when he fell. Keeping things in order (e.g., tools stored in their proper place) helps to prevent clutter and tripping hazards.

Needlesticks while Vaccinating Fish

Vaccinating young trout to protect them against bacterial and viral diseases involves injecting the vaccine in the fish's intraperitoneal cavity. The syringe is automatically filled between injections, and the needle is in a somewhat safe location between metal needle guard loops. The needle guard provides some degree of protection for a person, while the fish's body fits easily between the guard loops so the needle

Figure 16. Walking on the raceway spillway is risky.

can penetrate the body cavity. In spite of the needle guard, one trout farm owner injected her

finger with a vaccine for the bacterial pathogen *Yersinia ruckeri* , which causes enteric redmouth disease. No serious problems resulted from this single injection. However, a neighbor of one of the interviewed trout farmers accidentally injected herself more than once with the enteric redmouth disease vaccine, resulting in a serious rash (red streak running up her arm) that required hospitalization. Anaphylactic shock has also been reported in workers who accidentally inject themselves more than once (Durborow, 1997).

The following interventions have been used to prevent accidental needlesticks: fish can be anesthetized and/or they can be stabilized on a table made of corrugated roofing material (fig. 17). This helps to prevent sudden lateral movements of the fish being injected. Additionally, trout farmers have built shelters around the injection tables (fig. 18) to protect workers from adverse weather conditions while performing vaccinations. The tables are suspended over the raceways, allowing the worker to simply drop the vaccinated fish back into the water through a hole on the table.

Allergies

The wife of one North Carolina trout farmer surveyed is allergic to wasp stings. In another incident involving allergy, a Kentucky trout farm manager developed dermatitis or hives on his skin while feeding fish twice a day. Precautions such as wearing gloves and a long-sleeved shirt may be necessary when contact allergies exist. Another trout farmer reported that the dust from fish feed resulted in respiratory irritations such as hypersensitivity pneumonitis (farmers' lung; Dickie and Rankin, 1958) as well as dermatitis on arms and hands. Wearing protective gloves and a respirator can help workers avoid feed dust exposure. Moreover, it is an important practice to monitor the feed for mold outbreaks, rancidity, and rodent droppings. Pest control and maintaining dry conditions help to avoid these problems.

Figure 17. A corrugated vaccination table top gives workers a place to stabilize the live, active trout during vaccination.

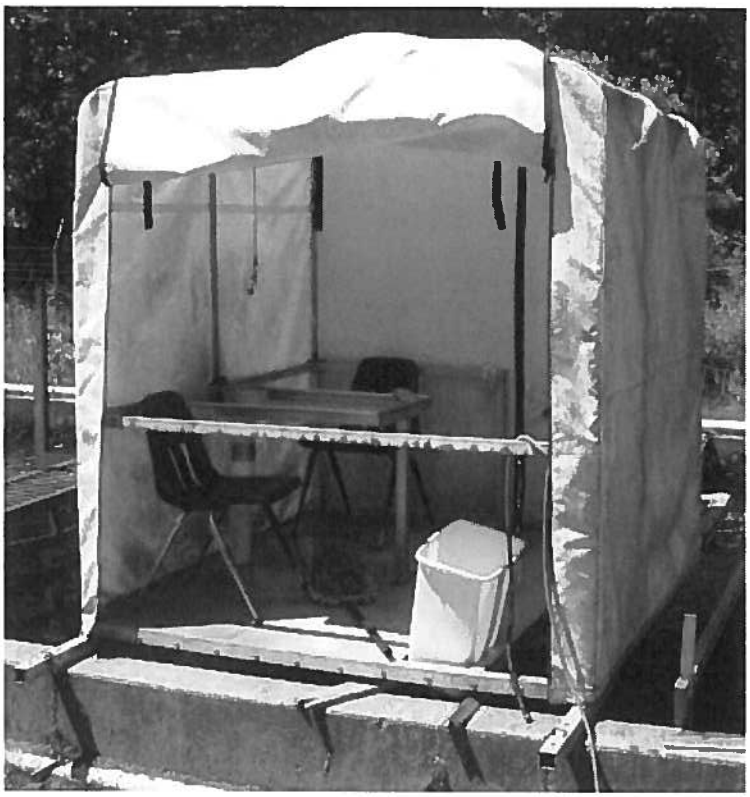

Figure 18. This vaccination table is protected from the elements and is a safe, stable environment for injecting trout with vaccines.

Hypothermia and Drowning

In an incident resulting in hypothermia or near-hypothermia, during -18□C (0□F) temperatures, a farm owner was breaking ice at the head box (the aperture allowing water intake by gravity from streams, fig. 30) of a trout raceway while wearing rubber waders when he slipped and fell into the water, getting a substantial amount of water in his waders. His ability to move was impaired, and he barely made it back to his truck to turn on the heater. Rubber waders can quickly fill with water and cause a person to drown or may weigh a person down in the water until he or she experiences hypothermia. Utilizing neoprene waders will prevent the frigid water from entering the waders (thereby eliminating the possibility of being weighed down in the water. In addition, working at the head box during stormy conditions at night with poor lighting can result in drowning. Adequate lighting for the entire raceway including the head box should be installed when working at night (see the Lack of Lighting or Visibility section). It is also a good precaution to have another person present while working at the head box during the winter or at night.

Bird netting covering raceways can be a source of entanglement for farm workers that may lead to drowning. Rigid plastic mesh in wooden frames reduces entanglement risk and acts as a barrier, preventing falls into the water while excluding birds (fig. 19). In a close call, the young son of one grower fell off of a raceway wall and into the waterfall. He was being responsibly monitored and was immediately pulled from the water without injury. A

Kentucky trout producer on a small farm would like to put a fence around his raceways to keep children away from the open water (to avoid potential drownings). His other goal of putting a roof over his raceways along with side barriers would achieve the same purpose but would provide the added benefit of shading his raceways, helping to keep the water cooler during the summer. He also plans to replace the bird netting currently in use with a steel mesh barrier that would exclude birds but not present a drowning hazard.

End-of-raceway barriers and crowder bars (a metal frame with parallel PVC pipes closely spaced; Stickney, 2009) clog less frequently and require less cleaning than metal screens (fig. 20). Trout farm features that reduce the amount of working time in the water reduce drowning risks. A valuable safety practice to prevent drowning is

Figure 19. Plastic mesh in wooden frames helps to prevent entanglement, falls into the water, and bird depredation.

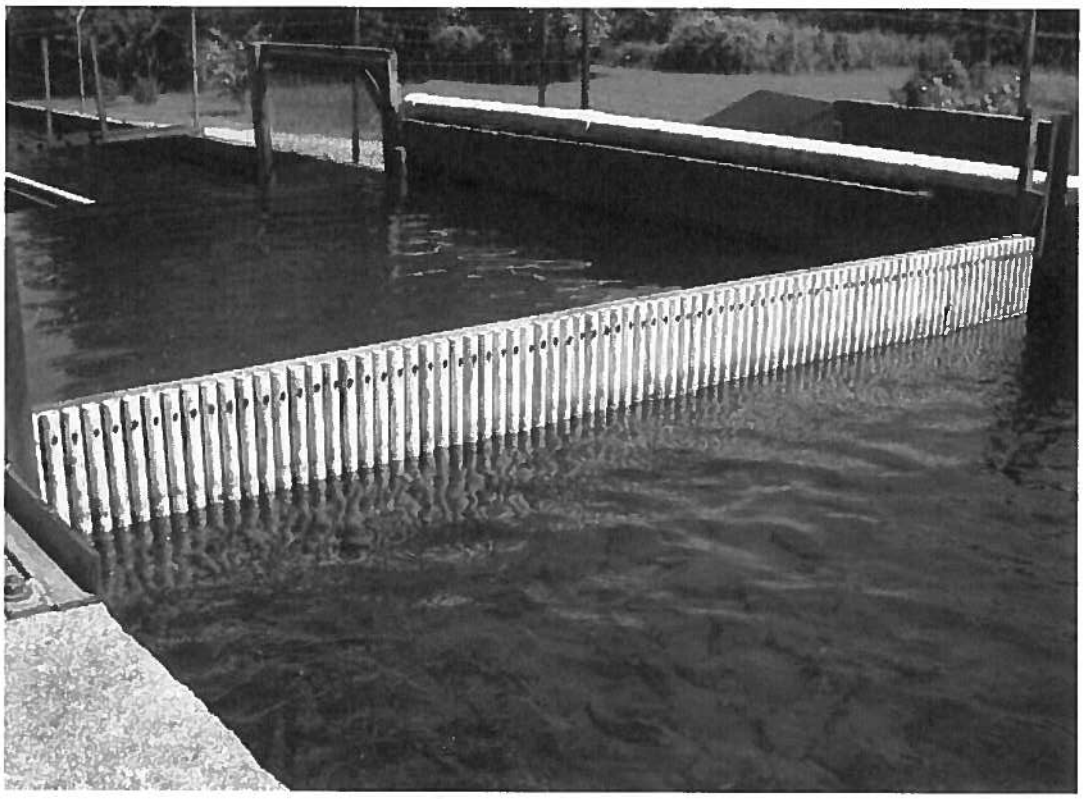

Figure 20. The parallel PVC pipes on this crowder bar clog less than metal screens, saving valuable labor time and increasing farm safety.

wearing a personal flotation device (life preserver). With such a device, a person would not only stay afloat when unconscious but would be protected from blunt force trauma to the chest, back, and ribs.

Falls from Cranes

In one case, a North Carolina trout farmer was using the boom on a crane to move nets full of fish when he fell from the tall crane, cracking a rib when he landed. The same farmer also bruised his knee deeply on the loader ladder as he was disembarking. At another farm, a worker tripped over the support legs of a crane and broke his leg. Slippery surfaces, ladder rungs, and awkward access on cranes can result in bad falls and serious injuries. The stabilizer struts that extend onto the ground from the crane pose tripping hazards. Non-slip surfaces used for climbing or walking on cranes need to be maintained or installed, and inexpensive flags can be used at the struts to warn of the tripping hazard.

Chemical Exposures

Chemicals can get into the mucous lining of workers' noses and in their lungs, and cause potential problems. Potassium permanganate, a purple powder, is noticeable when it gets into workers' noses or on their skin, and it was reported by one trout grower as a safety concern (fig. 21). Wearing a mask as well as gloves when handling chemicals is advisable (fig. 22). In addition to oxygen and potassium permanganate, multiple other compounds used on fish farms pose significant potential hazards to workers' safety and health. The frequency of chemicals reported as being used at the eight trout culture facilities surveyed is listed in table

2.

Fire or Explosions Related to Oxygen Exposure

Oxygen tanks (permanent emplacement) left on or tanks with broken valves can leak and cause fires or an explosion if they are close to an ignitable object such as a cigarette. The oxygen tank worker's clothing can become impregnated with oxygen, which can be ignited (i.e., by lighting a cigarette) even after stepping away from the oxygen tank. One farmer reported that a worker climbed into his pickup after working

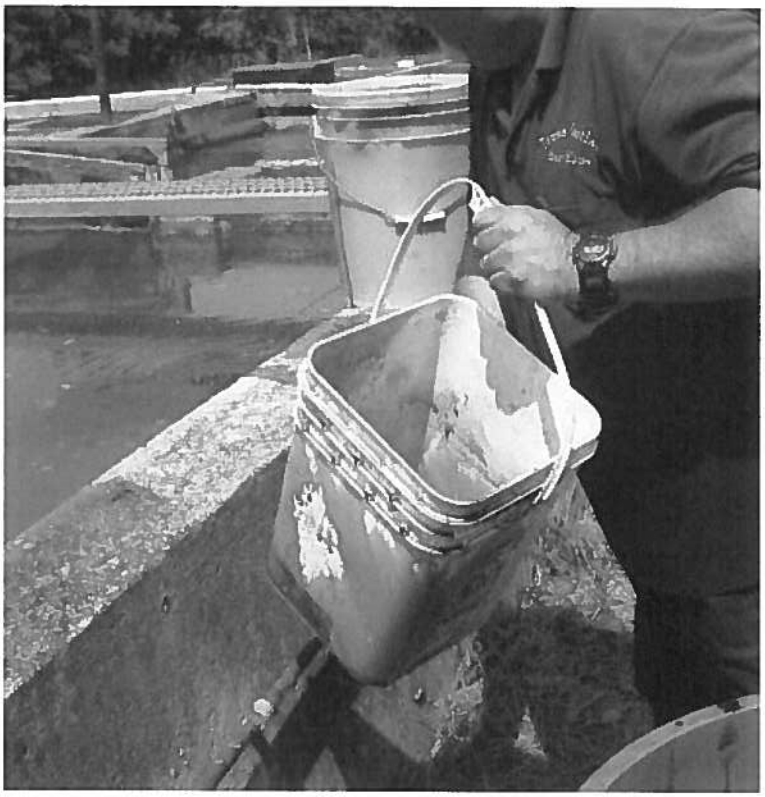

Figure 21. This trout farm manager is treating with potassium permanganate using no skin or face protection.

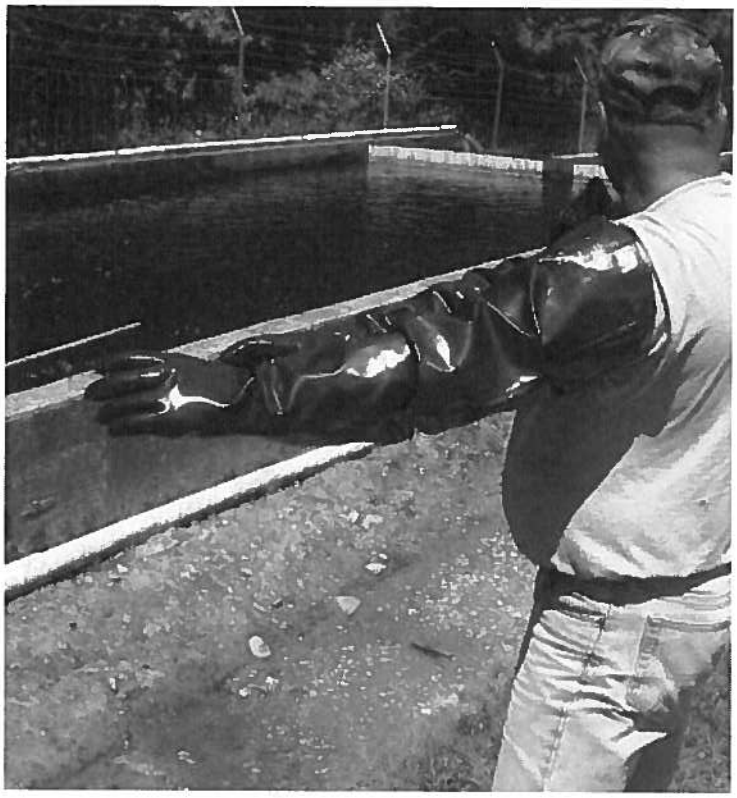

Figure 22. Long, thick rubber gloves are worn to protect workers' skin from chemicals.

Table 2. Chemicals used on the trout farms ($n = 8$) surveyed in North Carolina and Kentucky in 2008.

Chemicals	Number of Farms Where Use Was Reported
Calcium chloride	1
Calcium hypochlorite	1
Chlorine	2
Copper sulfate	3
Florfenicol	3
Formalin	6
Glyphosate	1
Hydrogen peroxide	3
Ice	2
Oxytetracycline-HCl	5
Potassium permanganate	4
Sodium bicarbonate ($NaHCO_3$)	2
Sodium chloride (NaCl)	6

Sodium hypochlorite	1
Sulfadimethoxine + Ormetoprim (Romet)	3
Tricaine methanesulfonate (MS-222)	3

on an oxygen tank, lit a cigarette that ignited his impregnated clothing, but was able to roll on the ground to extinguish the fire without injury. In another incident, a trout farmer was slightly singed when he had a lit cigarette in his mouth and put his head into an empty hauling tank chamber. The oxygen tank was accidentally left on and the accumulated oxygen caused a quick explosion when exposed to the lit cigarette.

To prevent fire and explosion hazards, oxygen tanks and cylinders should be routinely inspected for damage. "No smoking" signs should be posted, and cigarette use near oxygen tanks or after working on oxygen tanks should be banned. In addition, cylinders (manually handled) containing gasses or liquid oxygen should be secured to prevent them from falling. Falling cylinders can crush workers' feet or toes and can create a missile-like projectile if the valve breaks off the cylinder (fig. 23). Caution must also be used when working around liquid oxygen tanks. The extremely low temperature of discharged liquid oxygen can cause freeze burns on workers' skin and eyes (fig. 24).

Contact with Overhead Power Lines

One North Carolina farmer elevated the farm's overhead power lines from 9 m (30 ft) to 14 m (45 ft) to help to avert contact between farm equipment (such as boom trucks used to load fish) and the electric line. The more expensive alternative of relocating the line away from the raceways would have cost $10,000.00. Breaking electrical lines with booms seems to occur fairly commonly on fish farms. Couplers used to re-connect broken power lines are frequently seen at these facilities (fig. 25).

In one close call, a farm worker accidentally left the boom truck arm up when he drove forward. He snapped an electric line on the farm, and the broken line fell into the raceway, where the farm manager was standing and harvesting fish. No electrocution occurred. One trout farm has buried its power lines, and one trout farmer reported that he inspects extension and power cords regularly and replaces them if damaged.

Ground fault interrupters (GFI) are essential safety additions to aquaculture facilities. They immediately turn off the flow of electricity if the circuit becomes overloaded (as would happen if a person were being electrocuted). Major problems arise,

Figure 23. This liquid oxygen cylinder is not secured and appears like it could topple over very easily.

however, when GFIs prematurely cut off the electricity to equipment that may be keeping cultured fish alive (e.g., aerators operating in the middle of the night). If power to aerators, for example, is erroneously cut off at a time when the fish farmer is unaware, a whole crop of fish could be lost to suffocation. Farmers, therefore, often disable the GFI feature of their equipment.

In response to the survey question on the farmer's knowledge of injury suffered by other fish farmers, a Kentucky trout farmer relayed information about an Arkansas fish farmer who was electrocuted when the insulation on an electrical wire inside a power washer eroded, allowing the wire to come in contact with the power washer's metal casing while the farmer was standing in a puddle and holding the washer wand. Much less seriously, a North Carolina trout farmer reported occasional bruises and skin injuries caused by his pressure washer (fig. 26).

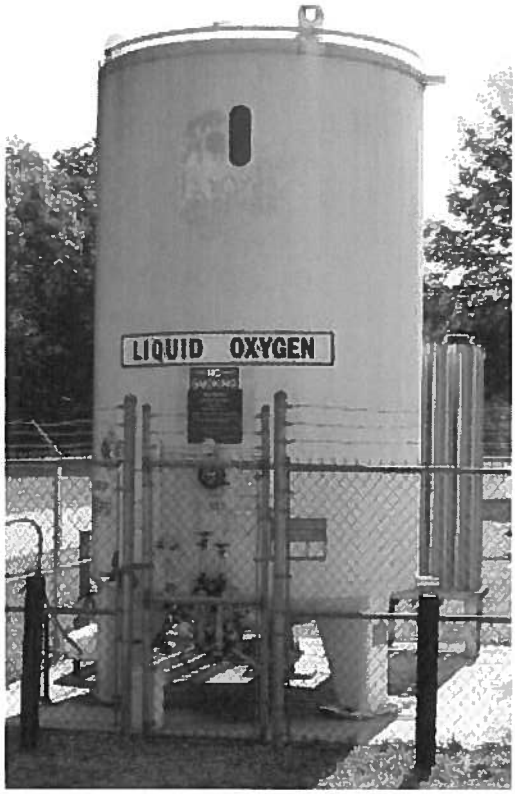

Figure 24. Combustion is a potential safety risk when working around liquid oxygen tanks.

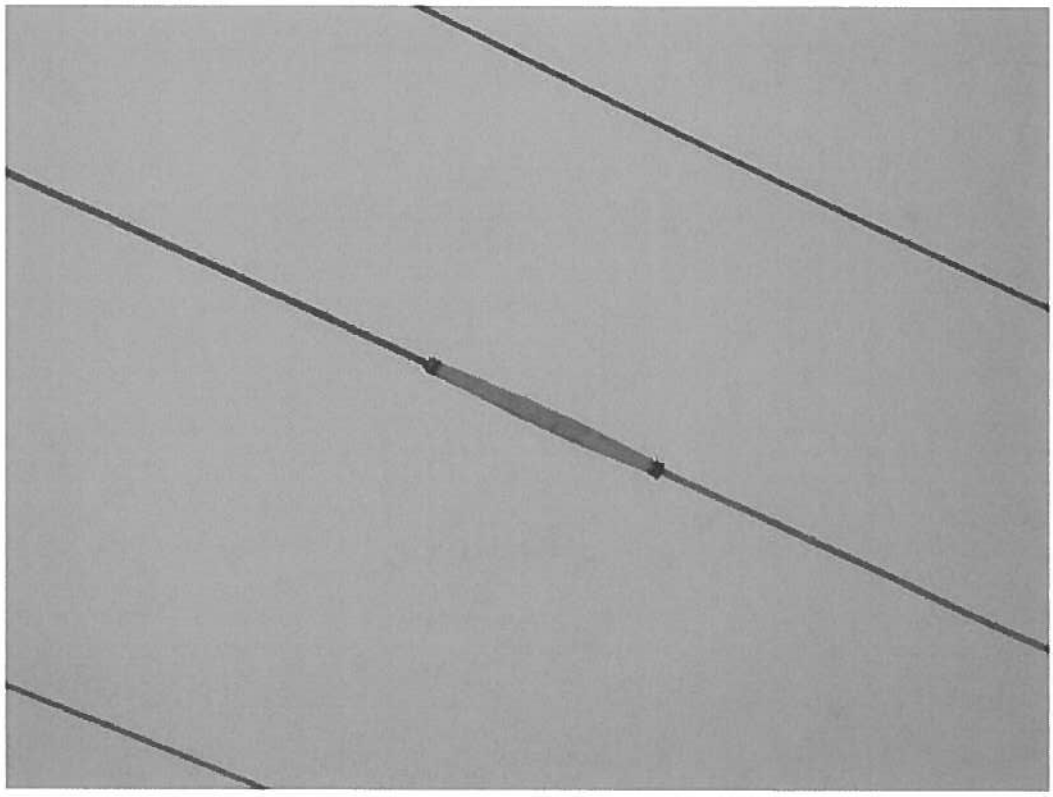

Figure 25. Couplers such as this one on an electric power line indicate that it was broken and had to be reconnected.

Figure 26. High-velocity water from pressure washers can cause skin injuries and bruises.

Additional Safety Hazards

Walk-through safety inspections of the trout farms revealed evidence of potential safety hazards that were not reported by the farmers during the interviews. The safety hazards observed by the researchers included unsafe tractor use, lack of lighting or visibility, sediment tank hazards, rodents and diseases, and falling hazards. These safety hazards are described in the following sections.

Unsafe Tractor Use

When slippery mud is in the pathway of a tractor, the vehicle may roll over (Myers et al., 2008). The combined use of a rollover protection structure (ROPS) and a seatbelt during tractor use can save lives if the tractor overturns (figs. 27 and 28). In addition to the risk of crushing if these safety devices are not used, the fish farm worker runs the risk of being pinned under water and drowning.

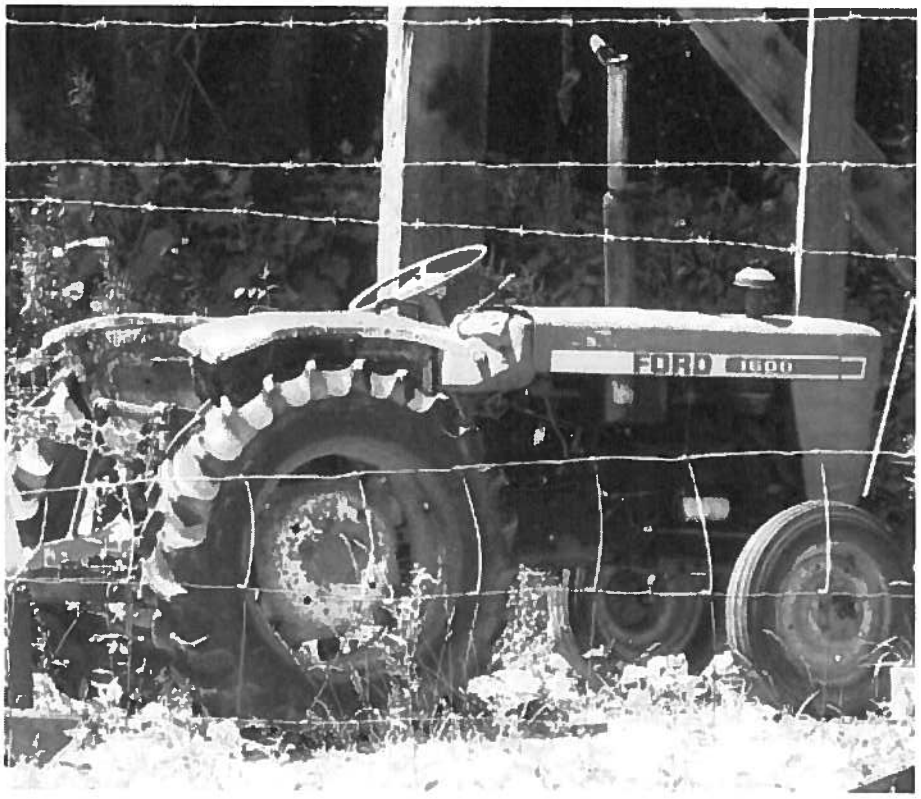

Figure 27. This tractor lacks a ROPS.

Figure 28. The cab compartment of this tractor is designed to serve as a ROPS. When operating around water, the cab door (which is only on the left side) should face away from the water so that the driver of an overturned and submerged tractor could escape through the

door (instead of having the door blocked by the pond bottom).

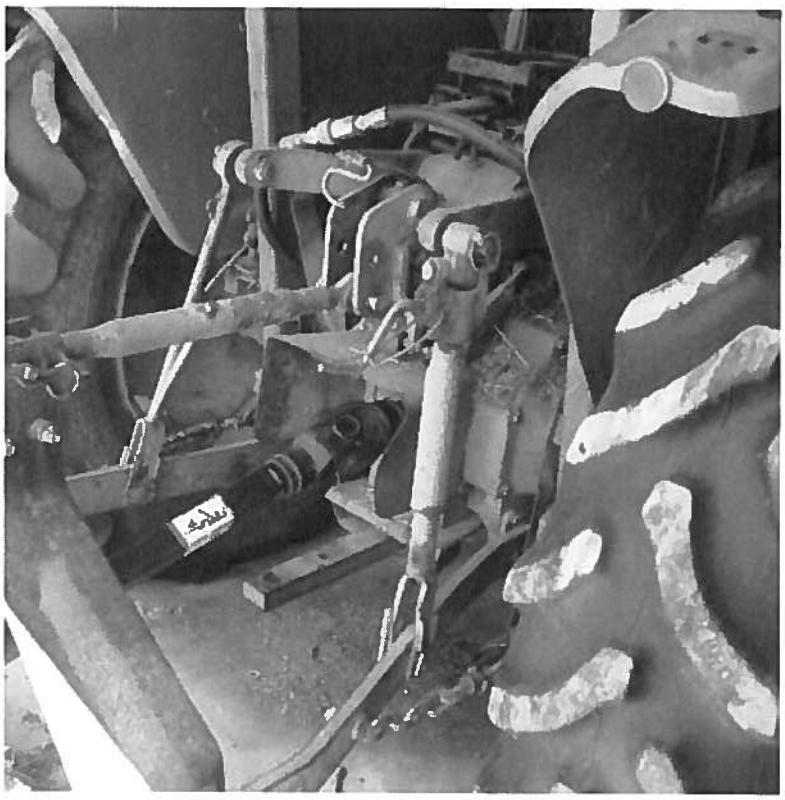

Figure 29. The PTO shield is missing from this tractor.

Another important safety feature on tractors is the power take-off (PTO) shield that protects workers from getting loose clothing caught in the spinning PTO. The plastic PTO shield sometimes disintegrates, cracks, and falls off, while in other instances farmers remove it to make maintenance tasks easier (fig. 29). The risk of injury increases substantially when these safety features are not used or installed on tractors.

Lack of Lighting or Visibility

Generous amounts of lighting around water intakes (head boxes) are essential for trout farmers' safety while cleaning the water intake area (fig. 30; see earlier section on Hypothermia and Drowning). As mentioned earlier, it is a good precaution to have another person present while working at the head box during the winter or at night. Concerning visibility, one trout farmer had heavy tree growth that obscured the view of his farm from his house, reducing the chances of him seeing potential problems, such as a worker or family member needing help in a dangerous situation (fig. 31).

Sediment Tank Hazards

Sediment tanks store trout farm discharge waste until it can be pumped onto agricultural fields. Sediment tanks pose an obvious drowning risk, and gasses emitted from them can be toxic to farm workers. One trout farm had its settling tanks sunk into the ground (fig. 32). To prevent drowning hazards in sediment tanks, a walkway with hand rails can be installed (fig. 33).

Rodents and Diseases

Rats or mice can chew holes in bags of feed (fig. 34). Rodent urine can be a source of disease for humans. In the 1980s, published research attributed leptospirosis in four British fish farmers to *Leptospira icterohaemorrhagica* originating from rat urine con-

tamination of fish feed in the farms' fish storage areas (Durborow, 1997). A tightly enclosed feed storage area can be used to exclude rodents. Domestic cats can also be employed.

Falling Hazards

In other issues involving falling risks, ladders on feed bins are safer for workers when they are enclosed with metal guards (fig. 35). A harness and vertical life line can

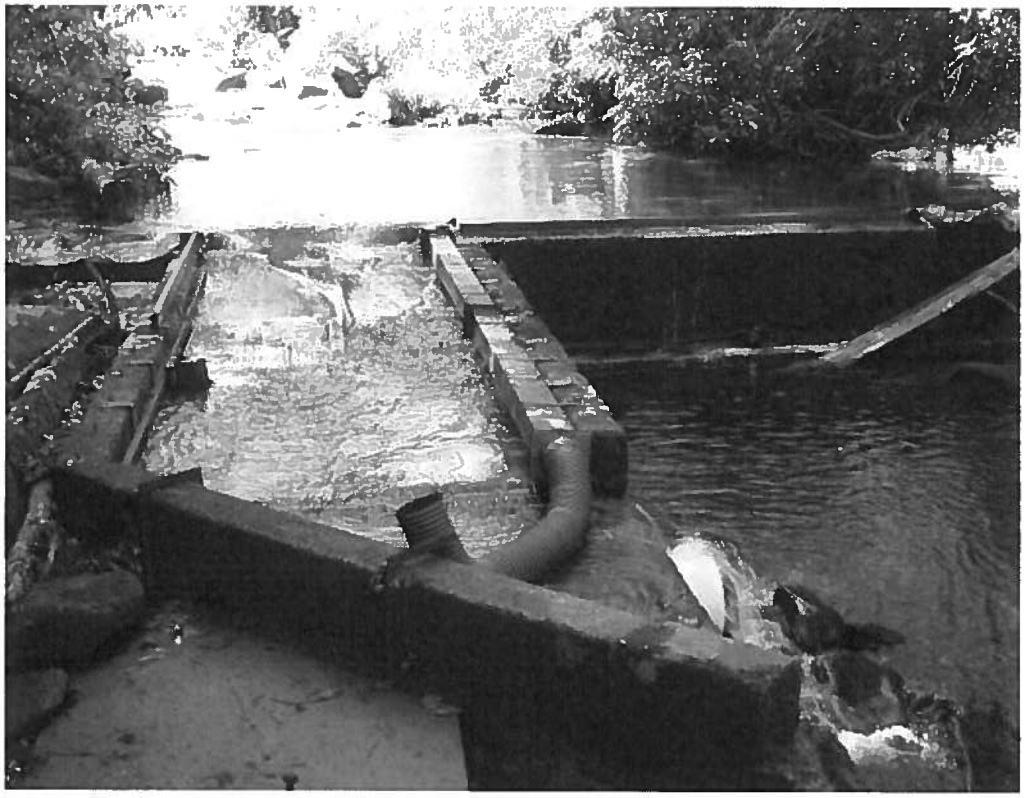

Figure 30. Trout farm head box in North Carolina bringing water from a mountain stream to the fish.

Figure 31. Better visibility from the farm manager's house would increase the chances of seeing a worker in trouble.

prevent a worker from falling if his feet slip from the ladder rungs. Rebar often extends out of concrete raceway walls to support electrical wires. Falls onto rebar can cause cuts, bruises, and even impaling. Exposed rebar should be covered with plastic caps (fig. 36) and/or bent to a horizontal position (fig. 37).

Wet concrete hatchery floors pose a falling hazard during the trout production season. The use of "gritty" textured material (sand or something similar) in floor paint can add traction when walking on wet floors. The proper amount and type must be used to ensure that the paint retains its adhesion to the underlying surface.

In response to a survey question on how the trout farmers would prefer to be informed and educated on safety issues, six managers replied that handouts and Exten-

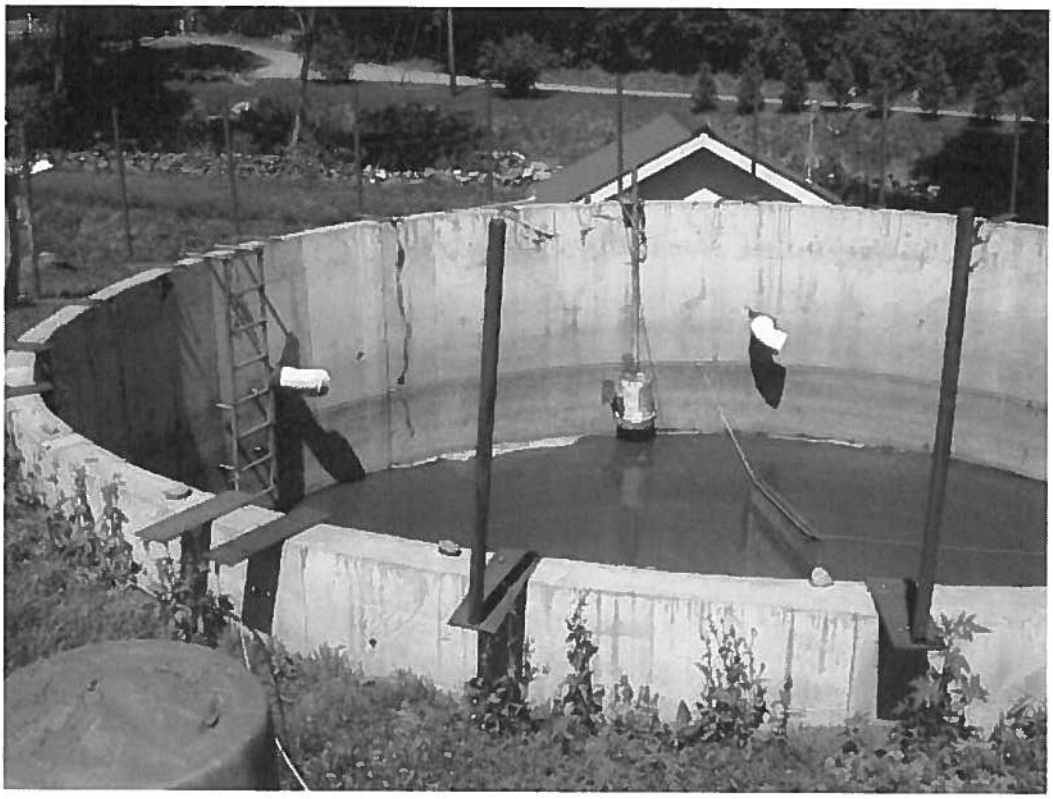

Figure 32. Trout farm sediment tanks can be potential drowning hazards.

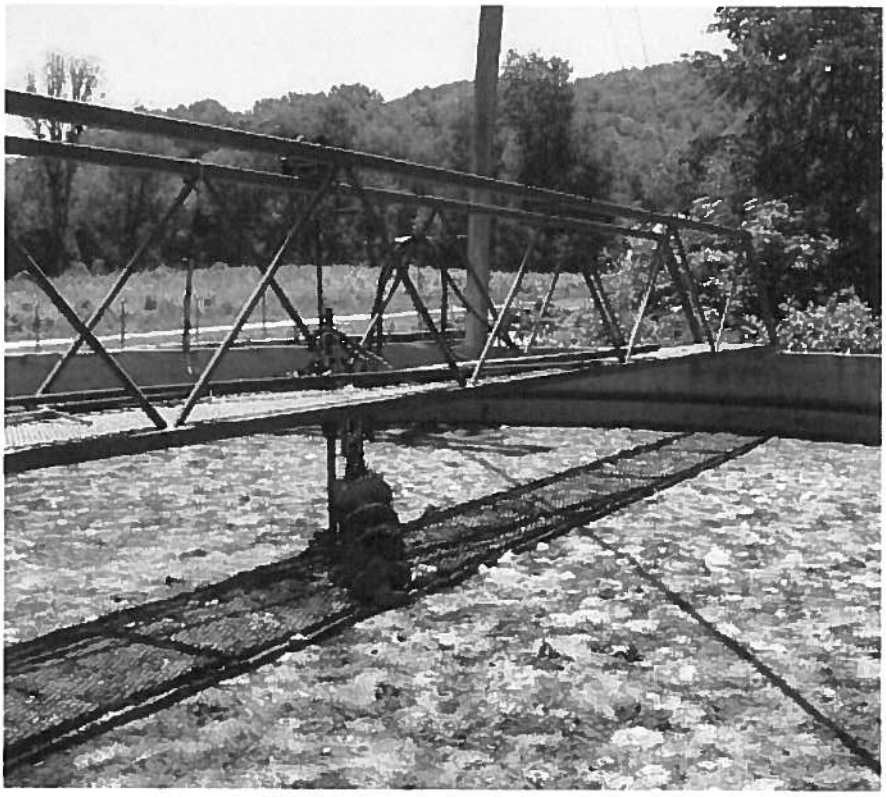

Figure 33. The walkway over this sediment tank has hand rails to prevent falling into the tank.

Figure 34. Rats or mice chewed a hole in this bag of feed. Rodent urine can be a source of disease for humans.

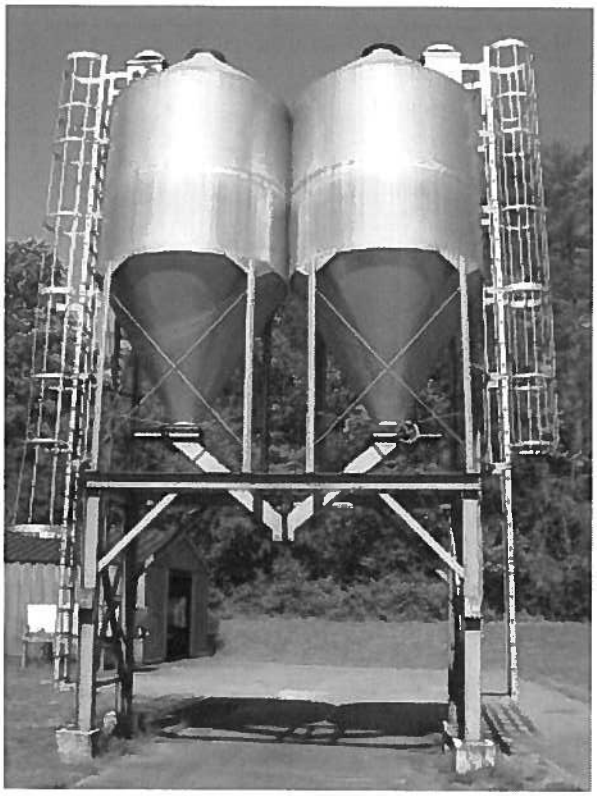

Figure 35. The ladder guards could prevent a fall if a worker slips from these feed bin ladders.

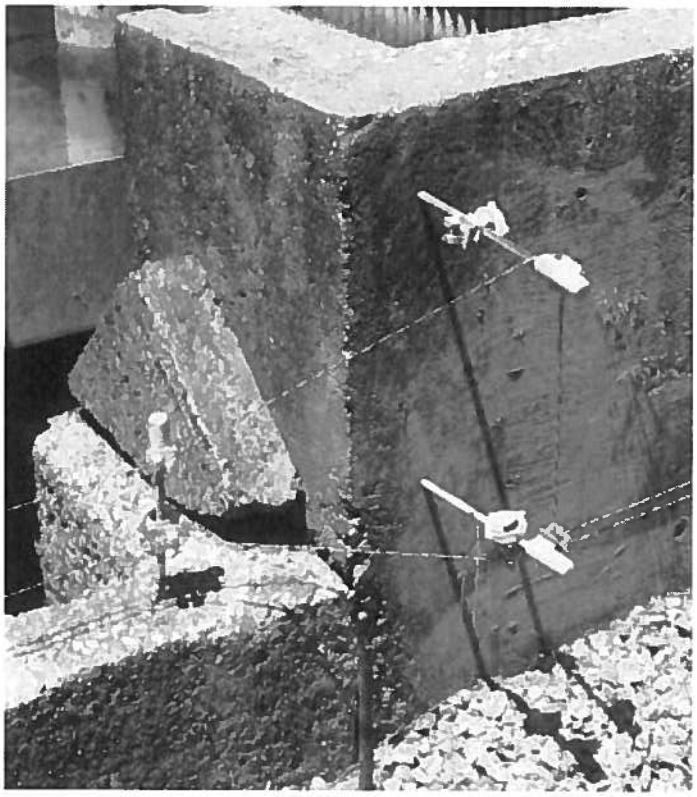

Figure 36. This rebar is in a horizontal position and is capped with plastic protectors to prevent cuts, bruises, and impaling.

Figure 37. This rebar is bent to a horizontal position to help prevent impalement of farm

workers.

sion newsletters were the most effective means to spread the word about best safety practices. Aquaculture magazines and newspapers were suggested by three farmers as a good way to communicate safety practices to a large audience. Two requests for safety workshops were also made. Two farmers suggested using educational DVDs or videos on safety, and one grower suggested using the internet as well as exhibits at national aquaculture trade shows to educate large audiences.

Conclusion

All of the farmers interviewed recognized some safety hazards on their farm, including injury or close call hazards, that were well known in the farming community. Trout farmers reported the following occupational safety hazards during the interviews: falling live tank lids, slippery surfaces on hauling trucks, lifting strains, falls from raceway walls and walkways, needlesticks while vaccinating fish, allergies, hypothermia/drowning, falls from cranes, chemical exposures, fire/explosions related to oxygen exposure, and electrical contact with overhead power lines.

The walk-through inspections of the trout farms revealed several safety hazards that the farmers may not have realized were dangerous. Countermeasures to prevent or reduce occupational safety hazards were developed by the researchers and farmers during this study. The results of this study offer the opportunity for transferring the technology of these countermeasures to the trout farming community.

The literature indicates that hazards and injuries are associated with gender and the age of workers on agriculture farms. Future studies should address these safety issues on trout farms. Until now, the literature has not provided information about the specific occupational safety hazards on trout farms. There is need for more research to identify the work-related hazards and injuries associated with trout (and other species) production.

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