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BIRD DAMAGE AT AQUACULTURE FACILITIES

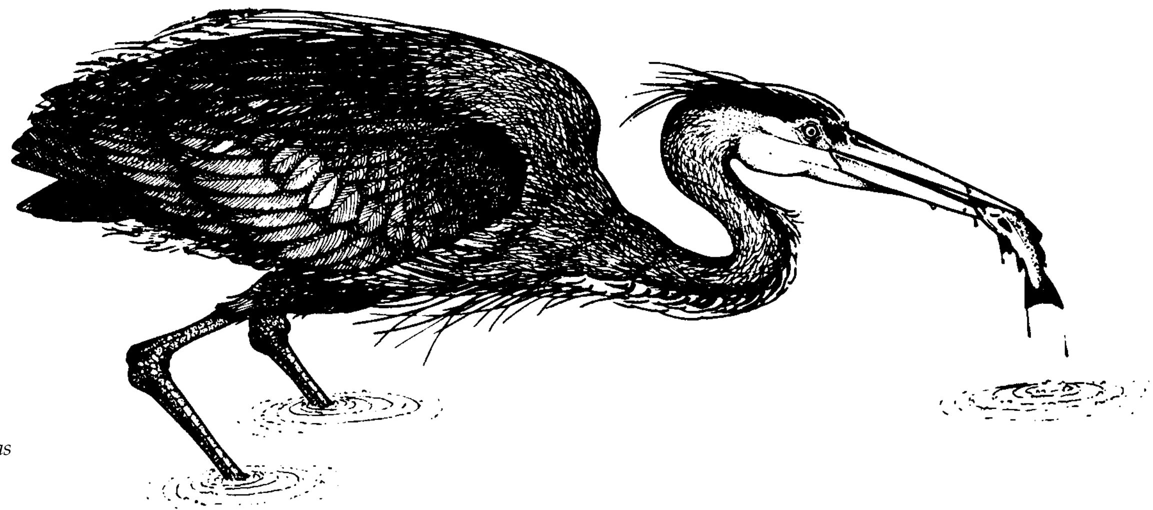


Fig. 1. Great blue heron, *Ardea herodias*

Damage Prevention and Control Methods

Exclusion

Completely enclose small ponds, tanks, and/or raceways with screen or netting.

Impediments

Partially covered systems with overhead wire, line, screen, or netting. Perimeter fencing or wires.

Metal spines, cones, or electrified wires for roosting problems.

Cultural Methods

Consideration of local bird populations, construction of pond margins and bottom profile, location of fingerling ponds, and feeding techniques may lessen damage.

Frightening

Various devices available include reflecting tapes, eyespot balloons, scarecrows, automatic exploders, pop-up scarecrows with exploders, pyrotechnics, alarm or distress calls, lights, water spray devices.

Aerial harassment with ultralight aircraft, radio-controlled model airplanes; ground harassment with vehicle patrols.

Roost dispersal may move depredating birds from the area.

Avitrol® is a chemical frightening agent for herring gulls and blackbirds.

Toxicants

None are approved for use by federal or state agencies.

Trapping

Except for some blackbirds, trapping is not allowed without a permit from the US Fish and Wildlife Service and upon recommendation by the USDA-APHIS-Animal Damage Control. Permits are issued to compliment ongoing nonlethal methods. Check county or state permit requirements.

Shooting

Same as for trapping, except that some blackbirds may be shot. Ducks may be hunted during waterfowl hunting seasons.

PREVENTION AND CONTROL OF WILDLIFE DAMAGE — 1994

Cooperative Extension Division
Institute of Agriculture and Natural Resources
University of Nebraska - Lincoln

United States Department of Agriculture
Animal and Plant Health Inspection Service
Animal Damage Control

Great Plains Agricultural Council
Wildlife Committee

Table 1. Bird species reported as predators at aquaculture sites in North America.

Common Name	Species	Common Name	Species
Common loon	*Gavia immer*	Red-breasted merganser	*Mergus serrator*
Western grebe	*Aechmophorus occidentalis*	Hooded merganser	*Lophodytes cucullatus*
Eared grebe	*Podiceps nigricollis*	Bald eagle	*Haliaeetus leucocephalus*
Pied-billed grebe	*Podilymbus podiceps*	Osprey	*Pandion haliaetus*
American white pelican	*Pelecanus erythrorhynchos*	Red-tailed hawk	*Buteo jamaicensis*
Brown pelican	*Pelecanus occidentalis*	Northern goshawk	*Accipter gentilis*
Double-crested cormorant	*Phalacrocorax auritus*	Northern harrier	*Circus cyaneus*
Anhinga	*Anhinga anhinga*	American coot	*Fulica americana*
Least bittern	*Ixobrychus exilis*	Yellowlegs	*Tringa* spp.
American bittern	*Botaurus lentiginosus*	Franklin's gull	*Larus pipixcan*
Black-crowned night-heron	*Nycticorax nycticorax*	Ring-billed gull	*Larus delawarensis*
Yellow-crowned night-heron	*Nycticorax violaceus*	California gull	*Larus californicus*
Green-backed heron	*Butorides striatus*	Herring gull	*Larus argentatus*
Little blue heron	*Egretta caerulea*	Glaucous gull	*Larus hyperboreus*
Great blue heron	*Ardea herodias*	Caspian tern	*Sterna caspia*
Cattle egret	*Bubulcus ibis*	Common tern	*Sterna hirundo*
Snowy egret	*Egretta thula*	Forster's tern	*Sterna forsteri*
Great egret	*Casmerodius albus*	Black tern	*Chlidonias niger*
White-faced ibis	*Plegadis chihi*	Great horned owl	*Bubo virginianus*
White ibis	*Eudocimus albus*	Barred owl	*Strix varia*
Wood stork	*Mycteria americana*	Belted kingfisher	*Ceryle alcyon*
Mallard	*Anas platyrhynchos*	American crow	*Corvus brachyrhynchos*
Northern pintail	*Anas acuta*	Fish crow	*Corvus ossifragus*
Blue-winged teal	*Anas discors*	Common raven	*Corvus corax*
Wood duck	*Aix sponsa*	Black-billed magpie	*Pica pica*
Redhead	*Aythya americana*	American dipper	*Cinclus mexicanus*
Greater scaup	*Aythya marila*	European starling	*Sturnis vulgaris*
White-winged scoter	*Melanitta fusca*	Common grackle	*Quiscalus quiscula*
Surf scoter	*Melanitta perspicillata*	Boat-tailed grackle	*Quiscalus quiscula*
Bufflehead	*Bucephala albeola*	Brown-headed cowbird	*Molothrus ater*
Common merganser	*Mergus merganser*		

Identification

Reduction of the damage caused by fish-eating birds requires accurate bird identification and some knowledge of avian biology and habits. Responsible bird management requires knowledge of both the problem species and other birds that use the aquatic habitat without harming aquaculture efforts. Not all birds are harmful to production efforts. Birds only become a problem if their activities directly or indirectly result in fish loss. Many species benefit from the association with production facilities without interfering with production efforts.

Table 1 lists 61 species of birds reported as pests at aquaculture sites. Table 2 presents a brief description of the appearance, characteristic feeding habits, and behavior of birds responsible for damage. Although some birds are limited in the way they feed and may be easily deterred by control measures, many birds have a repertoire of feeding behaviors available to overcome various damage reduction schemes. As an example, Table 3 illustrates the variety of feeding behaviors used by six species of herons.

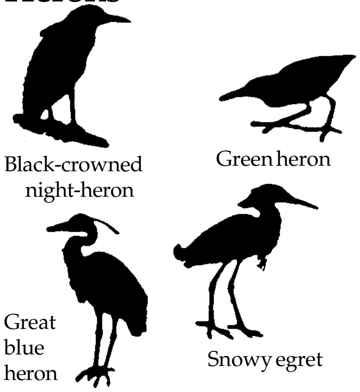
Damage and Damage Identification

The open-water areas and large concentrations of aquatic livestock at aquaculture facilities are natural attractants to many birds. Birds can have a significant economic impact on the culture of aquatic products including fish, shellfish, crustaceans, and other invertebrates. For our purpose here, we will refer to these birds as fish-eating birds, and the aquatic products as fish.

Fish-eating birds are highly mobile and adaptable predators, able to rapidly

Table 2. Identification and description of the feeding habits and behavior of birds commonly responsible for damage at aquaculture facilities.

Herons



Description:
- Body length varies, 11 to 38 inches (28 to 97 cm).
- Long legs and toes, short tail, large wings.
- Wingspan varies; great blue heron, 70 inches (178 cm); black-crowned night-heron, 44 inches (112 cm); snowy egret, 38 inches (96 cm); green-backed heron 25 inches (64 cm).
- Neck usually long, bent in S shape when flying; beak long, pointed.
- Plumage variable: all white, brown, gray, blue; or pattern of stripes and streaks.
- Sexes colored alike; immatures duller than adults.

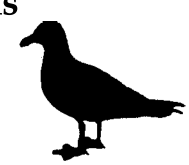
Feeding and Other Habits:
- Various methods used depending on species. See Table 3 for more details.
- Feed mostly during day or at dusk; black-crowned night-herons feed mostly at dusk or night.
- Most nest in colonies; often perch or nest in trees near water.
- Depending on species, hunt singly but can occur in large, loose flocks that tend toward even distribution across foraging area.
- Foraging birds attract others.

Cormorants

Description:
- Five species in North America; double-crested cormorant described below is a major pest species at aquaculture facilities.
- Body length 32 inches (81 cm).
- Wingspan 52 inches (132 cm).
- Plumage uniformly dark, with large, orange throat patch; young with lighter underparts. Sexes colored alike.
- Neck long and snakelike; flies with neck kinked; beak with hooked tip.
- Short legs and webbed toes; short tail often used as prop when perched.
- Swims with body often nearly submerged, but with neck erect and bill pointed at upward angle.

Feeding and Other Habits:
- Dives from surface; pursues fish underwater.
- Daytime feeder; hunts singly or in flocks that may number 500 to 600 birds. Birds in feeding flock form line that advances on fish.
- Foraging birds attract others.
- Runs across water to take off.
- Nests in colonies; often perches on trees, poles, rocks, or buoys that overhang or project from water.

Gulls



Description:
- Many species; in general, stout body, total length 12 to 32 inches (30 to 81 cm).
- Long, pointed wings; wingspan 36 to 65 inches (91 to 165 cm).
- Bill slightly hooked; webbed feet.
- Adult plumage mostly white, wings white or dark on upper surface with dark tips. Immatures darker, mostly brown or grayish.
- Sexes colored alike.

Feeding and Other Habits:
- Variable methods: plunges from flight, perches on raceway walls; swoops down to scoop up prey; bobs while swimming.
- Forages along shoreline; scavenges dead fish.
- Daytime feeder.
- Highly social; breeds in colonies.
- Feeds in flocks.

Terns

Description:
- Streamlined, slender body, total length 9 to 23 inches (22 to 58 cm).
- Long, pointed wings; wingspan 20 to 53 inches (51 to 135 cm).
- Bill slender, sharp and pointed; tail usually forked.
- Plumage mostly whitish with gray on top of wings; black cap present except in winter.
- Sexes colored alike.

Feeding and Other Habits:
- Flies over water, hovers above surface, dives head-first into water.
- Daytime feeder; hunts individually.
- Nests in colonies; does not normally swim.
- Light, graceful flier.

(continued on next page)

Mergansers

Description:
- Three species in North America: hooded, red-breasted, and common mergansers.
- Body length varies: hooded merganser 16 to 19 inches (41 to 48 cm); larger species 20 to 27 inches (51 to 69 cm).
- Wingspan from 26 to 37 inches (66 to 94 cm).
- Slender, spike-like bill with hooked tip.
- Crested head except for male common merganser.
- Plumage varies with sex: males at distance appear mostly black and white; females appear gray and brown.

Feeding and Other Habits:
- Dives from surface; pursues fish underwater.
- Daytime feeder.
- Normally in small, loose flocks; large concentrations unusual.
- Runs across water to take off.
- In flight, body, head, and neck are horizontal.

Blackbirds

Description:
- Many species: in general, small-bodied, total length 6 to 16 inches (15 to 40 cm); sharp, pointed bill.
- Plumage iridescent black; some species have brightly colored areas of yellow, red, or orange on head or wings.
- Females smaller-bodied; plumage brownish, often with streaked breast.

Feeding and Other Habits:
- Catches prey in shallow water at impoundment edges, or climbs down raceway screens to water surface.
- All species daytime feeders.
- Gregarious; flocks number from few birds to thousands.
- Some species congregate in huge winter roosts.

Belted kingfisher

Description:
- Compact body, total length 12 to 13 inches (30 to 33 cm).
- Large head, short neck, heavy pointed bill.
- Short legs and toes; wingspan 21 to 24 inches (53 to 63 cm).
- Plumage blue-gray above; males with gray band across white breast, females with gray and rusty band. Head crested.

Feeding and Other Habits:
- Plunge-dives head first from perch or hovering position.
- Daytime feeder.
- Territorial and solitary.
- Loud rattling call given in flight.
- Uses poles, wires, and other elevated objects as perches to scan foraging areas.

Pelicans

Description:
- Two species in North America: American white pelican described below is pest species at aquaculture sites.
- Body length 62 inches (158 cm).
- Wingspan 108 inches (274 cm).
- Very large white bird with black wing tips and enormous, orange bill with pouch. Sexes colored alike. Young grayish colored.
- Swims with great buoyancy; floats high on water.

Feeding and Other Habits:
- Feeds from water surface; does not dive. Plunges head underwater and catches fish in pouch.
- Daytime feeder; hunts singly in deep water; in shallow water forms small flocks that drive fish toward shore.
- Takes off from water with feet kicking in unison.
- Nests in colonies usually at sites remote from people.
- In flocks most of time; flies with series of slow wing beats followed by glide. Birds in flock fly single file; may soar to great heights.

Table 3. Occurrence of feeding behaviors among selected species of herons (from Kushlan 1978).

Species	Great blue heron	Great egret	Snowy egret	Green-backed heron	Yellow-crowned night heron	Black-crowned night heron
Behavior[1]						
Standing	X	X	X	X	X	X
Walking	X	X	X	X	X	X
Hovering	X	X	X			X
Dipping		X	X			
Plunging	X	X				X
Diving				X		
Feet-first diving	X					X
Jumping	X			X		
Swimming feeding	X	X		X		X

[1]Feeding behaviors defined as follows:

Standing	- stands in one place.
Walking	- walks at a slow or fast speed.
Hovering	- hovers over water or ground, picking up prey.
Dipping	- while flying puts head down and catches prey.
Plunging	- dives headfirst from air.
Diving	- dives headfirst from perch.
Feet first diving	- alights on water feet first.
Jumping	- jumps from perch feet first.
Swimming feeding	- swims or floats on surface of water.

exploit situations of food abundance. Aquaculture facilities are ideal feeding sites for these predators. The severity of bird problems will vary with the species and number of birds present and whether the birds reside only seasonally or tend to remain at the facility throughout the year. In recent years, populations of normally migratory waterbirds have been reported to remain near fish production facilities year-round. The proximity of nearby nesting or roosting sites and the availability of alternative feeding sites are also important factors. Problems are compounded when drought impacts alternative feeding sites, especially as the number and size of available wetlands continue to diminish due to human activities.

Besides consuming fish, birds can injure fish, disrupt their feeding activity, disturb broodstock, and contribute to the spread of diseases and parasites in aquaculture ponds and raceways. In marine environments, large numbers of birds often roost on shellfish culture or holding structures. Shellfish lots have failed to meet coliform bacteria standards set by health service agencies due to fecal droppings of birds roosting on these structures. Bird feces can degrade water quality and, through bacterial activity, leads to reduced oxygen levels. The economic impact on the farmer can be extensive and, in some cases, devastating. Bird depredation results in loss of crop and income. It can result in significant expenditure of time and funds in establishing bird management programs and training personnel.

The birds commonly responsible for most damage are herons, cormorants, pelicans, gulls, egrets, mergansers and other diving ducks, blackbirds, and kingfishers. Other problem species reported less frequently include dippers, grebes, ospreys, and dabbling ducks. Because most species of fish-eating birds are diurnal, or active during daylight hours, direct observation is the usual means of confirming bird presence and damage. Obvious signs of hunting and feeding birds include birds perched on trees or wires near raceways or ponds, hovering overhead and then plunging into the water, standing or stalking along the edges of ponds, or swimming and diving in the ponds. Some species, including the black-crowned night-heron and the yellow-crowned night-heron in particular, feed at dusk and night, when aquaculture personnel may not be present to observe damage. Because most fish are swallowed whole, often few direct signs of damage are left behind. The decrease in the number of remaining fish may not be obvious for some time. In these cases, the presence of whitewash (bird excrement), bird feathers, and/or bird footprints may be the only signs of bird predation. Additional observations at night should be made to verify bird depredation. Some fish may show scars from predatory attempts. Cormorants often injure fish, allowing access to fungal and bacterial disease organisms. Herons sometimes spear but do not kill or eat larger brood stock. Chewed or partially eaten fish may be a sign of predatory mammals, including raccoon, mink, and otters.

Legal Status and Permit Protocol

Resolution of bird depredation problems is complicated. All fish-eating birds that frequent aquaculture facilities are classified legally as migratory and thus are protected by federal, and in most cases, state laws. These laws were developed to protect US interest in migratory birds in concert with the interests of other nations that provide habitat to these same avian populations. The Migratory Bird Treaty Act (16 USC 703-711) consists of agreements made with foreign governments concerning migratory species and influences US domestic laws and regulations concerning these species.

Because of the economic loss caused by birds, a grower's first reaction often includes lethal action. Lethal control, however, is not allowed without a permit. Permits to use limited lethal action against depredating birds may be granted, but only after nonlethal techniques, have been used correctly, and after qualified USDA-APHIS-ADC personnel verify that these methods need to be reinforced by use of lethal methods. A permit is not needed to physically or mechanically exclude any fish-eating bird from raceways or water impoundments. Except for threatened or endangered species such as the bald eagle, a permit is not required to harass or scare fish-eating birds.

The USDA-APHIS-ADC recommends the following procedure when an aquaculture facility is experiencing damage from migratory birds.

(1) Contact the appropriate wildlife damage control biologist employed by the USDA in your region of the state. Assistance may be provided by the state office of the USDA-APHIS-ADC program listed under the federal government in the telephone directory.

(2) The wildlife damage control biologist will make contact by phone and conduct a site inspection if possible to identify the migratory species of concern, estimate the number of migratory birds, estimate damage, and document other information.

(3) Recommendations for nonlethal bird control techniques will be made by the wildlife damage control biologist.

If lethal reinforcement of existing hazing devices is required, wildlife damage control biologists may make recommendations on the damage report for lethal control of the species and the maximum number of birds that may be killed. This report will be attached to a completed US Fish and Wildlife Service (USFWS) Federal Fish and Wildlife License/Permit Application or Depredation Permit (Form 3-200) and mailed to the Special Agent in Charge in the appropriate USFWS Regional Office, along with a fee (currently $25) to cover administrative costs.

Exceptions to this procedure involve damage problems caused by specific species that may have special protection in your area. If a recommendation for lethal control is given for these species, it may require mailing the Form 3-200 with the filing fee to a different location. These details along with appropriate addresses will be provided by your wildlife damage control biologist.

(4) A self-imposed turnaround time for the issuance or rejection of depredation (kill) permits by the USFWS is 1 week, providing the permit application is complete and there are no unusual legal or environmental issues involved.

All recommendations include familiarization with federal and state laws related to bird depredation, knowledge of bird identification, and good communication with involved agencies. Actions that may be taken against a depredating bird species to protect a crop may vary from state to state and region to region. In recent years more incidences of aquaculture-related bird depredation cases have been reported, and increased legal action has been directed against growers charged with wildlife violations. Because of the severe legal consequences, it is highly recommended that a grower have knowledge of all these factors and proceed through the proper permit process before taking action against depredating species.

Damage Prevention and Control Methods

With the exception of total exclusion, single control methods rarely solve a bird control problem. Results obtained from nonexclusion techniques may vary. Keep in mind that all methods succeed or fail to some degree, and a combination of methods is usually required. The choice of control methods will be determined by a number of factors, including the species of birds involved, the extent of the damage, the projected cost of the control program, the type of facility to be protected, the species of fish grown, the size of the water impoundments, and the long-term effect on facility management. Finally, economics plays a role in the selection process; the expected cost of the control program must be less than the value of anticipated damage. Table 4 summarizes control methods most often used for various bird species.

Although a review of historical records of bird presence and abundance is an important starting point in the selection of control methods, be aware that bird populations can change dramatically due to unforeseen events and that some species can alter characteristic behaviors in response to new opportunities or to control methods. As an example, the double-crested cormorant population was held in check from the early 1900s until the 1970s by egg collecting, nest destruction by fishermen, and pesticide contamination. In the 1970s and 1980s, with the decline of the above factors and concurrent with the growth of aquaculture in the South, the cormorant population began to increase. By 1990 the cormorant population in the lower Mississippi Valley alone was 120,000 birds, with a mean annual growth rate of 18%. Migratory

Table 4. Control methods most often used for various bird species. Effectiveness is variable, and a combination of methods is often necessary.

Species	Control methods
Black-crowned Night-heron	Complete enclosure; Perimeter fencing; Automatic exploder; Pyrotechnics; Distress calls; Lights
Merganser and Diving Ducks	Complete enclosure; Overhead lines, wires; Automatic exploder
Great Blue Heron	Complete enclosure; Overhead lines, wires; Perimeter fencing; Automatic exploder; Pyrotechnics; Lights
Blackbird	Complete enclosure; Perimeter fencing; Automatic exploder; Pyrotechnics; Distress calls
Green-backed Heron	Complete enclosure; Perimeter fencing; Automatic exploder; Pyrotechnics
Belted Kingfisher	Complete enclosure; Automatic exploder; Pyrotechnics
Snowy Egret	Complete enclosure; Overhead lines, wires; Perimeter fencing; Automatic exploder; Pyrotechnics
Dipper	Complete enclosure
Gull	Complete enclosure; Overhead lines, wires; Automatic exploder; Pyrotechnics; Distress calls; Water spray
Cormorant	Complete enclosure; Automatic exploder; Pyrotechnics
Tern	Complete enclosure; Overhead lines, wires; Pyrotechnics
Osprey	Complete enclosure; Overhead lines, wires
Pelican	Complete enclosure; Overhead lines, wires; Automatic exploder; Pyrotechnics
Grebe	Complete enclosure

Key to Controls

- Complete enclosure
- Overhead lines, wires
- Perimeter fencing
- Automatic exploder
- Pyrotechnics
- Distress calls
- Water spray
- Lights

behavior was probably altered during this period, with more birds stopping off at aquaculture ponds than continuing on to traditional wintering areas along the Gulf of Mexico. Cormorants became a major pest for aquaculture in the lower Mississippi Valley. The large supply of clean fish on the farms probably improved winter survival and reproductive fitness for the following spring.

Exclusion

Exclusion is the complete enclosure (caging) of ponds and/or raceways with screen or net. It is effective for small facilities, but is not practical, however, for protecting most ponds larger than 5 acres (2 ha).

Total exclusion is the only legal method available that provides complete, long-term control. Complete screening or netting is effective in excluding all problem birds and has been adopted by a number of state and federal hatcheries. Some commercial producers have adopted complete facility exclosure or partial exclosure in combination with other management practices. This choice is based primarily on the monetary damage caused by the birds and/or self-protection from potential legal consequences associated with migratory, threatened, and endangered bird species.

Selection of a barrier system depends on the problem bird species and expected duration of damage, size of facility, and whether the barrier will interfere with other operations. Other considerations include possible damage from severe weather and the barrier's effect on site aesthetics in visually sensitive areas. Any physical barrier control system must be constructed so that it does not become a lethal object to birds, especially to threatened and endangered species. The barrier should be visible to birds to minimize accidental entrapment and/or injury. Avoid using loosely hung, small mesh netting such as mist netting, as it will cause excessive bird loss and draw public and regulatory attention.

Conduct a thorough benefit-cost analysis when considering complete enclosure. The initial capital cost for complete exclusion is often justified over time by reduced fish loss, less need for active control measures, and avoidance of expensive legal entanglements. The availability of relatively inexpensive, light-weight plastic netting and the developing technology to net large areas of 20 acres (8.1 ha) or more may reduce costs considerably.

In general, enclosing ponds and raceways to exclude all fish-eating birds requires 1- to 2-inch (2.5- to 5-cm) mesh netting secured to frames or supported by overhead wires (Fig. 2). Gates and other openings must also be covered (Fig. 3). In areas with harsh winter conditions, an adequate framework or support cables must be provided to prevent ice or snow accumulation from ripping the netting. Technical considerations applicable to netting large impoundments are provided by Martin and Hagar (1990).

Some hatchery operators use mesh panels placed on the raceway walls above the water to effectively exclude birds. Install small mesh wire or net less than 1 inch (2.5 cm), secured to wood or pipe frames to prevent feeding through the panel. Design panels to accommodate demand or automatic feeders and feed blowers that feed through mesh-covered raceways.

All exclusion structures must be strong enough to prevent the weight of large birds and their activities from sagging the net to within feeding distance of the water. Since panels may interfere with feeding, cleaning, or harvesting operations, they may be more appropriate for seasonal or temporary use.

Construct all exclusion structures to allow use of fish maintenance equipment and, if necessary, to withstand wind and the accumulation of snow and ice. Nonrigid exclusion structures such as suspended netting may need lines, pulleys, and counterweights to facilitate lifting and lowering during adverse conditions or maintenance.

Impediments

Impediments are partially covered systems with overhead wire, line, net, or screen, and devices that discourage birds from entering a feeding zone or perching nearby.

Impediments such as overhead lines are usually less expensive than enclosures, but do not exclude all bird species. For example, properly spaced overhead wires or lines can effectively deter most gulls, mergansers, and terns, but screening or netting is required for smaller birds such as kingfishers or birds that land beside and then walk into impoundments.

Overhead Wires or Lines. Ponds or raceways can be covered with overhead lines of braided or other extruded polypropylene material, or stainless steel wire, suspended horizontally in one direction (Fig. 4) or in a crossing pattern. These lines should be made visible to the birds by hanging streamers or other objects at intervals along the wires. The objective is to discourage bird feeding activities and not cause bird injury or death. Overhead wire networks generally require little maintenance other than maintaining proper wire tension and replacing an occasional broken wire. Reflecting tapes are also used in overhead networks, but they are prone to wind damage.

Spacing between wires or lines varies with the species. Overhead lines have been most successful with gulls. Various designs have been effective in creating a psychological barrier for gulls at reservoirs, nesting areas, outdoor restaurants, and hatcheries. Amling (1980) repelled gulls from reservoirs with wires 8 to 10 feet (2.4 to 3 m) above the water and spaced at 50- to 80-foot (15 to 24-m) intervals. Ostergaard (1981) excluded gulls from a hatchery using fishing line spaced at 16-inch (41-cm) intervals, 8 inches (20 cm) above the water. The lines were attached to S hooks so they could be removed as needed. A 4-foot (126-cm) spacing has also deterred gulls. Two-foot (63-cm) spacing is necessary to

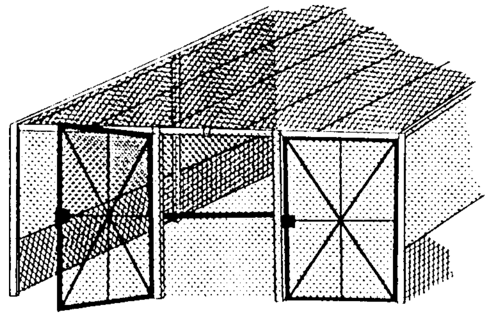


Fig. 2. Complete enclosure

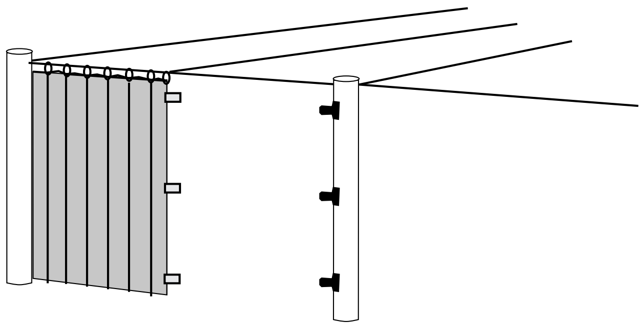


Fig. 3. Curtain-type gate for access to completely enclosed area.

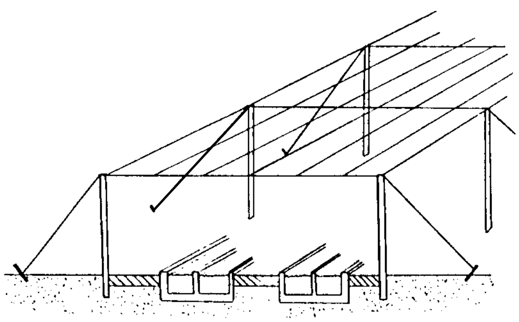


Fig. 4. Overhead lines or wires

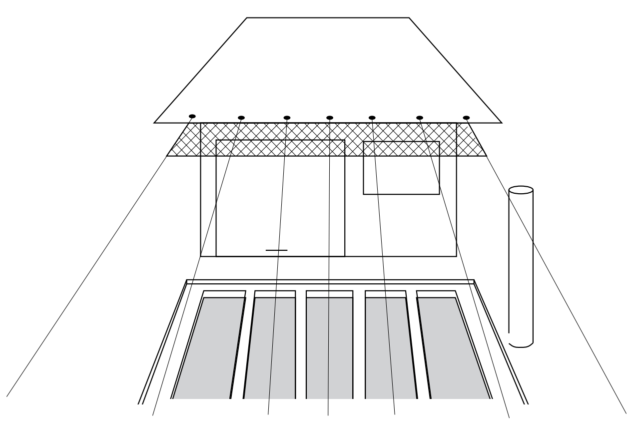


Fig. 5. Netting where wires attach to building prevents birds from walking down the roof and jumping through the wires into the facility.

exclude mergansers, and a 1- to 2-foot (30- to 61-cm) spacing is required for great blue herons or Forster's terns. Birds sometimes enter the system through sides or ends where wires attach to buildings, so these areas should be protected with netting (Fig. 5).

Some birds have adapted to overhead lines. At a California fish hatchery, overhead lines deterred gulls (but not herons) for years until one gull landed beside a raceway and walked in from the side. As more birds exhibited this learned behavior, the overhead lines had to be replaced with netting. Overhead lines have also been ineffective on cormorants. Flocks at a test site were deterred by overhead lines, but individual birds learned to avoid the lines 1 foot (0.3 m) above the water when landing or taking flight and continued to cause serious damage (Moerbeek et al. 1987).

Perimeter Fencing or Wires. Perimeter fencing or wire around ponds and raceways (Fig. 6) provides some protection from wading birds and is most effective for herons. For ponds, erect fencing at least 3 feet (1 m) high in water 2 to 3 feet (0.75 to 1 m) deep. Small mesh material can be used to prevent fish from entering the shallow water, but maintenance costs associated with algae buildup and accumulated debris can be substantial. Fences built in shallow water will not prevent birds from feeding on the pond side. Great blue herons have been deterred in Great Britain with a 2-strand fence with wires at 8 and 14 inches (20 and 36 cm) around a pool supplemented with floats spaced under 1 foot (30 cm) apart around the pool (Fig. 7).

Fences surrounding raceways should be high enough to prevent feeding from atop the fence. Occasionally blackbirds will cling to fencing or screening near the water and feed on small fish. A slick surface created by securing plastic over the fence or screen will eliminate the problem.

Electric fences with nonlethal levels of electric current have also been used but with varying success. Problems include maintenance and preventing

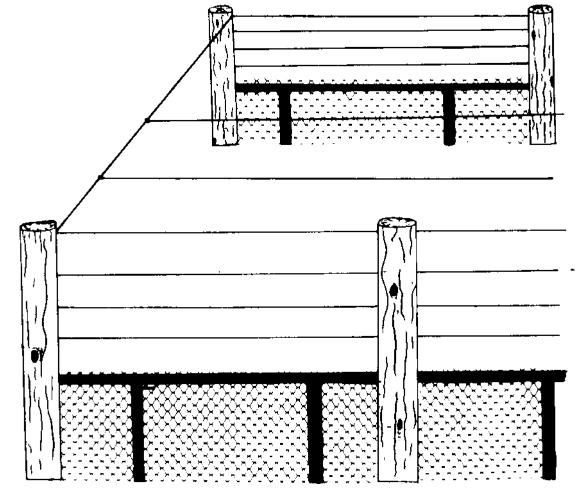


Fig. 6. Wires and fence protect side.

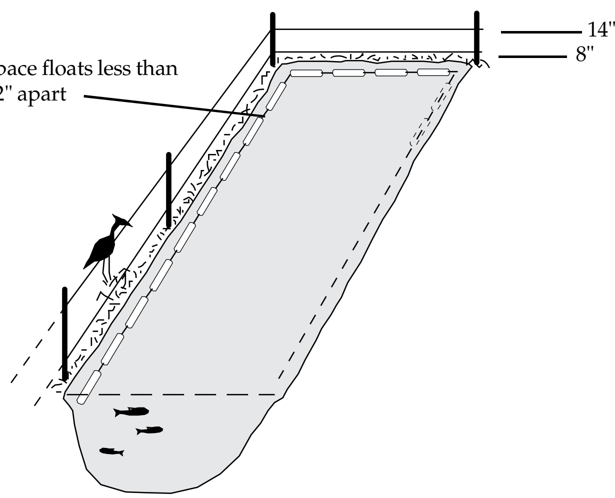


Fig. 7. Example of a 2-strand fence with wires at 8 and 14 inches supplemented with polyethylene floats spaced less than 12 inches apart around the pool edge.

the system from becoming grounded, commonly caused by vegetation interference and blowing debris. Wires are strung on supports that suspend the wire over the water's edge near the natural shelf that often forms in shallow areas of the pond margin. This system discourages wading birds from feeding on fish while walking along the shelf.

Metal Spines. For some situations, sharp, metal spines, sometimes called porcupine wires (Nixalite® and Cat Claws®) may be used to deter perching and roosting by birds. Such devices have been employed on shellfish racks and floats that hold and maintain shellfish stocks. The spines prevent birds from settling on the growout or holding structures, and the shellfish are protected from fecal contamination by the birds. These devices are used on fish farms to prevent birds from perching on a structure near the water.

Homemade versions of these commercial products can be built by hammering nails through wood lath and attaching the lath at the appropriate location (Fig. 8). Poles or posts may be guarded against perching birds by sharpening the end, by insertion of a guard spike, or by use of a sheet-metal cone over the end (Fig. 8). These devices are useful in discouraging species that hunt from an elevated perch or at roosting sites where fecal deposits are unacceptable.

Cultural Methods

Facility Location. The physical location, design, and construction of an aquaculture facility influence the susceptibility of fish to bird predation. Although water availability, water quality, and other parameters essential to fish production are prime considerations in site selection, locations away from obvious bird concentrations should also be considered. Facilities located in close proximity to rivers, roosting areas, marshes, and other wetlands will result in increased interaction with bird populations. Close proximity of rookeries and wetlands designated for protected and sensitive species, and flyways where sensitive species frequent, also increase chances for negative impacts from bird predation and associated legal problems.

Facility Design. Facility design also influences success in protecting aquatic products from birds. Complicating this issue are the aquaculture species produced and the type of facilities best suited for production of a given species. For example, intensive, compact raceway systems characteristic of the trout industry are more easily protected than large, extensive ponds used for many warm-water species.

Production systems should be constructed to discourage bird/fish interaction and limit birds' access to fish. With the exception of total exclusion, such as a caged facility, no single method can be used in large pond systems to alleviate all bird activity. More practical approaches include a combination of facility design and management practices to discourage certain bird behavior in some areas, and exclusion of birds from the most vulnerable aspects of the production system.

Size and shape of ponds influence the effectiveness of some control methods. Rectangular, smaller ponds are recommended. Scare techniques are more effective due to birds' proximity to shore. Ponds should be a minimum of 3 feet (1 m) deep to discourage wading birds such as herons and egrets. Pond bank margins should be fairly steep, necessitating compaction of heavy clay

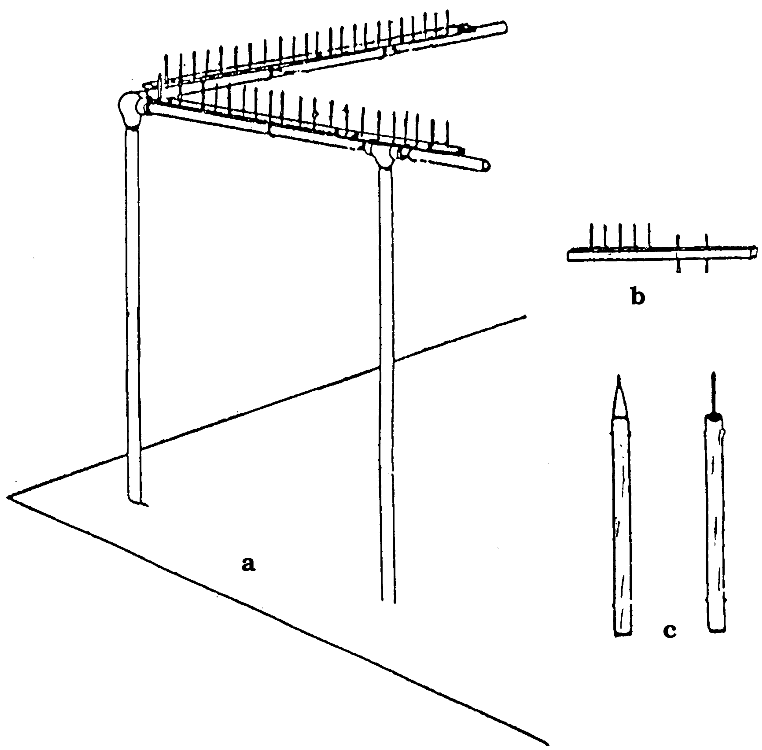


Fig. 8. (a) Spike and wood lath installation along top of pipe framework to deter fish-eating birds; (b) details of spikes and wood lath; (c) posts guarded against perching birds by use of a sheet-metal cone over end (left) or guard spike (right).

or other material to minimize erosion. Banks and levees should be clear of tall vegetation that could provide cover for birds. If possible, the site should not have structures such as telephone or light poles, or vegetation that provide roosts or perches.

Concrete raceways and tank systems with straight, vertical walls are more easily protected than earthen systems. Water depth should be at least 3 feet (1 m) and the water level maintained 2 to 3 feet (0.75 to 1 m) below the wall surface in uncovered systems to discourage feeding from the walls.

Tank and raceway systems are the most easily and economically covered, and this may be the most practical approach to avoid damage. Tanks and raceways may be covered individually or caged in units that allow access and operation of equipment. Most operators of covered facilities feel that the extra expense of covering at a height that allows the operation of equipment under one cover is quickly made up by the savings from the labor cost of operating individually covered systems. Associated hatchery buildings and nursery tanks should also be protected by exclusion techniques to prevent birds from entering a hatchery building and feeding from tanks and troughs. Again, the decision as to the extent of facility caging should be based on the extent of bird damage and legal sensitivity experienced annually, weighed against capital expense and annual operational cost.

Fish Management. Fish management and the ability to adjust programs based on changing bird habits are as important as facility design. Since fingerlings are more susceptible to bird predation, they should be located close to the center of human activity and near buildings that might be incorporated in a bird exclusion system. Larger fish usually need less protection because they are better able to avoid bird predators. A compromise strategy is to concentrate the more susceptible fingerlings under nets covering smaller ponds, and use larger ponds and an intensive bird harassment program to protect the larger fish. Problems have become so severe for some ornamental and baitfish producers that they have adopted complete exclusion techniques.

Studies indicate that birds are more likely to feed on ponds that are heavily stocked with fish than in ponds with moderate stocking rates. Reducing stocking rates may make ponds less attractive to depredating birds.

Feeding techniques may also influence the effectiveness of bird management programs. Floating rations produce surface feeding activity among fish that aids the grower in monitoring fish health, but this activity may also attract gulls and mallards that consume the floating food and feeding fish. The activity of these birds often attracts other fish-eating birds to the pond. The advantages of using floating rations should be weighed against the problems they may cause.

In addition, surface feeding species are more difficult to protect than species that can feed on the bottom, and some ornamental species are harder to protect than less visible animals.

It is important to monitor water quality in fish-rearing facilities. Low dissolved oxygen levels may force some fish species near the surface, making them more vulnerable to predation.

Frightening

Frightening devices and techniques modify behavior and discourage birds from feeding, roosting, or gathering at a location.

Many visual and sound-making devices are commercially available for scaring birds. These include gas-operated exploders, pyrotechnics, electronic noisemakers, bird distress calls, standing or pop-up effigies, eyespot balloons, raptor models, strobe or flashing lights, reflective plates or lines, and water spray devices.

The value of these devices is usually limited to short-term control. Although bird damage can sometimes be reduced by using only one type of frightening device, better results over longer periods are often achieved by using a combination of devices and/or by changing methods frequently. In addition, scaring equipment, especially sound-making devices, is usually more effective when moved often to prevent birds from becoming accustomed to the device. Birds will eventually ignore any scaring device that is left in the same place or that emits sound in the same regular pattern over a long period of time.

It is important to start the frightening regime before the birds establish regular feeding patterns at a site. Once regular habits are established, they are difficult to break using frightening techniques. Although the majority of birds may be scared away initially by frightening methods, some individuals will soon ignore the control methods. These "hard-to-scare" individuals attract others to the feeding site. These birds require a control method involving real danger from the bird's point of view, such as pyrotechnics or exploders, reinforced by human presence. The effectiveness of frightening devices can be improved by incorporating the use of rifles or shotguns to remove birds (with permit) that have habituated.

Because of all the variables involved, the success of a frightening program is dependent on the skill and motivation of the operator. Frightening devices will not be effective unless used aggressively in a carefully planned program.

Bird dispersal patrol teams can be used to harass and frighten birds in the immediate area of larger aquaculture facilities. Patrols must be adequately equipped with radio-equipped vehicles, bird distress calls, shotguns, live ammunition, and pyrotechnics. Patrol personnel must be trained in bird identification and dispersal methods.

Blackbirds, cormorants, herons, and other species establish roosts, especially during winter, that include many individuals (hundreds of thousands in the case of blackbirds). These birds may cause significant losses if they feed in aquaculture facilities. Frightening devices and cultural methods can be used to drive depredating birds from the area. See the **Bird Dispersal Techniques** chapter for specific information on roost dispersal.

Choosing the most effective combination of frightening devices requires careful consideration. One must match the devices to the bird species causing damage, assess the cost of the equipment and labor requirements, and consider possible interference with culture operations. For example, loud noises disturb spawning catfish. They may also disturb neighbors or others near the aquaculture site.

Automatic Exploder. The automatic exploder resembles a small cannon. It commonly operates on propane gas or acetylene and emits loud explosive blasts at adjustable time intervals. While the number of exploders necessary will vary from site to site, one exploder can usually cover 3 to 5 acres (1.3 to 2 ha) if used properly and reinforced with other control techniques. Explosion frequency is important since short intervals increase the chance that birds will become accustomed to the sound. Timers that automatically start and stop the operation to produce irregular explosion intervals, and rotary mounts that change the direction of the sound after each explosion, improve the effectiveness of the device. For best results, move exploders every 1 to 2 days to a different part of the facility. If necessary, elevate them to prevent foliage or adjacent equipment from interfering with sound projection. Exploders have been effective for herons, egrets, cormorants, diving ducks, and blackbirds.

Pyrotechnic Devices. Harassment of birds can be accomplished by firing shellcrackers from a 12-gauge shotgun. These shells contain a firecracker that is projected 50 to 100 yards (45 to 90 m) before exploding. Since wads from the shell may stick in the gun, it is important to check the barrel after each shot and to regularly clean the gun. Breech opening, open-bore shotguns are required.

Other pyrotechnic wildlife dispersal devices, variously known as noise, bird, clow, racket, or whistle bombs, noise rockets, or bird whistles, are among the most effective scaring devices. Though the range of these projectiles is only 35 to 75 yards (33 to 69 m), they are less expensive and more convenient to handle than shellcrackers. A recent study in Colorado using these handheld devices significantly reduced damage by great blue herons and black-crowned night-herons (W. F. Andelt, personal communication). Possession and use of pyrotechnics may require a permit from the local, county, and/or state fire marshal. Blackbirds and grackles have been effectively frightened by .22-caliber birdshot.

Alarm or Distress Calls. Many species of birds emit calls that communicate alarm or distress to other birds of the same species. Broadcasted recordings of these calls can frighten and repel some bird species. Reaction to the calls varies with species of bird, location, size of area, and time of year. For best results, broadcast distress calls as birds begin to arrive. A timing device can be used to play calls at predetermined intervals. Lengthen the time between broadcast intervals as much as possible while still achieving the desired response. Birds habituate to distress calls if they are played frequently or over a long period in the same location. Thus, calls need to be reinforced by other methods. Alarm calls have been used successfully on black-crowned night-herons, gulls, and blackbirds.

Lights. A variety of lights, including strobe, barricade, and revolving units, have been used to frighten birds with mixed results. Of these, strobe lights similar to those used on aircraft are most effective in frightening night-feeding birds. These extremely bright flashing lights have a blinding effect, causing confusion which reduces a bird's ability to catch fish. Black-crowned night-herons, however, may avoid the bright glare by landing with their backs to the lights or by moving to less well-lit areas. Avoidance may be minimized by increasing the number of lights to cover the unprotected areas.

Flashing amber barricade lights, like those used at construction sites, and revolving or moving lights may also frighten birds when these units are placed on raceway walls or fish pond banks. Most birds, however, rapidly become accustomed to such lights, and their long-term effectiveness is questionable. In general, the type of light, the number of units, and their location are determined by the size of the area to be protected and by the power source available.

Water Spray Devices. Water spray from rotating sprinklers placed at strategic locations in or around ponds or raceways will repel certain birds, particularly gulls (Svensson 1976). Individual birds may become accustomed to the spray and feed among the sprinklers. Best results are obtained when sufficient water pressure is used and the sprinklers are operated on an on-off cycle. The sudden start-up noise also helps to frighten the birds.

Ultrasonics. In general, birds do not hear in the ultrasonic range and fish-eating birds have not been shown to be repelled by ultrasonics.

Raptor Models. Strategic placement of owl decoys or raptor silhouettes has been used to discourage roosting of pigeons and other perching birds. For best results, models or decoys require frequent relocation, but their effectiveness is more often short-term.

Effigies and Scarecrows. Scarecrows and other human and animal effigies have had limited success in deterring birds. Pop-up models and models that show activity and produce a sound have shown some success on herons, ducks, and cormorants, but all require frequent relocation.

Aircraft. Ultralight aircraft have been used by producers to intercept large flocks of birds and herd them away from commercial facilities. This has been most effective with large concentrations of pelicans. Both this and radio-controlled model airplanes and model raptors have been used but are expensive, subject to weather conditions, high winds, and in the case of ultralights, may place humans at risk. They also may not be effective on species that seek safety by diving underwater.

Chemical Frightening Agents. Avitrol® is registered for use on herring gulls and blackbirds. For herring gulls, Avitrol® is applied to a bread bait; for blackbirds, several grain formulations are available (corn, sorghum, wheat, and mixed grains). The bait is lethal to the bird ingesting it, and the afflicted bird's erratic behavior and distress and alarm calls will frighten away other birds in the flock. Mortality is minimized by limiting the amount of bait offered. For further details on the use of Avitrol® see the **Blackbirds, Starlings,** or **Pigeons** chapters. State and federal permits are required to use Avitrol® on gulls.

Trapping and Shooting

It is illegal to trap or shoot all of the fish-eating birds described in this chapter (except blackbirds), without a permit from the US Fish and Wildlife Service. A permit is normally issued only to augment nonlethal methods. There may be additional state permits required. Blackbirds may be trapped and/or shot (see **Blackbirds**). Check with the state agriculture or wildlife department or USDA-APHIS-ADC before shooting or trapping birds that are causing damage at aquaculture facilities. Waterfowl (mallards, mergansers, and other ducks) may be legally hunted during the hunting season. A hunting license and federal duck stamp are required. In some areas, a state duck stamp is also required. Check state hunting regulations and local ordinances before discharging firearms near buildings or roads.

Economics of Damage and Control

The cost of bird damage to aquaculture can be difficult to quantify. Losses of stock can be due to cultural, mechanical, or environmental factors, in addition to predators. Identification of any single cause of loss is not always possible, and the total loss may not be known until harvest. There are data on the potential spread of disease by birds, but documented cases are rare because the size and nature of most aquaculture facilities preclude removing variables as required for controlled disease studies. The costs of control, however, are becoming available from grower surveys, and estimates of loss can be projected from food habit studies.

Loss estimation requires knowledge of the species and numbers of birds present, the length of time present, the amount of fish taken daily, and the value of the crop. Based on esophageal and stomach contents of four species of herons, Hoy et al. (1989) found that losses of golden shiners in Arkansas ranged from $0.10 to $1.12 per feeding. A flock of 100 wading birds present for a 3-month period could result in losses from $1,800 to $11,160, depending on the species composition. A flock of 2,000 birds, common at some sites during fall migration, could cause a loss of $20,000 in a 2-week period. Stickley and Andrews (1989) estimated the loss of catfish to double-crested cormorants in Mississippi at $3.3 million. A survey of Mississippi growers indicated that they spent an average of $7,400 per year on bird control for a total cost of $2.1 million. In a survey of hatcheries mostly in the eastern United States, Parkhurst et al. (1987) cited an average yearly loss per hatchery of about $7,600.

Production increases after exclusion of a facility have demonstrated the impact of birds on those facilities. The California Department of Fish and Game studied two trout hatcheries with long histories of severe bird problems. In 1979, annual losses were between $50,000 to $60,000. After exclusion, production increased 25 to 30% at both facilities. In these cases, the cost of total exclusion was high, but the return on investment was realized within 3 to 4 years.

A potential control program must first compare the anticipated or actual crop losses to costs and efficacy of damage control programs. Dolbeer (1981) described a simple process to assess this benefit-cost ratio. The model is based on the rule that the dollars saved by reducing damage must be greater than the costs of control.

Gorenzel et al. (1986) illustrated the model with an actual bird control program that used more than one control method. They discussed the problem of estimating the degree of damage reduction for a combination of control methods and suggested approaches to calculate a range of estimated damage and efficacy values.

Further Assistance

The Animal and Plant Health Inspection Service (APHIS) of USDA will provide assistance to aquaculture facilities that experience losses to birds. If required, on-site advice and instruction in the actual use of damage control methods is provided by the APHIS-ADC personnel. Kill permits are not routinely issued and are contingent on approval from APHIS and the US Fish and Wildlife Service. For information concerning assistance, permit applications, and sources of equipment and supplies, contact the appropriate state director of USDA-APHIS-ADC.

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Related Acts and Bills

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