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POND MANAGEMENT

Managing Fish Populations in Indiana Ponds

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Photo by Ryan Hagerty, USFWS.

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Introduction

Ponds provide a number of benefits to Indiana landowners, including attracting wildlife, providing water resources for livestock and irrigation, and providing recreation. Indiana ponds can also provide great fishing for both sport and food. Good fishing doesn't happen by chance; it requires proper planning and ongoing management. A pond with little-to-no management will quickly become overcrowded with small fish or aquatic weeds that can reduce the enjoyment of using the pond.

This guide will help Indiana landowners develop a management plan for managing fish populations in ponds. It provides advice for assessing the current status of fish populations, offers common fish management and harvesting guidelines, and discusses various problems that arise with fish populations and how to solve them.

Largemouth bass (top), bluegill (middle-left), redear sunfish (middle-right), and channel catfish (bottom) are excellent species to stock in Indiana ponds. Illustrations by Duane Raver, USFWS.

The Pond Management Plan

Ponds are complex ecosystems that play home to many plants, fish and other animals. If managed incorrectly, ponds can quickly become unbalanced and yield poor fishing. Just like planning for retirement, a good fishing pond requires careful planning and management. Therefore, it is recommended that you develop a written management plan for your pond. The first step in the management plan is setting the goals for your pond. These goals may be broad to start (e.g., swimming, fishing, etc.), but should be further refined if hoping to achieve good fishing (e.g., desired fish species and sizes, management effort required, etc.) Clearly defining your goals can help you select the best management options for your fish populations. If possible, it is best to define your goals and management plan before stocking fish in the pond. However, if your pond already contains fish, it is important to assess the current status of these fish populations. If you know where you are (i.e., assessment) and where you want to go (i.e., goals), you can determine what you need to do to get there (i.e., management). A written management plan will give you a point of reference to continuously check back to as you manage and assess your pond. And hopefully over time you will see your pond prosper and meet the goals you originally set. To obtain a template for developing a management plan, please visit Purdue's pond management website: https://extension.purdue.edu/pondwildlife.

Proper pond management can produce many years of good fishing.

Assessing Fish Populations

It is important to assess what fish are in a pond before starting any management. Likewise, regularly monitoring fish populations in a pond is important for assessing fish size distribution, maintaining balance between fish populations, and for detecting problems like disease and parasites. Pond fish can be sampled using a number of different methods such as fishing, seine netting, cast nets, and minnow traps. When using any method, be sure to sample different areas of the pond and at different times of the year to maximize the diversity of fish that you collect. It is also important to keep accurate and detailed records of fish sampling; this will allow you to track how fish populations change through time. First, record the total amount of time spent sampling and the type of sampling method used, even if you don't catch any fish. For each fish caught, record the species, total length, and whether the fish is released or harvested. It is also important to record the weather conditions during each fishing trip because things like temperature and sunlight can affect how fish move and feed. To record and organize data from each sampling trip, please download a fish sampling datasheet from https://extension.purdue.edu/pondwildlife.

Regular monitoring will allow you to assess fish growth and population balance, and detect any problems.

FISHING

The easiest way to sample fish populations in a pond is to simply go fishing. Fishing with hook and line can provide information on the species of fish in a pond, the size of each species, and the relative abundance of each species. You should consider fishing from both the edges and the middle of the pond. It is also important that you try using different baits, lures and fishing styles so that you catch a variety of species. Effective techniques include bobber fishing with worms for catching sunfishes, fishing with lures or live minnows for catching largemouth bass, and fishing with baits on the bottom for catching channel catfish. Fishing only catches fish that will eat a bait or lure; therefore, fishing does not do a good job of sampling small juvenile fish, minnow species or fish that eat plants (e.g., grass carp).

Fishing with hook and line is a great way to sample fish populations in ponds. Photo by Eugene Hester, USFWS.

Accurately recording data from fish sampling, even when no fish are caught, is essential to assessing fish populations.

SEINE NETTING

Seine netting is a fish sampling method that uses a fine-mesh net to capture fish living close to shore. For seining in ponds, it is recommended that you use a seine net that is at least 12 feet long and 4 feet high (from lead-line to float-line), with a mesh size of 1/4". Seine nets, sometimes called bait seines or minnow seines, can often be purchased from fishing tackle stores. Seine netting requires at least two people, often each wearing chest waders.

To use a seine net, one person holds one end of the seine net and wades into a pond perpendicular to the shore. Another person secures the other end of the net at the shore. The first person continues to wade out until the net is fully stretched out, or the water becomes too deep. The net is then brought back toward the shore in a U-shaped fashion. Once both people are back on shore, the net is brought in and fish are identified, measured and recorded.

A seine net can be utilized to sample fish living along the shore of your pond. Photo by Emily Musenbrock.

CAST NETS

A cast net is a sampling method for catching relatively small fish. A cast net is a round net, usually about 6-10 feet in radius (12-20 feet diameter), with lead weights all the way around the edge and a rope tied to the center. For pond sampling, it is best to use a cast net with a mesh size of 3/8" or 1/2".

Cast nets can be thrown out from the shore, a dock or a boat. Cast nets are thrown in a circular pattern into the pond. The weights will carry the net to the bottom before being retrieved by the rope, capturing any fish in its interior. Skill is required to get an effective technique for throwing cast nets, and tutorials can be found online on its proper use.

A cast net can be used to sample smaller fish along the shoreline. Photo by Mitchell Zischke.

MINNOW TRAPS

Minnow traps are a form of passive sampling used to catch small or juvenile fish. Minnow traps are small, cylindrical or square boxes made of plastic, mesh or wire, that are baited and left overnight. You can experiment with different bait types (e.g., bread, cat food, etc.) to try and catch different species of fish. Minnow traps are most successful in summer when water temperatures are high and fish are moving around the most.

A baited minnow trap can be left overnight to catch small fishes and crayfish. Photo by Hope Charters.

COMPREHENSIVE FISH SAMPLING

Fishing, netting and trapping are all sampling methods that a pond owner can conduct by themselves throughout the year. These methods provide a clear picture of the species present in the pond, their size and relative abundance. However, there are limitations to their use. For example, they do not efficiently sample all fish in a pond and cannot provide estimates of total fish abundance in a pond.

For in-depth assessment of fish populations, pond owners can work with fish biologists or pond consultants to conduct more comprehensive sampling. Comprehensive sampling may include using other methods, such as electrofishing, vegetation assessment and analysis of water chemistry. Typically, comprehensive sampling assessment is only needed in rare or unique situations. Routine sampling and assessment by the pond owner should be sufficient for managing most Indiana ponds.

PROPORTIONAL SIZE DISTRIBUTION

Once you have sampled your pond, you can crunch the numbers to assess where your fish populations are currently. The first calculation that is useful for pond owners is proportional size distribution (PSD). PSD is a numerical representation of fish population balance and growth (Table 1). PSD is calculated for each species based on fish length and represents the percentage of your stock that is currently at a quality size. To calculate PSD for each species, you count the number of individuals measured that are at the quality size or larger, and divide this by the number of individuals at the stock size or larger.

Table 1: Stock size, quality size and recommended PSD for four common pond fish species in a well-balanced pond.

Fish Species	Stock Size	Quality Size	PSD Range
Bluegill	3+ inches	6+ inches	20-60
Redear Sunfish	4+ inches	7+ inches	20-60
Largemouth Bass	8+ inches	12+ inches	40-70
Channel Catfish	11+ inches	16+ inches	20-50

The higher the PSD value, the larger the fish are within that population. For example, a PSD of 20 would mean most fish are small and may indicate a stunted population, while a PSD of 80 would mean that most of the population are larger fish. The recommended PSD range for common pond fish species, as well as the stock and quality sizes for each species, are listed in Table 1. PSD is useful for assigning a single number to fish growth and population balance that can be easily tracked through time.

An example showing how to calculate PSD for bluegill in a pond.

Calculating Proportional Size Distribution

You sample a pond with a seine net and catch 85 bluegill. 75 of the 85 fish are at the stock size of 3 inches or larger, while 25 of the 85 fish are at the quality size of 6 inches or larger.

PSD = (quality size / stock size) x 100
= (25 / 75) x 100
= 33.33

A PSD value of 33 is at the lower end of the recommended range (i.e., 20-60), and likely indicates a bluegill population that has a high number of smaller fish.

PSD provides good insight into the size balance of fish populations, but may be difficult for some pond owners to calculate because it requires at least 50 fish of each species to be measured. Luckily, there are other ways to calculate length distribution and condition.

RELATIVE WEIGHT

Calculating relative weight (RW) is a simple way to estimate the condition of individual fish in your pond. RW is the percentage of the actual weight of a fish relative to the standard weight for that species. The standard weight is the weight of a healthy fish of the same length. Fish with high RW are fatter, thus healthier, while those with low RW are thin and less healthy. To calculate RW one must divide the fish's observed or current weight by the standard weight for that species.

An example showing how to calculate relative weight (RW) for a largemouth bass.

Calculating Relative Weight

You go fishing in your pond and catch a largemouth bass that was 15 inches long and weighed 1.5 pounds. What would be the relative weight (RW) of that bass?

1. **Look up the standard weight of a 15-inch largemouth bass from Table 2. The standard weight for a 15-inch bass is 1.8 pounds.**

2. **Divide the weight of your fish by standard weight.**

RW = (your fish / standard weight) x 100
= (1.5 / 1.8) x 100
= 83%

The bass that you caught weighs 83% of what we would expect a 15-inch bass to weigh, suggesting that it has a lower body condition than is standard.

Table 2: Standard weight at different lengths for four common fish species in Indiana ponds.

Bluegill		Redear Sunfish		Largemouth Bass		Channel Catfish	
Length (in)	Weight (lb)	Length (in)	Weight (lb)	Length (in)	Weight (lb)	Length (in)	Weight (lb)
5.0	0.1	5.0	0.1	8	0.2	12	0.5
5.5	0.1	5.5	0.1	9	0.4	13	0.7
6.0	0.2	6.0	0.1	10	0.5	14	0.9
6.5	0.2	6.5	0.2	11	0.7	15	1.1
7.0	0.3	7.0	0.2	12	0.9	16	1.4
7.5	0.3	7.5	0.3	13	1.2	17	1.7
8.0	0.4	8.0	0.4	14	1.5	18	2.0
8.5	0.5	8.5	0.4	15	1.8	19	2.4
9.0	0.6	9.0	0.5	16	2.3	20	2.9
9.5	0.7	9.5	0.6	17	2.7	22	3.9
10.0	0.9	10.0	0.7	18	3.3	24	5.2
10.5	1.0	10.5	0.8	19	3.9	26	6.8
11.0	1.2	11.0	1.0	20	4.6	28	8.7
11.5	1.4	11.5	1.1	21	5.4	30	10.9
12.0	1.6	12.0	1.3	22	6.2	32	13.5
12.5	1.8	12.5	1.4	23	7.2	34	16.4
13.0	2.1	13.0	1.6	24	8.2	36	19.8

If you catch a number of fish and assess their RW, you can start to get an idea of the condition and health of the fish population. If you notice low RW among your fish, this may be due to a lack of resources, such as food or habitat. Low RW may also signify an unbalanced ecosystem. This may mean your fish populations are out of balance or there are not enough primary producers in your pond. It may be necessary to hire a pond consultant to help assess what your pond is lacking.

Managing Fish Populations with Harvest

Once you know what fish are in your pond, you can start to think about the best way to manage these fish moving forward. The best way to manage fish populations in a pond is through selective fish harvest. If you have recently stocked a good balance of fish species, harvest can help keep fish populations in balance with each other. If a pond has issues with existing fish populations (e.g., stunted fish or low PSD), selective harvest can help fix these problems and restore balance to fish populations by removing the stunted fish.

While it does take some ongoing effort from the pond owner to manage fish populations with harvest, there are different harvest options to choose from, each requiring different amounts of effort and yielding different fish population outcomes. In most instances, harvest simply involves going fishing and keeping some fish to eat, which many pond owners plan to do already. Nevertheless, it is important to understand each of the harvest options so that you can decide how much effort you are willing to put into your pond to obtain the results you are striving for.

Selective harvest is the best way to manage fish populations in a pond.

As a starting point for discussing pond fish management options, let's consider "no management". One option is to put little-to-no effort into managing a pond and as a result do not use harvest to manage fish populations. This approach is not advised for pond owners who wish to produce sustainable fish populations. "No management" typically takes two forms in a pond: 1) indiscriminate fish harvest, or 2) no fish harvest. If fish are indiscriminately harvested from a pond, by taking too many of a particular species or a certain size of fish, fish populations can easily become unbalanced, often resulting in poor fishing. On the other hand, if too few fish are harvested, some fish species can become too abundant, creating increased competition for resources and decreased growth, which often results in stunted fish populations. The bottom line is that sustaining a healthy fish population in a pond without some type of management is nearly impossible.

In this guide, we present four management options for Indiana ponds: 1) channel catfish only, 2) all-purpose fishing, 3) trophy sunfish and 4) trophy largemouth bass. Each option has advantages and disadvantages. When managing any pond, it is important to understand that all ponds are different physically, biologically, and chemically. While the harvest guidelines listed for each management option are estimates based on an "average" Indiana pond, your pond may not follow these guidelines perfectly. Use routine fish sampling to assess the specific growth rates and population balance in your pond and adjust the harvest guidelines as needed. Average growth of sunfishes, largemouth bass and channel catfish are shown in Figure 1. Use this as a guide to compare fish growth in your pond. It is best to wait 2-3 years after initial stocking before harvesting any fish, to allow fish to grow and mature.

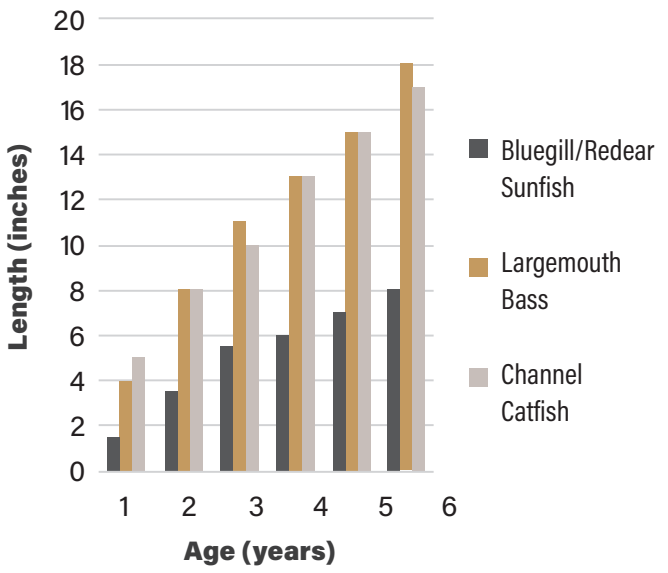
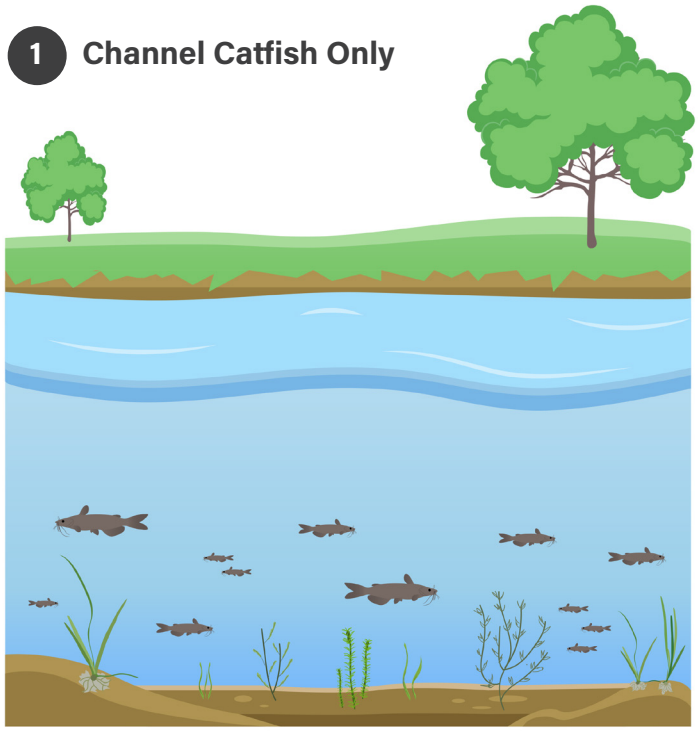
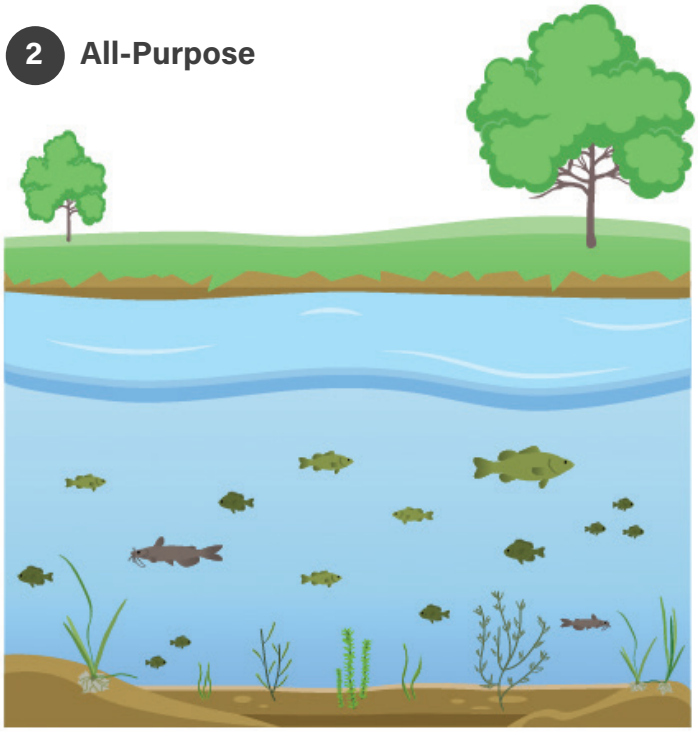
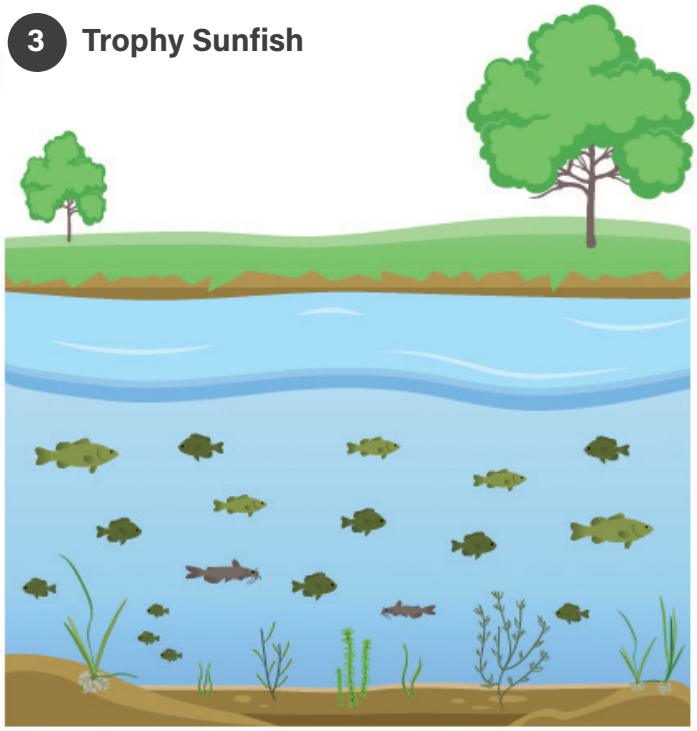
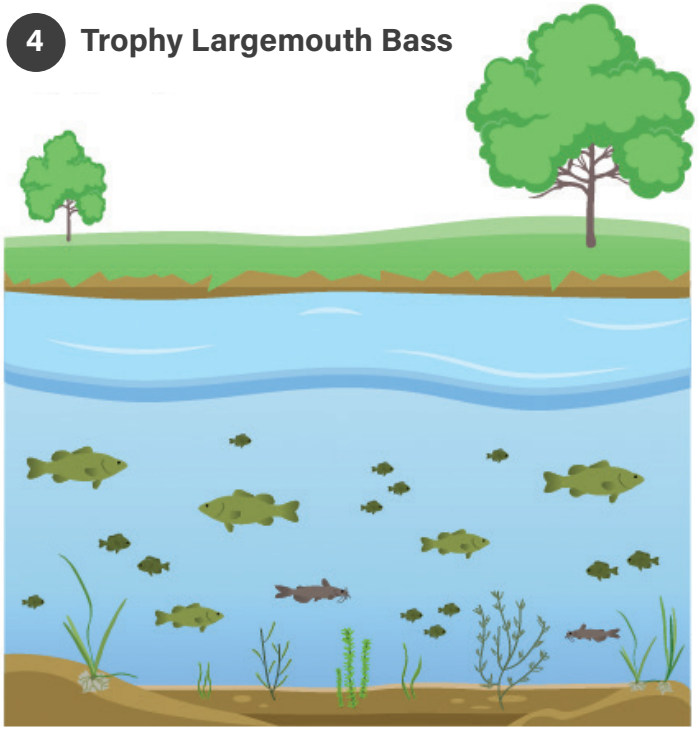


Figure 1: *Average growth rates of bluegill, redear sunfish, largemouth bass, and channel catfish in Indiana ponds.*









Four fish management options and the resulting fish population structure for Indiana ponds. Illustrations by Jade Layman.

OPTION 1: PONDS WITH CHANNEL CATFISH ONLY

A pond that contains channel catfish as the only fish species is a good management option in a number of situations. First, managing a pond that only contains one fish species often requires less effort and time than ponds with multiple species. Therefore, this option is great for those who wish to put minimal effort into managing their pond. Another situation that may benefit from a catfish-only management option is small ponds less than one acre in size. In these small ponds, it is often difficult to keep numerous fish species in balance with each other, particularly predators and prey. By stocking channel catfish only, you just need to manage one species and it is often much easier to ensure good growth and adequate population numbers.

A channel catfish-only pond is a good option for owners of small ponds or those who wish to put minimal management effort into their pond.

A pond with only channel catfish can become self-sufficient if you follow a few simple tips. First, consider adding artificial spawning habitat, such as barrels or large tires. This will promote channel catfish to spawn, and they should have good spawning success without the presence of predators such as largemouth bass. Channel catfish will eat invertebrates like worms and crayfish, as well as dead items off the bottom. With no other fish in your pond for channel catfish to feed on, you may need to supplement their diet with artificial food if the growth of the catfish is slower than expected.

It is important not to overfeed the fish because uneaten food increases the likelihood of excessive plant growth in the pond. You may also need to stock new channel catfish every 3-5 years if you find that populations are having difficulty reproducing and sustaining themselves. A channel catfish-only pond should provide good fishing opportunities and food for the table for many years. Once your pond is established (i.e., after 3 years), you may harvest up to 30 channel catfish at 15-20 inches in length for each surface acre per year. When assessing a channel catfish population in a pond, whether it is a catfish-only pond or any of the multi-species pond options below, the PSD of channel catfish should be 20-50.

OPTION 2: PONDS WITH ALL-PURPOSE FISHING

Many pond owners want a variety of fish in their pond, such as largemouth bass, sunfish and channel catfish. Managing ponds for multiple species requires ongoing effort to keep the species balanced. For this management option, it is recommended that a pond be stocked with largemouth bass and at least one species of sunfish (i.e., bluegill and/or redear sunfish). You may also stock channel catfish to round out the blend of species and create additional fishing opportunities. For specific stocking numbers and sizes, please refer to the Purdue Extension publication on Stocking Fish in Indiana Ponds (FNR-569) at https://extension.purdue.edu/pondwildlife.

An all-purpose fishing pond needs both predators (largemouth bass) and prey (sunfishes) to keep fish populations in balance.

To manage a pond with multiple fish species, it is important to understand the predator-prey relationship. Predators are important for keeping prey fish populations in check, while adequate prey populations are needed for good predator growth. The main predator in Indiana ponds is largemouth bass, while sunfish species serve as their primary prey. Maintaining a balance between predators and prey will ensure that both populations grow in balance with each other.

To manage a pond for all-purpose fishing, you should harvest some bass and sunfish each year. Once your pond is fully established (e.g., 2-3 years after initial stocking), we recommend harvesting 300 sunfish per surface acre at sizes of 5-7 inches, 10 largemouth bass per surface acre at sizes of 8-12 inches, and no more than 5 largemouth bass per surface acre at sizes of 15 inches or more. These numbers may seem relatively high, but harvesting fish will free up space and food for the remaining fish to grow faster and larger. It is important to harvest many sunfish in these ponds because sunfish reproduce rapidly and can easily overpopulate a pond. In many ponds, particularly large ponds, it is almost impossible to harvest too many sunfish. A good population of largemouth bass will eat many smaller sunfishes and can help keep populations in check. Channel catfish have little impact on the predator-prey relationship; therefore, approximately 15 catfish per surface acre per year can be harvested at sizes of 15-20 inches. This number is lower than the catfish-only management option because catfish reproduction will likely be lower due to predation of catfish fry by largemouth bass.

Managing a pond for all-purpose fishing requires assessing fish populations at least once per year. The target PSDs for an all-purpose pond are 20-60 for sunfishes and 40-70 for largemouth bass. Regular assessment will allow you to detect and fix any fish population problems. For example, if you notice high numbers of small sunfish (i.e., low PSD) or sunfish with low RW, it is likely that the overabundant sunfish are becoming stunted. To restore a balance, you should reduce largemouth bass harvest to increase predation. If you notice too few fish, either bass or sunfish, you may also consider reducing harvest of those species to allow populations to increase.

All-purpose fishing will allow you to harvest a variety of good-sized fish, such as these bluegill. Photo by Tevin Tomlinson.

OPTION 3: PONDS WITH TROPHY SUNFISH

An alternative management option you may consider is to focus on producing large trophy sunfish. Bluegill can reach at least 10 inches and redear sunfish can reach at least 12 inches in length in Indiana ponds if managed appropriately. The key to managing for large sunfishes is that you need to keep sunfish populations relatively low in number so that fish have lots of space and food to grow fast and large. The most efficient way to do this is to maximize the amount of sunfish predation by largemouth bass. Predation will remove many small sunfish, and those that are left will grow fast and may eventually become too large for bass to eat.

To manage ponds for trophy sunfish, it is recommended that you harvest 150 sunfish per year at sizes ranging from 6-10 inches. Note that this is a lower number of larger fish than the harvest guidelines for "all-purpose" fishing. You should limit the harvest of largemouth, particularly fish greater than 12 inches in size, to maximize the amount of predation on sunfishes. You can harvest the occasional large fish (>15 inches) as some of these may die from natural causes anyway.

Managing for trophy bluegill or largemouth bass is more difficult than managing for all-purpose fishing because fish populations need to be closely monitored and assessed 3-4 times each year.

This management option requires close monitoring of largemouth bass and sunfish populations to ensure they remain in balance. The target PSDs for a trophy sunfish pond are higher (i.e., 50-80) for sunfishes and lower (i.e., 20-40) for largemouth bass than in a pond managed for all-purpose fishing. As this lower PSD for largemouth bass

Managing your pond for trophy sunfish can result in large fish like this 9-inch bluegill. Photo by Emily Musenbrock.

suggests, large bass will be less common in your pond than in the all-purpose option. You may need to assess fish populations multiple times each year, making adjustments to harvest after each assessment. For example, if sunfish populations become overpopulated, the growth of individual sunfish will be limited. To remedy this, you need to restrict harvest of bass to encourage predation. You may need to also harvest some small sunfishes to help reduce sunfish populations. In contrast, if the largemouth bass become overpopulated, they will consume too many sunfish. With less food, bass may become stunted. Selective harvest of 8-12 inch largemouth bass may be necessary every 3-5 years to fix bass overpopulations. This provides more space for the remaining bass to grow larger and provides more sunfish for them to consume.

OPTION 4: PONDS WITH TROPHY LARGEMOUTH BASS

Another management option that you may consider for your pond is to focus on producing trophy largemouth bass. If properly managed, largemouth bass can grow to more than 20 inches and 6 pounds in Indiana ponds. The key to managing for trophy largemouth bass is to maximize the number of small sunfish available for them to eat. The best way to do this is by limiting harvest of sunfish to allow populations to become crowded and stunted. Stunted sunfish create large amounts of food for largemouth bass, resulting in faster growth rates.

A trophy largemouth bass pond requires large numbers of small sunfish to promote fast bass growth.

To manage ponds for trophy largemouth bass, avoid harvest of bass at sizes of 12-15 inches. It is important to maintain good populations of these medium-sized bass so that some may grow to become trophy-sized. It is recommended that you harvest approximately 10 largemouth bass per acre per year at sizes of 8-11 inches. This will ensure that these smaller bass don't overpopulate, causing stunted populations. You should only expect to harvest 1-3 bass that are 16-20 inches per acre on a yearly basis. This will open up some space for medium-sized bass to grow large, but be careful not to harvest all of your large predators.

Sunfish may be harvested at a rate of 150 sunfish per acre per year at sizes of 5-7 inches or larger each year. This will remove larger sunfish that may be difficult for bass to eat, freeing up space to produce more smaller sunfish. However, if your pond has a stunted sunfish population, you may find that it is rare for sunfish to reach 5-7 inches in size. In this case, it is not necessary to harvest any sunfish, as a good population of bass should be able to keep sunfish populations in check. A disadvantage of this is that it will be difficult to produce sunfish at a size suitable for harvest and eating.

Target PSDs for a trophy largemouth bass pond is lower (i.e., 10-50) for sunfishes and higher (i.e., 50-80) for largemouth bass than in a pond managed for all-purpose fishing. For some people, it is difficult to refrain from harvesting many largemouth bass. If 12- to 15-inch largemouth bass are harvested, future generations of large trophy bass may be removed. However, if sunfish become extremely abundant, they may negatively impact bass populations during breeding season; sunfish are known to eat bass eggs and fry. When sunfish populations become crowded, there may be less space for largemouth bass to grow despite there being abundant prey.

Managing your pond for trophy largemouth bass may result in bass larger than 20 inches and 6 pounds.
Photo courtesy of the Indiana Department of Natural Resources.

Table 3: Annual recommended harvest numbers per surface acre and sizes for common fish found in Indiana ponds.

MANAGEMENT OPTION	Sunfish	Trophy Largemouth Bass	Channel Catfish
Channel Catfish	—	—	30 @ 15-20″
All Purpose	300 @ 5-7″	10 @ 8-12″ 5 @ 15-20″	15 @ 18-20″
Trophy Sunfish	150 @ 6-10″	5* @ 8-12″ 5 @ 15-20″	15 @ 18-20″
Trophy Largemouth	150 @ 5-7″	10 @ 8-12″ 2 @ 15-20″	15 @ 18-20″

* Selective harvest of 8-12″ largemouth bass may be needed every 3-5 years to minimize the risk of stunted bass populations.

Increasing Fish Production

You may find that your fish are growing slower than expected or that reproduction is limited. In Indiana, these scenarios are not common due to the highly productive nature of our ponds. However, there are examples where several factors can limit fish growth and reproduction success. The two most common factors lacking in some Indiana ponds are suitable fish habitat and suitable nutrient levels to support growth and reproduction. There are a number of things that a pond owner can do to address each of these limiting factors.

ADDING FISH HABITAT

Fish require an abundance and variety of habitat for shelter, feeding and reproduction. The primary habitat for fish in ponds is aquatic vegetation. Vegetation provides a number of benefits including adding dissolved oxygen to the water, offering nursery habitat for juvenile fish, providing structure for fish spawning, and increasing feeding opportunities for juvenile and adult fish. While you may wish to reduce the amount of aquatic vegetation in your pond to allow for greater access and recreational use, it is important to maintain healthy aquatic vegetation to promote good fish production. Generally, it is recommended that approximately 25% of the pond's surface area include some type of aquatic vegetation.

Artificial fish habitat can increase fish reproduction, growth and survival.

In addition to vegetation, adding other types of habitat may also benefit fish. Some ponds, such as old quarries and strip pits, have low productivity and plant growth, and may benefit from artificial habitat. Adding artificial habitat can lead to a number of benefits for fish populations in ponds.

Artificial fish habitat comes in many shapes and sizes, each providing different benefits to fish. Enclosed structures like fish tubes, barrels and logs provide great spawning habitat for channel catfish. Hard flat structures like concrete blocks, rock piles or concrete-filled buckets provide habitat for largemouth bass to create their nests or beds. Sunfish also build beds, but do so in large groups. Adding open areas of sand or gravel can help promote their reproduction. Spawning discs or saucers (e.g., large plates) can also be used to encourage sunfish spawning. It is best to hand-place these structures from a boat or the shore to ensure that they are placed in key locations appropriate for fish spawning (e.g., shallow water for bass and bluegill).

Adding stakes and other fish habitat to a pond can improve reproductive success, provide additional shelter for fish and help congregate fish for improved fishing success.
Photo courtesy of Dave Osborne.

Another benefit to adding artificial habitat to your pond is that it provides shelter to your fish, which can also congregate fish to help improve fishing success. The type of structures that provide shelter in ponds are relatively large structures such as fallen trees and stakes. Some of these structures may already be present in your pond, but you may add extra structures so that you know their precise location for future fishing trips. Adding these larger fish structures can be problematic from the shore or a small boat. One technique is to wait until safe ice in the winter and place these structures on the ice. Once the ice melts in early spring, they will simply fall into the desired location.

Overall, there are many different types of structures you can add to your pond to help achieve your goals. There are natural structures, do-it-yourself structures, and commercially bought structures that you can add to your pond. To optimize the success of these structures, it is best to place them in depths between 2 to 8 feet. Structures should not be placed in the deepest areas of your pond as these areas are likely to have low dissolved oxygen in the summer. Take the time to do some research to determine what type of structure is best to achieve your goals.

SUPPLEMENTAL FEEDING

Supplemental feeding may increase fish production in some specific situations. However, supplemental feeding also adds nutrients to your pond, which may cause excessive plant and algae growth, and the problems associated with it. It is recommended that you speak with an Indiana Department of Natural Resources (IDNR) fish biologist before considering supplemental feeding in your pond. To determine if supplemental feeding is necessary, compare the growth rates of fish in your pond with the standard growth rates shown in Figure 1.

Supplemental feeding is more common when managing for channel catfish only. While catfish will eat natural foods like crayfish, invertebrates and dead organisms, it has been shown that supplemental feeding of pelleted fish food can increase the size of channel catfish. You may need to spend some time training fish to accept artificial food, and you need to closely monitor how much food is eaten so that you can avoid adding excessive food that goes uneaten. Uneaten food will drastically increase the nutrient levels in a pond and may lead to algal blooms and other aquatic vegetation problems.

Most Indiana ponds are highly productive and do not require supplemental feeding or fertilization.

Artificial pelleted fish food may also be added to a pond to increase production of sunfishes. The main purpose for doing this is to increase the number of smaller sunfishes to provide food for bass, thereby promoting trophy largemouth bass fishing. Artificial feeding is not needed to manage for trophy sunfishes. Largemouth bass rarely eat artificial pelleted food in natural ponds; therefore, artificial feeding does not directly increase bass production. If you would like to provide supplemental food for largemouth bass, you need to stock live fish such as fathead minnows. It is best to stock minnows into a pond first, adding largemouth bass in the subsequent year. The minnow population will then kick-start largemouth bass growth once they are added. Adding minnows to a pond with existing bass populations simply serves as expensive fish food. Fathead minnows will likely be consumed quickly and add little to overall bass production. Also, the reduction in sunfish predation while bass consume minnows may lead to unbalanced sunfish populations. For more information on stocking fathead minnows, please refer to the Purdue Extension publication on Stocking Fish in Indiana Ponds (FNR-569), found at https://extension.purdue.edu/pondwildlife.

If you wish to add supplemental food to your pond, you should consider a few other factors. Feeding is most productive in ponds that are less than 5 acres. It can be very expensive to add large quantities of artificial fish food to large ponds. Larger ponds also make it difficult for fish to notice when feeding is occurring, and therefore, much of the artificial food can go uneaten. To train fish to recognize when and where supplemental feeding is occurring, you may want to consider installing a feeding ring. A feeding ring is a large circle that is at least three feet in diameter, made out of PVC pipe or plastic lining and stabilized on the surface of your pond. The feeding ring will train your fish to go to that area to feed – much like a dinner bell or a neon sign! A feeding ring allows you to add food to a smaller area of your pond, while also signaling to your fish where to get this food. It is recommended that you feed your fish close to the same time each day in the feeding ring. The feeding ring is also helpful in preventing pellets from floating onshore or into thick vegetation where fish cannot reach it. This helps reduce the amount of uneaten food in your pond.

If you choose to use supplemental feeding in your pond, feed your fish a pellet food that is at least 25% protein. A high-protein diet will produce the best fish growth. When feeding fish artificial pellets, do not feed more than the fish can eat in a 15- to 20-minute time frame. Also, avoid feeding during rainy or cloudy weather as fish are less likely to see and eat the pellets.

Continually feeding your fish is expensive; therefore, supplemental feeding is not recommended for most pond owners. Maintaining balanced fish populations through fish harvest is the easiest way to achieve strong fish growth and good fishing.

Feeding rings create a feeding space for your fish, while also ensuring that the money invested in the fish pellets does not go to waste. Photo by Emily Musenbrock.

FERTILIZATION

The vast majority of Indiana ponds have excessive amounts of nutrients, as evidenced by abundant aquatic vegetation and algae around the shore bank and out into deeper water. The application of a fertilizer should only be considered under specific conditions. For example, some old quarries and strip pit ponds can have very low natural productivity, as evidenced by little vegetation and clear water.

One way to measure water clarity is to use a Secchi disk. A Secchi disk is a circular piece of plastic with white and black sections and a rope attached to the center. To use a Secchi disk, lower it into the water column until you cannot see it anymore and measure the depth (i.e., length of rope) at which you lost sight of it. If the Secchi disk measurement is greater than 10 feet, it is likely that your pond has low natural productivity. This means it cannot support adequate plant life to sustain high populations of fish.

Ponds with low natural productivity can benefit from fertilization; however, the pond must be monitored closely to prevent overfertilization and blooms of algae or other aquatic vegetation. Measure water clarity in the spring or early summer, when natural productivity will be the highest.

It is recommended that you speak with a fish biologist or pond consultant before supplemental feeding or fertilizing your pond.

A Secchi disk is used to measure the clarity of your pond water. Photo by Hope Charters.

Fertilizing a pond works the same way as fertilizing a garden or agriculture field. It adds nutrients such as nitrogen, phosphorus, and potassium. The first type of plants that grow from added nutrients in a pond are tiny microscopic plants called phytoplankton. These form the base of the food web in ponds and are essential for the overall health of most organisms. Microscopic animals called zooplankton in turn feed on phytoplankton. Zooplankton are then eaten by invertebrates and small fish, which in turn feed larger fish. This is the process by which fertilization can help increase fish production in ponds.

If you work with a consultant to assess and fertilize your pond, they may ask you the following questions:

- Is the watershed area-to-pond surface area ratio less than 20:1 acres? This means that the watershed for your pond has to be less than 20 times the size of your pond for fertilization to be safe, otherwise runoff may bring excessive nutrients.
- Is the watershed your pond resides in primarily woodland with soils that have low fertility? This will ensure a lower likelihood of excessive nutrients from agricultural fields and other areas.
- Does the pond have a minimal amount of shallow water that prevents plant growth? If your pond water is relatively deep, few plants may take root and establish.
- Is the Secchi disk reading greater than 10 feet? If not, it is likely that your pond already has sufficient nutrients for good fish growth.

If you answer "yes" to all of these questions, it may be beneficial to fertilize your pond. To fertilize your pond, use monthly applications of a liquid fertilizer with a formula of 10-34-0 (N-P-K) at rate of 2 gallons per surface acre. Liquid fertilizer is preferred over a granular formulation because it is quicker to add to your pond and there are no dissolving processes to consider.

Most fertilizer applications are made in the early spring when water temperatures are less than 80.° Do not apply fertilizers when water temperatures rise above 80° F to prevent low dissolved oxygen and fish kills. Continue to monitor the water clarity of the pond using the Secchi disk. If the reading from the disk is 18 inches or less, you should cease fertilization until water clarity increases. Similar to supplemental feeding, once fertilization is started, it must become a permanent part of your assessment and management program.

Excessive fertilization or supplemental feeding can lead to algae and plant problems. Photo courtesy of Purdue Pesticides Program.

Common Pond Problems

There are a number of problems that pond owners can encounter as they manage fish populations in Indiana ponds. A few of the most common problems, and potential solutions, are discussed below.

STUNTED FISH

Stunted fish are small for their age, and don't reach their full size due to limitations in food resources and lack of predation. For example, you might catch hundreds of 4-5" sunfish, but seldom catch any that are larger. Stunted fish populations are almost always caused by overcrowding. When there are too many fish for the space and food available, competition between individuals will slow growth and cause stunted fish. The best way to fix stunted fish populations is by increasing harvest and not returning the smaller fish back to the pond. Harvesting fish will free up space and food, allowing those remaining to grow faster and larger.

Stunted sunfish populations can also be reduced by increasing largemouth bass predation. This can be accomplished by limiting bass removal or stocking new bass into the pond. Recommended solutions to stunted fish problems based on your selected fish management option are listed in Table 4.

Table 4: If stunted fish are a problem, the fish management option selected for your pond will determine the solutions to those problems.

MANAGEMENT OPTION	Stunted Sunfish	Stunted Largemouth Bass
All Purpose	▪ Increase harvest of sunfish ▪ Reduce harvest of bass to increase predation	▪ Increase harvest of bass
Trophy Sunfish	▪ Harvest sunfish that are 5-7″ in length	▪ This is expected when managing for trophy sunfish ▪ Harvest bass that are 8-12″ in length
Trophy Largemouth	▪ This is expected when managing for trophy bass ▪ Follow normal harvest guidelines	▪ Increase harvest of bass that are 8-12″ in length

MUDDY PONDS

A muddy pond is caused by fine sediments that are suspended in the water column. While this sediment often settles to the bottom, some situations cause ponds to stay muddy. This can cause problems with lowering dissolved oxygen in water, leading to stressed fish and sometime fish kills. The suspended sediment prevents sunlight from penetrating through the water column, therefore reducing plant growth. With plants as the primary source of dissolved oxygen in a pond, reduced plant growth means reduced oxygen levels. The most common causes of muddy ponds include: soil erosion along pond banks, too few deep-rooted plants in the watershed, trampling of the bank by livestock, and an abundance of bottom-eating fish, such as common carp or bullheads.

The easiest way to avoid erosion is to maintain grasses and other deep-rooted plants along the banks of your pond to prevent soil being washed into the pond. You can reduce erosion caused by wave action by placing large rocks or rip-rap along the banks of the pond. Rocks can stabilize the soil and also prevent unwanted aquatic vegetation growth. If livestock need to enter the pond to use it as drinking water or to cool off, it may be difficult to prevent a muddy pond; however, if your pond is large enough, you may consider restricting livestock to a small area of the pond.

Muddy water caused by bottom-feeding fish, such as common carp and bullheads, can be reversed by eradicating these fish. Completely draining your pond and physical removal, or partial draining and chemical treatment, may be necessary to remove these unwanted fish.

A muddy pond has sediment suspended in the water column and can have a number of causes. Photo by Robin Webster.

UNWANTED FISH

Largemouth bass, bluegill, redear sunfish and channel catfish are the fish species best suited to ponds in Indiana. Fathead minnows, grass carp and tilapia may also be stocked in certain situations. As a general rule, other fish species that are common in Indiana streams, rivers and lakes do not do well in artificial ponds. For example, bullheads, which are a smaller catfish species, are not desirable in ponds because they often overpopulate and disturb the bottom, which leads to muddy ponds. Their presence may also limit the success of channel catfish.

Carp and other sucker species are not recommended in Indiana ponds because they disturb the bottom and uproot vegetation, leading to sediment being suspended in the water. Crappies and yellow perch are not well suited for ponds less than 10 acres. These fish not only compete with sunfish and bass for food and space, but can also directly predate on juvenile sunfish and bass. They also have high reproductive output and can overpopulate ponds, causing stunted fish populations.

Some species of sunfish, such as green sunfish and pumpkinseed, are also undesirable. Green sunfish are very aggressive and often outcompete other sunfishes for food. Pumpkinseeds do not grow much larger than 5 inches in length, therefore they do not provide good fishing opportunities in a pond. Some species of bait or forage fishes, such as gizzard shad, are also undesirable in a pond as they can grow too large for bass to eat and can easily overpopulate, causing sunfish and bass populations to become stunted.

Bullheads, carp, crappie, and green sunfish (top to bottom) are a few species that can cause problems in Indiana ponds.
Illustrations by Duane Raver, USFWS.

Removing unwanted fish can be difficult, expensive and time-consuming. The best defense against unwanted fish is to prevent them entering a pond in the first place. If you do need to eradicate unwanted fish from your pond, one option is to completely drain the pond and physically remove all fish. The downside to this is that you will also kill desirable fish such as bass and sunfish, and you will need to restock the pond once it is filled.

Sometimes a pond cannot be drained. If this is the case, chemicals can be used to kill unwanted fish in ponds. They are not only expensive, but require a state certification to be purchased. Rotenone is a restricted use chemical and you must obtain a license to buy and use this chemical. Rotenone kills undesirable and desirable fish equally by obstructing oxygen uptake through the gills. It is best to contact an aquatic application firm to do these treatments as there are many facets in purchasing and applying rotenone to a pond. For instance, the label instructions will require that livestock and people be kept out of the pond for an extended period of time. Before restocking a pond, it is recommended that you test the pond water with a few fish to ensure that it is no longer toxic. This and other safety and environmental reasons are why we suggest that only professional aquatic applicators make rotenone applications.

It is important to follow the label directions. In some cases, rotenone can be used at lower doses to kill particularly sensitive fish species, such as gizzard shad. The potency of rotenone is dependent on the water temperature: fish in warm water breathe more rapidly and therefore die more quickly than fish in cooler water.

Before applying rotenone, it is best to lower the water level in the pond. This will allow you to use as little chemical as possible. It will also prevent the pond (and chemical) from overflowing into natural waterways and killing other organisms off-site.

You can also apply a second chemical to the pond, potassium permanganate, to deactivate the harmful effects of rotenone. It is recommended that you remove dead and dying fish from the water and the edge of the bank to prevent the build-up of excess nutrients and preventing oxygen levels from dropping as the result of decay.

You may need to drain your pond to completely remove unwanted fish species. Photo by Emily Musenbrock.

UNWANTED ANIMALS

Semi-aquatic animals may be drawn to your pond. In some cases, these animals are desirable as they are an important part of the ecosystem and may add to the aesthetic value of the pond. However, in some cases, these animals may become a nuisance to the pond.

Turtles are one of the most common pond dwellers. Common turtles in Indiana include snapping turtles, painted turtles, and softshell turtles. Most turtles eat algae, plants, crustaceans and insects, and pose little threat to your fish. They are also rarely in high-enough numbers to consume too many plants or fish.

One turtle species that may be problematic is the common snapping turtle. Snapping turtles are opportunistic omnivores and will eat fresh meat, carrion and plants. Often given a bad reputation for eating prized game fish, snapping turtles are too slow to chase down game fish, and the ones they eat are probably sick or dead. However, large snapping turtles can intimidate and change the behavior of young waterfowl and other small animals. Snapping turtles can be caught in traps that are baited with fresh meat held in mesh bags or canned sardines with holes punched in the can. Turtle traps often consist of wire or mesh traps in a box or hoop formation. Position the trap in shallow water with at least some of the trap exposed to allow turtles to breath air once captured. Snapping turtles can also be caught with baited hooks or by hand by grabbing the rear of the shell. Once you catch a snapping turtle you may transport it to a new location or euthanize it if you want to guarantee it won't return. You may also decide to eat the snapping turtle as they make excellent table fare. Check with the IDNR for restrictions on turtle harvest.

Another nuisance pond dweller is the muskrat. Muskrats like to build dens in steep banks along ponds. When muskrats are abundant, they cause serious damage to banks and may cause a pond to leak. To discourage muskrats from burrowing, the pond bank should have a minimum slope of 3:1 on the water side – that is, the pond bank slopes at least 3 feet horizontally with every one vertical foot. Be sure your bank is not too steep for humans or animals to safely exit the pond. Adding rip-rap to your banks may also help discourage these burrowers. Another approach is to stake down wire mesh (e.g., chain-link fencing) to the water side of the pond bank or dike to prevent muskrats from burrowing. This approach also works for other nuisance species such as beaver. For muskrats, it can also be helpful to remove their favorite food items, such as cattails, bulrushes, and arrowhead. Trapping can also be an effective way to remove muskrats. Muskrats are furbearing animals and are managed during a regulated

trapping season. Consult the annual IDNR hunting and trapping regulations for open seasons. The IDNR allows landowners or tenant to legally capture muskrats (and some other animals) without a permit under specific conditions. For more information on these conditions, consult your local IDNR biologist or visit their website at www.in.gov/dnr.

Holes dug in a pond bank by muskrats which can cause a pond to leak. Photo by Dave Osborne.

Another common fish predator in Indiana is the Great Blue Heron. These animals may come and go from a pond and eat many smaller fish, such as bluegill. Fish are particularly susceptible during the spawning season as they are in shallow areas of the pond that are most accessible to herons. The Great Blue Heron is protected by state and federal law, which means you cannot capture or kill these animals without a permit. As such, it is best to consider methods to deter these birds from your pond by using frightening devices, electronic calls, mylar tape, decoys or fences made from netting or wire grids. like wire grids or netting. For netting, the net mesh size must be less than 1 inch to minimize the chance that birds get entangled. Considering that herons like to wade in shallow water while fishing, you can also try to add vegetation along the edges of your pond to give your fish more places to hide. If you have a hard time growing thick vegetation, the use of artificial lily pads may help provide temporary water cover.

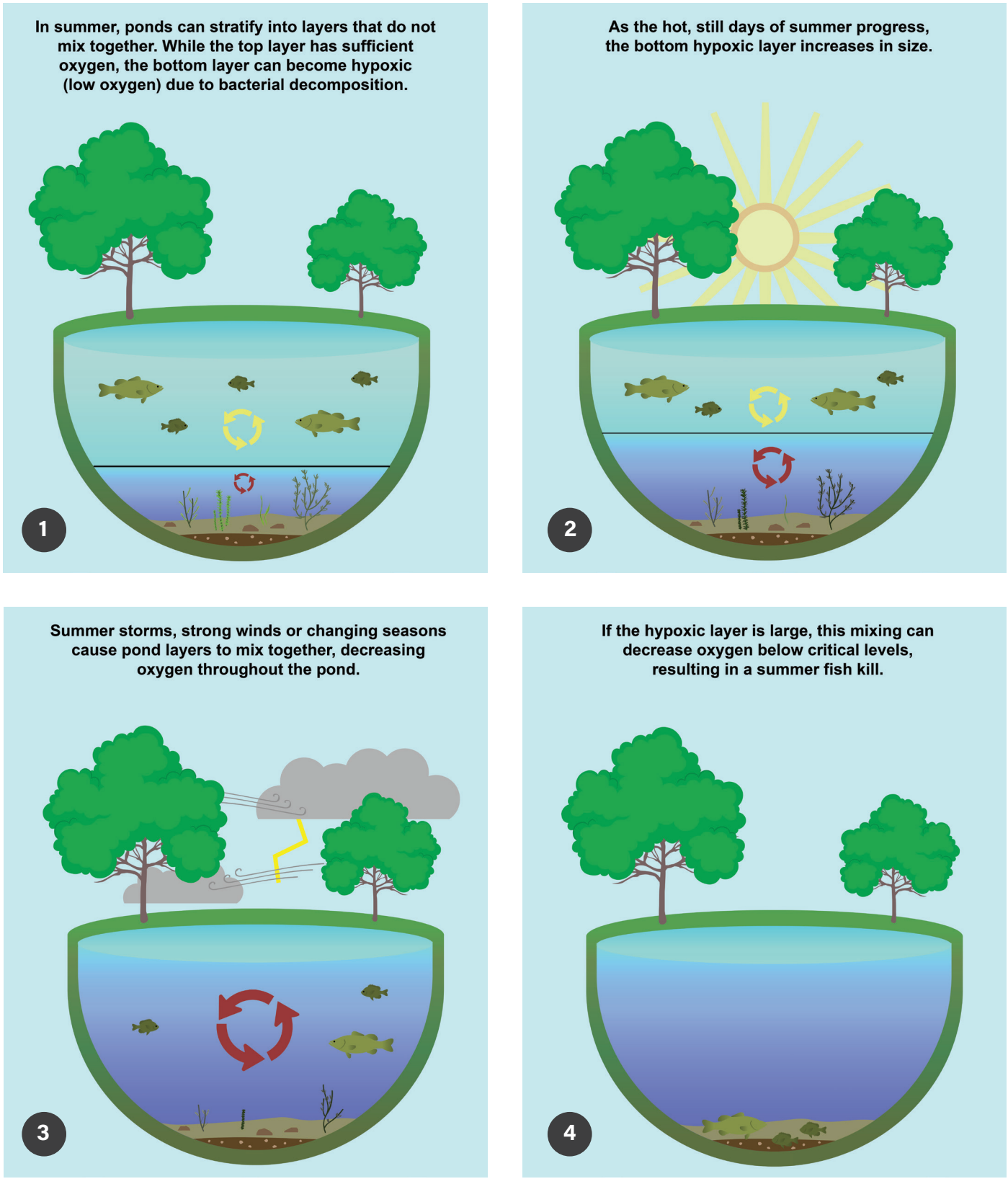
There are other nuisance animals that you are less likely to encounter, like river otters and beavers. There are many ways to trap and repel these creatures as well. There is a specific trapping season for both of these animals, so always consult the IDNR before taking action.

FISH KILLS

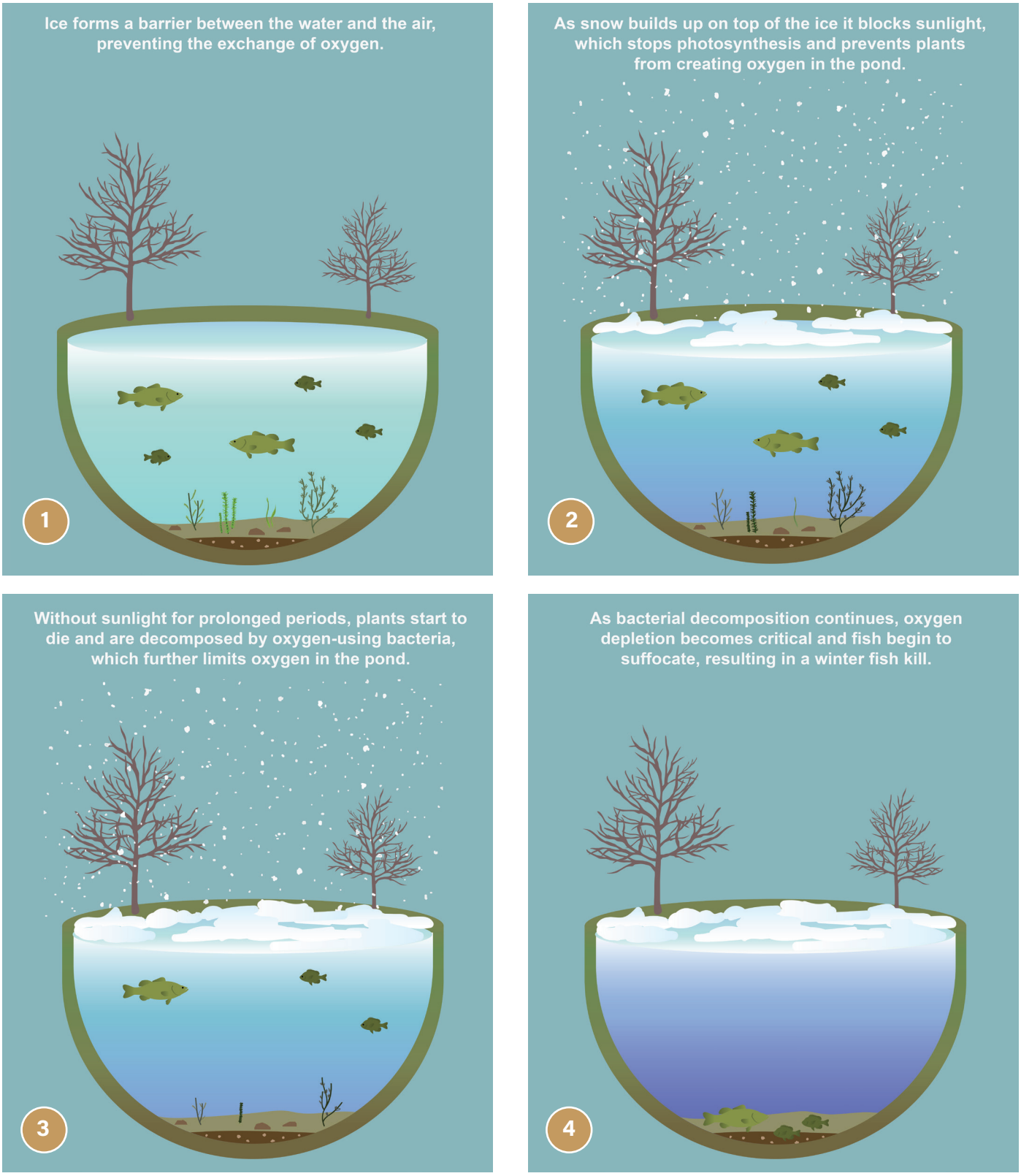
A fish kill is when a large number of fish die at the same time. The most common cause of fish kills in a pond is low dissolved oxygen levels. Fish kills can happen at any time of year, but tend to be more prevalent during the change in seasons as drastic water temperature changes are more common. Although relatively uncommon, large-scale fish kills can be quite dramatic and detrimental to a pond.

During summer months, ponds warm and the water column separates into distinct layers. This process is called stratification. The top layer of the water is warmer and less dense, and has higher dissolved oxygen levels due to gas exchange at the surface and plants growing in shallow areas. The bottom layer is cooler and more dense, and contains lower dissolved oxygen levels due to respiration by bacteria as they decompose dead plants and fish. There is little mixing between these two layers, and the low oxygen layer can grow to be quite large by late summer and early fall. During storm events, these layers can mix together, which causes the drastic lowering of dissolved oxygen throughout the entire pond. In some cases, oxygen levels drop below what is needed to support fish.

During winter months, a layer of ice forms on the surface, which inhibits the exchange of oxygen. If the ice remains uncovered with snow, sunlight will continue to penetrate into the water column allowing plants to photosynthesize, adding dissolved oxygen to the water. However, if the ice is covered with a blanket of snow, sunlight can no longer penetrate. Without sunlight for prolonged periods of time, plants die and bacteria start to decompose these dead plants, using oxygen in the process. This process will lower the overall dissolved oxygen in the pond, and if snow and ice conditions persist for a long period, dissolved oxygen can reach critically-low levels and fish may die.



A summer fish kill occurs when a pond stratifies for an extended period, causing low dissolved oxygen in bottom layers. If the bottom layer is large, and is then mixed by wind or a storm event, the overall low oxygen level in a pond can kill fish. Illustration by Jade Laymen.



A winter fish kill occurs when snow and ice block sunlight, causing plants to die. Bacterial decomposition of dead plants depletes dissolved oxygen in the entire pond, killing fish. Illustration by Jade Layman.

There are a few things you can do to try and prevent fish kills in your pond. First, you can tell when fish are being deprived of oxygen — they will be near the surface, gasping for oxygen. Under extremely stressful conditions, you might find them jumping on the bank. If you see fish gulping at the water's surface, it is a good indicator your pond has low dissolved oxygen. In most cases, these events will be relatively minor and it is best to just "ride it out." However, some pond owners have chronic fish kills because of shallow water, muddy ponds or excessive nutrients. The best way to combat these chronic fish kills is by adding some type of aeration or water circulation. However, it is important to start these devices in the spring before a pond stratifies, and continue running them until water temperatures start to drop in the fall. Adding aeration or circulation once a pond is severely stratified will most likely prolong the fish kill by mixing low oxygen water from the bottom with the rest of the pond.

Aerators create surface agitation to promote the transfer of oxygen between water and air, as well as generating a small amount of circulation in the pond. You may also install more advanced circulation systems that pump deep water to the surface, promoting water circulation and minimizing stratification and critically-low dissolved oxygen in deeper parts of the pond. In the winter, an aerator is also helpful in preventing ice from forming and the accumulation of snow. You may also remove snow from the ice to allow sunlight to penetrate. Be cautious when performing this task; you want the ice to be at least 4 inches thick before walking on it. These options can help with oxygen distribution throughout your pond year round and prevent fish kills.

FISH DISEASES AND PARASITES

Fish are susceptible to a wide range of diseases and parasites, which are a natural part of the pond ecosystem. It is uncommon to see a large number of fish killed due to disease. Disease and parasite outbreaks are often associated with severe stress, such as changing environmental conditions or poor water quality.

Diseases are more common in the spring when fish have lived through the stresses of the winter. The best way to determine if your fish are diseased is to catch and examine them for unusual signs on the skin. Examples of common diseases are yellow grub, black-spot and white-spot disease. These are parasites that appear as spots or marks on the fins, gills, skin and fillets of fish which can be found on fish year round.

One form of control for these parasites is the introduction of redear sunfish. Redear are prolific consumers of snails, which are intermediate hosts for many parasites. Redear sunfish cannot remove parasites from existing diseased fish, but they can help prevent the further spread of disease.

Lymphocystis is a viral disease that is commonly seen when fish are stressed for extended periods of time. It causes a yellow or white wart-like growths on the fish's body. This disease is similar to a cold-sore in humans because it may subside only to return again. Luckily, lymphocystis does little harm to the fish. Bacterial fish diseases can occur when environmental conditions are unfavorable. No control is available for bacterial problems in ponds; but fortunately, these infections rarely reach epidemic proportions.

Most fish diseases and parasites are harmless to humans.

Many parasites and bacterial diseases are visible on the outside of the fish, on the gills, or on the organs of the fish. Always examine your fish and take note of any unusual markings, spots, or sores. In most cases, fish diseases or parasites do not transfer to humans, so there is no serious risk with consuming diseased fish, particularly if these fish are cooked.

A bluegill with common "yellow grub" on the tail, anal and pectoral fins. These yellow dots are caused by a parasite and rarely have negative impacts on fish populations. These parasites cannot transfer to humans.
Photo by Dave Osborne.

Conclusion

Most people incorrectly assume that a pond will take care of itself with little management. A pond requires a great deal of care if one expects to use it for fishing, swimming, or other recreational uses. It often requires human intervention to keep the pond healthy and balanced. Unfortunately, the natural forces of erosion, small and large plants, fish populations, and water chemistry are constantly interacting with one another, making proper management extremely important. We hope that this guide has provided enough information for you to take action so that your pond meets your desired goals.

Assessing fish populations and following a management plan, including selective harvest, is essential to creating a balanced pond that can provide many years of good fishing. For more information on creating your pond management plan, visit https://extension.purdue.edu/pondwildlife, or contact Dr. Mitchell Zischke at mzischke@purdue.edu.

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Additional Resources

A Length-Categorization System to Assess Fish Stocks. Authored by Gabelhouse Jr., D.W. 1984. North American Journal of Fisheries Management, 4:273:285.

A Revised Standard Weight (Ws) Equation for Channel Catfish. Authored by Brown, M.L., Jaramillo, F., Gatlin III, D.M., and Murphy, B.R. 1995. Journal of Freshwater Ecology, 10:295-302.

Fisheries Techniques: Third Edition. Edited by Zale, A.V., Parrish, D.L., and Sutton, D.M. 2013. American Fisheries Society. 1009pp.

Indiana Division of Fish and Wildlife's Animal Information Series – Channel Catfish. 2012. Indiana Department of Natural Resources, Division of Fish and Wildlife. 3pp.

Indiana Fish Pond Management. Indiana Department of Natural Resources, Division of Fish and Wildlife. 24pp.

Managing Michigan Ponds for Sport Fishing. Authored by J.D. Schrouder, C.M. Smith, P.J. Rusz, R.J. White & D.L. Garling, 2015. Cooperative Extension Service of Michigan State University. 69pp.

Managing Mississippi Ponds and Small Lakes: A Landowners Guide. 2015. Extension Service of Mississippi State University. 51pp.

Managing for Large Bluegill. 2012. Missouri Department of Conservation, Aquaguide, 4pp.

Ohio Pond Management Handbook: A Guide to Managing Ponds for Fishing and Attracting Wildlife. Authored by M. Austin, H. Devine, L. Geodde, M. Greenlee, T. Hall, L. Johnson & P. Moser, 2015. Ohio Department of Natural Resources, Division of Wildlife, 42pp.

Providing Structure for Fish in Private Ponds, Indiana Department of Natural Resources, Division of Fish and Wildlife, Indiana Department of Natural Resources, 8pp.

Stock Density Indices: Development, Use, and Limitations. Authored by D.W. Willis, B.R. Murphy & C.S. Guy, 1993. Reviews in Fisheries Science, 1:203:222.

Stocking Fish in Indiana Ponds. Authored by T. Tomlinson, M. Zischke, J. Brooke, F. Whitford, D. Osborne & J. Ferris. Purdue University Extension, Department of Forestry and Natural Resources, and Purdue Pesticides Program, FNR-569, PPP-125, IISG19-RCE-BRC-060, 8pp.

Variable Responses of Channel Catfish Populations to Stocking Rate: Density-Dependent and Lake Productivity Effects. Authored by Michaletz, P.H. 2009. North American Journal of Fisheries Management, 29:177-188.

What Killed the Fish? Using Observation, Sampling, and Science to Solve the Mystery. Authored by F. Whitford, J. Becovitz, B. Robertson, B. MacGowan, G. Blase, B. Avenius, J. Donahoe, D. Zimmerman & A. Blessing. 2009. Purdue Extention, PPP-79.

Photo by Ryan Hagerty, USFWS

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