Seasons of the Pond

The nature of ponds throughout the year.

By Stephen M. Meyer

Ponds live by seasonal rhythms. The water, its microscopic life, insect residents and visitors, aquatic and bordering plants, fish, and, yes, even the pondkeeper respond to the repetitive cycle of seasons. Of course, the scope and magnitude of seasonal changes are less pronounced as you move south, but the underlying cycles of pond life never completely disappear.

These seasonal rhythms are the foundation of pond ecology — the ways in which the biological and non-biological elements of the pond interact — and therefore must also be the foundation of good pond keeping. In this article I describe some of the key rhythms of natural and ornamental ponds. Learn to recognize them, understand what they mean, and use them to enhance enjoyment and management of your pond.

Winter Tranquility
No matter where you live, winter is a time of relative tranquillity in and around the pond. The combination of lower temperatures and shortened day light (photo-period) lulls pond life to rest.

Fish Under Ice

Does fish load matter? Consider that goldfish and koi consume about 10 mg (milligrams) of oxygen per hour per kilogram (kg) of body mass. Now, let's examine what happens in a 2000-gallon (about 7500 liters) pond.

Sealed with ice, we will assume that the oxygen concentration is near saturation: 12 mg/l (liter). So we have a store of 90,000 mg of oxygen. The 70 percent (very high) extractive efficiency of carp means that about 63,000 mg will be available for use. How large a fish load can the pond support until the animals die of hypoxia (lack of oxygen)?

If the ice cover lasts from December through February — 90 days — then 700 mg of oxygen are available for each day, or 29 mg per hour. If 10 mg are needed per kg of fish, then slightly under 3 kg of goldfish or koi could last until the ice cleared. This is roughly a half dozen 12-inch koi or two dozen mature goldfish.

Of course, this back-of-the-envelop calculation did not take into account other oxygen consumers in the pond, such as decomposing bacteria. It also neglects the very real likelihood that disturbances during these 90 days will rouse the fish and increase oxygen consumption.

Then too, this calculation takes the fish right to the edge of oxygen depletion. A more realistic number might be two koi or eight goldfish. You can choose to not believe these numbers, but your fish will be the ones to suffer.

In the northern U.S. and across Canada a thick ice cover forms. Below, the waters are cold, dark and still. Biological processes — from bacterial decay to fish metabolism — are running on idle (although never completely stopped). Even in regions where ice does not form a noticeable calm envelops the pond for several months.

The ice cover floating on the surface blocks normal gas exchange between the pond and the air. This can spell big trouble for ponds heavily loaded with fish because dissolved oxygen concentrations can drop too low to support fish respiration, or carbon dioxide concentrations can climb to levels sufficient to put the fish to sleep (permanently).

Fortunately, colder water holds more dissolved oxygen. For example, a pond at 40 degrees Fahrneheit will hold about 40 percent more oxygen than at 68 degrees Fahrenheit. So, just before the ice forms the pond water will be loaded up with oxygen. Your fish appreciate this.

The many metabolic and decay processes that consume pond oxygen (and generate carbon dioxide) are slowed substantially by the cold. Oxygen consumption rates for wintering fish and other pond animals are just a fraction of summertime rates. In winter, goldfish will consume less than 10 milligrams of oxygen per kilogram of body weight per hour. In summer the figure is about five times greater. Thus, in winter the pond oxygen supply is highest and demand is lowest. That is how the fish make it through the winter.

The most common pond fish — koi and goldfish — have especially high oxygen extraction efficiencies while at rest. Animal studies have found that goldfish can use about 75 percent of the oxygen available per volume of water, whereas trout may be able to use less than half this percentage. This means that when left undisturbed, goldfish and koi can survive in conditions of low dissolved oxygen.

Conversely, koi and goldfish are fairly inefficient oxygen users while active: only about 35 percent of available oxygen is utilized. Other studies have shown that resting goldfish in winter demand only 5 percent of the oxygen needed by active goldfish in winter. This is because all of their metabolic process rates — including disease-fighting processes — are drastically reduced. The implication of this and the preceding observation is that any disturbance of pond fish that results in increased alertness and swimming during mid to late winter in ice covered ponds can kill your fish within a few hours. The higher the fish load the earlier the danger period arises in the winter.

Of course, all the other living things inhabiting your pond are also idling. In particular, the bacteria that detoxify ammonia are not doing much of anything once the water temperatures drop into the low 50s (Fahrenheit).

Fortunately, the fish are not producing significant amounts of ammonia at this time (unless the pond is overloaded or the fish are disturbed frequently), so this reduction in nitrification is usually inconsequential. Decomposing bacteria are either shut down or working very leisurely.

Pathogenic organisms, including large parasites, are also inactive or exist only in immature (egg) forms. Thus, the fish are safe despite reduced immune functions.

Another winter effect is pond water stratification. In general, colder water is heavier per unit volume. That is, it's more dense than warmer water.

But one of the miracles of nature is that once the water temperature drops to 40 degrees Fahrenheit the water starts to get lighter (less dense) again — this is why ice floats on water. Thus, after the ice forms, bottom water tends to be several degrees warmer than water at the top of the pond. Even shallow (18 inch) ponds exhibit stratification.

Last winter I measured water temperature a few inches below the ice at 36 degrees Fahrenheit and 18 inches down at 44 degrees Fahrenheit. This is quite significant for koi and fancy goldfish, which do not tolerate very low water temperatures well.

Thus, pond fish will tend to settle in at the bottom of the pond and often bury themselves in silts and leaves. Frogs and turtles burrow in to the soft mud and silts. The burrowing serves several purposes. First, it offers protection from predators. Second, it buffers the animals from currents and environmental disturbances that might require compensating energy expenditure. Third, it is literally warmer down there.

Some Pond Management Suggestions for Winter

1) The danger of fish suffocation or asphyxiation from prolonged ice cover is a serious one. One way to provide some breathing space — literally — is to slightly lower the pond water after the winter ice cap has formed. Dropping the water level about 1 inch below the ice will create an artificial lung allowing CO_2 to escape and permitting some oxygen to replenish supplies in the water.

2) You can also keep an ice-free area open at the surface by using a series of high-wattage pond de-icers with thermostatic controls.

3) Breaking the ice cap or maintaining water movement with pumps or bubblers are bad ideas. Both will force your fish into an active cycle, causing them to consume internal fat reserves, demand higher levels of oxygen and utilize oxygen less efficiently. Circulating under-ice pond water also removes the temperature stratification and chills all the water down to the lowest temperature.

3) Keep fish density low. The fewer the fish in the pond the greater the odds that they will all overwinter successfully. (See the sidebar entitled "Fish Under Ice.")

Changes of Spring

Spring is perhaps the most dynamic of the pond seasons. A fascinating array of biological and non-biological events take place during this time, all of which the pondkeeper should be aware. The events are linked to the warming temperatures and lengthening photo-period.

As the ice melts away the first thing you may notice is that the pond water begins to get "murky" — in contrast to the crystal clarity of the winter water. This is a sign of bacterial and phytoplankton blooms.

A new cycle of pond life is starting up, beginning with the microscopic inhabitants. Warmed by sunlight and increasing water temperatures, the decomposers start to break down organic material on the pond floor and suspended in the water. This releases nutrients and energy locked up in the dead organic matter. The decomposers consume oxygen and release carbon dioxide and ammonia as wastes.

Meanwhile algae start to grow as a result of amazing recipe of sunlight, carbon dioxide and ammonia. As almost all pondkeepers come to learn that this is when the pond turns green — bright, impenetrable pea-soup green. Algae and bacteria form the base of the pond food web, and warming temperatures stimulate the birth of microscopic and macroscopic herbivores and subsequently, carnivores.

Unfortunately, pathogenic bacteria and parasites also begin to burst forth at this time. As nature would have it, these disease-causing pests get going several weeks (at lower temperatures) before fish immune systems begin to pick up. This is when fish are especially vulnerable to disease and infestation.

Depending on the local weather and the stocking density of the pond, the headstart that some parasites — such as anchor worm and fish lice — get can be so substantial that they plague the pond for the rest of the year. Only the advent of winter produces a lull.

The acceleration of pond biology along with the seasonal shift produces a gradual change in water chemistry. As already mentioned, dissolved oxygen levels begin to drop as demand for oxygen increases and water temperatures rise. pH is also likely to decline because the processes of decomposition tend to acidify the water, as does the growing quantity of fish waste produced.

At the same time, algae blooms may create wide diurnal fluctuations in water chemistry. Dissolved oxygen may peak above saturation levels by mid day due to heavy rates of photosynthesis, only to plummet precipitously as algae respiration sucks the oxygen out of the water during early morning hours. This is the time when most large fish are in the greatest danger of hypoxia.

Moving in rhythm with daily oxygen fluctuations, pond pH levels may gyrate wildly as carbon dioxide levels change. pH could be 8.2 at noon when plants remove CO_2 from the water and 6.2 at four in the morning when they dump it back into the water.

As water temperatures rise above 50 degrees Fahrenheit you will notice your fish begin poking around for food. Accelerating metabolisms need energy, so the fish graze lazily on pond algae adhering to pond walls and around the base of pond plants.

They will also scavenge along the pond floor, eating dead insects and plant material. These natural aquatic foods are composed mostly of water and therefore cause few problems in the still tentative digestive systems of awakening fish.

Aquatic insects — chewers and shredders — begin their work chomping on the leaves and other debris that fell into pond during the fall and winter. These animals are essential for pond ecology because their chewing and shredding creates openings in the tough leaf and wood surfaces. Without their efforts much of the organic matter in the pond would be unavailable to the decomposers.

A rite of spring is, of course, breeding. Everything from the tiniest microbes to the largest local mammals begin to reproduce.

Aquatic plants begin putting out soft shoots. The first vertebrate breeders in the pond may not be true aquatic species at all. Wood frogs and tree frogs spend almost all of their lives on land, although they return to ponds to breed. During winter they hibernate in the forest leaf litter or under tree bark (aquatic frogs hibernate in the pond floor).

Look for wood frogs as soon as the ice begins to recede from the pond edge. Tree frogs follow several weeks later. (The chances of having these animals breed in your pond are much greater if you do not keep fish in the pond over winter and return them in late spring. Fish eat frog eggs.)

Similarly, several species of salamanders may adopt your pond as a breed place. They will show up in early spring.

And your pond fish will certainly get into the act, although fish tend to breed later in the spring. After regaining some body mass, goldfish and koi begin spawning tussles in response to lengthening day light as spring advances. Spawning may extend into the early summer. Be careful not to mistake a fat female loaded with eggs for a diseased fish. Egg carrying often looks a lot like "dropsy."

Some Pond Management Suggestions for Spring
1) Do not handle, move or otherwise stress your fish during this period. Any stress — especially handling — will greatly increase the advantage of pathogens at a time when fish immune systems are least capable of coping with disease organisms. Avoid taking your fish to shows and competitions at this time.

It would be wise to put off cleaning out leaves and debris until the at least the late spring or early summer. Having the fish dart around the pond within a few days or weeks of just beginning to feed is a sure way to kill them. The leaves and other matter in the pond are not harmful.

2) Keep the fish density low. The fewer the fish and the smaller the fish load, the lower the odds that fish pathogens will find new hosts, take hold in your pond and plague your animals.

3) Start your aeration/circulation system and biological filter (if you have one) as soon as the ice clears. Circulation will reduce the diurnal fluctuations in pond dissolved oxygen, pH and carbon dioxide, thereby providing more stable water quality for the fish. Stability is very important at this time, even if the parameter values are not optimal (such as a low pH). (You may notice a foul smell during the first 24 hours after the circulation system has been restarted. This is sulfur and methane byproducts from decomposition. Your fish will not be bothered.)

4) Partial water changes should be carried out slowly and gently so as not to spook the fish. Replacing 10 to 20 percent of the pond volume weekly after the ice clears is a good policy.

5) Do not begin to feed commercial foods until water temperatures remain above 50 degrees Fahrenheit day and night. Par-boiled vegetables, such as peas, are acceptable in very small amounts. The best situation, however, is to allow the fish to graze on plant material — especially attached algae — that grows naturally in the pond. For this to work you need to be relaxed about the "cleanliness" of your pond and you must maintain a low fish load.

6) When spawning begins remove any sharp objects from the pond. Pad hard features with spawning mats, mop pads and so on to protect the fish from injury and to capture the eggs.

Hot Times in the Summer
If spring is a time of rapid change, summer is a season of stability and beauty in the pond, stimulated by long hours of daylight and warm temperatures. Plants have filled out with leaves, showy water lilies paint the water's surface and iris wave in the breeze. Frogs and turtles bask in the early morning sunlight to jump-start their digestive tracts. Dragonflies patrol along the pond edge looking for mosquitoes. Fish plump up as they gulp furiously for food.

Intense solar illumination and long periods of hot weather cause water temperatures to soar. In well shaded ponds with water circulating over aerating waterfalls or down pebble streams the water temperatures hover around 72 to 78 degrees Fahrenheit. Ponds lacking shading and with minimal circulation can reach temperatures of 86 degrees Fahrenheit or more. This is far too high for healthy rearing of goldfish and koi or other native aquatic animals.

Weeks of warm weather mean that the nitrifying bacteria on the pond walls, plant surfaces and in biological filters have hit their stride — the pond water should be free of ammonia and nitrite. The planktonic algae that plagued the pond in spring and reduced visibility to zero is now just a faint greenish tint. These algae thrive on ammonia (not nitrate), and if the nitrifying bacteria are doing their job there should be precious little for the algae to consume. The reduction in the phytoplankton correspondingly reduces the diurnal fluctuation in pH, oxygen and carbon dioxide concentrations.

Similarly, decomposing bacteria and fungi are hard at work reducing pond litter to a fine silt. Pathogenic bacteria and parasites are also in full swing. This is the most likely time to notice a real infestation, even though careful examination in the late spring would have revealed the problem in a more timely manner.

Insect, bird and mammal activity around the pond is intense during the summer months. The pond is, after all, a permanent water feature that animals can count on (unlike Mother Nature, you never let it go dry — certainly not if you've stocked it with $1500 koi!).

Morning, noon and night critters of all types visit the pond. If you have not bothered to check in and around your pond by

flashlight at two in the morning you are really missing out on a great experience. I can guarantee that you will see more than sleeping fish (yes, fish sleep).

Some Pond Management Suggestions for Summer
1) Monitor water temperatures. In southern locations the pond should be shaded to prevent severe overheating. Whether you use tree canopy, aquatic plants (lotus and water lilies), an artificial canopy or some combination is your choice. The key is to moderate and stabilize water temperatures.

2) An aeration system — a cascading waterfall or a rocky stream bed — should be integrated into your pond design. This is essential for keeping dissolved oxygen levels up.

3) Maintaining water circulation rates between one-half to one pond volume per hour flowing over a waterfall or down a rocky stream bed can aid greatly in stabilizing water temperatures.

4) If you have a true disease problem in your pond this is the best (actually the only appropriate) time of the year for treatment. Pathogen response to treatment is good and fish immune systems are operating effectively.

5) Summer is a time to enjoy the beauty and vitality of your pond.

Patterns in Fall
Fall returns us to a pattern of transition. Days grow shorter and air temperatures drop, especially at night. Even before the leaves start to turn color the fish respond by cutting back on feeding. Fish-produced ammonia drops.

As the water chills, Nitrobacter — the bacteria that detoxify nitrite — stop working before Nitrosomonas (which control ammonia) do, so nitrite levels might begin to inch up slightly in the pond. Here algae is the pondkeeper's friend because both attached and planktonic algae remove substantial amounts of ammonia, making it unavailable for nitrite-producing Nitrosomonas bacteria. Nevertheless, heavily stocked ponds can see dangerous levels of nitrite at this time.

The changes in photoperiod and temperature signal plants to begin to prepare for winter. Tiny cells along leaf axes close off water flows from the stem to the leaves, which then shuts down photosynthesis. As chlorophyll production ends the leaves revert to their natural colors: mostly yellows, with some reds, browns and purples. Eventually, leaves drop into the water and come to rest on the pond bottom.

Some chewers and shredders begin their work now, preparing the way for the decomposers. But much of the real work is left for spring. (I usually do not remove leaves from my ponds unless their is an unusually large accumulation — such as after a hurricane. Huge masses of leaves coat the pond floor from October through May, providing hibernating shelter for frogs, aquatic insects and other residents. By July all that is left is a fine silty organic layer.)

Many fish parasites drop their final batch of eggs at this time, seeding the pond floor with next year's generation. Nothing like something to look forward to in the spring.

Some Pond Management Suggestions for Fall
1) Monitor fish food consumption carefully. Cut back on food rations when the fish show reduced interest. Don't feed the pond food that will only cause water quality problems later on.

2) If you are managing a pond heavily stocked with fish you should be vigilant about removing fallen leaves. The process will not bother the fish now and it will reduce the demand for oxygen in the pond during the spring. It may also remove some fish parasite eggs.

3) As the fish become more sedentary examine them for signs of disease and parasites. Treatment is not effective in the cold ponds of late fall or winter. You might consider removing unhealthy individuals for indoor treatment over winter.

Conclusion
The seasonal rhythms of ponds represent a unique aspect of this form of fish keeping. From both an aesthetic and a management point of view the annual cycle of a pond should be first and foremost in the thinking and planning of the conscientious pond keeper.

I know it is for me, for here I sit in early November contemplating moving all my koi indoors tomorrow. This is a two-day job of preparing the circulation and filtering system, pumping thousands of gallons of water into the basement, corralling 20 large koi and carting them across the yard in 8 gallons (64 pounds) of water. This also involves moving 16 cubic feet of

biologically active filter media from the outdoor facility to the indoor filter.

Each year the fish get heavier — and I get older. Fortunately, I have the winter to rest before I have to bring them back out in the spring. Maybe it will be a long winter.