Fish Aquarium Lighting Systems

Get a complete rundown of fish aquarium lighting systems.

By Timothy A. Hovanec, Ph.D.

I have been in the aquarium hobby for more than 40 years, first as a kid with what my parents considered to be too many aquariums, then as a hobbyist with more tanks in my second-floor apartment than probably was safely prudent, and for the last 14 years as the head of aquatic research for a major aquarium equipment manufacturer. During this time, many facets of the biology and chemistry of the aquarium hobby have been thoroughly investigated and explained.

However, one area of the hobby where success almost still seems to be based more on luck and/or magic rather than science is aquarium lighting systems. Success with lighting is influenced by many variables, from tank size and shape to aquascaping choices to how filtration is set up to the size and number of fish. For some aquarium setups, correct lighting is the difference between success and failure, whereas for others, lighting is purely for aesthetics. The goal of this article is to introduce you to some of the basic lighting terminology and types of lighting systems. With this information, you'll be ready to consider if you'll need to change or upgrade your lighting system for your current tank or the next one.

What is light?
The simplest definition is that light is energy, and this energy runs almost every ecosystem on earth. Light is captured by primary producers (organisms that convert carbon dioxide into biomass), such as plants and algae (and some bacteria), and converted to food for other organisms and so on up the food web.

Aquariums are indoors and thus are generally removed from direct sunlight. An aquarium lighting system is meant to at least partially substitute for the lack of sunlight. If nothing else, light on the aquarium is needed to see the inhabitants within - an aquarium without light is an unappealing dark box. But with the growing popularity of reef aquariums and planted tanks (popular in Europe for decades), proper lighting became a necessity for success because these tanks are filled with primary producers that need light to survive and thrive.

The sun radiates a spectrum of light that ranges from ultraviolet (UV) light to visible light to infrared light. This spectrum is divided into wavelengths measured in nanometers (nm), and a nanometer is one billionth of a meter. The visible part of sunlight is only a small portion (about 25 percent) of the total light spectrum. The UV portion of the spectrum is absorbed by ozone and oxygen as it travels toward the earth.

Aquarists are most interested in the visible portion of the spectrum that ranges from 380 to 780 nm out of the spectral range of about 300 to 3,000 nm that bathes the earth's surface. The UV portion is important for disinfection in reef tanks and ponds (UV sterilizers) but is not important to our discussion here. White light contains all the wavelengths from 380 to 780 nm. When white light passes through a prism, it disperses into the wavelength groups that comprise the visible color spectrum. The light exits the prism in bands of colored light, starting with violet (400 nm) and continuing - as the wavelength gets larger - with blue (460 nm), green (520 nm), yellow (580 nm), orange (620 nm) and red (680 nm). Certain wavelengths are important to hobbyists wishing to maintain certain plants or corals.

Lighting terms
Lighting has its own terms, or jargon. A few basic terms will be introduced and defined at this point, so you can start to understand the language of lighting.

Color Number
This is more correctly called color temperature and refers to the absolute temperature in degrees Kelvin (K) of the light produced. This matters when trying to simulate the color of natural sunlight, which is about 5000K.

Lumens
A lumen is a measure of light intensity. It is the radiant energy from the visible portion of the light spectrum hitting a given area (typically a square meter) when the surface is the unit distance (in this case, 1 meter) from the light source. It is a way, in some cases, to compare one light source to another.

Lux
Lux is a measure of illumination: the illumination from all light sources hitting a surface from a distance of 1 meter. It is equal to lumens per square meter.

Full-Spectrum Light
This is a light source that emits all the wavelengths of the visible spectrum in proportion to that of natural sunlight. A lamp or bulb labeled full spectrum means that it emits light over the entire visible spectrum with a spectral output similar to that of the sun. Most lamps have technical data sheets providing a spectral chart that can be used to determine the intensity and color of the lamp.

Intensity
In many cases, this is the most important term to consider when determining a lighting system. One can have the right color temperature and full-spectrum lighting, but in most cases, success will be the result of having the right amount of light intensity for a given aquarium situation. Although for many aquariums, light intensity usually needs to be increased, there are cases when one can have too much intensity.

Intensity is usually related to the electrical consumption (in watts) of the lamp or bulb, and is measured in lumens. The more watts a lamp requires, the greater the light intensity. Most books on aquarium lighting give a formula or guide for determining the total wattage one should have over an aquarium. In some cases, this requires a large number of lamps. If lamps of higher wattage are substituted, the number of lamps can be reduced without sacrificing intensity. Furthermore, advances in light technology are making it possible to have greater light intensity in a relatively small area. For example, there are HO and VHO lamps.

High output lamps are labeled HO, and very high output lamps are VHO. Compared to a normal 24-inch lamp with an output of 20 watts, an HO lamp of the same length is 40 watts, and a VHO is 75 watts. So, one can have twice to more than 3.5 times the light intensity in the same fixture. For 48-inch lamps, the wattages are 40, 60 and 110 for normal, HO and VHO lamps, respectively.

HO and VHO lamps require special ballasts. Do not use them in standard fixtures with normal ballasts. Some applications for HO and VHO lamps are deep tanks, reef setups and plant aquariums.

Wavelength
An important term, especially in the context of lamp descriptions, such as full spectrum or peak wavelength. These terms refer to the wavelength output of a particular lamp or bulb. Actinic lights, for example, produce only light at a specific wavelength: 420 nm. This peak wavelength value, which produces a very blue light, is important for coral growth because during photosynthesis, chlorophyll A absorbs light near this wavelength (see the section "Lights for Different Setups" for further details about the different types of chlorophyll).

To promote photosynthesis in reef corals, actinic lamps are used. Other lamps have two or even three peak wavelengths.

Now, let's consider the various types of lighting available.

Incandescent Lights
In the beginning, aquariums were equipped with incandescent light bulbs. These were so hot that they heated the water (and sometimes burned the aquarist), while being rather inefficient - incandescent lights did not last long and consumed relatively large amounts of electricity.

Improved manufacturing technology has resulted in incandescent lights that last longer and do not consume as much electricity, but they're still not really the best choice for most aquariums. Many small tanks come with a bulb of 15 watts or less, which is fine, as long as one knows these bulbs are purely for illuminating the organisms in the tank, and not for contributing to the growth and health of any aquatic plants, much less species of soft or hard corals.

Fluorescent Lights
Fluorescent tubes or lamps are convenient for aquarium lighting manufacturers and hobbyists alike. They're more efficient than standard incandescent bulbs and don't produce nearly as much heat. Fluorescent lamps are filled with a special vapor, and the inside of the lamp is coated with phosphors. Turning the lamp on charges the vapor, which emits UV light. The UV light hits the phosphor coating, causing the lamp to produce visible light. Special use and various types of lamps are made possible by changing the coating material. By combining different phosphors or groups of phosphors, lamps can be made that emit light with certain peak wavelengths.

When fluorescent tubes first came out, there were not a lot of choices, but today one might argue the opposite: There are too many choices! To compound the confusion, a whole new set of fluorescent lamps has been coming onto the market in the last few years due to government regulations, making fluorescent light even more efficient and reducing national

electrical consumption. Although this will help everyone in the long run, for the short term there will still be intermixing of old-style fluorescents and new ones.

Generally, the new lamps will work in most old fixtures, but there can sometimes be problems getting the new lamps to fire up in some old or poor-quality units. If you are experiencing repeated problems with getting new lamps to work in your light fixture and the fixture is old, chances are you need to replace it.

Just to add another choice to the mix, there are also screw-in fluorescent lamps. These have a socket like a regular light bulb to fit in a standard light fixture, but the lamp is fluorescent, and thus cooler and more efficient. Some newer, smaller aquariums are equipped with these as standard equipment from the factory.

Metal Halide
Metal halide lamps are another choice and are common on reef aquariums. They produce a very intense light and have various color temperatures. Several fixture manufacturers combine metal halide lamps with fluorescents. For many reefkeepers, this has become the lamp system of choice. The halides produce a lot of intense light, and actinic fluorescent lamps provide light in a narrow wavelength good for photosynthesis.

Metal halides work well but do have some drawbacks compared to fluorescent tubes. They're less efficient than fluorescent tubes and can get very hot, which usually means you'll need to run a small fan to blow air across the lamps to take heat away from the aquarium water. In some cases, the addition of metal halides to your aquarium will necessitate adding a chiller to get water temperatures within an acceptable range.

Power Compacts
The latest lighting innovation is the compact fluorescent or power compact. Fluorescent lamps of this type look like the ends have been bent back together or, in some cases, twisted into a series of small spiral loops, one on top of another. A compact fluorescent lamp connects on only one end (as opposed to tubes that connect on two).

When power compacts first hit the market, there was a limited selection of lamp sizes, wattages and color temperatures. Now, there is an almost bewildering range of choices. To further complicate matters, there are several types of bases that the lamps fit into, along with 2-pin and 4-pin lamp configurations.

With all the different compact types available, it's easy to end up with the wrong one for your system when you try to replace a worn lamp. Probably the easiest way to not make multiple trips to the store when you need to replace your compact fluorescent lamp is to buy the same brand lamp as the original manufacturer of the light hood. While that can't guarantee success in all cases, it will eliminate most problems. Of course, you can also discuss makes and models with fish store personnel.

Any possible confusion caused by the multitude of available lamps is outweighed by the their advantages - chiefly, more light intensity from a fixture the size of a normal lamp, while producing much less heat. Several aquarium manufacturers are now using compact fluorescent lamps on small, integrated aquarium systems.

Although it's possible to construct your own lighting setup, there are numerous ready-made systems available to fit almost any size aquarium. If you feel you must build your own light system, please make sure you are qualified and include the necessary safety features.

General lighting guidelines
Most of the animals and plants that are kept in freshwater and marine aquariums come from the tropical regions of the world, so it's generally best to mimic the day length of these locations. Length of daylight varies little seasonally in tropical areas, being about 12 hours with an intense period of nine to 10 hours. One can use an automated system to turn on different numbers of lights (and so increase intensity) over the course of a day, but these systems are not necessary to maintain healthy organisms.

Another popular lighting setup is the so-called moon light system, which is designed to be on at night and provide low-light intensity similar to the moon over a coral reef. Again, while these provide a nice effect, they are not required for maintaining the organisms.

Keeping lights on for more than 10 to 12 hours per day is of no practical benefit and can cause algae blooms. It's best to buy an inexpensive timer and automate the light system. If you suddenly notice that your tank is being covered with a blanket of algae, check the duration of the lights. Perhaps the timer has failed, or someone plugged the lights directly into a wall socket.

Another cause for a sudden outbreak of algae growth is old lamps. Usually, lamps should be changed before they actually stop emitting light. The reason is that the color spectrum of a lamp changes as it ages. Although the lamp may still work, it does not emit light of the original wavelength. Lamps should be changed at least once a year but preferably every six to eight months.

Lights for different setups
There's no one correct lighting system for a particular aquarium setup. The choice of what to use can only be made by weighing the species mix of organisms and aquarium size against the depth of your pocketbook.

For instance, fish-only tanks need just a simple light system. The purpose of light is to show off the fish and tank setup. The final decision depends upon the hobbyist's individual taste. For tanks of 20 gallons and less, one fluorescent or compact fluorescent lamp is adequate. For 30 to 55 gallons, use at least two lamps. Add an additional lamp for each 20 to 25 gallons of water capacity.

A lamp with a temperature range of 5000K to 6000K is recommended, but many hobbyists prefer lamps that emit more red because they better highlight fish colors. This is fine, but these types of lamps will not promote plant growth. However, many people in the U.S. do not use live plants in their aquariums (a mistake, but that's another story), so this may not be a big concern.

On the other hand, plant tanks require the correct lighting to be successful. One of the most common reasons for failure in growing plants in an aquarium has to be the use of the wrong lamp. Plants have two types of chlorophyll: A and B. Chlorophyll A absorbs light at 405 and 640 nm. Chlorophyll B has peak absorptions at 440 and 620 nm. Plant lamps are designed to emit light at red wavelengths to duplicate the light of the sun, but too much red color can cause aquatic plants to grow tall and thin. For best results, use a daylight (5000K) lamp in combination with an actinic white or actinic day lamp. The actinic day or white lamp is a mixture of 50-percent actinic (blue light) and 50-percent daylight. In large or deep aquariums, consider using HO or VHO lamps. Just remember, intensity is important.

To have a successful reef aquarium, adequate light is absolutely required. Reef tanks typically contain soft and hard corals that harbor zooxanthellae (symbiotic algae), which must thrive in order for the coral to live. To do this, they need the correct amount of light (intensity) at the right wavelength (peak absorption). Actinic lights provide a concentrated light wavelength that promotes photosynthesis. If only actinic lamps are used, however, the water color in the tank will be very blue - which is not visually appealing - and the light will not be intense enough. Therefore a reef tank should have a combination of one actinic lamp and one or two daylight lamps for each 30 gallons of water.

The daylight lamp can be a metal halide bulb or daylight fluorescent lamp (preferably HO or VHO), or a compact fluorescent. As discussed earlier, the other popular type of reef lighting is to combine metal halide lamps with fluorescent lamps. Figure on one metal halide per 25 gallons of water for a successful reef tank. However, the species of corals do come into consideration.

These guidelines are only starting points for your lighting system. For most community aquariums, the lighting system that comes with the tank is adequate for showing off the fish and the tank. Only when considering whether to delve into more specialized setups, such as heavily planted tanks or marine reef aquariums, does one need to really worry about the lighting system. Before making a decision, read some more, and consider the opinions of others. There are many choices available, and most will work for a wide variety of situations. Good fishkeeping!

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