# Lighting Spectrum and Intensity: Duplicating Natural Lighting in Aquariums

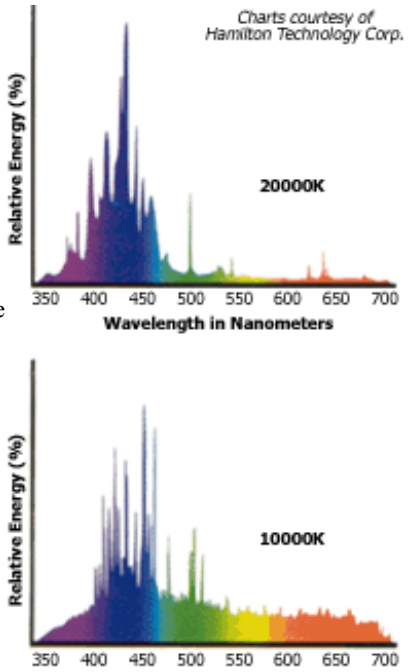
*Drs. Foster & Smith Educational Staff*

The lighting in an aquarium is responsible not only for the aesthetic value of the system, but also for the general health of the fish, plants, and invertebrates. The goal when designing a lighting system is to duplicate, as closely as possible, the conditions that these organisms are subjected to in nature. This has become an easier task due to the advancements made in lighting technology in the past 10 years. This article will explain the characteristics of light and how natural light can be duplicated in aquariums.

Measuring light characteristics

Light spectrum

The commonly used unit to measure the spectrum or "temperature" of light is called degrees Kelvin (K). Kelvin is a scale that has been developed to describe the color of light. It is based on the spectrum of light a "blackbody" would radiate at the corresponding degrees Kelvin. At 0 degrees Kelvin (equivalent to -273° Celsius), no light is emitted. As the blackbody warms, red light would start to be emitted. As the blackbody increases in temperature, the light would emit more yellow wavelengths. Warmer still, the light would consist of more green, blue, and finally violet wavelengths. A candle flame on the Kelvin scale has a rating of 1800 K. Sunlight at noon has a Kelvin rating of 5500 K. This light is typically referred to as full spectrum because it contains a blend of all colors throughout the spectrum scale. Remember, the lower the K rating, the greater the color of the light will lean toward the red side of the spectrum. The higher the Kelvin rating, the greater the color of the light leans toward the blue end of the spectrum and is said to have a higher color temperature.




In the natural environment, as light enters the water and passes through the first 15 feet of water, the red and orange wavelengths are absorbed by the water, increasing the K rating of the light, and giving the light a bluer appearance. As the light penetrates to the 30 foot mark, the yellow spectrum is absorbed. As the light continues past the 50 foot depth, the green wavelengths have been filtered out, leaving just the blue and violet wavelengths. This results in light with the highest Kelvin rating.

Light intensity

Light intensity can be measured at the source and at the surface which the light impacts.

Lux: The intensity of light which impacts a surface is described by an international unit of measurement called a "lux." It is the metric measurement similar to a foot-candle: 1 foot-candle equals 10.7 lux. The intensity of the sun on the water surface on the reef can reach values exceeding 120,000 lux, but due to the weather patterns and air quality, will average more in the range of 75,000 lux. As the light enters the water and the different wavelengths are absorbed, the intensity of the light diminishes. Water clarity is going to determine how fast the light degrades in the different aquatic environments. For example, the level of intensity on a reef with clear water will average about 20,000 lux at a depth of 15 feet, and 10,000 lux at 30 feet. Again, having an idea of where an organism lives in nature will give you an idea of the light intensity that will be required to maintain that organism in an aquarium. Lux meters are available and are relatively inexpensive, and can be used to both check your lighting for the intensities that are required, and to determine when bulbs in the system need to be replaced.

Watts: When most of us think of light intensity, we think of watts. When selecting a bulb for a reading lamp, for example, we know that the higher the watts, the more intense the light, and the more energy that will be used to produce the light. A 100-watt bulb will give off more light than a 40-watt bulb, and will cost more to use.

A watt is actually related to a lux. One lux is equal to 1.46 milliwatts (0.00146 watts) of energy of one specific frequency (555 nm) hitting a surface area of one square meter. However, since bulbs used in aquariums emit light of many frequencies, not just 555nm, there is not an exact formula that can be used when determining the number of lux produced by a bulb of a certain wattage.

Light spectrum and intensity in nature

There are a number of factors that affect the color and intensity of light in aquatic environments in nature. These factors include the depth and clarity of water, weather, and clarity of air. Because of these factors, and the fact that water conditions vary between habitats, the spectrum and intensity of light will vary from one aquatic environment to another.

Light spectrum and intensity for aquariums



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Fish-only aquariums

The function of the lighting system on a fish-only aquarium is to provide the fish with a simulated day and night cycle that is necessary for their overall health. Because the spectrum and intensity of the light are not as important as they are for an aquarium with plants or corals, the lighting system for this type of aquarium can be designed based upon other factors involving cost and aesthetics. When determining the cost of a lighting system, take into account not only the initial cost, but also the operating cost of the system. When budgeting, choose a lighting fixture that does not consume excessive amounts of electricity or the need for frequent bulb changes. A good rule of thumb for a fish-only aquarium is to allow 1 to 2 watts per gallon of water. A good choice for this type of setup would be either a standard or a compact fluorescent system. The spectrum of bulb chosen for this type of setup will only be determined by personal preferences. Generally, a lamp that is focused more on the red part of the spectrum (low K rating) will exhibit colors better than a lamp with a higher Kelvin rating. But, lamps with a low Kelvin rating tend to grow algae at a much faster rate, resulting in more maintenance. If your goal is to illuminate the aquarium with a color-enhancing bulb, you can avoid the excessive algae growth by either using a liquid algae destroyer, or by decreasing the number of hours in a day that the lights are on.

Freshwater planted aquariums

There are a few considerations that need to be made when deciding what type of lighting to install on a freshwater planted aquarium. These considerations are; intensity and spectrum of light, initial and operating costs, and the heat generated by the lighting system.

Most of the freshwater aquatic plants that are available on the market originally came from the shallow tributaries and rivers of Central and South America. The water clarity in these areas is typically murky to stained. Because of the shallow waters that these plants come from, the spectrum of light that they are subjected to is going to be in the full spectrum range, similar to natural daylight. This range on the Kelvin scale is between 5500 K to 7500 K. The intensity of light that the various plants require is going to vary due to the contrasting water qualities in that part of the world. A general guideline to follow when customizing a system is to provide between 2 and 5 watts per gallon depending on the species of plant to be kept.

The initial and operating costs vary widely among the different types of lighting, as well as the type of ballast used with that lighting system. Again, it is often a better idea to buy the system that may be more expensive in the beginning, but is less expensive in electricity usage and bulb replacement. Also, when considering a particular lighting system, make sure that bulbs are available for that system in the proper spectrum range. Some lighting systems are targeted specifically towards saltwater reef aquariums and full spectrum bulbs may not be available.

Last, the heat generated by most of the more powerful lighting systems is considerable, and has to be addressed in the installation of the system. Cooling fans and possibly a water chiller may be needed to maintain the aquarium at the proper temperature. Room temperature also plays a big role in aquarium temperature and needs to be addressed along with the heat developed by the lighting.

Once you have decided on a lighting system, you can then research the different types of plants that are available. Base your decisions on the type of plants that you wish to incorporate into the system by the amount of light that you can provide for those plants.

Saltwater reef aquariums

The type of light provided for a saltwater reef aquarium is very important due to the fact that the photosynthetic corals and invertebrates that live in the system rely on light for a major portion of their nutritional needs. The intensity of light that corals and invertebrates require varies dramatically. This is due in part to the varying landscape of the reef and the adaptations that many corals have made to survive in low light conditions. If the correct spectrum and intensity of light is not provided for these organisms, their survival rate will be poor.

Most of the corals that are collected for the hobby come from areas surrounding the reef at a depth of 15 to 65 feet. In the wild, they receive light that is primarily blue in color with a high Kelvin rating.

As with any aquarium, when considering different types of lighting, both the initial and operating costs, intensity and spectrum of the lighting, and the heat that is associated with the unit must be considered. Due to the high costs involved with lighting systems for reef aquariums, they tend to be one of the major expenses of the installation. Not only is the initial expense high, but also the amount of electricity needed to run these systems. Also, depending on the type of lighting, the regular bulb changes can be very costly and will add to the operating costs.

A general rule, to correctly light a reef aquarium that is 24" deep or less, provide between 4 to 6 watts of light per gallon. Of course there are exceptions to this rule. Aquariums that are shallow, 16" or less, do not require the intensities of taller aquariums. Also, a reef aquarium could be set up to house both corals and invertebrates that require low levels of light, as well as non photosynthetic invertebrates.

Because of the conditions in nature, all invertebrates have adapted to use light that is from the blue side of the spectrum. There are bulbs available for most lighting systems that focus on this wavelength. For example, fluorescent systems offer bulbs that are strictly blue in color. These bulbs are called actinic. Although most corals and invertebrates can be successfully grown under blue light, this type of setup may not be pleasing to the eye. So, most systems will employ actinic bulbs for the health of the system in conjunction with another light source that is mostly white in color for aesthetics. A general rule for



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reef aquariums is to provide approximately ½ of the light from actinic bulbs and ½ from bulbs producing white light in the range of 8000 to 12000 K. This mixture of lighting provides the invertebrates with the spectrum that is necessary for growth, and produces the spectrum that is necessary for accurate color rendition within the aquarium.

The heat that is associated with the lighting systems designed for reef aquariums is substantial and needs to be addressed prior to the installation. Typically, wattage is translated into heat no matter what type of lighting it is. But, there are two types of heat involved. The first type of heat is in the air surrounding the bulb, which can be removed with the use of fans. The second type of heat is the radiant heat that is produced by the lighting system. This heat, unfortunately, is absorbed by the aquarium water and cannot be removed with the use of fans. Because of this radiant heat that is produced by all of the more powerful lighting systems, it may be necessary to consider the price of a water chiller when determining the cost of the system.



As with planted aquariums, base your decisions on the type of corals and invertebrates that you wish to incorporate into the system by the amount of light that you can provide for them.

Conclusion

When budgeting and designing an aquarium, research lighting requirements to provide the inhabitants with the spectrum and intensity of light that they receive in nature. By duplicating these conditions, we greatly increase both the survival and growth rate of these organisms, while portraying that ecosystem in a more realistic manner.



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