Why Use Blue Light For Underwater Fluorescence Rather Than UV Light

Scientific analysis and experience shows us that blue excitation light is better at causing fluorescence than Ultraviolet (UV) light. No one wavelength of light will make everything fluoresce, and indeed UV can and does make some creatures fluoresce …. just not as effectively and efficiently as monochromatic blue light in the vast majority of cases. This white paper will endeavor to explain why that is. A number of torch manufacturers offered UV torches for fluorescence diving early on but it has been shown time and time again to lack the qualities and effectiveness of blue light so there are very few sources who still produce UV torches.

We are all familiar with UV or what's more generically called "black light". Posters, T-shirts, displays in night clubs, museums etc. are all designed to provide maximum light emission in the UV range. Corals and other sea creatures are not! Why is that?

Consider this: 95% of all UV light from the sun is reflected off the surface of water. This by the way is why you get such bad facial sunburn if you sit on the surface for even a few extra minutes waiting for the dive boat to pick you up on a bright sunny day. You are getting direct sunlight on your face from above and very nearly a double direct dose from below your chin. The remaining 5% of UV light only penetrates about a meter or two below the surface.

Now think back to your entry level Open Water Scuba class. We all learned that below, about 10 meters / 30 feet, the only light left is blue. Hence the need for strobes, video lights or red color correction filters when doing standard underwater photography past just a few meters of depth.

From an evolutionary standpoint, the only light available for eons of time for sea creatures to evolve in has been blue light. Many theories abound as to why some sea creatures actually do fluoresce but that discussion transcends this one. Suffice it to say that many do and they only have blue light to do it with.

Dr. Charles Mazel a noted marine biologist did much of the contemporary scientific work on determining which wavelength(s) of light cause the greatest spectral emission of sea creatures in the 1980's and 90's. Much earlier work had been done in the 1920's by Charles Phillips and the fluorescent effect was actually discovered in the 1830's by Irish physicist Geo. Stokes. This process is called the Stokes shift and actually relates to quantum mechanics, the topic for a different paper. This is not "new science"!

Subsequent study and analysis has been done by Lynn Miner and Steffen Beyer of FireDiveGear.Com to "fine tune" the light sources and associated filters to provide the greatest efficiency and provide maximum color saturation for fluorescent viewing and photography.

Much of Mazel's work consisted of "collecting fluorescing corals in the field and bringing them back to the laboratory to measure their fluorescence properties." His work centered on measuring what the exact distribution of wavelengths of light coming off the illuminated subject is (the emission spectrum) with the use of a spectrofluorometer. This is a laboratory instrument that measures the excitation spectrum (the light emitted from the target after being excited).

When he started measuring excitation spectra he created graphs like Figure 1. By looking at the spectrum of light that was emitted it is apparent that blue light was more efficient at making the organism fluoresce. A recent replication of Mazel's work is shown below.

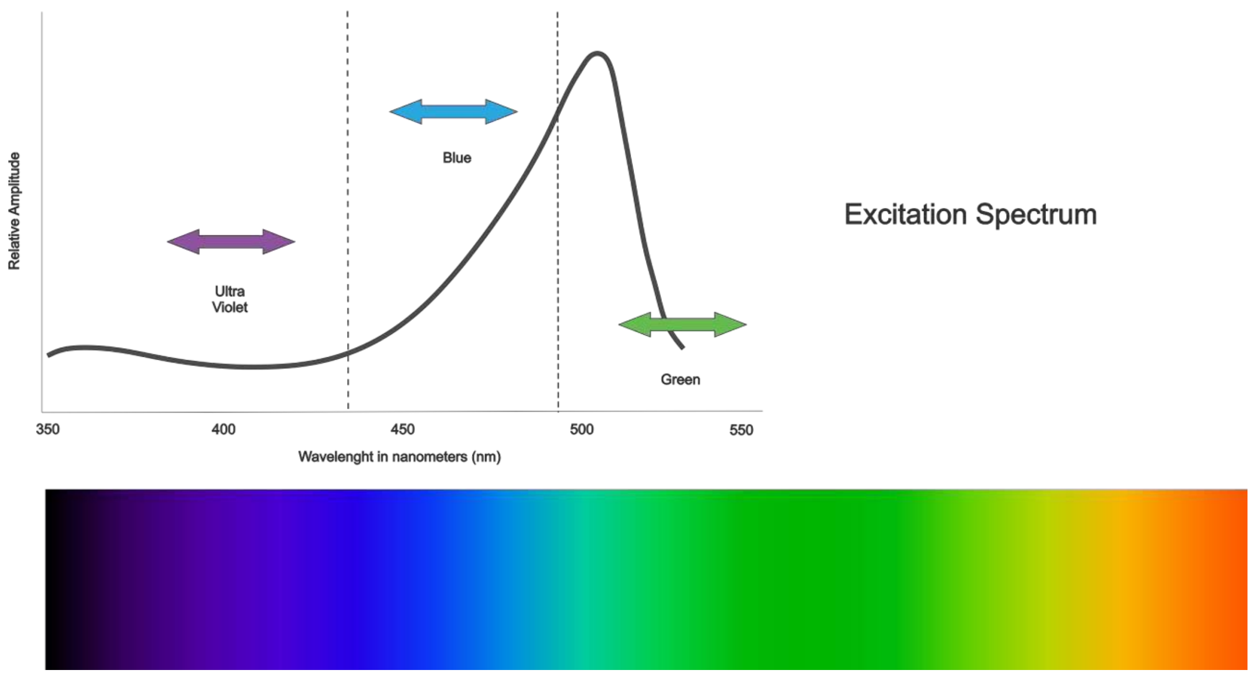


Figure 1

The plot in Figure 2 below shows what we might expect if we illuminated the coral with equal power densities of UV and blue light. We expect a more intense (brighter) return from blue rather than ultra violet and that is exactly what occurs.

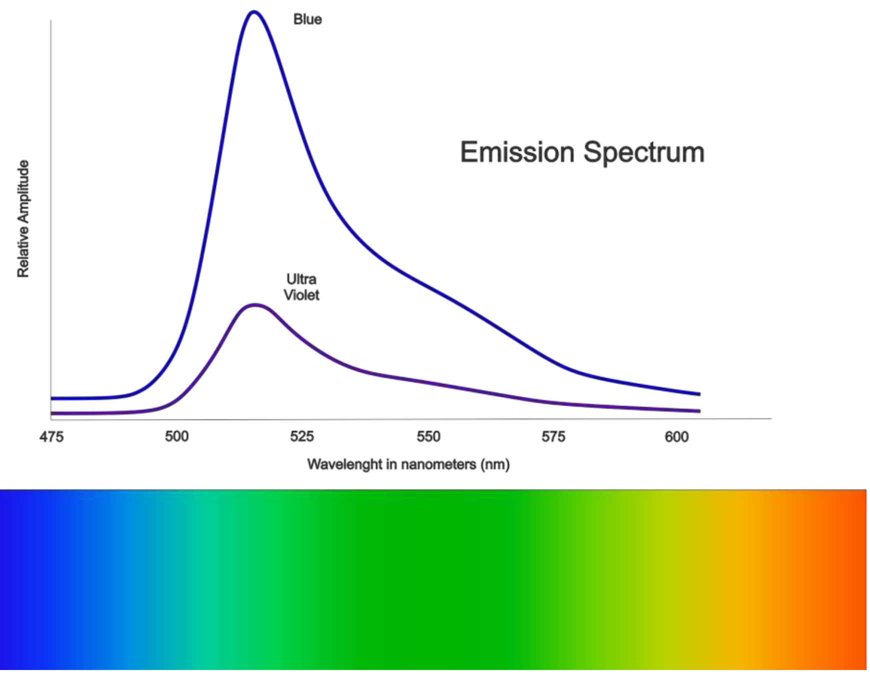


Figure 2

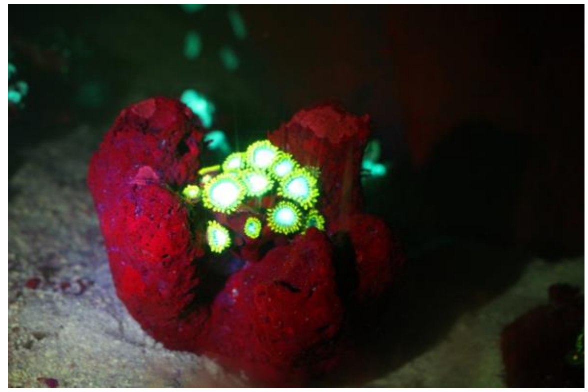
Figure 2 displays a generic fluorescence emission spectral response for an organism illuminated with equal intensities of blue and UV light. One can clearly see the relative amplitude of the emission light is dramatically higher with blue light than with UV light.

There are things do that fluoresce under UV and don't fluoresce under blue, but the opposite is vastly more common. Marine creatures that do fluoresce do so much more dramatically under blue light. Note the images below. These images were taken with torches that were identical in every respect except the wave length of the emitted light. They were FireDiveGear MiniBlueFlame torches. Figure 3 was shot using a UV (395nm) LED and figure 4 was using a Blue (455nm) LED. ***<u>ALL</u>*** other hardware parameters were the same.

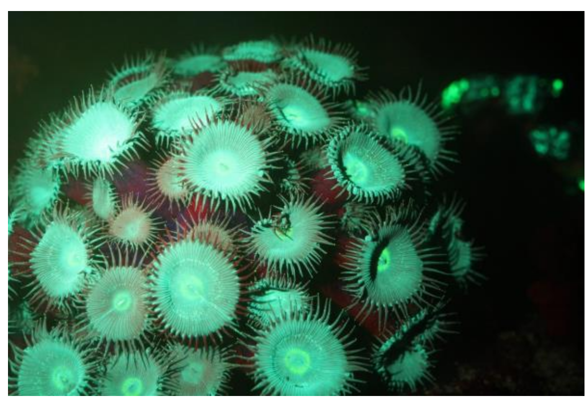
Figure 3

Figure 4

More examples are shown below. All were shot with the same camera parameters as shown in Figures 3 and 4 respectively and are detailed below with UV illuminated targets on the left and Blue illuminated targets on the right:





Camera / Lens / Settings:

Camera	Canon SL1 DSLR	
Lens	Tokina 35mm Macro	
ISO	1600	
Aperture	F6.4	
Shutter Speed:		
	UV Images	1 second
	Blue Images	1/4 second

The camera was configured for aperture preferred and ISO locked so the shutter speed was the only variable allowed. Hence the only difference in the camera parameters was the shutter speed. It took 4 times as much exposure for the UV images as it does for the Blue light images and yet the color saturation of the UV source is not even close to that of the Blue source. Again referring to Figure 2 above, this is exactly what one would expect to find.

You will notice that in all of the blue light shots, the colors are dramatically more vibrant and there is less “haze” (dispersion) in the images.

With UV light no barrier filter is needed which to many is a distinct advantage. With blue light you do need a barrier filter to block the reflected blue light. However, the increase in emission efficiency and color saturation far outweigh any disadvantage caused by needing a filter. The fluorescent emission is very weak and the blue will completely overwhelm your eyes and your camera, hence the need for a yellow barrier filter. Not all barrier filters are the same. They are available from various sources who simply cut them from off the shelf yellow plastic. At FirediveGear.Com (FDG), we use a custom blended cast acrylic that provides better color saturation in your images. The FDG filters also “allow” about 2% of the blue to pass. The blue that one sees in the image is actually “contamination” or simply a small portion of the reflected blue light off the target or surrounding area. This has advantages both aesthetically in imaging and for the research community.

UV (as you certainly know) is VERY bad for your eyes. This is why we wear sunglasses. What happens when your dive buddy shines his UV light in your face? You are temporarily blinded. The effect is dramatically worse than white light torch blindness. It can last the remainder of the dive.

Now consider this: you see a fish or crab or some other creature (with eye balls) and you zero in on it to take a series of macro shots spending a few minutes on target. At a minimum you will temporarily blind the animal and if you spent enough time on it, it may cause permanent blindness and the creature won’t last through the night because a predator will get the animal who won’t see it coming. Blue light exhibits none of these problems.

Marine fluorescence research is now a hot topic in marine institutes and universities around the world doing climate change research. The blue lights and filters are used for monitoring the effects of ocean acidification, coral bleaching and coral polyp population census studies as well as general coral health.

Lynn Miner March 2016
Physicist SSI IT
PADI MI
DAN IT
HSA CD
info@firedivegear.com