Reference Notes for *A Play of Shadow* provided by Abby Dominy, summer 2013. Reproduced here with her permission. – Julie Czerneda

Common misconception(s) about terrapins:

Well, I would say there are at least a few misconceptions that tend to come up rather frequently ☺. Having worked for the past seven years on different turtle projects (freshwater turtles, sea turtles and terrapins), many of which that relied on the utilization and integration of Earthwatch volunteers and others, I've learned that many do not understand some basic things about turtles, especially terrapins.

1. First, their common name can be confusing. The word terrapin is a Native American word for turtle, so terrapin should be synonymous with turtle, right? Not always. In the US, terrapin is specific to the diamondback terrapin (*Malaclemys terrapin*); most likely due to the fact that terrapin is the species name! However, in nearly the rest of the world, terrapin is a term used to describe any turtle. So if you Google 'terrapin', you'll get 'European terrapins' or 'African terrapins,' which are not diamondback terrapins. A clarifying point you could make? Maybe something about how common names are often abandoned by scientists and others because they can lead to miscommunication between different communities/cultures (a theme you seem to like!). As an aside, we always have to explain to our European and Japanese volunteers (they really like us in Japan) that we do not study any or all 'American terrapins' but a specific species that is found only in certain areas of the US.

2. Terrapins are endemic to coastal estuaries along the Eastern and Gulf coasts of the US. They occupy a dynamic ecotone that combines environmental features from both freshwater and marine habitats. As a result, the terrapin is rather unique among turtles. It is the only turtle species that can tolerate and preferentially occupy brackish estuarine habitats in the US (there are turtles in Asia that occupy estuarine habitats, but we know very little about them). Freshwater turtles can tolerate only low levels of salinity while sea turtles cannot, although juvenile sea turtles tend to forage in northern coastal estuaries (many get caught in the intake of nuclear power plants located in bay systems).

So, like freshwater turtles, terrapins have much of the same external anatomy; small-bodied with clawed feet. But, like sea turtles, terrapins have salt-excreting tear ducts that enable them to drink salt water. So the terrapin is neither a freshwater turtle nor a sea turtle… but an estuarine turtle. Most people have common knowledge of tortoises, pond turtles and sea turtles, but have little to no idea that there is yet another category of turtle. I'm not sure what point you could make here, but as you mentioned educating readers about the differences between frogs and toads, you may have a chance to mention that there are many types of turtles that lead very different lives.

Terrapin coloration:

It is difficult to describe a color that humans cannot see, but this is what I believe is happening. (JCz note: How cool is this???)

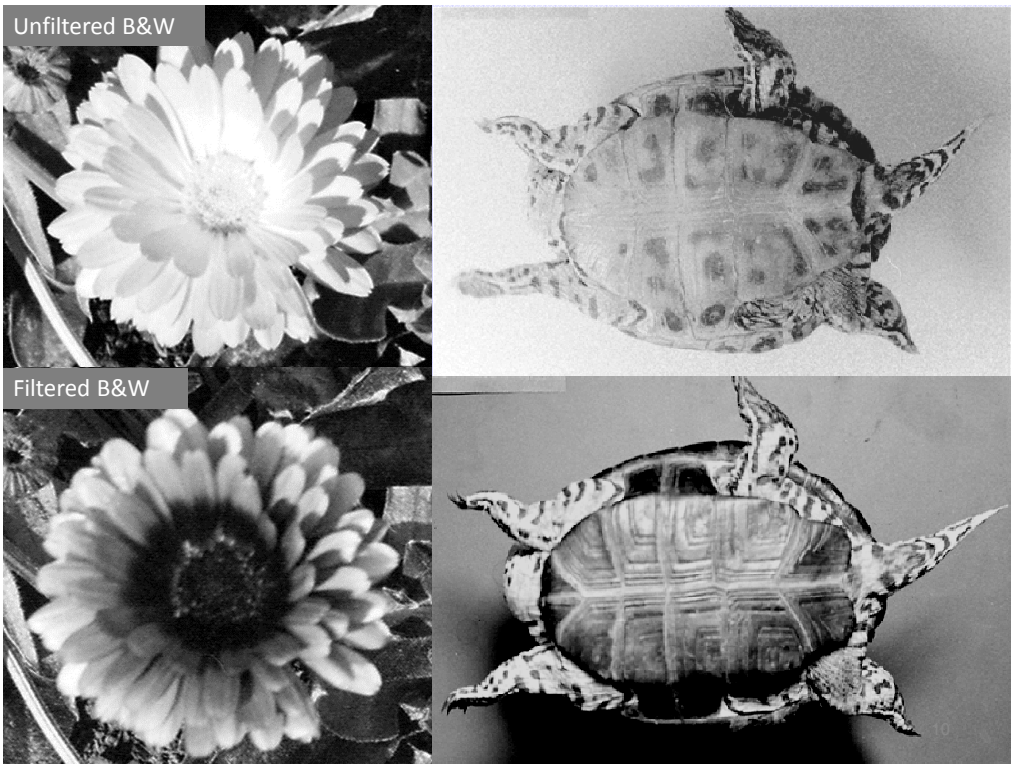
Terrapins have the ability to see not only more colors than humans, but also further into the red; we are actually very blind to most of the red wavelengths. If we can see millions of colors—sum of the permutations of all hue combinations—then terrapins can see billions of colors. When the realized color

(the actual reflectance regardless of observer) is viewed by different visual abilities, the perceived color(s) can be quite different. You can make good parallels with color blind humans and how they recognize, or rather cannot recognize, different colors. Since most colors in nature are not pure, and are a combination of wavelengths that excite different kinds and numbers of photoreceptors in a viewer, we can make some partial associations between the human-observed color and that which might be perceived by the turtle. In other words, the light blue-green-grayish color of terrapin skin has a very strongly associated UV-color component. In my spectral data, the UV color was either stronger, the same or weaker than the light blue-green-gray color that we could see, but it is always there. However, in dark-skinned terrapins, there was very little to no UV-color associated with it. The reason for this variation may be due to a cost-benefit tradeoff in coloration, which might explain the persistence of color variation. UV-colors may be attractive to females, but may increase the risk of predation (avian and reptilian predators can also see UV-colors; mammalian predators cannot). Dark colors may be better for camouflage, but aren't attractive to females.

In the figure below, I demonstrate the UV-reflecting parts of the terrapin—with a flower for comparison. The plant-pollinator co-evolved relationship has led to flowers expressing UV patterns that are visible to pollinating insects and birds. As you can see, the flower appears monochromatic (all yellow) to humans in the unfiltered BW image, but if you cut out the visible spectrum and expose the film to only UV wavelengths of light, you can clearly see that the flower reflects UV at the tips and absorbs in the middle—effectively creating a bull's eye to attract a pollinator. In the unfiltered BW terrapin, the skin and shell patterns are somewhat continuous and might help camouflage the individual from a mammalian (UV-blind) predator. On the other hand, the filtered image show UV-reflecting skin and UV-absorbing shell, creating very high UV contrast and conspicuousness to any UV capable observer.

I have often been asked to create or render an image so that we could 'see' the UV color on a color photograph. I hesitate to do so because I think it gives a false impression. Many UV-flower photographs (you can Google some images) tend to false-colorize a UV photo with purple hues to demonstrate the expression of this non-visible color. However, it's not really purple—it's a color we can't even comprehend! Instead, I only go so far as to demonstrate the presence of UV colors through differential brightness in BW images. This is the best and only way to get a genuine idea of what's going on. I have also attached some color images so you can get an idea of how colorful terrapins are even to our limited abilities.

In general, my hypothesis is that UV coloration has evolved as a way to increase conspicuousness to conspecifics while not increasing visibility to predators that cannot see UV. In other words, creating a private communication channel. I can see a lot of potential using this idea in a science fiction/fantasy story.



Phenotypic variation

Visual target coloration

I want to thank Abby again, not only for her willing generosity to help me sneak some of the real world into my fantasy one and to share this with you, but also for her hard work, imagination, and dedication to discovering the secrets of an animal who lives in one of the most challenging environments a biologist could pick for her work. May mud ever wash easily from your boots, and those not get stuck for hours.

And may you continue, Abby, to open our eyes to what's seen by our fellow inhabitants of this planet. -- Julie Czerneda, November 2014.