Can Fish See Color?

by Mark Fisher

Like most vertebrates, the eye of a fish has a cornea (outer covering), an iris (aperture for light passage), a lens (to focus the image), a retina (receives the image from the lens), and an optic nerve (transmits the image to the brain). One difference between a fish eye and most other vertebrates is a fish can change the focus of the lens by changing the distance between the lens and the retina; other vertebrates (including humans) focus by altering the shape of the lens. Fish can focus their eye just like a camera. Also, the iris of most fish lacks muscles and is fixed in shape—they cannot control the amount of light entering the eye by contracting or dilating the iris. Sharks and rays do have movable irises and are the exception.

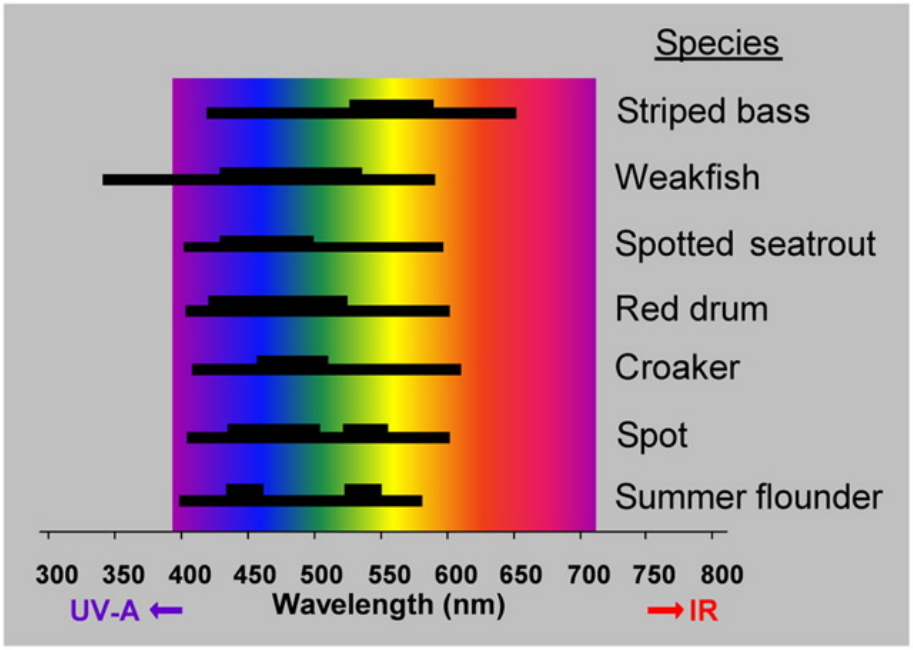
The retina contains special receptor cells called rods and cones. Rods are more light-sensitive than cones, but only respond to black and white. Cones respond to color and produce more detailed images than rods, but are only about one-thirtieth as sensitive to light as rods. Rods "see" light, while cones provide color and detail. Like us, fish cannot see color at night, or other low-light conditions.

A fish's eye is adapted to better see movement and contrast at the expense of detail. The cones in a human eye are densely packed around the retina, allowing for better detail. The cones in a fish's eye are distributed throughout, which provides better detection of movement and contrast, but with lesser detail.

In daylight, the rods contract and the cones expand. Pigment granules move toward and around the rods to shield them from light. At night, the pigment is drawn back to expose the rods, and they expand to become exposed to more light. This process takes about an hour, and most predatory fish are able to adapt faster than their prey. This is probably the reason many predatory fish feed most actively at sunrise and sunset—their eyes can adapt to changing light faster than their prey, giving them a distinct visual advantage.

Color vision requires different types of cone cells to detect each of the three primary colors, and most fish possess at least two while some have all three. In general, fish can see farther into the violet range than humans, and some can see into the ultraviolet range.

Researchers at the Virginia Institute of Marine Science have used electroretinography to better understand how fishes see color. This method exposes a range of colors to an anesthetized fish, and uses electrodes to measure which colors elicits a response in the retina. The article can be found here. This figure (from http://www.vims.edu/newsmedia/press_release/fish_vision.htm) shows the color range for each species, with the thicker black bar depicting the peak response. Except for striped bass, none of these species can see red, while weakfish can see far into the ultraviolet range. Spotted seatrout and red drum can see a range from violet to orange, with a peak in the blue-green range.



Color vision is used by fishes to help them see prey against a variety of backgrounds. Duplicating the exact color of a prey item is less important than choosing a color that ensures good contrast between your fly and the background. For example, chartreuse is a color that does not occur in nature, yet can be an effective color choice for a fly because it is so visible. Not only is chartreuse well within the visual range of a fishes eye, it is also fluorescent when exposed to ultraviolet light, and many fish can see into the ultraviolet range. Red and white is another effective color combination, but many fish (including reds and trout) cannot see red; instead, red appears as a shade of gray. Red and white is effective because it has good contrast against a variety of backgrounds. Gray and white would be just as effective.

The amount of light available and the color of the background is dependent upon a number of factors, including time of day, water clarity, bottom type, water depth, and vegetation. A fly with high contrast would be more visible under low light (sunrise/sunset) or turbid water conditions. Black is a good color choice at night because it provides the best silhouette against a moonlit sky. Fluorescent colors are highly visible on cloudy days, when ultraviolet light is more prevalent than clear days. A fly with high contrast is less important in clear water and on bright sunny days, and may even "spook" some fish.

Finally, in addition to vision, fish also depend on hearing and smell to help them find prey. A large fly that "pushes" a lot of water can be detected, even if they can't see it. Poppers and gurglers are examples of flies designed to make noise. Also, some fly anglers targeting black drum have used "spray-on" fish attractants with great success.

In summary:

- Fish can see color, but they use color vision to help them find prey against different backgrounds, not necessarily to identify prey. Fish cannot see color at night.
- A fish's eye is adapted to see movement and contrast at the expense of detail. An exact replica of a prey item is not necessary, but movement and general shape is.

- Many predatory fish are well adapted to find prey at sunrise and sunset.
- In general, the brighter the day and the clearer the water, the lighter your fly should be. Consider the background when choosing a fly.