Understanding Fish – The Science of

Introduction

Being human is very difficult from a learning prospective. We begin life by learning our very basic functions and capabilities such as walking, speech, language, dexterity, use of our senses, etc. The life of a human being is a perpetual challenge in learning our capabilities and the limits of our senses.

Everything we learn about the use of our senses is regulated by our ability to absorb and retain references for comparison. (A child would have no idea what an onion was – until he was told and/or experienced it for the "second" time. The first experience was only an anomaly.) The numbers of different senses associated with the experience determine the manner in which the "memory" is retained.

This document is not about the psychology of a learning process – but it is about senses and their relationship to other life forms. It is imperative that we understand that all learning is primarily based on need and the relationship of "need" to survival. The "relationship" of "need" to survival is based on the available assets (senses), environmental demands and how they are used.

It seems that all life forms have the ability to modify or enhance certain senses based on "need". An example would be that a blind person has much stronger senses of touch, hearing, etc. (to compensate for the lack of sight) to survive in his environment. The evolution of time, based on "need" and environment, determines the development of basic senses – as well as the types of senses (receptors).

Understanding the environment and the required senses for any species to survive is what determines our efficiency to become more successful researchers and/or predators.

The different environments of different species have caused some species to evolve with very different senses (receptors) than humans. Understanding the senses (receptors) to survive in their unique environments is a key factor in becoming a successful researcher or predator of any given species.

This paper is to make available to the fishing sportsman, some scientific research as it applies to understanding what makes a fish (or other species) react to certain things and to develop an understanding of the how, where, when and whys associated with becoming more successful in their sport.

Having an Understanding of the Environment of Fish

In this section we will accept that there are many different species of fish and that there are also many different environments in which fish live and thrive. Hence, there are a great many variables. There are however many fundamental common factors to take into consideration before we approach the complexities of the variables

1.) Fish live in water. Basically their environment is in either salt and/or fresh water.

2.) Sustenance - Being life forms, fish have to eat to survive. Some are vegetarian, microbial or meat eaters.

3.) Sensors - In order to feed or survive, all have evolved with one or more senses (receptors).

We shall look at each of these fundamental common denominators first. By doing so, we will lay the foundation for understanding the evolution of the sensors that have developed in different species and the basics of "why" it has happened. The number of "sciences" required for a thorough understanding are numerous as will become apparent.

Number 1 – Fish live in water… What is water, and why is it so hard for some to understand that it is an environment vastly different from our own? There is far more to water than most people perceive that is simply taken for granted. There are so many variables associated with water that the study would be endless… In our case we shall stick to some relative basics that are commonly overlooked.

Water is composed of many things such as microbial organisms, nutrients, minerals (many types – not just salt), a vast assortment of other matter stirred into a perpetually changing mix of "stuff" from shorelines, air etc.. This "stuff" is constantly being stirred by winds, currents, storms and so forth.

Some basic constants about water clarity is that it is not pure, it is not clear and it is very seldom exactly the same in any single place all the time. Water is also very dense.

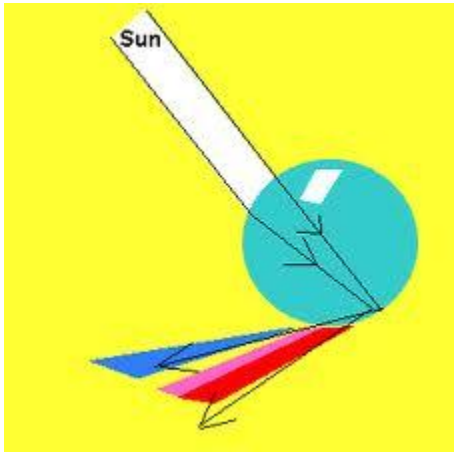
From an environmental habitat point of view, in relation to fish species, we have the following basic considerations:

a. Because of the composition of water, some life forms can and can not survive. Therefore, just like on the surface of our planet in the air environment, variables such as temperature, fertility and density determine what species live where. The composition of water also determines how light and magnetic fields are affected.
b. Because of the density and composition of water, light (one of the key ingredients of life), is changed from what the human body is capable of "seeing". The term "light" is a common

human term used for what the human eye interprets as the solution for darkness and color. In reality, which we will address later in this document, light is by no means exclusive to humans… and in many cases (for humans) is far beyond our sensory capabilities and perception without instrumentation.

c. An interesting fact of light (the human perceived color spectrum) associated with water is that light is only constant in perfectly still water – a condition which does not exist in nature.

The following pictures demonstrate some of the things that happen to light in a relatively controlled environment. The light diffraction of the surface becomes very apparent on smooth defined surfaces. Intensity and colors begin to "breakdown" immediately at the surface of water.



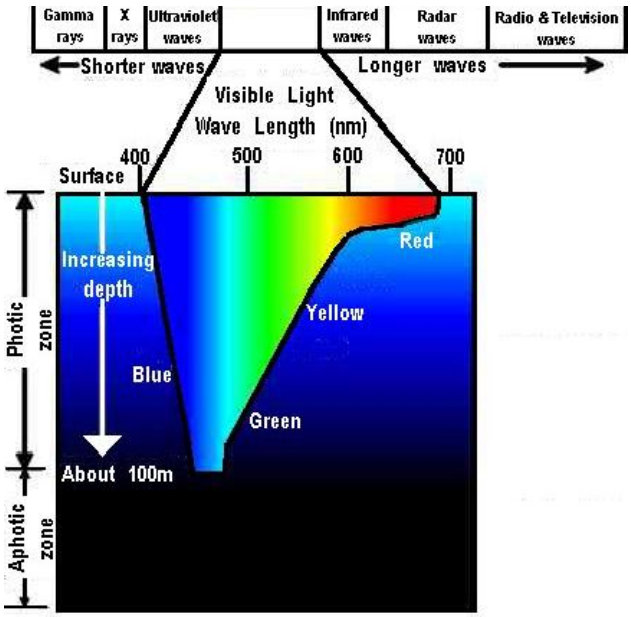
Refracted light on a rocky lake bottom in relative calm water

Light Absorption

Light absorption occurs in water. The color spectrum (red to violet) from natural light diminishes with depth and water composition.

Artificial light is required to see the color spectrum as depth increases because the color spectrum of sunlight is absorbed.

In clear open ocean water the color red is the first to be dissipated. The following chart shows the color spectrum absorption characteristics in open ocean.



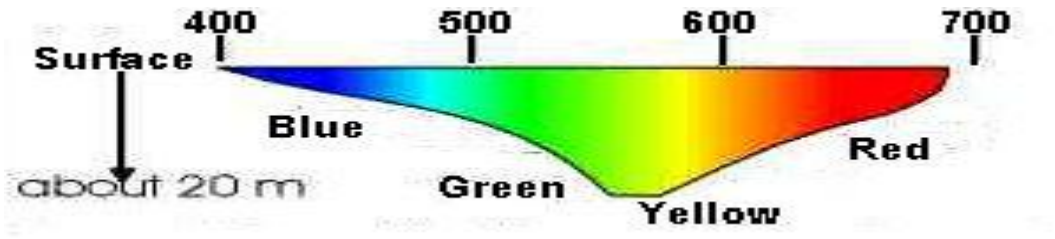
Light Absorption

Absorption of light occurs in the water, it filters out the colors progressing through the color spectrum from red to violet. As one dives deeper the natural light will not provide as much color information.

Red is the first color to be filtered out. If you bleed underwater it will appear black.

Transmission of light in "pure" fresh or salt water.

Please note that the color spectrum penetration changes considerably with inland (estuarine) waters. In clear open ocean the color blue has much more penetration where as Green becomes the dominated available light in inland waters.



Transmission of light in estuarine waters

Number 2… Sustenance - Being life forms, fish have to eat to survive. Some are vegetarian, microbial or meat eaters.

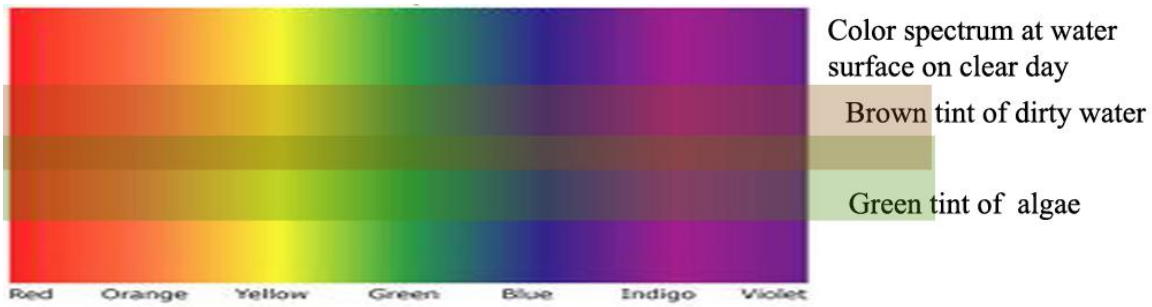
The effect of sustenance or "Food" is extremely relative to water and fish as well as fishing. Simply put – fish go where the food is…

The food for different fish is as variable as the number of species of fish. Some fish have evolved to change to the demands of available food to survive, while others simply follow the desired food of preference.

The smaller the fish the smaller the food and visa versa (sometimes). There are a few exceptions where gigantic fish live on micro organisms and so forth.

What all this amounts to is that in order for most fish to survive the chain of food is required. This chain of food acts as additional filters to water…

Algae and other micro organisms tint the water and diffract light creating different color filters. Here is a simulation using Adobe Photoshop that show the full color spectrum as would be available on a perfectly clear day (which is extremely rare) using a very light tint of brown (as is common dirty water) and adding a light tint of green representing algae found in most all waters.



Note the color changes in this simulation....

The colors green and violet are the only consistent colors that show through the tinting.

In real life, the effects are much more dramatic. Especially when you add the diffraction and absorption considerations mention earlier in this text.

Number 3… **Sensors** - In order to feed or survive, all have evolved with one or more senses (receptors).

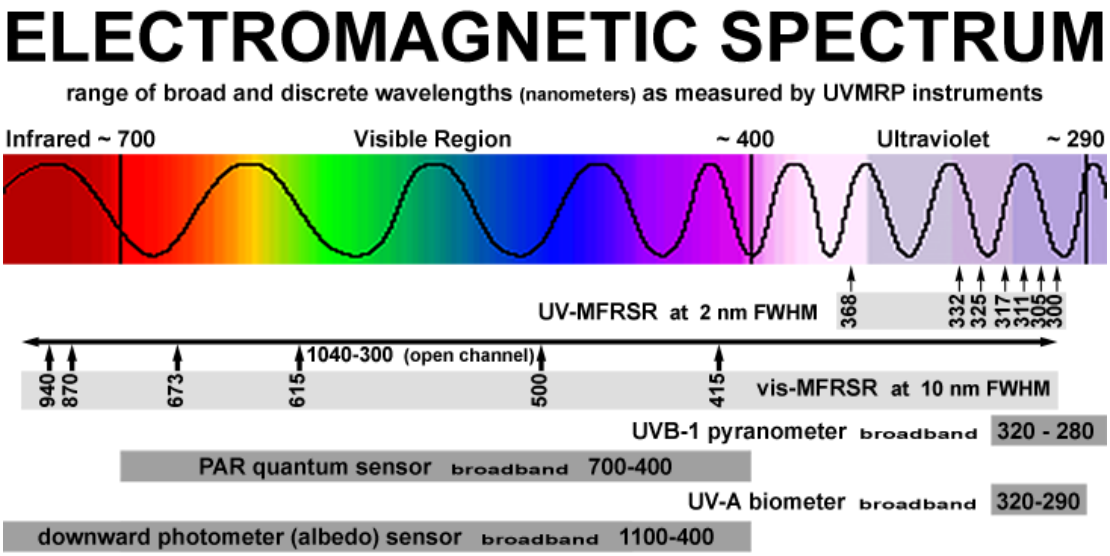
Fish have several types of sensors (receptors):

Fish Eyes;

Fish eyes are very different than those of humans. Their spherical lenses allow them to focus better underwater because of light diffraction. As depth of residency of fish increases, so does the size of the fish eyes to allow for gathering more light. Fish can not dilate their eyes to adjust for light.

Below the Photic Zone fish eye size decreases because there is no (humanly visible) light.

Some fish have an eye structure known as the Tapetum lucidum, which amplifies the incoming light. It is a layer of guanine crystals which glow at night. Photons which pass the retina get bounced back to be detected again. If the photons are still not absorbed, they are reflected back out of the eye. It seems to be the combination of a natural light intensifier and UV light source (not visible to the human eye). Unlike humans that can only see from .34 - .73 microns, fish can see fish are capable of seeing in also the UVa and UVb spectrum.



An interesting observation that many hunters have become aware of is that today's modern color enhancing (UV Blockers) detergents are extremely visible to wildlife and fish. In fact they render what we see as camouflage virtually useless. To fish, a person standing on a shoreline or boat will almost glow… compared to their background.

Chemo-Receptors (the sensors associated with Smell & Taste);

Smell…

In general, fish have two holes or nostrils on their heads and there is no physical connection between the throat and the nostrils. The olfactory rosette located in the nostrils is a chemo-receptor capable of chemical differences (smells) as small as 1 part per billion.

Taste…

In the mouth and the area close to the mouth there are a variety of different receptors which allow fish to "taste" sample their environments. These sensors can be located on their lips, tongue, and all over their mouths. Some fish have whiskers (known as barbels). Some of these are visible as whiskers such as one would see on catfish, while other fish have small, almost hair like barbels around the outside of their mouths. In many fish, this ability to "taste" is as important as the ability to see.

Most fish are believed to be able to taste their prey before they see or come into contact with it. Many prey for fish leave a distinguishable (to a fish) trail which allow fish to track their prey in the 3d environment of water much the same as predator on land would track the sent of a prey on land..

Feel….

Mechano-Reseptors (hearing and touch)…;

Fish do not have ears as humans do. In the water environment sound, feelings and vibrations can be interpreted as pressure changes and resonance.

Fish have extremely sensitive sensors (receptors) located in their bodies that allow them to feel very minute changes in their environments.

Sound vibrations readily transmit from the water through the fish's body to its internal ears. These sensors are divided into two sections, an upper section (pars superior) and a lower section (utriculus) The pars superior is divided into three semicircular canals and give the fish its sense of balance. It is fluid-filled with sensory hairs. The sensory hairs detect the rotational acceleration of the fluid. The canals are arranged so that one gives yaw, another pitch, and the last- roll. The utriculus gives the fish its ability to hear. It has two large otoliths which vibrate with the sound and stimulate surrounding hair cells.

Fish have another sense that provides them with important information about their environment. It is referred to as the neuromast, a cluster of hair cells which have their hairs linked in a glob of jelly known as 'cupala'. All fish posses free neuromasts, which come in contact directly with the water. Most fish have a series of neuromasts not in

direct contact with the water. These are arranged linearly and form lateral linesalong the side of the fish.. A free neuromast gives the fish directional input.

A lateral line receives signals stimulated in a sequence, and gives the fish much more information (feeling the other fish around it for polarized schooling, and short-range prey detection 'the sense of distant touch').

Electricity: electro-reception. Most fish have special organs for detecting electrical potential [voltage]. A set of pits comprise the electro-receptive system called the ampullae of Lorenzini. These are canals in the skin filled with a gelatin-like material that also contain sensory cells. Movements or disturbances near the fish change the voltage levels along the canals, which allow the fish to sense other organisms nearby.

They can detect muscular contractions of struggling prey and even the earth's magnetic field (which many fish and other animals use for navigation).

The range or sensitivity of this is still unknown. Some fishermen believe that fish can sense their sonars… they may be right…

Conclusion – A Little Fishing reality.

The information that I have provided here is based on extensive research I have done on a multitude of different scientific specialties and sources.

I would like to express my sincerest gratitude to those who have specialized in their prospective fields and provided the resources for people such as myself to learn from.

In the world of the internet there is so much bad information that it is very time consuming to weed through it and find actual facts. I have, however, done just that in this document, and based on confirmation from multiple resources have the opportunity to present this document.

I have tried to find data on discussions and testimonials with fish that would provide first hand insight to what appeals to them… alas however, the few articles that I found seemed to less than credible…

I will strive to conduct interviews as and when I have the opportunity to go fishin'….

My background is in electromagnetic physics and one of my hobbies is fishing. I have been accused of "over complicating" things by colleagues and associates…. Where they get that opinion from… I'll just have to research…

Don Abernathy
Wildcat Lighting