Horodysky Throws Light on Fish Vision

Andrij Horodysky's research can be summed up in a simple saying—what you see is what you get.

Horodysky, a VIMS graduate student working with faculty members Drs. Rich Brill, Rob Latour, and Jack Musick, is using electroretinography—a technique first developed for studying human vision—to explore how fishes see the underwater world of Chesapeake Bay.

Brill, an internationally recognized fish physiologist who heads NOAA's Cooperative Marine Education and Research (CMER) program at VIMS, has recently turned his attention to the sensory world of fish and other marine organisms.

The research is part of an emerging field called "visual ecology" that promises to throw new light on animal behavior and the interactions between predators and prey. Horodysky and his advisors are pioneers in applying this field to Bay fishes.

The researchers are focusing their initial studies on recreationally important Bay species such as striped bass, weakfish, croaker, and drum. This reflects the source of their funding, which comes from the Recreational Fishing Advisory Board of the Virginia Marine Resources Commission. The Board uses money from Virginia's saltwater fishing license to fund projects that improve the Commonwealth's recreational fisheries.

Horodysky also benefits from collaborations with Charter captains like Steve Wray, who provide him with the fish he needs for his experiments.

Horodysky's preliminary results provide basic insight into how Bay fishes see the world. The results show that some species, like striped bass, are adapted to see large, swiftly moving prey in daylight. Others, like weakfish, are adapted to see small, sluggish prey at night.

He is also comparing the types of prey that fishes are adapted to see with the prey items that are actually in their stomachs—with some surprising results that could hold important implications for fisheries management in coastal waters.

Electroretinography involves exposing the eye of an anaesthetized fish to all the colors of the rainbow and more—from ultraviolet to infrared—and then using electrodes to record which wavelengths elicit a response on the fish's retina. Horodysky conducts these tests night and day to account for rhythmic changes in the structure of the fish's eye.

Even though Horodysky keeps his fishes in a dark laboratory, the rod and cone cells in the fishes' eyes still shift position in concert with sunrise and sunset. The color-sensitive cone cells move toward the surface of the retina during daylight hours, and retreat to make room for the contrast-sensitive rod cells at night. This "circadian rhythm" changes with the seasons, which makes for some late nights for Horodysky during summer, when he is not able to start his dim-light experiments until 8 or 9 in the evening.

"The end result of these experiments," says Horodysky, "is the ability to unambiguously ask the retina whether it can see a particular color, and whether it can resolve the color in bright or dim light."

He also tests the fish's "flicker fusion frequency," essentially the shutter speed of its eye. Humans have relatively "fast" vision and can discern the flickering of a light or image at up to 60 cycles per second (that's why TV screens, fluorescent lights, and computer monitors are designed to flicker at a rate faster than this threshold). Values in marine fish range from around 25 in swordfish, which require a "slow shutter speed" to detect prey in the deep, dark waters where they spend their days, to around 55 for mahi-mahi, which often hunt at the surface in the sunlit tropics.

Horodysky's research shows that striped bass are most sensitive during daylight hours to a wide range of colors from blue to red, with a peak at chartreuse. They have a flicker fusion frequency of around 50, relatively fast for a fish, which allows them to track large, quick-moving prey like menhaden.

Compared to striped bass, weakfish have slow vision (around 25 cycles per second) and are more sensitive to contrast than color. This allows them to see best under dim conditions, just right for detecting the small fish and shrimp that prowl the nighttime Bay. They also have the unusual ability to see in ultraviolet.

Seeing in ultraviolet is a dangerous proposition, says Brill, as UV light is very damaging to cells and even DNA. Using UV light allows weakfish to distinguish between dark and light objects in dim conditions, but forces them, like bats and owls, to avoid bright sunlight.

"There's no such thing as a free lunch," says Brill. "You can have a really good UV-sensitive eye, but then you have to work at night."

"Even though these two predators may swim side-by-side, they exist in different visual worlds," adds Horodysky.

Continued on page 7

VIMS graduate student Andrij Horodysky (L) and faculty advisor Dr. Rich Brill (R) are studying the "visual ecology" of popular recreational fishes from Chesapeake Bay. Horodysky's red-light head lamp allows him to work in the dark without affecting his experiments.

W&M Bestows Honorary Doctorate on Van Engel

VIMS Professor Emeritus Willard A. Van Engel received an honorary doctorate of science from W&M Chancellor Sandra Day O'Connor during commencement ceremonies at The College of William and Mary in May.

Van Engel is credited with being one of the individuals responsible for the creation of the Virginia Institute of Marine Science, when in the mid-1940s he and colleagues at the Virginia Fisheries Laboratory developed the scientific community that later became VIMS.

Van Engel conducted research and taught at VIMS until 1985 when he retired at age 70. Upon retirement, he had dedicated 39 years of his life to VIMS and its School of Marine Science.

Van Engel, also known as "Van," led the way with cutting-edge research in the Chesapeake Bay and was a pioneer in many marine science research areas, including his seminal work on blue crabs and the blue-crab fishery.

Van Engel is also credited with first recognizing the need for keeping duplicates and reprints of scientific papers and reports in one centralized location—an effort that grew to become the VIMS Library. He has also been a strong supporter of the college and his generosity has allowed for the Van Engel Graduate Fellowship and VIMS Library to continue in perpetuity.

In 2003, VIMS awarded Van Engel with its first ever Lifetime Achievement Award for his outstanding contributions to the state and the college.

Dr. Willard van Engel receives his honorary doctorate from William and Mary Chancellor and former U.S. Supreme Court associate justice Sandra Day O'Connor during commencement ceremonies at the College on May 14th. Photo by Steve Salpukas.

Fish Vision
continued from page 3

"You've got two animals that are competing for the same food. How do they do it? Stripers use color to see and feed during the day. Weakfish use contrast sensitivity to see at night."

"What these fishes have done is divvy up the visual world," says Brill.

For the most part, study of stomach contents by VIMS researchers confirms what Horodysky's vision research predicts. Work by Dr. Rob Latour shows that the stomachs of weakfish are largely empty during the day, and then quickly begin to fill with small fishes and shrimp as evening falls. Work by graduate student Kathleen McNamee shows that striped bass have full stomachs during daylight hours, but that the stomachs gradually empty through the night.

One intriguing aspect of Horodysky's research is the disparity he's found between the prey items that striped bass are adapted to see—large, fast-moving fish like menhaden—and the items that actually occur in their stomachs—mostly small crustaceans like juvenile blue crabs and mysid shrimp.

Horodysky and his faculty advisors hypothesize that striped bass are living in a visual world very different from the one evolution prepared them for. That's because human activities in the Bay watershed and the demise of the native oyster have dramatically reduced the clarity of Bay waters.

VIMS graduate student Andrij Horodysky monitors the progress of a vision experiment using an Atlantic croaker (Micropogonias undulatus).

The world of Chesapeake Bay stripers was once bright and colorful. Anecdotal evidence from Captain John Smith and others suggests that visibility in the Bay once measured in the tens of feet. Even a century ago, Bay waters were clear enough to allow plant growth at depths of more than nine feet. Now sunlight penetrates to only half that depth.

"Chesapeake Bay used to be very clear," says Brill. "Now we've made it mucky. So we see the visual ecology of the Bay changing. Our argument is that over evolutionary time these fish have made certain visual choices, then suddenly find themselves in a visual environment they didn't evolve in."

This visual mismatch could have important implications for fisheries managers, who traditionally make management decisions based on the relative abundance of predator and prey—the number of striped bass or menhaden netted per unit area.

"What we're getting at," says Horodysky, "is that it isn't the number of prey per meter that's most important to these visual predators. It's the number they can see. Is there a visual issue, with the Bay being turbid, being murky? If you can't see very far, how is that affecting your ability to feed? These are larger questions we can begin to chip away at once we get our baseline data. We can't start to answer these questions until we know the limits of the eye."

In the meantime, Brill and Horodysky plan to expand their research to other popular recreational fish like summer flounder and cobia, and also to the forage fish—most notably menhaden—that so many recreational species depend on for food.

For Virginia's anglers, the most important question for Horodysky might be how a better understanding of fish vision can give them better luck on the water. "I can't guarantee that anyone who uses these data is going to catch more fish," responds Horodysky. "But they will be able to make more informed choices."

Horodysky, himself a fly-tier and avid angler, notes that his color research does confirm at least one common saying that Bay anglers use when selecting a lure for striped bass: "If it ain't chartreuse, it ain't no use."

"Nothing in the wild is ever chartreuse," says Horodysky, "but the color is right smack dab in the middle of a striper's visual range. They can see it really well."