In UMBC’s Department of Marine Biotechnology, Yonathan Zohar and his colleagues are creating sustainable fish farms that may revolutionize our notions of fishing and seafood.

By Anthony Lane
A well-known proverb appears on a wall near the entrance to the Columbus Center on Baltimore’s Inner Harbor: “Give a man a fish, he eats for a day. Teach a man to fish and he eats for a lifetime.”

A worthy sentiment, yes. But what happens if we use up the bounty of the world’s oceans and seas? Talk for a few minutes with aquaculture pioneer Jonathan Zohar and you might be moved to coin a new proverb:

“ Teach too many people to fish, and there might one day be nothing left to catch.”

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A Trick Business
Zohar grew up in Jerusalem, and he developed an early fascination with oceans and marine life studying magazines such as National Geographic. Though he was close to the Mediterranean Sea all his life, it was not until he was teenager that he first visited the water during a school trip to the beach. “I loved it from first sight,” he says. This passion for the sea eventually brought Zohar to Baltimore. In 1990, he joined the Center of Marine Biotechnology at the University of Maryland to conduct aquaculture research. He later became the director of that center, remaining in that position until July 2010, when he became chair of the new Department of Marine Biotechnology at UMBC.

Aquaculture was in its early stages when Zohar studied biology as an undergraduate at the Hebrew University of Jerusalem. Completing his master’s degree in oceanography in the mid 1970s, the young researcher started working at a national lab in Israel dedicated to developing techniques for raising marine fish such as European sea bass and sea bream. But progress in aquaculture in that era was stalled by a roadblock: The fish couldn’t reproduce in captivity. This approach wasn’t working, so Zohar decided to try something different, examining instead how the fishes’ hormonal systems respond to the environmental changes that lead to reproduction.

In an effort to understand why fish held in confinement fail to reproduce, Zohar’s research team collected spawning fish from the wild to compare them with their captive, reproductive challenged cousins. It became clear that a surge of a particular hormone resulted in spawning. His group traced the failure of captive fish to release this hormone to a malfunction in a related hormone system in the brain that produces what are known as gonadotropin releasing hormones (GnRHs). They eventually found completely new forms of GnRH, a breakthrough that spurred reproductive research in animals and humans.

Zohar and his colleagues learned to synthesize a specific type of GnRH, and they discovered that injecting it into captive fish would trigger the reproductive response. Or the start of it, at least. After the injection, it turned out that enzymes in the fish would naturally break the hormone apart. So Zohar’s team spent a period of years developing a novel form of the hormone resistant to that process. They also engineered a ‘sustained delivery system’ so that the hormone could be released at just the right pace to induce spawning.

That approach effectively cleared a path for the field of aquaculture to develop. In the recent New York Times bestseller Four Fish, Paul Greenberg details Zohar’s aquaculture research, characterizing him as a prophet for modern aquaculture. “Over the years he has gained a reputation as one of the world’s best at cracking the reproductive codes of the marine world.”

Reproduction is a tricky business with marine fish. In the wild, they will migrate hundreds or even thousands of miles to reach the spawning grounds where their offspring are most likely to survive. During these migrations, changes in temperature, water depth, salinity and other environmental factors essentially serve as an elemental sort of foreplay. The fish spawn only when these conditions are just right. One way around the reproduction roadblock would be to mimic these environmental conditions in captivity. This approach wasn’t working, so Zohar decided to try something different, examining instead how the fishes’ hormonal systems respond to the environmental changes that lead to reproduction.

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A Sustainable System
Challenges in marine aquaculture are not limited to reproduction. For a system to be sustainable, it must be engineered to reproduce its miniature microbial processes that support life in the oceans. The system Zohar and his colleagues have developed over the last 15 years now sprawls across 18,000 square feet in the Columbus Center’s basement. Zohar beams proudly as he leads tours through the facility, explaining how it defines a new level of sophistication in aquaculture systems. “Ours is the first system in the world to be fully and completely self-contained,” Zohar says.

The Columbus Center is only two blocks from the National Aquarium in downtown Baltimore, and its aquaculture facility feeds in many ways like an industrial version of its tourist-oriented neighbor. Massive round tanks brim with European sea bass, seabream, cobia and other fish species. The fish circle intently, abruptly striking with open mouths when Zohar throws in a handful of food pellets.

Next to each tank, water churns through towering filtrations units filled with a garden of objects that appear to be wagon-wheel pasta pieces. A labyrinth of pipes and tubes connect with a web of filters and sensors to keep the water within healthy limits for the fish. The “seawater” in the tanks is actually manufactured: the system starts with dechlorinated tap water, which is mixed with salt and other elements to simulate what is found in the oceans. In this water, the fish go about their daily business, leaving behind food waste and producing ammonia and feces that would soon turn the water into inhospitable sludge.

A network of filtration systems keeps the water in pristine condition. The first separates out the food and feces, producing a viscous, salty sludge. In freshwater systems, the sludge can be used as fertilizer. This can cause pollution, however, and it’s not an option given the leftover salt in marine systems. Enzyme Kevin Sowers, a professor in the Department of Marine Biotechnology, who has found a blend of organisms that can effectively devour the sludge created in the Columbus Center aquaculture system and convert it into methane.

“If we don’t do anything about it, the oceans could be out of 90 percent-plus of the major fishery stocks by the year 2050.”

Fishing for the Future
The aquaculture system developed by Zohar and his colleagues has grown healthy fish in Baltimore. But where does it go from here? "We’ll figure it out," he says. "We’re not alone: Marine biotechnology members and the IMET colleagues are also continuing research on other fronts, including the use bacteria to break down contaminants in the ocean, the development of algae that can be used in the production of biofuels and the exploration of the seas as a source of new pharmaceuticals.

As Zohar looks for new insights into the interplay of environment and biology, he envisions a future where aquaculture and marine biotechnology both contribute to the health of the world’s oceans. “We have too many fishermen,” Zohar says, “and too many fishing boats.” For now, anyhow, Zohar predicts a more sustainable future: “Fishermen, I think, can readily become aquaculturists.”