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Aquatic Invaders of the Chesapeake

contents

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Cover: *Before being eradicated in 2019, these invasive dreissenid mussels were thriving in Hyde's Quarry near Westminster, Maryland.* PHOTO, MICHAEL EVERSMIER

Unwelcome INTERLOPERS

Northern snakehead *is an invasive species in the Chesapeake region, first discovered spawning in a pond in Crofton, Maryland, in 2002.* PHOTO, WILL PARSON / CHESAPEAKE BAY PROGRAM

No matter how invasive species enter our state and waterways, they all have one thing in common: it's hard to get them out.

That's why the story of how the US Fish and Wildlife Service and the US Department of Agriculture eradicated nutria is so inspiring. The agencies, along with more than a dozen partners, managed to rid Maryland's Eastern Shore of the buck-toothed aquatic rodent that was munching its way through precious marsh habitat. It took years, cost millions of dollars, and encompassed thousands of acres of farms and wildlife habitat on Maryland's Eastern Shore. But Maryland's nutria eradication efforts are among the few in the country where a region appears to have rid itself of a nuisance and thus slowed the destruction of vital habitat. It was so successful that Virginia wants not only to emulate the program but also to use the same staff and equipment to handle its own nutria problem.

In this issue, Eastern Shore historian Phillip Hesser helps tell the story of how the nutria arrived on the Shore, and how scientists and trappers got rid of them. Also in this issue, we examine how county and state officials quickly acted to rid a quarry of highly destructive quagga and zebra mussels. We'll introduce you to the Mid-Atlantic Panel on Aquatic Invasive Species, a volunteer program that shares information about unwanted species' movement within the region to help stop problems before they begin. Finally, you'll meet Jackie Takacs, one of our longest-serving Extension specialists, who has spent her career working on watershed issues throughout the Eastern Shore and Southern Maryland.

It's by no means the last word on aquatic invasive species. We chose these stories to examine some solutions on what is a growing and complex problem.

We hope you enjoy the stories and photos. If you have thoughts about nutria, invasive plants or animals, or other Chesapeake Bay topics, feel free to drop us a note.

—Rona Kobell

Solving a Problem Like NUTRIA

By Phillip Hesser and Rona Kobell

The dogs are out, training to look for something no one wants them to find.

In a field at Blackwater National Wildlife Refuge, Bradie, a Labrador retriever mix, and her human handler, Trevor Michaels, are playing a strange game of fetch. Michaels, an acting supervisor for the Chesapeake Bay Nutria Eradication Project (CBNEP), commands Bradie to "find it," sending the dog searching for nutria scat he'd planted earlier. When she does, he verifies her find with a "Good girl!" and throws her a tennis ball.

These exercises are the late stages of what may be a continuous monitoring project to rid Maryland's Eastern Shore of nutria *(Myocastor coypus),* an invasive South American rodent that has grazed its way through delicate marsh habitat since it arrived here over 80 years ago. With much of the work already done through intensive trapping, monitoring, and even "Judas nutria" sent in to reveal the location of others, the dogs are seeking traces of whatever nutria might be left behind. It doesn't take many of these prolific breeders to bring numbers back up; on just one 10,000-acre parcel in Maryland's Dorchester County, the nutria population climbed from 150 in 1968 to more than 35,000 by the early 2000s.

Smaller than a beaver but larger than a muskrat, with orange buck teeth and webbed feet, nutria are strong swimmers and live in colonies, where the females reproduce copiously. They are believed to live up to six years in the wild, a lifespan during which they can destroy plenty of marsh, which they do as they feed. Their genus name comes from two Greek words: "mys," which translates to "mouse," and "kastor," which means beaver. These "mouse beavers" are also sometimes called "swamp rats," in part because their tails are round and rat-like, with very little hair.

Adult nutria *can weigh up to 20 pounds and consume a quarter of that body weight in marsh grasses daily.* PHOTO, USDA

Margaret "Marnie" Pepper, a district supervisor and wildlife biologist for the US Department of Agriculture's (USDA) Wildlife Services Division who has been leading the detector dog program, said while nutria may look menacing, they're more a case of an animal in the wrong place.

"They're very interesting creatures," she said. "They're just not where they should be."

These semi-aquatic rodents are just one of many invasive animals and plants that affect the Chesapeake Bay and other watersheds, species that cause billions of dollars of damage to infrastructure projects and ecosystems every year. Zebra mussels clog discharge pipes in the Great Lakes and can be spread via recreational boats from state to state. Blue catfish eat their way through estuaries and lakes, out-competing native fish populations. Plants like English ivy and multiflora rose crowd out native flowers and shrubs.

They're called invasive because they *invade.* Adaptable and opportunistic, they are difficult to eradicate once established. So, when multiple agencies launched the CBNEP in 2002 to get rid of nutria at Blackwater refuge in Dorchester County and elsewhere on the Delmarva, success was not assured.

Yet despite the odds, the last confirmed nutria in Dorchester County was trapped in 2015 according to the US Fish and Wildlife Service (USFWS). The program has been so successful that the USFWS and the Mid-Atlantic Panel on Aquatic Invasive Species have recommended the techniques and equipment be adapted to an area south of the James River in Virginia that needs to control a growing nutria population. (See "Moss Balls, Whelks, and Snakeheads," page 9.) California wildlife officials have also looked toward the Eastern Shore as a blueprint for a successful eradication program.

"It's a heck of a lot cheaper to protect the marshes from nutria than it is to rebuild them after the fact," said Michael L. Fies, a wildlife research biologist and furbearer project leader for the Virginia Department of Wildlife Resources, who has been consulting with Maryland leaders to help his state eliminate its nutria populations in the early stages. "They can totally wipe out a marsh once their numbers get sufficient. But if you catch it early enough, and you don't destroy roots, you can get it back."

Root of the Problem

Marshes are some of the country's most important and fragile habitats for juvenile blue crabs, grazing waterfowl, and migratory birds. They are home to non-woody vegetation that grows well in wet soil conditions, as their soil is saturated much of the year.

Marshes are dynamic, meaning they do not always stay in place. Sediment coming in on tides or during storms can help marshes remain where they are as the sediment piles up on the marsh, a mechanism known as sediment accretion. But a shortage of sediment making its way to marshes may cause marshes to disappear, through sediment erosion. These eroding marshes are replaced eventually by open water as the capture of sediment onto the marsh fails to keep pace with sea level rise. Marshes were misunderstood for many decades as managers filled them in to advance agriculture, develop land, and otherwise industrialize the nation. Today, society recognizes their ecological importance. They also may serve as living barriers during storms, absorbing wave action along the shore.

In more recent years, rising sea levels, land subsidence, and more intense storms have also threatened marshes. In *Sea Level Projections for Maryland,* a 2018 report that the University of Maryland Center for Environmental Science prepared, "the Likely range (66% probability) of the relative rise of mean sea level expected in Maryland between 2000 and 2050 is 0.8 to 1.6 feet," with those numbers escalating if the population does not reduce emissions. As erosion and rising water levels diminish marshes, North American wildlife such as muskrats and waterfowl compete for vegetation that is left.

Nutria only add to the problem. Adults can weigh from 15 to 20 pounds and consume a quarter of that body weight daily. Instead of grazing just the top portion of marsh plants, they dig into the soil to eat the rhizomes and the tubers, the very roots of the marsh systems. It's not unusual for Fies, in Virginia, to return to a marsh in the morning light and find visible proof that the nocturnal invaders have munched their way through crucial habitat.

"They literally destroy the marsh vegetation, and when that vegetation dies, that results in increased erosion," said Fies. "Then you get mudflats, and then you get open water. It causes a complete loss of the marsh."

Nutria are indiscriminate eaters, but the plant they seem to consume the most in Blackwater refuge is *Schoenoplectus americanus,* also known as Olney's three-square bulrush. This native sedge shares an ecosystem with *Phragmites australis* and various other semi-aquatic plants, grasses, and algae, all of which were found in nutria stomachs during a study conducted by The Wildlife Society in the 1970s, which focused on Maryland.

In 2004, a report for Maryland's Department of Natural Resources (DNR) projected the economic cost as a result of nutria damage to the marshes over the next 50 years to be $132 million when factoring in multiplier effects. The number included losses for commercial and recreational uses, including hunting, fishing, birding, and crabbing. The 2004 report cited nutria as the major culprit responsible for Blackwater refuge losing 2,905 acres from about 1954 to about 2004, representing 17 percent of the refuge's historical marsh.

"Bay wetlands have declined for a number of reasons, including development, siltation, pollutants, and introduction of non-native species, among others," the report states. "This erosion of wetlands continues to this day, with nutria being increasingly viewed as a major contributing

NUTRIA, BEFORE AND AFTER

These photos depict a scene that USDA officials observed many times as they canvassed the Eastern Shore's marshes looking for nutria damage to marshes from the invasive rodent, which destroyed the plants at the root level. They were taken where Ellis Bay meets the Wicomico River in the marshy areas of the Ellis Bay Wildlife Management Area. The before image was taken while officials were determining the extent of the area's nutria population. The after image was taken after the nutria were removed.

This photo shows "eat-outs," areas where nutria consumed the marsh plants and their rhizomes down to the mud. In this case, they got to it "right in time," according to Trevor Michaels, a supervisor with the Chesapeake Bay's Nutria Eradication Project. This marsh had not reached loose mudflat or open water, considered the point of no return. The plants could still recover.

In this photo, the bulrush is lush again, with nutria gone. "Once we are done, we let nature take its course," Michaels said. "You remove the animals, and you give it a couple of growing seasons, and it will bounce back."

PHOTOS, STEPHEN KENDROT / USDA

factor." And, among all of these threats, they are one of the few that managers can potentially control.

Once they're in a system, they're hard to stop. They become sexually mature at four months and can produce two or three litters a year, with up to 13 young in each, according to the Chesapeake Bay Program. With no natural predators, a trapping program is the only way to rid an area of them, wildlife officials say. Even then, success is uncertain. This is why even though nutria have been considered extirpated on the Delmarva since 2015, wildlife investigators still go out to look for them in case a remnant population exists or one enters the Eastern Shore from elsewhere, particularly the western side of the Chesapeake.

For his part, Fies knew his state had a problem when a motorist hit a nutria north of the James River, near the Chickahominy River northwest of Richmond. He'd never seen one there before, and he knew it wasn't the only one. This nutria had friends.

Nutria: A History

Fur trapping and trading between Native Americans and French and Dutch settlers was part of the American experience in the late 1600s and throughout the 1700s. Beaver pelts, and later otter pelts, were currency to trade for land, food, and even secure borders. Once colonists and foreign powers hunted fur-bearing animals to near extinction, some entrepreneurs considered farming them for their furs. As noted by A.R. Harding in his 1909 book *Fur Farming,* "The time is approaching when the ever-increasing demand for furs must be met by some way other than trapping the wild animals—but how? Fur farming appears to offer the only solution to the problem."

The market for furs led enterprising importers to bring species to the United States from other countries, including two South American animals, the chinchilla and the nutria. The first US nutria fur farm appeared around 1899 in California, but disappeared a few years later. Nutria did not gain a permanent foothold in North America until 1932 in Oregon and Washington. In the late 1930s, E.L. McIlhenny of the Avery Island Tabasco Sauce empire brought nutria to Louisiana, where they remain today.

As Americans emerged from the Depression and World War II, the get-rich-quick idea of nutria farming took hold. A 1948 ad for Blanke Nutria Farms of Wisconsin trumpeted the advantages of raising nutria for the fur industry. The ad makes its

case with a string of attributes about the animals, among them that clean, easy-to-handle nutria are "easiest to raise . . . immune to disease . . . [and] adaptable to almost any climate." It also notes that they breed early and often, producing many offspring. Finally, the ad states that breeding is "interesting, requires little work . . . and less capital to start," and the fur produced is "truly luxurious, comparing favorably to otter"—marketing that sounded like easy money with little downside.

At Blackwater refuge, where nutria would eventually number between 50,000 and 100,000, the government helped open the door for the rodents. The USDA Fur Field Station and the USFWS shared space at the Blackwater refuge, with USFWS managing the grounds. In 1938, the USDA released some nutria into the marsh, according to historian Phillip Wingate's book *From Before the Bridge: Reminiscences.* USDA officials hoped the nutria would help trappers who were dealing with a plummeting muskrat population and needed replacement fur-bearing animals to hunt.

But the entry of other breeders offering "America's great new opportunity" during the 1940s and 1950s meant more people were getting into the nutria business, depressing the prices. In 1956, an Alabama newspaper, *The Montgomery Advertiser,* reported that Cajun trappers in Louisiana, the largest fur-trapping state at the time, stated that the introduction of nutria was "the worst thing that has ever happened to them." The animals had multiplied to uncontrollable levels, and the pelts were "practically worthless." Worst of all, the article noted, the nutria were driving out the smaller, more profitable muskrats from the marshes the two species shared.

The following year, in 1957, came another warning, from *Kiplinger's Personal Finance:* "If you're tempted by lures of quick cash to go into the nutria-raising business, think twice . . . Practically no furriers are interested in nutria. The few there are can get all they want at 50 cents to two dollars per pelt." The Better Business Bureau expressed similar cautions later that year, but by then, many rural residents had already bet the farm, so to speak, on nutria.

It would take longer in Maryland for doubts to surface over the buck-toothed rodent. In the 1950s, M. Baker Robbins introduced six or eight pairs of nutria from Louisiana to the Eastern Shore. Fur buyer Morgan K. Bennett, who had a farm near the Choptank River, wrote classified ads around that time announcing that he had "released a few nutria in the marshes" around the Choptank. Bennett requested that trappers free them if they were caught so that "we will all have enough to trap" in the future.

But a decade later, Maryland newspapers recorded second thoughts about the wonder rodent. In 1960, USFWS' Clifford Presnall told the Associated Press he was concerned about nutria numbers skyrocketing at Blackwater refuge, as their numbers had reached several hundred, making it appear that the invaders were "reasonably happy with Maryland's climate," Presnall said. Key Wallace, then the refuge's manager, concluded the animals were "nothing but a nuisance . . . They have been burrowing our dikes . . . keeping us busy repairing them." He added: "Our aim is to control them."

That would prove challenging. Rather than building dens, nutria "platform" into dogpiles during winter weather, usually resulting in the death by exposure of the nutria at the top of the piles. Nutria introduction at Blackwater refuge coincided with mild winters, helping them thrive. Also, the price of nutria pelts declined. Trapping numbers in Maryland nonetheless continued upward, starting with only four trapped in 1949, increasing to 41 in 1960, reaching the thousands from 1965 to 1975, and climbing to the all-time high harvest of 29,679 in 1976.

But other factors cut into both the population and its value. Harsh winters in 1977 and 1978 killed many Delmarva nutria. The anti-fur movement that began in the 1970s in response to the harvest of seal pups gained momentum in the 1980s, spreading to all fur-bearing animals trapped for the garment trade. The stock market crash of 1987 also cut into fur business, according to *The New York Times.* Often dyed to resemble beaver, nutria fur had the reputation of not wearing as long and was relegated to coat linings and collars. And it failed to take off as a food item other than for novelty cook-offs. No one seemed to want to make a dietary staple out of a species that goes by the nickname "swamp rat."

State wildlife officials had to acknowledge nutria had reached a problem level, with populations in the Blackwater, Choptank, Nanticoke, and Wicomico rivers. None other than Morgan K. Bennett, Jr., son and namesake of one of the fur dealers who had introduced nutria into Maryland, agreed. "They are just destroying the habitat," he told *The Star-Democrat* in 1989. "Something's got to be done sooner or later about these animals or we won't have much left."

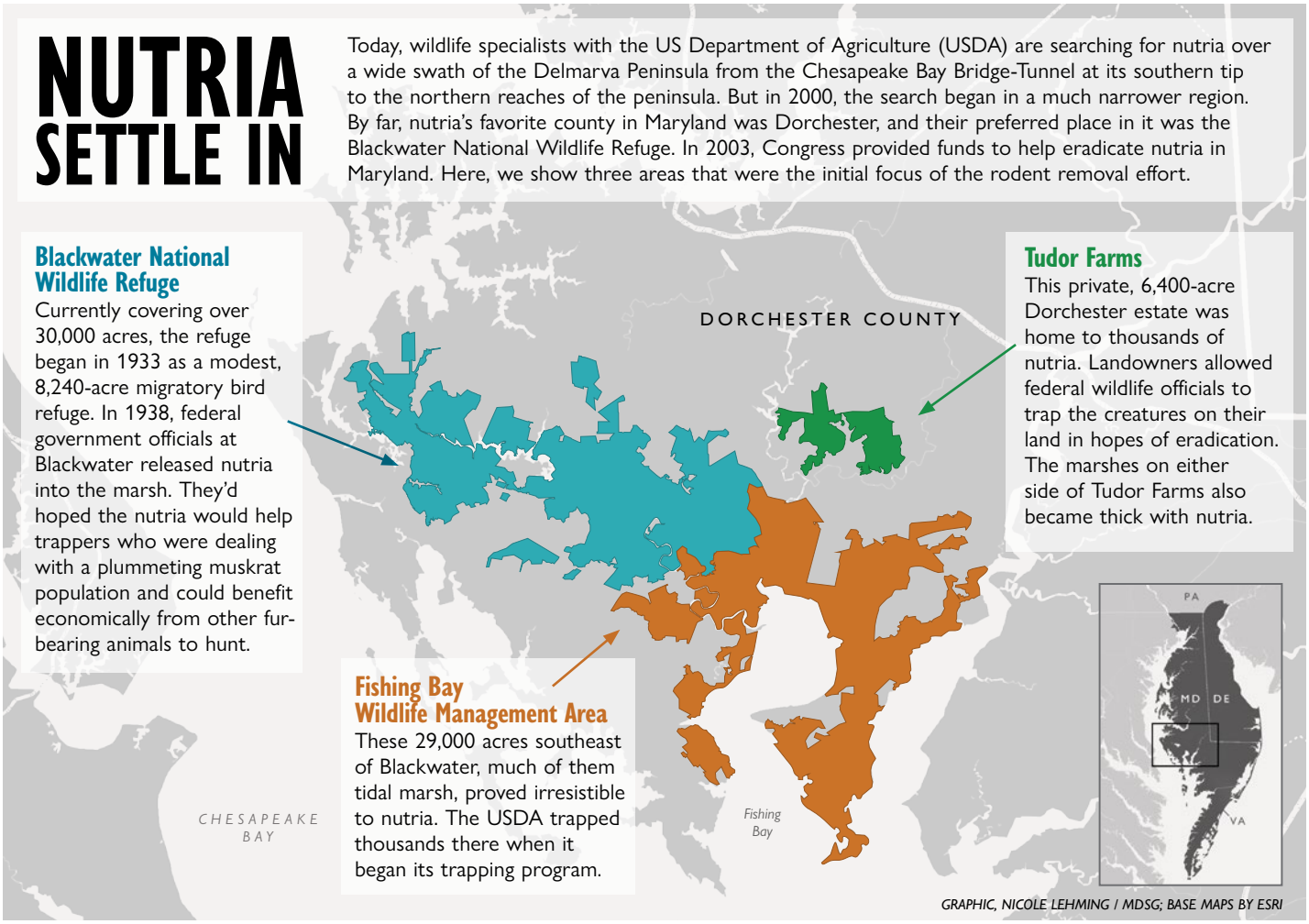
Solving a Problem Like Nutria

The idea of eliminating nutria on the cheap led to offering $1.50 rebates on trapping permit fees for each nutria tail turned in at Blackwater refuge beginning in 1989, and staging nutria cooking demonstrations at the annual National Outdoor Show, which promotes conservation, education, and preservation of the outdoor-centered culture of Dorchester County. Neither really helped.

Researchers then looked to British nutria eradication programs. Harsh winters and an intensive trapping program led to the elimination—and near extirpation—of 40,000 nutria in the region of East Anglia between 1962 and 1965. In 1981, when surviving nutria re-established themselves, a second campaign took shape with the objective of eradicating them from Britain within 10 years. It relied on a three-step strategy: researching the terrain to identify the spread of nutria

NUTRIA SETTLE IN

Today, wildlife specialists with the US Department of Agriculture (USDA) are searching for nutria over a wide swath of the Delmarva Peninsula from the Chesapeake Bay Bridge-Tunnel at its southern tip to the northern reaches of the peninsula. But in 2000, the search began in a much narrower region. By far, nutria's favorite county in Maryland was Dorchester, and their preferred place in it was the Blackwater National Wildlife Refuge. In 2003, Congress provided funds to help eradicate nutria in Maryland. Here, we show three areas that were the initial focus of the rodent removal effort.



GRAPHIC, NICOLE LEHMING / MDSG; BASE MAPS BY ESRI

and their population concentrations, dividing the terrain into sectors that could be covered methodically, and returning to the same sectors to confirm eradication or conduct mop-up trapping.

In 1997, the USFWS and Maryland DNR teamed with 17 other public agencies and private groups to develop a strategy. Their pilot study concluded that it was feasible to eliminate nutria through what was termed later "repeated and ongoing culls." A year later, Congress and President Bill Clinton signed off on a $2.9 million, three-year pilot project, and the Chesapeake Bay Nutria Eradication Program was off and running—funded by USFWS and carried out by the USDA Animal and Plant Health Inspection Service's (APHIS) Wildlife Services program and other partners. Its mission was to eradicate nutria from nearly 800 square miles of Delmarva using a series of different trapping methods and then doubling back with detector dogs to make sure none remained.

A research phase from 2000 through 2002 collected data on nutria populations, behavior and movement, reproduction, and general health at three Dorchester locations: Blackwater refuge, Fishing Bay Wildlife Management Area, and Tudor Farms, a privately owned tract. The approach began with the area where the nutria were most plentiful and then moved to where they were more sporadic—beginning with Blackwater refuge, then the rest of the accessible public and private lands (with permission) in Dorchester, and then the surrounding counties. From 2002 to 2006, the collaborators began eradicating the populations with a "rolling thunder" formation of teams moving together in the same direction to cover 40-acre sectors in areas of suspected nutria populations. They followed the British model, which spread out column by column in the brackish marshes, methodically laying traps. The teams removed 4,496 nutria from Blackwater refuge in 2003.

Moving on from Blackwater refuge to other areas in Dorchester County with lower-density populations, tracking dogs brought in from Alabama and Georgia located nutria in wildlife management areas, repeatedly rechecking areas. Using this systematic strategy, the teams saw success, with the number of nutria they removed declining from 3,442 in 2004 to 540 in 2006.

The next phase expanded from Dorchester into Talbot, Caroline, Somerset, and Wicomico counties with even lower-density populations, removing as many as 1,400 in 2008 and as few as 202 in 2010, according to project officials. As the major nutria population areas were covered across

Handler Mario Eusi *and Cain (left), a chocolate Labrador retriever mix with a calm demeanor and "a very high toy drive." Handler Marnie Pepper and her canine, Tide, (above) at Blackwater National Wildlife Refuge. Both dogs are part of the Nutria Detector Dog training program.* PHOTOS, USDA

the various counties, the project in 2009 began to introduce "Judas nutria"—a dozen sterilized animals equipped with radio-tracking collars. These nutria would travel up to 10 miles to seek out others of their species—indicating where populations still existed.

The Last Nutria?

In 2010, CBNEP installed floating platforms near high-travel areas at the intersection of creeks, based on the finding that nutria preferred loafing on these platforms to other spots, such as the tops of muskrat dens. Since the nutria would defecate on these platforms as well, their scat would be more likely discovered here than on flooded marsh, where scat floats and disperses with the tides. To detect the presence of nutria on these platforms, team members collected scat but also set up cameras and later installed hair snares that would catch hair for analysis when an animal passed through the platform.

As isolated captures slowed, one final group of nutria was reported by a trapper at Mud Mill Pond near the source of the Choptank River on the Maryland-Delaware border, where six nutria were removed in 2012.

In 2014, as the program was moving from the knock-down to the verification stage, it started an official detector dog program in cooperation with the USDA National Detector Dog Training Center. Program personnel were trained with mostly Labrador retriever mixes to create human-dog teams. Working from the dogs' desire to be rewarded with a tennis ball, like Bradie, the dogs were trained to sniff out nutria scat and other samples taken from nutria in captivity at Blackwater refuge. The detector dogs remain local after their work in the program; in many cases, their handlers adopt them.

The detector dogs found 16 nutria in early 2015 at the Ellis Bay Wildlife Management Area at the mouth of the Wicomico River. Those were among the last nutria found on Maryland's Eastern Shore. Now, the program is well into its verification phase. CBNEP human-dog teams retrace their steps, checking every sector where eradication has taken place. Pepper said they are out almost every day, and with two refrigerators full of nutria scat samples, they are always testing the dogs with different scents.

The effects of climate change, land subsidence, and sea level rise point to a grim fate for Blackwater refuge and other Delmarva marshes. But at least scientists and managers can point to the collaborative nutria eradication effort as a success that has strengthened these critically important places against an uncertain future, and as an inspiration for those trying to protect other jeopardized habitats.

"It was absolutely successful," Pepper said, adding that she's gotten calls from as far away as Israel and China for advice on eradicating their nutria. "A lot of lessons were learned along the way, and that is the true value. Now, we can help these other places."

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Phillip Hesser is a writer, historian, and educator focusing on the landscape, life, and livelihoods of Delmarva and the Chesapeake Bay watershed. His latest book, co-authored with Charlie Ewers, is Harriet Tubman's Eastern Shore—The Old Home Is Not There.

Rona Kobell is the editor of Chesapeake Quarterly.

MOSS BALLS, WHELKS, AND SNAKEHEADS

A regional panel helps protect Mid-Atlantic waterways.

By Rona Kobell

In 1998, scientists discovered that a ravenous and predatory mollusk had arrived and established a population in the lower Chesapeake Bay. The veined rapa whelk *(Rapana venosa)* had no natural predators. A native of the northwestern Pacific Ocean, from Japan and Korea and south through Taiwan, the whelks likely arrived in the Chesapeake by ship in ballast water; it's common for ships to take on water in one port to serve as ballast in cargo holds or ballast tanks, then release it upon arrival in another port. The invading whelks quickly expanded their range in the Bay and devastated the already fragile wild oyster and clam populations as well as the state's growing aquaculture industry.

Roger Mann, a marine scientist at the Virginia Institute of Marine Science (VIMS) specializing in mollusks, wanted to work with watermen who would catch the whelks, both to remove them from the water and so the scientists could study the animals and their reproductive abilities. Many species enter estuaries, Mann said, and few become established. But those that do remain spread rapidly and are hard to eradicate, and Mann wondered if the whelk would thrive here long-term.

The Virginia General Assembly and NOAA provided funds for VIMS to offer a bounty for each whelk—$5 for every live one and $2 for the dead—to answer some of these questions. Over 12 years, watermen collected more than 22,000 rapa whelks. The work helped scientists determine their local range and reproductive cycles, provided students with experience in the labs, and cemented a close relationship between watermen and scientists in Virginia.

The collected specimens revealed something unexpected. Mann and colleague Michael Unger, an environmental chemist, discovered that tributyltin (TBT), a biocide used to coat the hulls of ships to deter hitchhiker organisms below the waterline, was present in many places where watermen found whelks. TBT also leaches into the water from those hulls, and its highly toxic chemicals can cause female whelks to grow a penis—a phenomenon known as imposex—which can lead to sterility. In 2006, Mann's work showed a drop in whelk reproduction, which he suspected was due to TBT in the waterways.

Unger, who was studying TBT in bottom sediments, sampled where Mann had collected whelks. When he found a decline in TBT—which may have been because the shipping industry was phasing out its use—he and Mann wondered if that meant the whelk population would explode again. But because the bounty program had ended in 2008, they didn't know.

So Mann turned to the Mid-Atlantic Panel on Aquatic Invasive Species and received $20,000 for a two-year project to ask a small group of watermen to collect whelks in particular areas where the TBT had declined, and help determine if the population was again exploding.

"Given Unger's TBT analysis, not to go back to look at the animals would have been criminal. And when we did, it showed us that both the TBT and the anomaly had declined," Mann said. "And now we know we should not expect this population to go away. Will they be around? Yes. Will they be an ecological and economic problem? The answer is also yes. They are here in sufficient numbers, and they are not going away."

Turning to the Panel

Investing in researchers like Mann is crucial to keeping invasive species out of regional waterways, where they can cause billions of dollars of damage to infrastructure, wildlife, tourism, recreational and commercial fishing, and ecosystems. The Mid-Atlantic panel is one of six regional bodies that coordinate with the Aquatic Nuisance Species Task Force (ANSTF), an intergovernmental group representing more than a dozen federal agencies. It is the only one of the six regional panels that uses its $50,000 federal allotment to fund research projects through a competitive grants process, said longtime panel member Jonathan McKnight, an associate director at the Maryland Department of Natural Resources. That, he said, makes the panel's work both essential and effective.

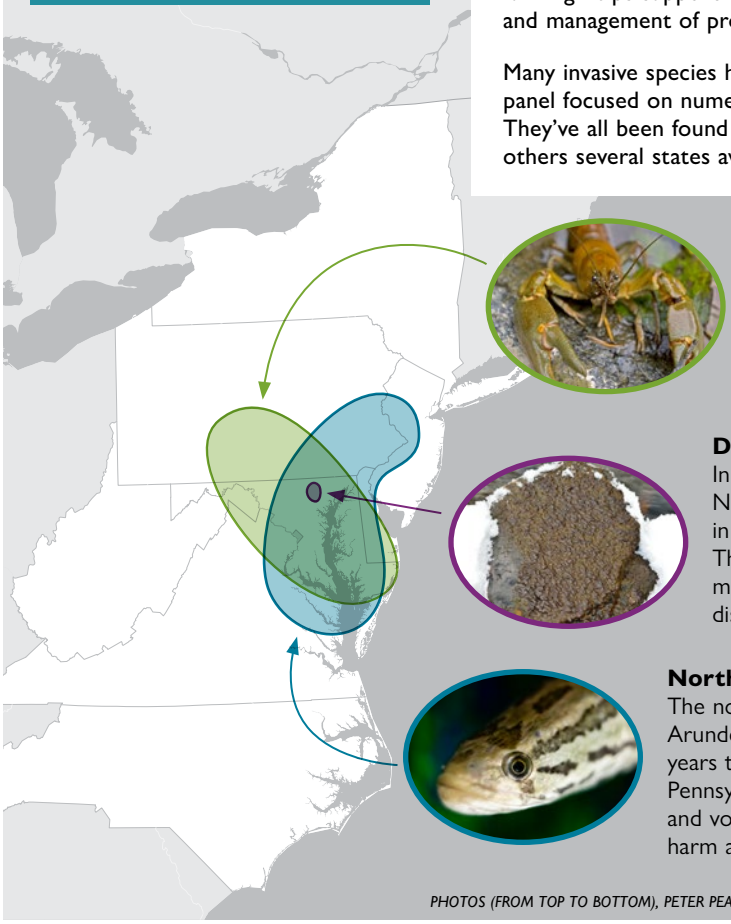
"You put a little money in Roger Mann's pocket to spend on stuff, and you are making a good investment," McKnight said. "He knew it was a delayed system—you remove something that's been holding them back and then, blammo . . . we can see the population blow back up."

Veined rapa whelks are but one worry for the panel, where state representatives from Delaware, Maryland, New Jersey, New York, North Carolina, Pennsylvania, Virginia, and West Virginia come together twice a year to discuss the latest invaders, relevant research, new statutes, management actions, and funding. Through the rest of the year, they stay in touch through email and occasional calls. Because invasive species do not respect politically drawn borders, cooperation is crucial. What is Virginia's problem one year can be Maryland's problem the next, and Delaware's the next, and so on along the coast.

The Mid-Atlantic's INVADERS

Invasive species don't respect state boundaries and can cause significant environmental and economic impacts. Since 2003, the Mid-Atlantic Panel on Aquatic Invasive Species—with representation from **Delaware, Maryland, New Jersey, New York, North Carolina, Pennsylvania, Virginia,** and **West Virginia**—has been meeting and sharing information to try to slow the invaders' spread. The panel's funding helps support biological surveys, education programs, community outreach, and management of projects.

Many invasive species have been reported in multiple states. In the past decade, the panel focused on numerous issues, including the three invaders highlighted below. They've all been found in Maryland, as well as in other places—some close by and others several states away.



Rusty Crayfish ***(Faxonius rusticus)***
Native to the Ohio River basin, rusty crayfish have spread into the Susquehanna River as well as into the middle and upper Potomac River in Maryland. They compete with native fish and have led to reduced native crayfish populations. They consume eggs and invertebrates, diminishing biodiversity.

Didymo ***(Didymosphenia geminata)***
In 2008, this slimy-looking diatom, a native to Northern Europe and North America, was first confirmed in the Chesapeake Bay watershed in Gunpowder Falls between Prettyboy and Loch Raven reservoirs. This single-celled algae has stalks that weave together to make dense mats, which can trap sediment and smother smaller organisms, disrupting the ecology of impacted streams.

Northern Snakehead ***(Channa argus)***
The northern snakehead was first discovered in Maryland in an Anne Arundel County pond in 2002. Its regional range has expanded in recent years to the Potomac River and throughout Maryland, Virginia, and Pennsylvania. Native to regions of China, Russia, and Korea, these large and voracious predators can breathe air outside of the water and can harm aquatic food webs by consuming native fish and eggs.

PHOTOS (FROM TOP TO BOTTOM), PETER PEARSALL / USFWS, MATTHEW K. SHANK, WILL PARSON / CHESAPEAKE BAY PROGRAM; BASE MAP BY ESRI

The panel's small grants often fill the breach or kickstart new initiatives when home institutions or state agencies struggle to come up with funds; often, the small investment from the panel yields a bigger one from a university or organization when initial work shows the need for further study. One recent project in Pennsylvania created outreach mechanisms to determine the scope of flathead catfish in the Susquehanna River. A forum on aquatic invasives in lakes and a symposium on snakehead fish, both panel-funded, brought together scientists and managers to discuss invasive species across borders.

Interagency and interstate cooperation is also crucial to prevent and control invasive species because state laws vary.

"If we wanted to make something illegal in our state, there is a 26-step process. At the federal level, it may be even more complex than that," said panel chair Edna Stetzar, a wildlife biologist with the Delaware Department of Natural Resources and Environmental Control. Her state's laws regarding invasive species are rather reactive, she said, while others, such as Virginia, have ramped up penalties over the past five years for possessing or introducing non-natives.

Spreading the Word, Funding the Science

The panel has funded a diverse group of what McKnight says are some of the best scientists in the world, ranging from renowned experts at the Smithsonian Environmental Research Center to emerging scientists at The George Washington and George Mason universities. The money supports drafting prevention plans, holding conferences and symposia, coordinating outreach campaigns, and determining best practices for eradicating invasive species on private lands. Sometimes, as in Mann's bounty project, it funds the direct collection of the invasive species.

Mike Allen, Maryland Sea Grant's associate director for research and administration, coordinates funding for the panel, which Maryland Sea Grant has supported since its founding in 2003. Allen said the panel is about tackling the big problems, such as predatory

northern snakeheads and destructive nutria, as well as smaller successes and efforts in outreach and communications.

"It's also us sharing updates and potential management strategies others have tried," he said. "Those informal conversations that spread knowledge are important."

The panel also continues to recommend providing resources to Virginia and North Carolina to eradicate their nutria populations, replicating the success of Maryland's program on the Eastern Shore (see "Solving a Problem Like Nutria," page 3). In 2019, it recommended the national task force ask for between $1.5 to $2 million annually for seven years to eradicate the invasive South American rodents in Virginia. It's even recommended that Maryland's personnel train Virginia on its eradication methods and send some resources to its neighbor, something that specialized US Department of Agriculture (USDA) canine teams in Maryland, who are trained to locate signs of nutria in the field, have said they have started and are willing to continue.

"On our own, we can push them pretty much out of Virginia, but for a long-term success, we would need the cooperation of North Carolina," said Michael L. Fies, wildlife research biologist and furbearer project leader with the Virginia Department of Wildlife Resources. He credits the panel with helping to push for funding in Virginia and North Carolina to work on the eradication and a strategic plan, and with helping Virginia come up with a plan that draws on Maryland's work.

Among the recent panel-funded projects are: eDNA monitoring of didymo *(Didymosphenia geminata),* a freshwater diatom nicknamed "rock snot" for its appearance; the publication of *Mid-Atlantic Field Guide to Aquatic Invasive Species;* and a study of bloodworms and the macroalgae their trade can inadvertently bring in to local waters.

Key vectors for spreading invasive species unwittingly include recreational and commercial fishing vessels and even shoes. Didymo can spread via anglers' boots when they go from one stream to another. Bloodworms are commonly sold in Mid-Atlantic fishing tackle stores, and their packing material can contain tiny invasives; helping proprietors understand and communicate proper disposal methods of the packaging can help keep those species out of waterways. Such education is critical, panel members said, because prevention is far easier than eradication.

"Early detection and rapid response are great, but really, you want prevention," said Delaware's Stetzar, "because once these things invade, it's really difficult to get a handle on it."

Mussels on Moss Balls

Not every aquatic species brought into the United States is invasive; some non-natives fail to thrive here. But those that do take hold can wreak unprecedented damage. According to a paper published in 2021 by researchers from Europe, South Africa, and the United States, aquatic and semi-aquatic invasive species have cost the global economy at least $345 billion since 1971. Some introductions are intentional without knowledge of consequences, like blue catfish, which were released into Virginia rivers to establish a new recreational fishery. Others happen accidentally, through the hulls and ballast of shipping vessels or when recreational boats travel between waterways and carry invaders along for the ride.

The best course of action is to keep existing numbers down, keep new invaders out, and share information about emerging threats to protect local fishing industries and ecosystems.

"All of us are working to move that needle," said Susan Pasko, ANSTF's executive secretary at the US Fish and Wildlife Service (USFWS), who frequently briefs the regional panels on national activities. "What are those key messages, key tools, that really work?"

Pasko's task force had its work cut out for it in February 2021, when invasive zebra mussels *(Dreissena polymorpha)* were found at a Seattle Petco store attached to aquarium moss balls—live spheres of green algae, *Chladophora aegagropila*. The fear was that they would enter public water systems and waterways when people cleaned their fish tanks and flushed contaminated water down domestic water pipes or into gardens, or disposed of the moss balls improperly. The task force quickly warned Washington state and then got word out to all the regional panels. Scientists with the US Geological Survey (USGS), USDA, and USFWS began contacting pet stores in every state; by early April the zebra mussels were found in moss balls in all but four: West Virginia, Delaware, Rhode Island, and Hawaii. (For more on invasive mussels, see "Pulling the Mussels," page 12.)

Almost right away, Pasko said, states began contact tracing. Major stores, including Safeway, PetSmart, and Petco, pulled the moss balls from their shelves. The USGS' Ian Pfingsten, a member of the Mid-Atlantic panel who works on mapping the spread of non-native invaders, tracked the moss balls to their likely source, a lake in Ukraine known to be full of zebra mussels. Because the USDA regulates plants but not aquatic pests, its officials didn't look for the aquatic hitchhikers. Now, the USGS is looking at moss balls for other invaders, including worms and other mussels, and USFWS will be notified if more aquatic pests are found.

"Our top two priorities are to stop imports if we can and deal with what's already here," Pasko told the Mid-Atlantic panel at a recent meeting. The moss ball response, she added, "really is an example of how rapid response can escalate to a national level."

For Mann, the Mid-Atlantic panel's investment in his work could convince Virginia to resume efforts to catch the invasive whelks and try to remove them from the Chesapeake.

"It wouldn't surprise me if there were literally tens of thousands still breeding in the Chesapeake Bay," he said. "My suggestion is to prepare for the next wave."

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PULLING *the* MUSSELS

Resource managers have ejected an invasive species—for now.

By Wendy Mitman Clarke

In early spring 2018, Matthew Patterson of the US Fish and Wildlife Service (USFWS) was scuba diving in the chilly waters of Hyde's Quarry near Westminster, Maryland, when he came upon something that made him stop in his fins.

It was a small bivalve, and he suspected it was a member of the dreissenid mussels, a family that includes the famously destructive zebra mussel *(Dreissena polymorpha)* and its close cousin, the quagga mussel *(Dreissena rostriformis bugensis)*. He sent some photos to a Maryland Department of Natural Resources (DNR) expert, and a few weeks later, three DNR divers confirmed his find, locating the mussels on a submerged dive platform and on rocks at the quarry's southern end. They estimated the mussels were three to four years old.

Invasive mussels weren't new to Maryland; zebra mussels first were reported in 2008 in Conowingo Pool just above Conowingo Dam on the Susquehanna River, and a year later, DNR biologists found 11 adults downstream of the dam. Since then, they've been regularly found on buoys and structures in the upper Chesapeake Bay as far south as Hart-Miller Island just east of Baltimore, though they have not spread as dramatically in the brackish estuarine system as initially feared.

But this was the first time that invasive mussels had been identified in a freshwater Maryland quarry. Carroll County had purchased the 8.2-acre Hyde's Quarry in 2007 as a potential public water supply. (The quarry had been actively mined for marble until 1958, when a breach flooded it.) Though the quarry has no direct connection to the Bay, Little Pipe Creek runs only 175 feet away. If microscopic larvae, called veligers, from either mussel made it into that creek, the next stop would be Double Pipe Creek, then the Monocacy River, then the Potomac River, which supplies drinking water for much of metropolitan Washington, DC.

"The last thing we wanted to see was for them to spread from the quarry," says Zachary Neal, hydrogeologist for the Carroll County Department of Land and Resource Management.

Diving for Answers

Zebra and quagga mussels are so similar that many resource managers use the term zebra mussel to describe both species, though research indicates that quaggas could be more destructive long-term to ecosystems. And, according to the US Geological Survey (USGS), quagga mussels are now out-competing and displacing zebra mussels in the Great Lakes and elsewhere. (For more about the differences between zebra and quagga mussels, see bit.ly/invasive-mussels). Both species have had catastrophic effects on water-based infrastructure, occluding pipes and fouling other hard surfaces. Their growth can entirely block water intake pipes to utilities such as nuclear power plants, sewage treatment systems, and public water systems. Precise costs associated with their management and control are difficult to pin down but range from the millions to

Mark Lewandowski, *a biologist with the Maryland Department of Natural Resources, collects invasive mussels from the walls of Hyde's Quarry.* PHOTO, MICHAEL EVERSMIER

billions of dollars, depending on the economic sectors and methods of calculation.

Working with DNR, the county immediately began to develop a plan to eradicate the mussels in Hyde's Quarry. Concerned that continued public access would spread the mussels, the county notified Undersea Outfitters, the Westminster business that had provided recreational diving opportunities there since 2003, that it had 30 days to stop all quarry diving. The county closed the quarry to the public on July 7, 2018.

That same month, DNR divers collected about 350 mussels over 492 square feet going down to about 25 feet and finding "populations on the quarry walls, in cracks and crevices under rocks," Neal says. DNR dredged part of the bottom but didn't find mussels there. Managers estimated the potential habitat in the 115-million-gallon, 55-foot-deep quarry to be hundreds of thousands of square feet.

DNR also surveyed 1.5 miles of Little Pipe Creek but found no evidence of invasive mussels. Because the quarry has no direct access to surface water, and groundwater fluctuations determine its water level, Neal says the county also measured groundwater flow-through to determine how quickly water might be leaving the quarry. This was for two reasons: one, to assess whether flow was rapid enough that the free-swimming veligers could escape via groundwater through openings in bedrock downstream, and two, to help determine how long a chemical treatment might stay in the quarry. This flowthrough was estimated between 1 to 5 percent by volume annually—"so we didn't need to worry about them getting out too quickly."

In August, the county created a task force to assess how best to eradicate the mussels—a science that continues to evolve as stakeholders manage established and new outbreaks worldwide. They consulted resource managers who had stopped mussel invasions elsewhere, including Millbrook Quarry in Virginia, the first open-waterbody eradication of its kind. Also a popular quarry among

Quagga mussels *(top), and zebra mussels look and behave so similarly that they are often misidentified. But unlike zebras, quaggas can inhabit soft sediment, not just hard surfaces. And while quaggas are slower to establish, they become dominant over time in most water bodies. See* ***bit.ly/invasive-mussels*** *for more about the differences between zebra and quagga mussels.* PHOTO, DAVE BRENNER / MICHIGAN SEA GRANT

divers, in 2002 Millbrook became the first documented population of invasive mussels in Virginia.

According to a 2005 USFWS final environmental assessment on Millbrook, managers examined nine options to eradicate the mussels—among them injecting chlorine, shifting the pH, increasing salinity, removing the water, and injecting liquid carbon dioxide (CO_2) to lower dissolved oxygen—before choosing to apply muriate of potassium chloride (KCl). Now considered a fairly standard method, this process injects quantities of KCl—commonly called potash—that essentially asphyxiates the mussels but doesn't harm other aquatic species or humans.

Among the species common in Hyde's Quarry are bluegills, smallmouth bass, largemouth bass, and sunfish, as well as water fleas and snails, Neal says. The county also reviewed USGS studies that evaluated the toxicity of potassium chloride to invasive mussels and non-target species.

"The studies suggested that the project target concentration would not adversely impact non-target species included in those studies," Neal says. "Finally, we asked the Maryland DNR to review their databases and assess for the potential presence of rare, threatened, or endangered species (plants or animals) within a two-mile radius of the quarry; none were identified." This information, along with the quarry's possible use as a future water source, led the task force to treat with potash.

Treatment and Aftermath

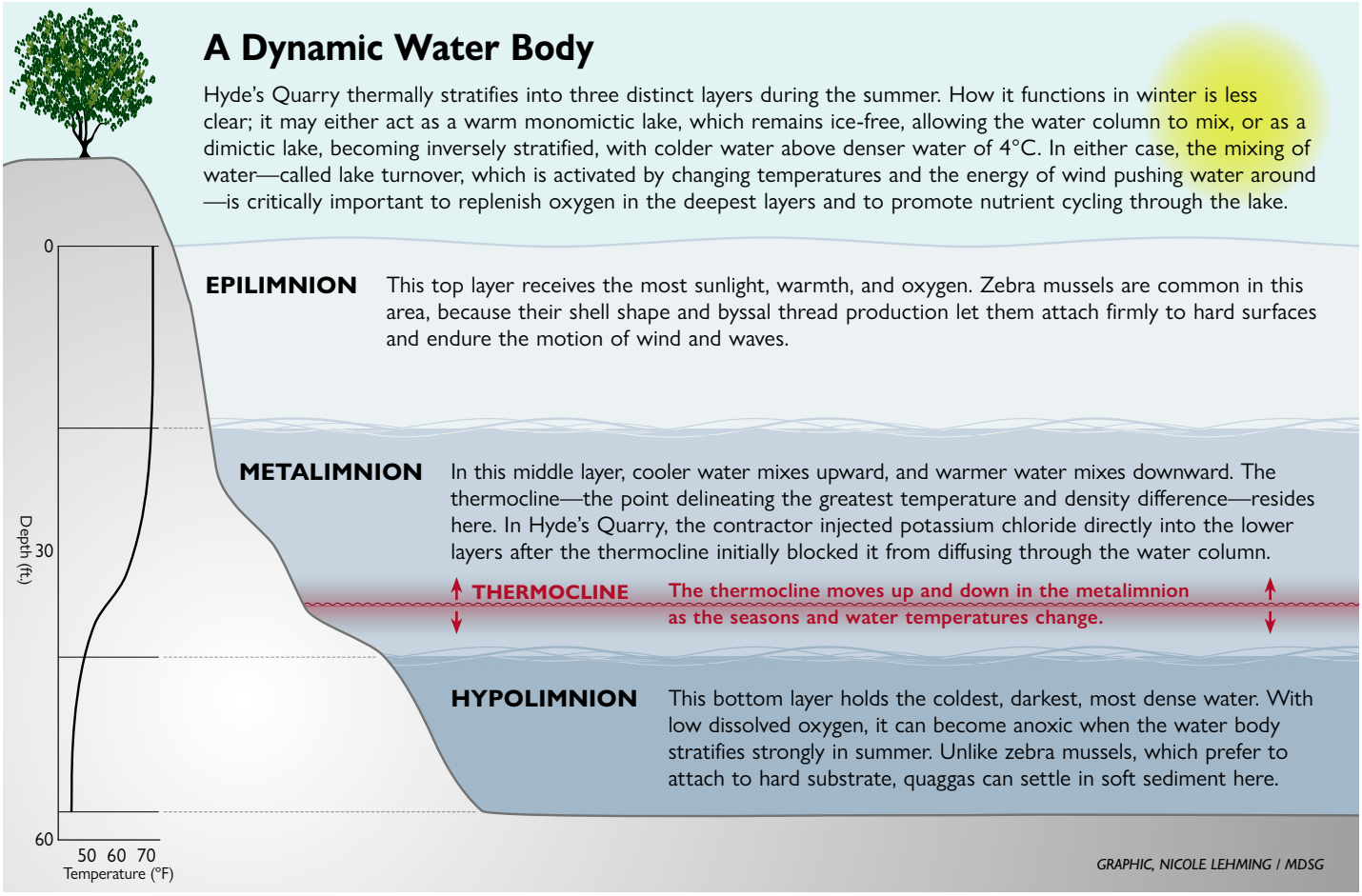
After months of navigating the complex permitting process, treatment began in August 2019. First, DNR divers gathered about 4,800 mussels from the quarry to be used as in-situ bioassays to measure the effectiveness of KCl on mussel mortality. The contractor, ASI Marine, would place 43 mesh bags, with 100 mussels in each bag, at 15 monitoring stations in the quarry, which included locations and depths throughout the water column.

Among these mussels gathered for bioassay, ASI's expert determined that about 90 percent were quaggas.

Between August 15 and 23, the team pumped 470 metric tons of 20 percent KCl solution into the quarry. It wasn't easy. The quarry functions much like a lake, with distinct thermal layers that grow increasingly stratified as the weather warms. A thermocline—the area where the temperature and water density changes most dramatically—is located in the metalimnion, or mid-layer transition zone. By August at Hyde's, the thermocline is at 15 to 20 feet deep.

This stratification challenged efforts to get the potassium levels consistently to the goal concentration of 100 milligrams/liter throughout the layers, particularly in the mid-levels where the thermocline held sway. Although the metalimnion concentration never was as high as in upper and lower layers, ASI's final samples taken in November averaged 86.5 mg/L, well above the minimal lethal concentration of 30 mg/L. ASI also collected the bioassay mussels in November; all were dead.

Sampling at several sites including Little Pipe Creek and neighboring water-supply wells—once before treatment, twice during, and once



after—found some increases in potassium. Concentrations ranged from 3.4 mg/L to a maximum of 12.7 mg/L, well below the 20 mg/L that the toxic materials permit issued by the Maryland Department of the Environment (MDE) noted as a trigger at which property owners and MDE would need to be notified. Neither the EPA nor the MDE have established standards for potassium in drinking water; the World Health Organization (WHO) notes that, "it is not considered necessary to establish a health-based guideline value for potassium in drinking water."

Likewise, other species in the quarry appeared unaffected throughout and after the treatment.

In 2020, DNR surveyed and found no living invasive mussels. The county continues to monitor the quarry and nearby groundwater wells quarterly, and current assessments indicate that the quarry will remain lethal to mussels for up to 12 years, although Neal adds "that estimate is certainly subject to change as new information is collected and analyzed."

The mussel eradication cost the county $365,966. In local news reports, some commissioners expressed frustration at having to fund the project while acknowledging they had little choice. There have been other costs, too. Laird Brown, owner of Undersea Outfitters, says that on a busy weekend, as many as 80 people daily would dive for fun or conduct their scuba certification check-out dives, and the annual New Year's dive drew hundreds. Divers also patronized local hotels and restaurants. Brown says the closing "damn near put me out of business."

The USFWS report on Virginia's Millbrook Quarry—which was reopened to divers after the eradication there—noted that, "unintentional transport by divers from the quarry to other state waters is likely (the microscopic veligers can easily be transported in water-containing pockets of buoyancy compensators, weight belts, or other dive gear, or even on linings of wetsuits)." But Brown says that divers try to avoid becoming veliger vectors by washing gear after every dive.

Carroll County officials do not plan to re-open the quarry to the public. If they use it as a public water source, the MDE may require a lower potassium concentration than is currently observed in the quarry, which "could be achieved either through natural dilution over time, or by also partially draining the quarry until concentrations drop sufficiently," Neal says.

Ed Rothstein, president of the Carroll County Board of Commissioners, said that while county leaders were alarmed to find the mussels, they are pleased about the outcome. "By all accounts," he says, "the eradication seems to be successful and will also protect our environment for years to come."

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Jackie Takacs started college thinking she would be a teacher. And for 25 years she has been one—just not quite in the way she envisioned. Takacs is a senior watershed specialist with University of Maryland Extension–Sea Grant program. Her teaching ranges from helping community members install rain gardens and cisterns to working with local governments to secure funding for stormwater management projects.

"It has been my first job, and my only job, and the job I'll retire from," said Takacs.

The job's focus has changed over time. But one thing that hasn't, she said, is the need for Extension's services. These can range from helping with outdoor plantings that reduce flooding to more unusual tasks like removing snakes from a resident's shoreline protection. Extension specialists often describe themselves as the gears that start things moving—they can help secure grants for tree-planting projects, negotiate with construction engineers about where to put rain gardens, or facilitate dialogue in a community.

Extension Specialist Jackie Takacs *in front of a pond on the farm where she lives.*
PHOTO COURTESY OF JACKIE TAKACS

"That's the hardest thing in Extension, just being distracted by a gazillion different things that come up," she said. "It's really hard to say no. We don't push people off. We're the people that folks get pushed to."

Growing up as one of seven children on Long Island, Takacs got used to change. She moved to Salisbury, Maryland, her senior year in high school when her father opened a facility for a large defense contractor. Already planning to attend University of Maryland, College Park (UMCP) as a soccer recruit with plans to be a teacher, Takacs relished being near home and the water.

She took a job to help pay for school at The Red Roost restaurant and began tending to their fish ponds. Realizing she loved it, Takacs sought out Reginald Harrell, a UMD professor and Extension specialist who was then running an aquaculture program.

"I walked into Reggie's office and essentially said, 'How have you lived without me?' and he gave me a summer job," Takacs recalled. The position was at what is now called the University of Maryland Center for Environmental Science Horn Point Laboratory, where she would eventually work on striped bass and oysters.

She earned her BS with an emphasis on marine biology from UMCP in 1991, and her MS in marine, estuarine, and environmental science in 1995. From there, Takacs worked as the marine specialist for Extension at the Chesapeake Biological Lab. She also developed and taught two environmental courses at St. Mary's College of Maryland. Working with Maryland Sea Grant's Assistant Director of Education J. Adam Frederick, Takacs co-created Aquaculture in Action to train educators how to engage students using aquaculture.

In 2009, she became the senior member of a team that includes five watershed specialists who cover different regions in the state. She oversees Southern Maryland, running stormwater management workshops focusing on how citizens can install their own rain barrels, cisterns, and rain gardens to minimize the rainwater running off their property.

Along with her colleagues, Takacs also runs Watershed Stewards Academies throughout the state. These 12- to 18-month programs train volunteers to assist their local communities with stormwater and pollution issues through more than 40 hours of instruction and a capstone project. (For more on the WSA, see "Cleaning up Stormwater Pollution One Town at a Time," *Chesapeake Quarterly,* May 2017.)

Takacs worked closely with Calvert and St. Mary's counties to create and support a full-time county watershed specialist position, which Nicole Basenback filled. In 2020, Takacs and Basenback began a virtual Watershed Stewards Academy in Calvert County. They mailed at-home lab kits to participants and used web-based sessions to teach what is typically a hands-on, outdoor class. The online format allowed part-time residents to participate, Takacs said.

"I truly believe in hands on," she said. "If you show people how to do it, and give them the resources and confidence, they will be able to do it themselves."

—Rona Kobell

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Maryland Sea Grant Publishes Book on Eastern Oyster Diseases

Maryland Sea Grant has published a comprehensive, color-illustrated guide to diseases, pathogens, and parasites that infect the eastern oyster, *Crassostrea virginica*. The book includes 18 chapters and more than 100 figures and diagrams.

This book should be of much interest to both entrepreneurs who are starting oyster aquaculture businesses and resource managers restoring populations of wild oysters in the eastern United States. Oyster aquaculture in Maryland is a rapidly growing industry; already, our neighbors in Virginia have built the East Coast's largest oyster industry on the US Atlantic Coast, the foundation of which is a disease-resistant oyster that the Virginia Institute of Marine Science (VIMS) helped develop. Other states, including South Carolina, Delaware, and Massachusetts, have increased their aquaculture operations in recent years. Yet, success in oyster aquaculture and restoration relies on close attention to diseases in order to prevent or mitigate serious impacts on production and survival. The book addresses that need with detailed information on the histological presentation of diseases and parasites affecting eastern oysters, as well as diseases caused by viruses and bacteria. The first comprehensive book of its kind, it shows close-up details of disease in the oyster through its 18 chapters as well as prevalence of various parasites and viruses in the Chesapeake. The information can help growers spot disease problems before they become worse.

The book is authored by three oyster experts—Ryan Carnegie of VIMS, and Chris Dungan and Carol McCollough, both of the Maryland Department of Natural Resources. Maryland Sea Grant staff designed, edited, and produced the book.

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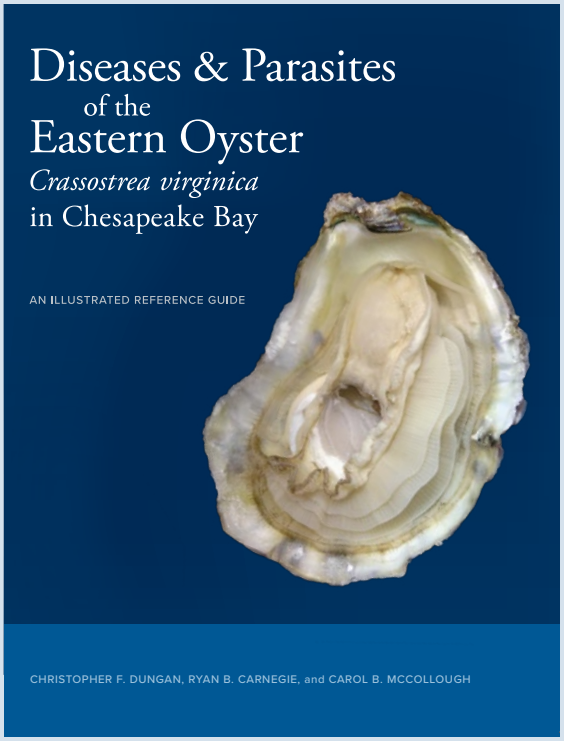

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