1 - https://www.flickr.com/photos/vims_photos/52215402747/

Foreword

When Bill Hargis, the first director of the Virginia Institute of Marine Science, stepped into the Gloucester County courtroom in September 1976, and looked across at the 12 jurors, he felt very much alone – abandoned. Twenty years of wall-to-wall meetings, phone calls, lectures, panels, committees – all the schmoozing, glad-handing, selling, arguing, cajoling – all the scientists, bureaucrats, staffers, governors, senators, congressmen - even presidents and foreign dignitaries. Not to mention the endless hours poring over a microscope, sketching and taking notes, compiling statistics, writing scientific papers, presenting at conferences – *presiding* at conferences. And the interminable, mind-numbing road trips back and forth to DC, Annapolis, and Richmond. This was the thanks he was getting – being treated like a common criminal! And this was serious stuff – grand larceny. If convicted, he could go to the state penitentiary.

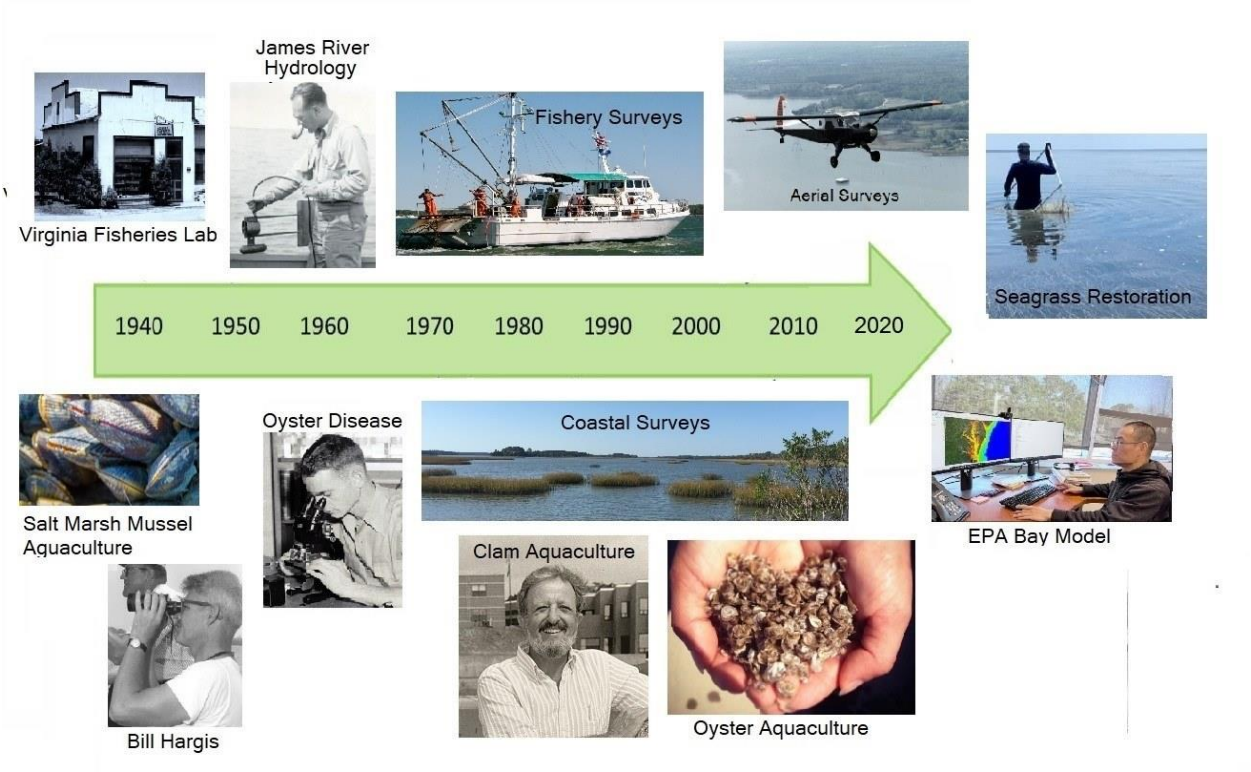
At the trial, a ship's carpenter testified that an allegedly stolen item, a boat engine, was traded in exchange for his labor. Judge James Wilkinson dismissed the charge, commenting, "It's rather shocking to me that the Virginia State Police have wasted 9 months on something like this." It was a victory for Hargis, but he wasn't smiling when he left the courthouse.

No stranger to controversy and not one to keep his opinions to himself, Hargis was a force of nature. He had a rugged, handsome appearance, with a premature shock of silvery white hair. He could charm, he could sell, and if the situation warranted, he could intimidate.

He became the head of VIMS when the state's most lucrative fishery, oysters, was in steep decline due to diseases. It was his mission to find out why. The answers didn't come easily, and the solutions took decades.

Our story begins with stressed-out Chesapeake Bay watermen.

To access the Table of Contents, click the icon at the bottom right.



The Early Years

The Oyster Wars

Before the Civil war, the Chesapeake Bay was brimming with oysters. Captain John Smith complained about running aground on oysters, "thick as stones".

After the war, northern cities prospered, and railroads made it possible to ship goods cheaply and quickly all over the U.S. An oyster that was harvested in the morning in Tangier Sound could be loaded onto a train and appear on a dinner plate in New York that evening. As far west as Colorado and California, prospectors and miners were consuming oysters with gusto. Steamed, stewed, raw, roasted on the half shell, oysters were as popular as hot dogs and hamburgers today. (See funny oyster ads here.)

Chesapeake Bay watermen could hardly keep up with the demand. There were lots of oysters if you knew where to find them without getting shot. It was never easy, though. The work was carried out in the cold months, months with the letter "R". (Oysters "R" in season.)

In 1884, according to Harpers's magazine, there were "700 boats manned by 5,600 daring and unscrupulous men." To say that working conditions were miserable is an understatement. Back then there were no government regulations. Factory workers were expected to work 10 to 14 hours a day, 6 days a week, with no paid time off. Out on a small boat on the Chesapeake in the winter, many workers were treated like slaves. In the Baltimore area, locals refused to sign on.

In the late 1800s, oysters were as inexpensive and popular as hot dogs and hamburgers today.

So the word went out to shipping agents in Philadelphia and New York. They'd get 2 dollars for each unfortunate soul they could sign up. According to historian John Wennersten: "Many German immigrants who had come to New York or Baltimore were kidnapped and intimidated by brass knuckle and pistol into manning the windlass on an oyster boat." The crews "began to work at five o'clock in the morning, received only scarce rations of coarse food, and had to sleep without bedding in the small forepeak of the boat. Often at day's end the men were locked below deck to prevent their escaping, and when in port they were not allowed onshore. Men who refused to work received a cruel beating and were put ashore without pay to make their way back to Baltimore."

When killings took place, the captains pleaded self-defense or mutiny, and the workers generally didn't have the means or the incentive to appear in lengthy court trials.

Like the boomtowns out west, Crisfield, Maryland, attracted merchants, immigrants, gamblers, bootleggers, and prostitutes. After raw, frigid workdays out on the water, the men had money to spend and were ready to eat, drink, and be rowdy. Bare-knuckled boxing was a spectator sport, and barroom brawls often spilled out into the streets.

By 1900 there were 150 seafood processing plants in Crisfield that sent 20 to 30 railcars of oysters to market, six days a week.

By law, Virginia watermen could work only in Virginia; and Marylanders, in Maryland; but who was checking? Skirmishes broke out among the watermen, accusing each other of poaching. Boats from New York and Massachusetts, having depleted their local grounds, heard about the Bay's bounty and entered the fray, bringing a new technology – the dredge – a heavy rake-like device fitted with a bag to catch the oysters as it was dragged along the bottom.

After 1890, oyster harvests began a slow, steady decline.

After 1890, oyster harvests began a slow, steady decline.

Something Had to Be Done

In the 1860s both Maryland and Virginia passed the first laws regulating the fishery. Both states created marine police forces, but quickly found out that policing the waters wasn't easy. It didn't help that in open water and even on land it wasn't clear where the boundary was. A Crisfield man opened a saloon on Fox Island and blatantly violated liquor laws. He avoided prosecution in Maryland by claiming he was located in Virginia and *vice versa*.

A healthy oyster bed, reef, or rock as they are sometimes called, is like a coral reef. It's a mound that builds up over time as each generation grows on top of the previous one. Wild oysters grow in clusters, sticking out in all directions; they provide a labyrinth of nooks and crannies for a myriad of tiny creatures to inhabit.

As oysters are repeatedly harvested, by a rake or dredge, the reef mounds are gradually flattened. Sediment and epiphytes begin to cover the remaining shells, making it unlikely that new larvae will attach and grow. In the late 1800s, the beds were being raked and plundered at the same time that sedimentation into the Bay was increasing. Habitat was being destroyed by fishing and siltation.

As oysters were repeatedly harvested, the reef mounds were gradually flattened.

In the early 1880s, to get a handle on the dwindling resource, the US Coast and Geodetic Survey began surveying Virginia's oyster grounds. It was a maddening task – imagine trying to site a distant object from a telescope in a rocking boat. In the end they had mapped and annotated 200 thousand acres of oyster ground, subsequently known as "Baylor grounds" after the chief surveyor. Productive areas were designated for public use – that was the original goal. But some saw the future potential of the remaining, non-productive bottoms – they were to be leased out to private parties.

Thus began the era in which Virginia watermen could lease oyster ground and care for their "crop" in a farm-like operation, bringing in "seed" oysters as necessary, and protecting the bottoms from overharvesting. Many of the newly leased grounds were unproductive because they had been scraped bare by dredgers, or drudgers, as they were sometimes called. To make them productive again, oyster shells were spread out along the bottom to provide a clean, hard surface for larvae (spat) to adhere. To guard these private beds, some owners built "watch houses" on pilings in the marshes.

The First Chesapeake Bay Labs

The Chesapeake Biological Laboratory

Reginald Truitt grew up on the Eastern Shore of Maryland. His father harvested oysters in Chincoteague Bay. In 1914, after he graduated from the University of Maryland, he took a job as a high school principal. When WWI came along, he joined the Army and became a pilot. After the war he earned an M.S. degree at University of Maryland, excelling not only in science but also lacrosse, as a player and coach. He charmed the ladies on the dance floor; in those days ragtime music was popular and his friends called him "Rags".

2 - https://umdarchives.files.wordpress.com/2022/06/clipping-6.jpg

After earning a PhD at American University, he joined the faculty at University of Maryland where he tried, unsuccessfully, to convince them of the need for a marine lab. Taking matters into his own hands, he opened a makeshift lab in an oyster house on Solomon's Island with a borrowed microscope. His initial goal was to find the best locations to "plant" and grow oysters. He kept the place going and named it the Chesapeake Biological Lab. He was eventually able to get state support, at which time he began to recruit marine scientists.

According to John Wennersten, Truitt was "the Jay Gatsby of the scientific community**.** He drove a nice car, he wore a nice suit, he was in demand at cocktail parties in Annapolis, he flourished in the highest circles. He'd put his arm around you and talk about bridge or snooker or pool or the latest yachting regatta."

According to historian John Wennersten, Truitt was "the Jay Gatsby of the scientific community".

Truitt's first major achievement came early. On the west coast, along the Pacific Ocean, watermen were successfully transplanting Japanese oysters. There were local growers who wanted to try it in the Bay. Truitt experimented and found that Japanese oysters readily cross-bred with local oysters, creating a less palatable hybrid. He argued that importation would lead to degradation of native stocks. He also pointed out that the foreign oysters could bring parasites. For this, he was way ahead of his time. In 1957, the protozoan parasite MSX (*Haplosporidium nelsoni*) decimated oysters in Delaware Bay. The pathogen spread southward along the coast and into the Chesapeake. In 1996 Virginia Institute of

Marine Science (VIMS) researchers Gene Burreson and Nancy Stokes, using DNA matching, found convincing evidence that the parasite originated from Japanese oysters.

In the 30 years that Truitt was the director, he built a world class laboratory that eventually became the University of Maryland Center for Environmental Science (UMCES). During retirement he championed the creation of the Assateague Island National Seashore.

The Virginia Fisheries Laboratory

3 - https://www.flickr.com/photos/vims_photos/15049503443/

In 1925, William and Mary biology professor Donald Davis began advocating for a state-owned marine science lab. In 1931 the Commission of Fisheries hired Victor Loosanoff.

Born in Kyiv, Ukraine, in 1899, Loosanoff fled to the United States to escape the Bolshevik Revolution. He worked as a logger and commercial fisherman while he learned English. In 1931 he graduated from the University of Washington in fisheries science and came to Virginia to work on shellfish culture.

That he was not entirely satisfied with the job may have been, in part, because his "lab" was formerly the men's room at the Old Point Comfort ferry terminal, and he was frequently interrupted by those who weren't aware that the lavatory was now a laboratory. Less than a year after taking the job, he left to work for the U.S. Bureau of Fisheries in Milford, Connecticut.

Loosanoff went on to research the life history of oysters, and devised methods to spawn and rear shellfish in a hatchery, a process that came be known as the "Milford Method". He served as director of the Milford Laboratory from 1936 to 1962. Loosanoff and his coworkers published more than 200 scientific papers on shellfish biology, still referenced today.

In 1938, a small lab was set up in a former gas station at Yorktown, a joint venture between William and Mary, the Virginia Commission of Fisheries, and the U.S. Bureau of Fisheries. In 1940 it was named the Virginia Fisheries Laboratory (VFL).

Davis had the foresight to anticipate conflicts of interest between scientists and regulators. He envisioned an independent role for researchers so that they could communicate their findings without bias or political pressure and be honest brokers in negotiations between regulators and fishermen. That, Davis believed, would be best achieved by having the marine lab affiliated with the College.

Davis envisioned an independent role for researchers so that they could communicate their findings without bias or political pressure and be honest brokers in negotiations between regulators and fishermen.

Davis' vision has been compared to Thomas Jefferson's "wall" of separation between church and state, and it was encoded into Virginia state law. VIMS and its predecessor, VFL, were tasked with science, education, and advisory services; and the Virginia Marine Resources Commission (VMRC) and its predecessors were tasked with regulation and enforcement.

In 1949 the state authorized construction of a new lab across the river in Gloucester Point. It was named after Matthew Fontaine Maury, and contained offices, lab space, a library, dormitories, and a small exhibit area. In 2020 the building was renamed "York River Hall".

Also in 1949, Nelson Marshall, the VFL director, was appointed dean of the William and Mary faculty, and was expected to carry out both roles. At this time, millions of World War II (WWII) veterans had taken advantage of the GI Bill and entered colleges and universities. Intercollegiate sports were popular, and many athletic departments recruited top athletes by cutting corners academically. When William and Mary was implicated, Marshall investigated, but later resigned, "protesting the handling of the matter by the Board of Visitors". At the University of Maryland, Truitt's boss, H.C. "Curley" Byrd, who later became president of the university, "believed very sincerely that the way for a university to become a great university was for it to become known, for it to become loved by the people, and the best way for it to become known and loved by the people was to have winning teams."

Bill Hargis

4 - https://www.flickr.com/photos/vims_photos/15669397292/

In 1959, 35-year-old William Jennings Hargis became the VFL director.

Hargis was born in 1923, in Russel County, Virginia, near the Kentucky border. His forefathers were said to be frontiersmen who travelled with Daniel Boone. His mother was from Tangier Island, where young Hargis spent summers with his grandmother. After high school he enlisted in the Army Air Corps and was a radar operator in the Pacific theater. After the war he took advantage of the GI Bill and enrolled at the University of Richmond, but dropped out after his freshman year. He married and moved to Oxford, Md, his new wife's hometown, and took a job as an assistant manager at a finance company. He worked *two* jobs on the side: selling insurance, and a part-time job at an airport where he trained for his pilot's license. He was about to take a job as a crop duster and charter pilot when they decided to move back to Richmond for Bill to finish college. Mrs. Hargis worked to put him through college and one year of grad school for a master's degree, after which they moved to Tallahassee where he got his PhD at Florida State in 1954.

His first professional job was as a faculty member at the Citadel in Charleston, but he soon left to join the staff at VFL to study oyster drills - snails that can rasp a hole in an oyster shell and consume the oyster. With a background in parasitology, Hargis was well suited to the challenges that awaited.

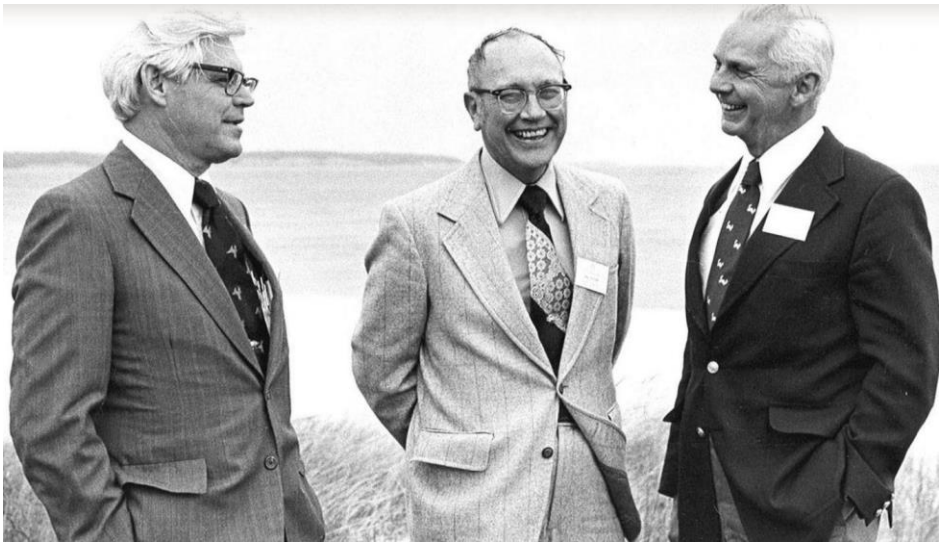
To grow the lab, Hargis needed to hire good people. He did the staffing himself – he recruited, negotiated, and made the hiring decisions without consulting anyone. He allowed researchers to spend 25% of their time on their own research, but the remaining 75% was for Hargis' initiatives: "The state is paying your salary and that's the way it's going to work." That commitment to public service has waned in modern times.

5 - https://www.flickr.com/photos/vims_photos/15048347453/

The Chesapeake Bay Institute

In 1951, VFL director Marshall and CBL President Truitt approached the Office of Naval Research to request funding to study Bay currents. It was a good time to ask. The Navy, headquartered in Norfolk, was interested in protecting the fleet from submarines, and both Virginia and Maryland required places to store dredge spoils.

Estuarine circulation was not the sort of thing that Marshall and Truitt's labs had studied – they had focused on biological issues that impacted fisheries. The Office of Naval Research agreed to fund a new lab at Johns Hopkins University, to be called the Chesapeake Bay Institute. The lab would specialize in estuarine physics, and not compete with Marshall and Truitt's biological labs. The first director was 27-year old Donald Pritchard.



6 - Hargis, Pritchard, and Gene Cronin *https://hub.jhu.edu/magazine/2021/summer/chesapeake-bay-institute-don-pritchard/*

Pritchard was born and raised in Santa Ana, California. At the California Institute of Technology he studied chemical engineering and played football – quarterback. During his sophomore year he enlisted in the Army and was assigned to a special program at Scripps Institution of Oceanography to learn to forecast weather and sea conditions for amphibious landings. He was assigned to the team of meteorologists who, during a period of stormy weather, advised General Eisenhower when to launch the Normandy invasion, based on weather observations from the mid-Atlantic that the Germans were not privy to. After the invasion Pritchard was sent to Normandy where he co-authored daily forecasts. While the Germans anticipated the allies would try to take a nearby seaport, the Navy was offloading troops, tanks, and artillery onto the beaches of Normandy.

After the war Pritchard returned to Scripps to study oceanography under two Norwegians, Jacob Bjerknes and Harald Sverdrup, who applied their knowledge of the physics of the atmosphere to the ocean and started the first graduate school of oceanography in the US. Many of their students went on to start new departments of oceanography at other US universities.

7 - Pritchard, smoking and handling a current meter.
https://www.vims.edu/about/at_a_glance/photo_galleries/early_vims/index.php

Pritchard began investigating the currents of the James River. His team crafted some of the instruments themselves; one of which was a plywood paddlewheel current meter. Analyzing the results, Pritchard described what was later to be called a “salt wedge estuary”, with light, fresh water flowing downstream at the surface, and dense, salty water flowing upstream along the bottom. Mixing occurred at the interface between the two “layers”.

Pritchard’s 1952 model of estuarine flow has held up and is still being taught today, with refinements.

Virginia Fisheries

8 - Rita Crockett sampling a Healthy Oyster Reef *https://www.flickr.com/photos/vims_photos/52266192290/*

Oysters

It's hard to overstate the importance of oysters in Virginia's history. We know from archeological digs that oyster shells are abundant in ancient waste pits.

When the early Jamestown colonists were starving, oysters may have been the one food that kept them going.

Colonial Williamsburg archeologists can examine an oyster shell and tell how old it is from tree-ring-like markings on the hinge. They can tell how salty the water was from the porosity - salty water has more boring worms - and this is a clue to where the oyster came from. A lab test, the oxygen isotope profile, indicates the temperature of the water, which, in turn, indicates what season of the year it was harvested. Finally, the length and depth and texture of the shell indicates whether they were bed, sand, channel, or reef oysters.

In 1957 the MSX pathogen infected oyster populations in Delaware Bay. It was harmless to people, but devastating to adult oysters

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Oystering was a dependable livelihood, a way of life passed down from father to son. However, over the years, fewer and fewer young men became oystermen due to declining harvests. But with higher and higher prices, it remained a viable livelihood.

Then, in 1957 the MSX pathogen infected oyster populations in Delaware Bay. It was harmless to people, but devastating to adult oysters. Anticipating its spread southward, Hargis established a temporary field lab at Wachapreague on the Eastern Shore to monitor the spread of the disease. Virginia was spared at first, but the pathogen appeared in the lower Chesapeake Bay in 1959. It crippled the industry.

In the1980s, another microorganism, initially called Dermo (*Perkinsus marinus*), evolved into a devastating pathogen. This was the last straw - the oyster industry effectively collapsed. Hargis and his team investigated but had no solutions.

Something had to be done.

Crabs

9 - https://www.flickr.com/photos/vims_photos/3570130581/

Around 1900, when it was obvious to anyone who cared that the era of unlimited oysters was over, Tangier Island oystermen started crabbing in the summer months. Crabs had always been around, obviously, but they had not been harvested commercially.

At that time, the boxy chicken-wire crab pot had not been invented. Crabbers used 'trotlines" - a line that is baited every 3 feet or so and lays on the bottom. No hooks are used. The crabber runs his boat along the line, lifting it out of the water as he goes. Crabs cling to the bait as it rises out of the water and are caught in a net.

In the winter, crabbers started using dredges similar to those used for oysters, to catch hibernating crabs in bottom sediments.

Crabs that are about to molt, called peelers, were sorted out from a day's catch. Watermen can identify peelers by looking at the backfin to see if a new shell is forming inside the old. A "white line " appears first, and then a "red line". Peelers are held in water tables and harvested as soon as they molt to be sold as soft shells. In the summer, crabbers dragged dredges without teeth across the then-extensive eelgrass beds to catch peelers.

Like oystermen, crabbers rise early. By law, they can only work certain hours; nowadays that is between 6AM and 2PM. Soft crabbers rise even earlier to check their holding tanks, open tanks that contain peelers. Once the crabs molt, they are soft and command a high price. Tanks must be "bustered up"

every 6 hours, around the clock, to pick out those that have finished shedding. These soft crabs are immediately refrigerated or frozen and sent to market.

Watermen are like farmers in many ways. At times, the work can be arduous and incessant. The weather controls their work schedule, and both "crops" are subject to predators, pests, and disease.

Watermen are like farmers in many ways. At times, the work can be arduous and incessant. The weather controls their work schedule, and both "crops" are subject to predators, pests, and disease. But that's where the similarity ends. A farmer can use commercial seed and can plant when and where he wants. He can water his crop, fertilize, and spray herbicides and pesticides. He can qualify for government subsidies. Nobody pays crabbers not to crab.

Hard crabs and oysters are sold to "buy boats" and the prices are set by the buyers. The watermen are not in a position to bargain - their seafood is perishable. It's a hard life. A 2016 report found that the number of Chesapeake Bay watermen declined from 10,000 to 3,000 since the 1990s.

Earl Swift, author of the acclaimed Chesapeake Requiem, spent time with watermen on Tangier Island. After a long day on the water, he once asked Mayor James "Ooker" Eskridge why they don't just catch the adults and grow them in their tanks until they molt. Eskridge explained that it wouldn't work, that crabs don't flourish in captivity.

Crab aquaculture has been tried also, but it has proven too costly. A major problem - they must be kept separated to keep them from eating each other.

Anyone who has tried to pick up a big blue crab, especially a female, will tell you - they are feisty critters. They have almost 360 degree vision and if they snag you with that right claw - the one they use for crushing - even if you have gloves on, it's gonna hurt. And they don't let go.

Crab aquaculture has been tried, but it has proved too costly. A major problem - they must be kept separated to keep them from eating each other.

Crab Pots

Frustrated by decades of trotlining, waterman Frank Lewis, in his late 60s, started work on the first crab trap. His son said when Pop first got the idea it was a hot summer day and he sat under a tree for several hours mulling it over and didn't hear when his wife called for dinner. His design was a chicken-wire box with funnel-like openings on opposite sides and a bait box in the middle. Crabs would find their way inside, and then try to escape by swimming upward through a narrow opening that led to the "parlor" compartment. A hinged top enabled the crabber to shake out the crabs.

Lewis patented his crab pot in 1928. He initially charged a $4 patent fee for every 50 pots. Once the design became known, for some reason people didn't seek him out to pay up. Lewis was one of the first car owners in his town; a Model A Ford, which he bought for his son to go around and collect

fees. According to journalist Janet Evans Hinman, “Sadly, he wasn’t able to collect even a fraction of what was due him for his invention. … in most history books he is largely unheralded. But for those who care to know, this humble and industrious waterman can claim the distinction of revolutionizing an industry forever.”

Lewis’ design is still being copied all over the East Coast. At some point, a similar "peeler pot" was invented with a bait box designed to hold live, sexually mature males (big Jimmys), who secrete a pheromone that attracts juvenile females about to molt.

"...for those who care to know, this humble and industrious waterman can claim the distinction of revolutionizing an industry forever.”

In recent years, abandoned pots have been identified as a problem. It is estimated that 15% of deployed pots become detached from their floats - sometimes clipped by boaters' props - and are lost. After a while on the bottom, the chicken wire gets fouled up, and crabs and other critters can become trapped. Newer pots have biodegradable panels designed to prevent entrapment.

VIMS has launched campaigns to find and remove derelict pots. They hired crabbers to do the work. In a 6-year period they removed 34,000 pots. “We estimate that crabbers harvested about 60 million more crabs due to the ghost-pot removals,” says VIMS researcher Donna Bilkovic.

VIMS was recently awarded an 8 million dollar grant to lead a 4-year national program for managing derelict fishing gear. VIMS will sponsor a nationwide competition which will award funds to state and local groups to find and remove derelict nets, pots, and traps. Applicants will need to submit detailed plans and agree to document successful removals. VIMS will collate the data and publish it on a website. The goal is to assess the ecological and economic impacts and hopefully come up with preventive measures.

VIMS was recently awarded an 8 million dollar grant to lead a 4-year national program for managing derelict fishing gear.

10 - Derelict Crab Pot *https://www.flickr.com/photos/vims_photos/48899500588/*

Pickers and Shuckers

Once hard crabs and oysters are harvested, they must be readied for shipping. Each can be shipped live after being packed into suitable containers, but most oysters are shucked and canned, and most crabs are cooked and the meat is picked out. By and large, this is still done the way it has always been done, manually, one at a time, and pickers are typically paid by the pound picked. Good shuckers and pickers are fast and highly coveted by employers, but the pay is low and the hours are long – and early - a tradition before air conditioning and refrigeration.

Nowadays immigrants do most of the picking. A few years ago, there was a guest worker program that allowed Mexicans to enter for seasonal work, but the program has been halted in recent years in response to public concern about immigration. Economist Doug Lipton, a VIMS graduate, calculates that for every immigrant worker, 2.5 jobs are created. "The immigrants are not taking American jobs", Lipton says, "they are creating them".

On Smith Island, Maryland, there has long been a tradition that the men crabbed and the women picked. The women also made a delicious confection known as Smith Island multi-layer cake. In the film, *An Island Out of Time*, by Tom Horton, Dwight Marshall and his wife Mary Ada talked about their work lives.

On Smith Island, Maryland, there has long been a tradition that the men crabbed and the women picked.

Like most soft crabbers, Marshall worked long hours tending the pots and his tanks. His wife, Mary Ada, said, **"**Dwight and I have always worked together side by side. A typical day for me would be get up at 2:00 and 2:30 in the morning, pick a bushel of crabs; stop at quarter to seven. And go to the boat, put your meat on there, come in, put in a tub of clothes, make your beds, line up what you're going to have for your evening meal, then go down to the shanty, cut about 5 trays of soft crabs and wrap them. Come up, and if it was cool enough, you'd cut the grass. Get your supper - we'd eat our evening meal by three o'clock, and at 4:00 o'clock you were back out picking again. And by 7:00 o'clock you were done, had you shower and ready to go to bed by 8:00 o'clock." She didn't mention that she also cooked breakfast and got 4 kids off to school.

One day before going to school, Mrs. Marshall's daughter, Maria, announced, "Ma, it's one thing, you can take this to the bank. I'm not picking crabs and I'm not standing here making cakes and cooking like you do."

Mrs. Marshall replied, "What *do* you want to do, young lady?"

Maria: "I want to wear high heels and work in the city and carry a briefcase in my hand."

As it turned out, Maria got her wish. Most of her friends also left the island after high school.

Crackin' Claws and Breakin' Laws

In 1992, health department personnel announced that Smith Island women must adopt modern sanitation practices or be shut down. The regulators were concerned that a food poisoning incident might scare off consumers state-wide.

According to Janice Marshall, in Tom Horton's entertaining book, *An Island Out of Time*, "I didn't see how we could afford to do what they wanted; but I didn't see how I could afford to chance it, either - married to a waterman with heart problems and oysters in the bay hittin' the lowest catch in history that very winter. Lately, it takes picking as hard as some of us can go just to pay off our last year's taxes by August 15 (the filing extension deadline)."

"They would give us a reprieve, the state lady said. We could pick the next summer, but we had to have a plan for going legal, and prove we were working on it and would meet all rules and regulations of the mainland by April of 1994. We broke up the meeting agreeable, which people from off (the island) often take to mean that everybody's agreed on something. We served all the visitors bootleg crab balls, bootleg crab Norfolk, and bootleg crabcakes, which they agreed was some of the best they had ever ate."

"...We served all the visitors bootleg crab balls, bootleg crab Norfolk, and bootleg crabcakes, which they agreed was some of the best they had ever ate."

Sea Scallops

At the beginning of the new millennium, year 2000, the oyster industry was comatose and the crab fishery was suffering. It seemed that all the news about seafood was bad. However, there was one fishery that was growing – sea scallops.

Sea scallops are large bivalves, like clams, with a smooth shell that can be snapped shut to jet-propel them through the water. They range from North Carolina to Newfoundland, where they live in “beds" on the surface of the ocean bottom at depths of 100 to 300 feet.

Offshore fisheries between 3 and 200 miles offshore are regulated by the *National Marine Fisheries Service* (NMFS). Sea scallops are regulated by the NMFS *New England Fishery Management Council* (NEFMC), based in Massachusetts.

Sea scallops can live up to 20 years and grow up to 9 inches long. They become fertile starting around age 4. If an annual survey finds a site with a predominantly young population, regulators will close the area to allow the scallops to reach at least 5 years old, so that they have the chance to grow and reproduce.

Sea scallops can live up to 20 years and grow up to 9 inches long.

11 - Juvenile Sea scallops. https://www.flickr.com/photos/vims_photos/8368762212/

Nationally, the fishery started growing in 1975 and reached a peak value of $90 million in 2004. In the '80s and '90s, watermen could harvest sea scallops all year long. As a result, the stock was overfished and the population plummeted. The NEMFC gradually cut back fishing days from 120 to 30-

something. According to NEFMC spokesperson Deirdre Boelke, "(Now) vessels are actually landing more pounds and more product than even when they had more days at sea because there's more scallops on the bottom and it's more efficient. Catch rates are a lot higher, and the animals themselves are a lot larger… And larger scallops happen to cost more."

Ocean-going scallop boats, typically 70 to 100 feet in length, are required to carry GPS tracking devices, to assure that they obey regulations. The crew size is restricted to 7 and the trips can be anywhere from 10 to 14 days. The work is exhausting. On land foul weather is one thing, but on the open ocean, the pitching and rolling can be incessant. The work shifts are 18 hours and the boats fish continuously. When the crew members are not manning the dredge, they shuck. Only the adductor muscle is kept; the rest is discarded at sea. The shuckers are really fast – it takes about 1 second per scallop – you have to see it to believe it.

The 2010 documentary, The Wreck of the Lady Mary, is the story of a scallop boat that sank in heavy seas near shipping lanes off the coast of New Jersey, and at first it was thought that it may have been hit by a container ship. Those behemoths move fast and can't maneuver well, and they can come up on a scallop boat very quickly. Much of the time the scallop boats are towing a dredge or trawl net, so they are also not maneuverable. The container ships are so massive they can hit a scallop boat and not even know it.

A typical cruise with 6-8 fisherman can net somewhere between $120,000 and $250,000. A deck hand can make as much as $20,000. It's hazardous work, though. An estimated 425 workers die on average each year per 100,000 full-time scalloping workers - more than the number who die in the Alaskan crab fishery.

The shuckers are really fast – it takes about 1 second per scallop – you have to see it to believe it.

Bill DuPaul

In 2018 VIMS scientist Bill DuPaul received an award from NEFMC for his part in reviving the sea scallop industry, which had declined in the 1990s and in 2018 was the second most valuable commercial fishery on the East Coast.

In particular, DuPaul was hailed for his ability to work with commercial fishermen. NEFMC Chair John Quinn said that DuPaul "earned the deep trust and respect of fishermen from his many years on deck, knee-high in scallop shells and fish slime with the best of them. He proved that cooperative research can break through seemingly insurmountable barriers and help resolve even the most challenging issues."

12 - David Rudders, Bill DuPaul, and Noelle Yochum aboard a commercial scallop boat during a monitoring survey.
https://www.vims.edu/newsandevents/topstories/archives/2009/dupaul_retirement.php

NEFMC spokesperson Janice Plante added, "Bill spent countless hours at sea with fishermen conducting biological studies and annual surveys that have helped gauge abundance and distribution of scallops both on Georges Bank and throughout the Mid-Atlantic. The annual surveys also helped document incoming recruitment, enabling fishery managers to identify and close areas with large beds of immature scallops for additional grow-out. This practice is a bedrock of the current rotational area management program - and one that Bill was in on from the beginning."

DuPaul was a highly respected participant in *Scallop RSA Share Days* where fishermen and scientists meet to discuss research results and exchange ideas about emerging issues.

.DuPaul was also instrumental in setting up the Scallop Research Set-Aside (RSA) Program, where NEFMC sets aside a portion of income from permission-to-harvest fees, for research and development. An innovative program, it requires no state or federal funding. David Rudders, a former student of DuPaul, currently leads the VIMS scallop research program, mostly funded by the set-aside program.

Sharks!

13 - 9421924445_61ed889d76_o.jpg

Anyone who is old enough to have seen the movie *Jaws*, remembers when a great white lunges out of the water at Richard Dreyfuss. *Jaws* was one of the most successful disaster movies of all time, and it turned out to be a true disaster for sharks.

For many years, VIMS fishery scientist Jack Musick would tell audiences, "You are 30 times more likely to be killed by a dog than to be bitten by a shark."

in 1973 Musick started a survey of shark populations in the Mid-Atlantic, and it's now the longest-running survey of its kind. Every summer they fish a 100-hook longline at 8 stations off the Virginia coast. Each shark is weighed, measured, tagged, and the sex recorded. Nowadays a DNA sample is taken also. (video link)

The survey began 2 years before the movie *Jaws*, which was fortunate, as public sentiment turned against sharks and led to negligence, overfishing, and an irrational fear of ocean waters. Musick's data documented the population declines.

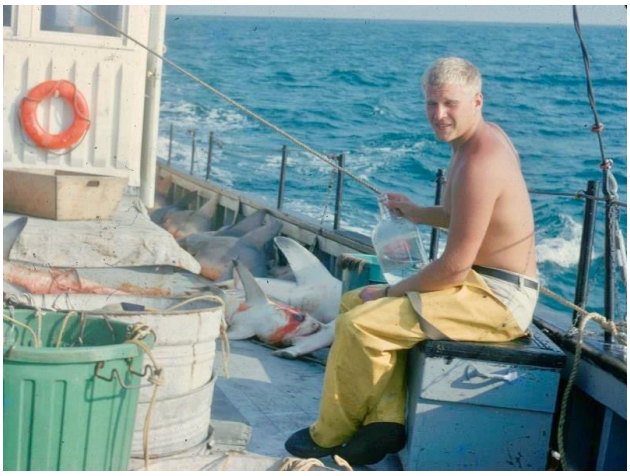
What most people didn't realize was that sharks are long-lived and reproduce slowly. According to Musick, "Sharks are at the top of the food web and when you remove the apex predators, it throws

everything out of whack. Their prey items become more abundant and tend to overeat plants and animals below them in the food chain.

What most people didn't realize was that sharks are long-lived and reproduce slowly.

Musick's studies of fish populations have served as a basis for management plans. During his tenure he collected a plethora of fish specimens – a collection that grew into the Nunnally Ichthyology Collection – currently 500,000 specimens used for study and research by scientists around the world.

Jack Musick



14 - Jack Musick https://www.flickr.com/photos/vims_photos/50947412561/in/album-72157718301623223/

Jack Musick was born in 1941 in Trenton, New Jersey. As a kid he collected frogs, worms, insects, snakes, and dead birds. As a teenager he fished and crabbed at local beaches. He studied biology at Rutgers, Harvard, and Woods Hole Oceanographic Institution; then joined the faculty at VIMS. He was a prolific researcher, writer, and mentor. During his tenure he served as major professor for 89 graduate students – many of whom have gone on to distinguished careers.

Each spring Musick took a group of students headed to the Appalachians to study freshwater fishes. They called it the "Roanoke Roundup", and it was quite popular. In Musick's words, "The rolling hills, redbuds and dogwoods in full bloom, and the gourmet meals (which only occasionally included fresh roadkill) are all just bonuses for the trip. It's a very special event."

Like Darwin's finches, fish in the mountain streams originated from the same ancestral stock, but evolved in isolation, resulting in new species with subtle differences. "Each spring, when it's time to mate, the males take on brilliant species-specific colors. So, although closely related species have the same body and fin shape, individual species can be recognized by the decoration of bright blues, reds, yellows, and oranges."

Like Darwin's finches, fish in the mountain streams originated from the same ancestral stock, but evolved in isolation, resulting in new species with subtle differences.

15 - Musick's crew pitches in to catch freshwater fish in a mountain stream. 21302970555_02c424159c_o.jpg

Three of Musick's books, *Biology of Sharks and Their Relatives*, *The Biology of Sea Turtles*, and *Fishes of Chesapeake Bay*, have received wide acclaim. Musick's wife, Beverly, a science writer, co-wrote some of his books including *The Shark Chronicles*, a tale of Musick's adventures on the sea and on the land.

If you were a friend of Musick's and owned a garage or outbuilding, you most assuredly did not want him to find out. If he did, he was likely to cozy up to you at a social event, offer to refill your drink, and mention that he may be looking for a place to store some fish specimens. What he may not have emphasized, was that to prepare a nice clean fish skeleton, he used scavenger beetles. There was only one tiny problem -- a certain olfactory experience, to put it in scientific terms. "Unforgettable" was a polite way to describe it.

16 - Hank Brooks of the VIMS Juvenile Fish Survey holds a longnose gar
https://www.flickr.com/photos/vims_photos/7314850836/

During the late 1970s, at the request of his students, Musick began researching sea turtles. Using some of the first satellite tracking devices, Musick and his students established that the Bay is an important nursery area for Loggerheads and Kemp's Ridleys. Musick's group monitored abundance in Virginia waters and evaluated the impact of conservation measures. This work was popular with the public and brought favorable press coverage.

With funding from the Virginia Coastal Zone Management (CZM) Program, Musick established Virginia's Sea Turtle Stranding Program and managed it for its first 20 years. After Musick retired, again with support from the Virginia CZM Program, the stranding program was transitioned to the Virginia Aquarium & Marine Science Center. All turtle and marine mammal strandings are now reported there.

Rays

A relative of sharks, the cownose ray, *Rhinoptera bonasus*, is a pizza-sized ray with jaws that are capable of chomping through bivalve shells like clams and oysters. They have a spine at the base of their dorsal fin that has a non-fatal but painful venom. They travel in schools; in 1988, a VIMS student photographed a huge school of rays in the Bay, covering an estimated 1,000 acres.

Cownose rays have been abundant in the Bay for many years. Captain John Smith speared one near the mouth of the Rappahannock River, and apparently got stung from handling it carelessly. The sting was painful and memorable enough that they named the nearest land "Stingray Point".

In the first decade of the millennium, there were oyster restoration projects where they would plant lab-raised "seed oysters" on depleted reefs. Predators were a problem. In the Piankatank River it was estimated that, on one occasion, cownose rays ate 90% of 775,000 recently planted oysters. Rays were also a problem for Castagna's clams on the Eastern Shore. There was also evidence that rays uprooted seagrass while foraging for food.

17 - Kristene Parsons releases a tagged cownose ray *https://www.flickr.com/photos/vims_photos/30463767228/*

Something had to be done.

A Regional Workshop on Cownose Ray Issues was held in Yorktown in 2006. The group started a campaign to encourage a recreational fishery and to promote ray wings as seafood. One of the papers was entitled *A Ray of Hope: Finding a Market for the Chesapeake Ray.* Marketers came up with the slogan, "Save the Bay, eat a ray".

Fast forward to 2016. Researchers were now concerned that rays were overfished. "…we have no estimate of their overall population, we have no idea what level of fishing mortality this represents. It also doesn't take into account landings in other regions along their migratory path, or from bow-fishing tournaments or bycatch. Cownose rays have one of the lowest reproductive capacities of any fish species. They don't mature until they're about 8 years old and produce only 1 pup per year."

VIMS tagging studies have found that although the rays migrate up and down the Atlantic Coast, they return to the estuary where they were born to give birth and mate. Many return to the Bay.

Fast forward to 2016. Researchers were now concerned that rays were overfished.

Abundance Surveys

Long term monitoring is essential for effective fisheries management.

There are two types of surveys. Fishery-dependent surveys make use of commercial fisheries data - catch statistics recorded by watermen. Sometimes observers accompany fishermen as they go about their work. Fishery-independent surveys are carried out for purely scientific purposes, to assess the populations.

Collection methods vary. There's **trawling** – towing a funnel-shaped net, **dredging** – pulling a heavy rake-like device that scrapes the bottom, and **longline** – a series of baited hooks. **Gill nets** form a vertical wall of light netting that traps the fish as they try to back out of the mesh. The juvenile striped bass survey is done by **seining**, wading into shallow water and dragging a shallow, wide net that looks a bit like a tennis net. Adult fish, in fresh or very low salinity water, may be sampled by **electrofishing**, where fish are temporarily stunned by an electrical current, and float to the surface. Consistency in timing, gear, and technique is important for multi-year data to be comparable. Occasionally improved technology warrants a change in protocol, in which case, old data may need to be "adjusted" to remain comparable.

Environmental conditions are usually noted. This information is particularly useful to modelers, who are interested in quantifying the relationships between fish populations and temperature, salinity, dissolved oxygen, nutrients, winds, waves, and currents.

Consistency in timing, gear, and technique is important for multi-year data to be comparable.

18 - https://www.flickr.com/photos/vims_photos/15484116230/

At each sampling site, fish are identified, counted, weighed, measured, and sometimes, tagged. All this data is recorded, some of it electronically using devices that can weigh, measure, and record. Sometimes tissue samples are taken for bioassays (DNA monitoring, bacteriology, etc). Occasionally a fish or two may be taken for age and growth studies, or as a museum specimen.

For age and growth studies, researchers measure length and weight, and determine age. Sometimes age can be determined from individual scales – there are markings like tree rings. A more reliable age can also be determined in a similar way from vertebrae or ear bones, called otoliths. It is important for population studies to know these details of life history, in order to estimate current and future abundance. Many graduate students have prepared and polished otolith slices under a microscope to determine age and growth relationships for various species.

Stomach contents may be inventoried to determine diet - important for studies of food webs necessary to sustain fisheries.

After the data is collected, it is analyzed. In the past, individual species assessments were carried out to calculate a "maximum sustainable yield". Nowadays, multi-species assessments are favored; they take into account ecological relationships, such as predator and prey. This is important for species like menhaden, on which other species feed.

Data from these surveys are used to assess the abundance of adults and juveniles, and to adjust regulations.

It is physically demanding work – wet, tedious, sometimes stiflingly hot, sometimes numbingly cold - in a boat that pitches, rolls, and vibrates. Not everyone can do it, no matter how physically fit they are.

Over the years VIMS has expanded the scope of surveys geographically and temporally. A complete listing of VIMS abundance surveys with details about sampling methods can be found here.

It is important for population studies to know the details of life history, in order to estimate current and future abundance.

Trawl Surveys

In 1955 the VFL began the first trawl surveys at 5-mile intervals in the York River. Gradually the sampling area was extended to the James and Rappahannock rivers and the Virginia portion of the Bay. The surveys were repeated on a regular basis, at a carefully monitored depth and time interval.

Now 22 stations in the James, York, and Rappahannock River are sampled each month; and in the Bay, between 39 and 45 stations are sampled each month except in January and March.

Many surveys cover areas outside Virginia. The ChesMMAP trawl survey covers the entire mainstem of the Bay. Sea Scallop dredge surveys and the NEAMAP trawl survey cover the mid-Atlantic region from Cape Cod to Cape Hatteras. (NEAMAP video link) In addition to Music's offshore shark longline survey, there is a survey of shark nursery grounds in the lower Bay and the seaside bays along the Eastern Shore.

ChesMMAP samples juvenile and adult fishes in the mainstem of the Bay, from Baltimore to the Virginia capes. There are 4 cruises each year, with 40 sites sampled in March and November, and 80 in June and September.

Single Species Assessments: **Striped Bass**

Some species get special treatment. Striped bass is such an important recreational fishery, there are both adult and juvenile surveys. Striped bass are *anadromous* - they return to freshwater in the spring to spawn. Some migrate into the ocean and some remain in the Bay year-round. The adult Striped Bass Program monitors spawning striped bass by setting gill nets in the James and Rappahannock Rivers. There is also tagging program that uses electrofishing to catch the fish. This program is part of a mullti-state tagging study.

The Juvenile Striped Bass Survey is also part of a multi-state study. There are 40 stations along the James, York, and Rappahannock rivers; and a few auxiliary locations. There are 5 biweekly sampling periods from July through mid-September.

19 - Seining for juvenile striped bass https://www.flickr.com/photos/vims_photos/40114792604/

Eels

American eels are a *catadromous* fish - they spawn in the ocean and live in fresher waters. That's the opposite of familiar anadromous fish like striped bass.

Eels are a valuable commercial species. Salted eel was once a popular crab bait but now European and Asian food markets are the best customers, for smoked eel.

Eel populations are smaller than a few years ago. VIMS researchers sample them as they enter the rivers and streams.

20 - Juvenile Eel Survey *https://www.flickr.com/photos/vims_photos/9353201134/*

Oysters

VIMS has been monitoring oysters since the 1940s. In recent years, they have partnered with VMRC. They use dredges and patent tongs to collect samples, and oyster shellstrings to measure spatfall. They monitor public oyster beds to determine if they need replenishment by bringing in seed (baby) oysters, or if VMRC needs to make immediate changes to current regulations. For example, in March 2023 VMRC extended the winter season 10 days into April because of better than expected abundance data.

Crabs

In 1990 VIMS teamed up with the Maryland Department of Natural Resources (DNR) and began an annual winter dredge survey. Each fall, female crabs, "sooks", migrate south to higher salinity water in the lower Bay to hatch their eggs, and overwinter buried in the sediments of the lower Bay. With all these sooks the Virginia population becomes mostly females. Winter is a good time for bottom dredge surveys because crabs are dormant and not moving around. Crews sample 1,500 sites, approximately half in each state. Assessment of the number of overwintering females is used to estimate next year's population. (Video link, Virginia) (Video link, Maryland)

21 - Dredge survey underway https://www.flickr.com/photos/vims_photos/52722293348/in/album-72177720306405725/

Menhaden

Menhaden are a small, abundant, schooling fish, related to shad and herring. They are filter feeders and can't be caught on a hook and line. That's not a big deal as they are too "fishy tasting" for most Americans, including native Americans, who used them for fertilizer. Nowadays they are harvested for crab bait or are processed (reduced) into oil and fishmeal.

Menhaden are considered a "keystone species" because of their large numbers and their importance to the Bay's ecosystem. However, a 2015 study that surprised researchers found that menhaden are not as important as once thought, and that Bay anchovies are now more numerous and the most important forage fish in the Bay. The study was based on analysis of 12 years of data from VIMS trawl surveys along the main stem of the Bay, repeated four times a year. During that time, 391,000 fish were caught, 285,000 were measured, and the stomach contents of 35,000 fish were examined. What they found was that menhaden are important prey for only one species, striped bass; and even for striped bass, they are less important than bay anchovies.

Ed Houde of the UMCES Chesapeake Biological Laboratory estimates that there 50,000 tons of bay anchovies in the Bay at any given time, and 458,000 tons are produced each year. "That means a huge amount is being eaten and is fueling the production of Bay predators," Houde said.

The menhaden reduction fishery once operated with dozens of factories all along the East and Gulf Coasts. Over the years, all but one plant in Reedville and two in Louisiana have closed, either from reduced stocks or odor abatement regulations.

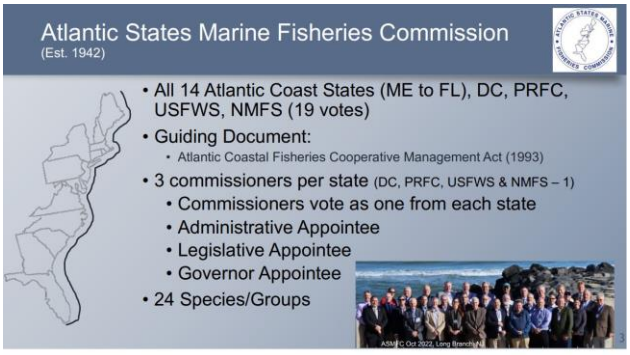
Industrial fishing is an inherently messy business. Many people are appalled when they learn about the sheer numbers of fish involved. “Spotter” airplanes locate the schools and direct the fishing vessels. With a crew of 15 or so, each mother ship, approximately 150 feet long, launches two skiffs - purse boats. The boats surround a school with a large net and draw it in alongside the ship where the fish are vacuumed into refrigerated holds.

Menhaden harvest A commercial vessel harvests menhaden from Chesapeake Bay. *Photo by Patrick Lynch.*

22 - https://www.vims.edu/research/units/legacy/menhaden/about/index.php

Schools of menhaden are often pursued by predators: Spanish mackerel, bluefish, croaker, hogchoker, and gray trout; and these may be swept up along with the menhaden. However, two studies have shown that bycatch is typically a very small percentage, much less than 1%. Nevertheless, a tiny percentage of a very large number can be significant. The most recent study was in 1992; and VIMS researchers were harshly criticized by opponents of the menhaden fishery and accused of colluding with the industry. John Lucy said, "It was like I had slapped a hornet's nest."

In the past, the fishery was regulated by the General Assembly - a special status for menhaden only. Now the fishery is regulated by VMRC, with annual catch limits set by the Atlantic States Marine Fisheries Commission (ASMFC).



23 - Atlantic States Marine Fisheries Commission
https://www.vims.edu/research/units/centerspartners/map/_docs/youngfishermenworkshops/managementpresentation.pdf

The ASMFC was established in 1940 by the states along the Atlantic Coast to manage fisheries within 3 miles of the Atlantic coast that span multiple states. The premise was that "fish do not adhere to political boundaries." Each state provides 3 Commissioners: the director for the state's marine fisheries management agency, a member of the state legislature, and an individual appointed by the governor. The commission employs fisheries scientists and economists to establish annual quotas for shared fisheries. For menhaden, there are two quotas for Virginia, one for the Bay and one for offshore.

Atlantic menhaden spawn in the ocean off Virginia and North Carolina and migrate up and down the coast and into the estuaries. In the past, each fish species was assessed individually, based on population statistics. Nowadays, catch quotas (ecologically sustainable yields) are determined by modeling studies that assess the impact of fishing to predator and prey populations. Menhaden are included in a model along with predators (striped bass, bluefish, weakfish, and spiny dogfish) and prey (menhaden, herring, and bay anchovy). These are considered the top predators and most likely prey species.

Amy Schueller, of the National Marine Fisheries Service (NMFS) Beaufort Lab, is the lead scientist for Atlantic and Gulf menhaden – she consults with scientists from the ASMFC to conduct modeling studies. Her detailed 2021 online presentation is available here. Schueller cites a study that found, counter intuitively, that there is very little correlation between forage fish and predator abundance. In particular, given that striped bass feed on small menhaden, and the fishery takes large menhaden, there isn't a conflict. They conclude that the controlling factor for forage fish abundance is environmental conditions. See this short video.

Although there have been overfishing incidents in the past, according to a 2022 assessment by the ASMFC, menhaden are not currently overfished. The same report also concluded that predators are not negatively impacted. The annual Bay quota for 2023 is 51,000 metric tons, same as 2022. The total quota for 2023, Bay plus ocean, is 233,500 metric tons, up 20% from the previous year.

Atlantic menhaden spawn in the ocean off Virginia and North Carolina and migrate up and down the coast and into the estuaries.

Critics point out that the population assessments on which the quotas are based, are for the entire East Coast, and not specifically for the Bay.

There is a smaller menhaden fishery that provides bait for crabbers and lobstermen. The largest bait boats, like the 80-foot FV Hush Puppy, are called “snapper rigs”. They use purse seines but have only one purse boat. The 2022 total allocation (Bay and ocean) for the purse seine menhaden bait sector was 13,000 metric tons. A smaller, non-purse seine bait fishery had an allocation of 2,000 metric tons. The non-purse seine fishery is operated by pound netters and gill netters.

There can be natural die-offs of menhaden. According to the VIMS website, "Summer die-offs of large numbers of Atlantic menhaden are common in Chesapeake Bay, mostly associated with episodes of low dissolved oxygen (i.e., dead zones) in Bay waters."

For decades, sportfishing groups have argued that the menhaden fishery should be banned in the Bay because of the impact to striped bass and other popular recreational species, but the fisheries data do not support this view. According to Mike Avery, chairman of the Virginia Saltwater Sportfishing Association, 600,000 Virginia anglers contribute $465 million to the economy each year, and support more than 6,500 jobs.

In November 2022, the ASMFC released an updated stock assessment on striped bass. According to the report, the resource is suffering from overfishing in the past - there are not enough spawning females. Nevertheless, current regulations are sufficient. CBL fisheries scientist Dave Secor expressed concern about mortality from catch-and-release, inhospitable summer hot spells, and low oxygen levels.

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Menhaden industry spokesman Monty Deihl argues that the menhaden fishery should be allowed to continue as long as it complies with regulations. Northumberland County, where the reduction and bait fishery are located, is rural and heavily dependent on the industry. The menhaden plant employs hundreds of workers and contractors. The industry brings $45 to $88 million into the local economy each year. According to Ken Pinkard, former VP of United Food and Commercial Workers Local 400, and past Labor and Industry chair of the Virginia NAACP, the menhaden fishery is the largest employer of minority and union workers in Northumberland County.

Banning fishing in the Bay, Deihl maintains, would make the workers' jobs more hazardous. Rough ocean seas make the boats difficult to handle and lead to on-the-job injuries. However, Diehl's employer, Omega Protein, does operate in the ocean; in fact they catch more than half their annual allocation there.

Menhaden abundance estimation is a bit tricky, as they are a near-surface schooling fish that flee from trawl nets.

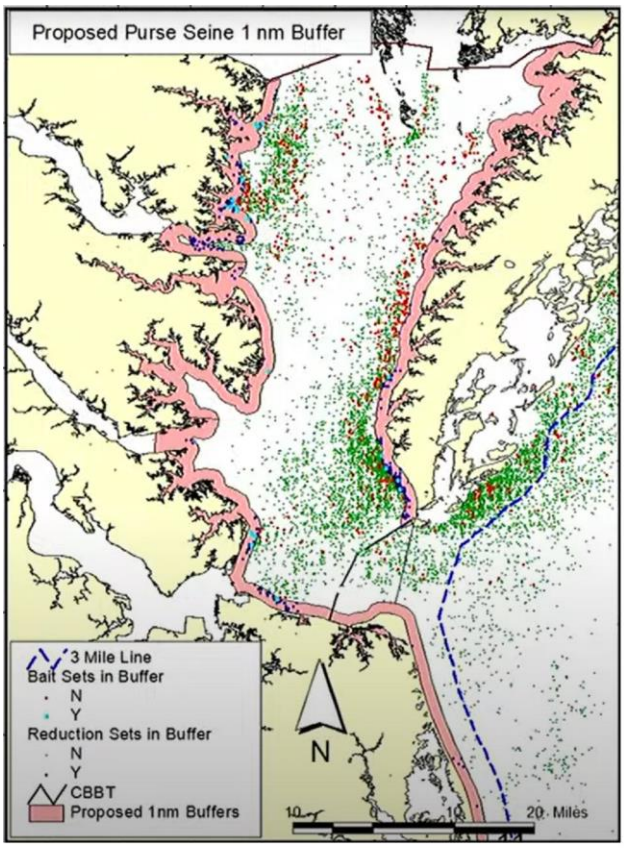
In 2010, VIMS published the results of a series of laboratory experiments designed to assess the impact of menhaden on Bay water quality. Elevated nitrogen levels are of Bay-wide concern, but based on their findings, researchers believe that menhaden do not have a significant impact on nitrogen levels. There is simply too much nitrogen in the Bay for menhaden to make much of an impact.

As menhaden grow, their "filters" become more porous, and their diet shifts from microzooplankton, phytoplankton and detritus (particles of organic matter) to larger zooplankton and detritus. Under certain conditions, like large schools feeding on large algal blooms, they may have a significant impact on nitrogen, but those conditions rarely occur. They also think that schools of menhaden are likely to steer clear of harmful algal blooms (HABs), so menhaden aren't helping with that problem either. HABs are algae that can produce toxins. VIMS scientists monitor HABs in the Bay.

Menhaden abundance estimation is a bit tricky, as they are a near-surface schooling fish that flee from trawl nets, which leads to underestimates of abundance. Recent researchers have tried to find ways to count them from aircraft. They tried LIDAR, a form of radar, but it was unable to estimate the depth of the schools. They concluded that high resolution video is probably the best option for aerial surveys.

Sometimes there are accidents that lead to fish kills. When there is a tear in the net, often from a net snagging on the bottom, fish spill out, some dead from the crowding and rough handling. According to the VMRC, there are an average of 3 reported spills per year, but between 2018 and June 2022, only two occurred in the Bay. However, there were three spills that fouled Eastern Shore beaches in 2022. One occurred near Kiptopeke, when a school of red drum got swept up along with the menhaden. When the crew found out, they released the catch, which resulted in an estimated 12,000 pounds of dead drum and thousands of menhaden. Two spills occurred at Silver Beach and spoiled the 4th of July week recreational activities. A Reedville crew cleaned up the spills a few days later.

December 2022 VMRC Hearing



24 - VMRC proposed buffers. Dots are 5 years of "net sets". https://www.youtube.com/watch?v=Cn-ow-dNfsE

In response to the summer fish spills, in December 2022 the VMRC hosted a hearing on proposed changes to menhaden regulations and got the biggest crowd of attendees ever – busloads from Northampton and Northumberland counties. The Board heard public comments and recommendations of its staff: a no-fish zone within a half mile of the CBBT and within one mile of shore in the Bay and along Virginia Beach; and no fishing during 17 days that include the three summer holidays. This would

apply to both reduction and bait fisheries – the purse seine fisheries. However, instead of issuing regulations based on staff recommendations, they negotiated a less restrictive memorandum of understanding with the menhaden industry.

Rob Latour

Rob Latour has been researching commercial and recreational fisheries at VIMS since the year 2000. He currently directs stock assessment programs for Bay finfish, coastal sharks, and striped bass. He served on the ASMFC Atlantic Menhaden board from 2006 to 2020, focusing on stock assessments and the move from single species modeling towards an ecosystem approach. He has received many awards for excellence in research, teaching, and advising graduate students.

Latour had the unenviable task of presenting VIMS expert testimony on menhaden at the December 2022 VMRC hearing.

He cited case studies that have shown that committees of diverse stakeholders are the most effective way to manage fisheries, as they allow affected parties and the public to participate and be heard. Since 2020 Latour has chaired the VMRC Menhaden Advisory Committee, which met the previous Friday and prepared the recommendations that were being considered.

He explained that the menhaden fishery has been around for 150 years, and that we have landings data since 1955 - the longest record of any East Coast fishery. In the 1950s there were 25 factories with 125 vessels, now there is 1 factory with 10 vessels. In the years since 1955, the largest annual harvest was 700 thousand tons; now it's around 200. Obviously, these are huge amounts of fish, but compared to an estimated 3 million tons total; we are currently harvesting approximately 7% of the population.

The first Bay quota was put in place in 2007; it is now half of the initial amount, at 55 thousand tons.

Latour explained that a 3-year-old female menhaden can spawn every 7 1/2 days for almost six months, releasing 3 million eggs. If one out of a thousand survive, that's 32 offspring each year. At that rate, a single female can produce over 12,000 descendants in her lifetime. "It is an unbelievably productive animal."

He addressed two of the concerns raised in public comments:

1. The impact of fishery on striped bass. Striped bass populations have fluctuated between "overfished" and "recovered", over the years. The Bay is a complex environment, an open system that exchanges with the ocean, and it's difficult to establish causal linkages.

2. Local depletion. We don't have data to assess this. We would need to know 3 things: abundance in the Bay, residence time of those fish in the Bay, and movements between the Bay and the ocean. The ASMFC does take this uncertainty into consideration by setting quotas conservatively, recognizing the ecological role of menhaden in the Bay.

While acknowledging the uncertainties, Latour concluded, "... right now moving forward, the best available science places the resource in a great place."

At the August 2023 VMRC meeting, Bryan Watts, the director of the Center for Conservation Biology at William and Mary, spoke. The center has been monitoring osprey populations for over 50 years. According to their findings, osprey reproductive rates peaked around 1980 after recovering from DDT pollution, but have declined over the years to a level that is now too low to sustain the population. In the 1980s menhaden comprised 70% of ospreys' diet; since 2006 it has been less than 30%. Watts' team notes a high correlation between osprey reproductive rates and an Atlantic Menhaden Relative Abundance index, representing the entire Atlantic coast, and they infer that there is a causal relationship. Watts praised the fisheries modelers for recently incorporating ecological reference points to account for predator populations, but he suggests it's not enough to sustain osprey populations.

Many good people would like to see the menhaden fishery shut down. Mostly they are not tied to the history and family traditions of commercial fishing in the Bay. In the Northern Neck, the fishery employs many good people who depend on a resource that, so far, has held up despite Bay health issues.

Controversy

Crabby Neighbors

With the fall exodos of females, the Maryland harvest becomes mostly males ("Jimmys"). Marylanders throw back the sooks and complain about Virginians taking them in summer pots and winter dredges, without regard for the impact of their own Maryland harvests. This animosity between Virginia and Maryland persists, and goes back to the early settlers - Protestants in Virginia, Catholics in Maryland - and the Oyster Wars.

As William Warner explained in his popular 1976 book, Beautiful Swimmers, the spring of 1968 was particularly bad for Maryland crabbers. Seafood dealers complained to politicians, who requested and were granted a Congressional hearing. Maryland's two senators waxed eloquent about growing up on the Bay and how much crabs meant to everybody: all the crab festivals, crab races, crab-boat races, crab-boat docking races, crab picking contests, crab this, crab that, etc. It was as if the blue crab was the state bird.

Senator Daniel Brewster pointed out that Virginia had already taken 8 times as many crabs as Maryland, and that there were reports of winter dredging of pregnant females in Virginia. Hampton congressman Thomas Downing acknowledged that there was indeed a winter dredge fishery that had been active for years. He argued that in the fall, Maryland crabbers took large numbers of fertilized females as they

migrated south. Finally, Hargis and VIMS crab expert Willard Van Engel presented statistics indicating that limited winter dredging was not correlated to poor harvests.

Ironically, as the season went on, the catch improved and it turned out to be a good year, overall. No one knew why, but unknowns like this fuel speculation and opinions.

Finally, Hargis and VIMS crab expert Willard Van Engel presented statistics indicating that limited winter dredging was not correlated to poor harvests.

Hargis In the News

In 1962 the General Assembly changed the name of the lab to the Virginia Institute of Marine Science. It was commissioned as an independent state institution governed by a board appointed by the governor.

VIMS is unique in that it was established with a mission not only of education and research, but also to advise state officials on issues impacting the coastal environment. Hargis made a refinement to the Davis model of separation of research and regulation. He separated research and advisory services, to assure that the latter was not short-changed when it came to funding.

As lab director, Hargis felt obligated to weigh in on marine public policy debates, to fulfill VIMS' science mission.

As lab director, Hargis felt obligated to weigh in on marine public policy debates. Looking back over his career, he explained it this way: "In the code of the Commonwealth of Virginia we were charged with providing scientific information to the General Assembly, to the public, and to the executive branch … so I used to go up to all the meetings of the committees of the General Assembly in which any topic that we were involved … and sometimes the chairman would say, Dr Hargis, we didn't ask you to come up here, we didn't call you. What are you doing here?"

"Well, you're working on a problem that we're supposed to be working on and I'm going to make the information available to you. OK, and after a while, if you recommend enough against enough political people's projects, you begin to become *persona non grata* with either the legislature or the executive. When you stand in the way of administrators, man, they find a way to run right around you. They did it here eventually, but it took them a hell of a long time."

Hargis liked to quote Kenny Rogers, "You gotta know when to hold 'em, know when to fold 'em…"

The following initiatives were not supported by VIMS. In some quarters, this was unpopular.

Being an objective provider of information is not always an easy or welcomed position, and often all sides of an issue will respond negatively, as it affects their bargaining positions.

The James River Navigation Project

Over the years, the James River has played a key role in the oyster industry, even after MSX and Dermo. It wasn't a great place to grow oysters, but it was consistently good for seed oysters, which were used to revitalize depleted beds all over Eastern Virginia.

In 1949, business leaders proposed widening and deepening the James River shipping channel to Richmond. The dredge spoil would be used for a manmade island in Hampton Roads, and the island would be used for a sports arena.

Hargis and his colleagues thought that VIMS should take a look at this, given the importance of the river for seed oyster production. They argued that this would increase the influx of salty water and oyster parasites. Hargis was supported by local watermen, who didn't want to see their livelihoods put at risk.

Eventually VIMS was commissioned to do a modeling study with the US Army Corps of Engineers (USACE) at their headquarters in Vicksburg, MS.

At that time, in response to the disastrous Great Mississippi Flood of 1927, the USACE had been building scale models of river basins to test potential flood control measures. By carefully adding water to the tributaries, they could simulate river flow. These were huge projects - the Mississippi river model occupied 200 acres and was built during WWII using German POWs as laborers. Despite the costs, the model proved its value for siting locks, levees, and diversion channels.

A scale model of the Chesapeake had been built in a 14-acre metal building on the Eastern Shore near the Annapolis Bay Bridge in Matapeake, Maryland. They nicknamed it "the Matapeake monster". Its first application was to assess the impact of deepening the Baltimore channel. The simulations showed little impact and the project went forward.

So, for the James River deepening project, a 2.5-acre scale model was built at Vicksburg. One of the findings was that the reason the James River mouth is so productive for oysters, is that there is a slow moving gyre current that takes about a fortnight, and that's exactly how long it takes oyster larvae to settle on substrate. The proposed island would disrupt this flow.

By the time the study was complete, people seemed to have lost interest and the project was abandoned.

One of the findings was that the reason the James River mouth is so productive for oysters, is that there is a slow moving gyre current that takes about a fortnight, and that's exactly how long it takes oyster larvae to settle on substrate.

25 - James River hydraulic model in Vicksburg https://www.flickr.com/photos/vims_photos/15666972721/

The James River Oil Refinery Project

Governor Mills Godwin proposed an oil refinery in Portsmouth near the mouth of the James River. Hargis again objected, speaking out against it at every opportunity. At one point Godwin summoned Hargis to his office and told him that it was unthinkable that he could not control the public statements of his agency heads. Hargis explained that VIMS was setup to be independent of political influence, and that was a good thing. Godwin replied that he would change that.

Kepone

In 1975 at Hopewell on the James River near Richmond, the municipal sewer system began failing routine water quality tests on the effluent flowing into the river. The problem was eventually traced to toxic chemicals from the manufacture of an insecticide called kepone; the chemicals had been poured down the drains at the manufacturing site, a former gas station.

When Hargis heard about it, he dispatched a team to take samples and they found kepone in sediments, finfish, and oysters. The Food and Drug administration investigated and labeled kepone a carcinogen; and as a result, the river was closed to fishing for 13 years and closed to oystering for 10 months. Consumers became wary of Virginia seafood, and watermen all over the state lost business. Bob Huggett, the lead investigator, received death threats: “I slept with a shotgun by my bed”.

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Bob Huggett

26 - Bob Huggett *https://www.vims.edu/newsandevents/topstories/2017/kepone_vims_vee_report.php*

Huggett grew up in Poquoson, across the York River from VIMS, the son of a waterman. ''If you wanted spending money, … you raked clams or you picked up oysters or you culled oysters on somebody's boat or you helped someone run gill nets. I did all that as a kid.''

Huggett met his future wife while he was working as a lab technician at a Dow Chemical plant near Williamsburg. She was a junior at William and Mary. When she graduated, she worked to put him through 4 years at W&M. When he graduated, in chemistry, they went to San Diego, to Scripps Institute of Oceanography, where he became interested in environmental science. Following graduation, he came to VIMS for his PhD and 20 years as an environmental chemist.

He left VIMS in 1994 for an administrative job at the Environmental Protection Agency in Washington, DC. When he arrived, ''I felt like I'd walked inside a beehive,'' he said. ''People have the impression often that federal employees don't work very hard; that's certainly not my experience… The demands on them from Congress, from the administration itself, are just immense.''

He found himself working 12-hour days. His biggest gripe was the bureaucracy: ''It's like turning a battleship or an aircraft carrier. It took three years to implement some of the things that I wanted to get done, that the administrator wanted me to do, and I felt I should have been able to do it a lot sooner. That was frustrating.''

After 4 years in DC, at the recommendation of a coworker, he took a job as Vice President for Research and Graduate Studies at Michigan State University from 1997 to 2004, followed by several years as a consultant.

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King William Reservoir

In the early 2000s, the city of Newport News came up with a plan to create a reservoir in King William County. They were granted an Army Corps of Engineers permit in 2005.

VIMS weighed in with a study that predicted negligible impact to wetlands. Pumping water from the Mattaponi would make the river saltier, but the wetlands would adapt.

However, another VIMS group had been studying anadromous fishes, marine fish that return to their birth river to spawn. They were concerned that the proposed site was an important shad nursery and recommended against the project. The Mattaponi tribe was against the plan also, arguing that it would flood former hunting and fishing sites and decimate the shad population.

In 2009 a federal court ruled that the ACE had acted arbitrarily and capriciously in awarding the initial permit, and the project was cancelled.

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Hargis on Center Stage

By this time Hargis' reputation as a champion of the environment was well-known. As such, he was often sought out for advice on marine affairs.

He was hired as a consultant to the State Department for fisheries negotiations with the Russians and the Poles. To prepare for these meetings, he studied Russian at William and Mary.

He became chairman of both the National Advisory Council on Oceans and Atmosphere (NACOA) and the Coastal States Organization (CSO), groups that made recommendations for research and public policy related to marine science. NACOA (now defunct) reported to the President and Congress; the CSO reports to NOAA and Congress. Hargis championed "green water oceanography", research in coastal waters as opposed to the deep ocean. He and his colleagues advocated for a national Coastal Zone Management Program, Sea Grant colleges, and estuarine sanctuaries. Their efforts brought in grant and contracts money, and VIMS entered a growth period.

In the 1970s, VIMS became headquarters for Virginia Sea Grant. This new role expanded the advisory mission to include the seafood industry, recreation, shoreline development, tourism, and public education.

The largest contract came from the Bureau of Land Management to conduct baseline surveys of marine life in the Mid-Atlantic outer continental shelf, in advance of possible offshore drilling. To work offshore for days at a time, a large oceangoing vessel was required. For this work, Hargis acquired a surplus minesweeper from the Navy, brought it to Gloucester Point, named it the *RV Virginian Sea*, and hired a crew to refurbish it and operate it on cruises. Minesweepers were wooden ships, so as not to attract magnetic mines. This one, outfitted with added steel infrastructure, proved to be top-heavy and unstable, and a costly failure – one that Hargis would come to regret.

According to UMCES president Don Boesch, having a big ship was "part of the manhood of oceanographic institutions."

Marine science was becoming popular worldwide. Starting in 1976, pioneer scuba diver and explorer Jacques Cousteau hosted a popular documentary TV series. Like Hargis, Cousteau was ambitious and entrepreneurial; and like Hargis, behind the scenes, he was plagued with financial problems.

There was one drawback with federal funding – in some cases, payment came at the completion of the project, and sometimes didn't fully cover the costs. To finance these projects, Hargis took out temporary loans from the state's general fund. He did this 11 times in 12 years, resulting in a large and growing debt. It came to the attention of state auditors.

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Don Boesch

27 - Don Boesch, not afraid to get his feet wet https://www.umces.edu/sites/default/files/Boesch_SandyPt030.JPG

Growing up in the 1950s, in the 9th Ward of New Orleans, where the locals sound more like they're from Brooklyn than Louisiana, Don Boesch enjoyed fishing with his dad, but was more interested in the marsh critters than the fish. The 9th Ward borders wetlands, lakes, and the Mississippi River, and was flooded by Hurricane Katrina in 2005.

Encouraged by his 10th grade biology teacher, Boesch applied for a summer program at nearby Gulf Coast Research Laboratory, but, with average grades, was not accepted. Undaunted, he continued to dream about a career as a marine scientist.

He graduated from Tulane, on the far side of New Orleans, and went off to grad school at VIMS in 1971 to study benthic ecology. Benthic ecologists study the bottoms: the seagrasses, oysters, clams, worms, snails, barnacles, and other critters that are vital to the ecosystem. He became a close friend of classmate Bob Orth.

From VIMS he went to Auckland, Australia for a Fulbright post-doc research gig. He returned to VIMS as a professor, where he spent the next 8 years conducting research and recruiting an enthusiastic group of graduate students, research assistants, and post docs.

A colleague from Louisiana State University invited Boesch to apply for a position back in Louisiana. He would be building and staffing a new lab in the swamps bordering the Gulf coast, 90 miles south of New Orleans. Boesch, 35 years old at the time, interviewed along with 4 older, qualified candidates.

He did not expect to get the job offer, but he did. And he did not expect the reaction he got from Hargis. Hargis reached out his hand to congratulate him, calling it a great opportunity, like his own experience building VIMS. Looking back on his time at VIMS, Boesch said, "I learned a lot from him (Hargis): lead with a strong vision, stand up for the truth, avoid administrative over-reach, and step down before they want you to."

"I learned a lot from him (Hargis): lead with a strong vision, stand up for the truth, avoid administrative over-reach, and step down before they want you to."

His new workplace at the fledgling Louisiana Universities Marine Consortium (LUMCON) was an aging mobile home, where he worked with two staffers. The site was chosen because it was state-owned with convenient access to the Gulf, and marshes as far as the eye could see. According to Boesch, the location was "neither too far east nor west, but equally inconvenient to all parts of the state."

From the air, what Boesch and his architects came up with looks like an airport terminal photoshopped onto a post card with a caption like "The entire coast of Louisiana is occupied by extensive salt marshes". It's elevated on pilings with a scenic view from the front deck, which seemed a bit over-the-top when it was first presented to Boesch, but he grew to love it after seeing and hearing the reaction of visiting elementary school students.

The complex was eventually named for W.J. "Woody" DeFelice, a banker and former s superintendent of schools in Lafourche Parish, who advised Boesch on the politics of southern Louisiana. "Woody told me that every day he looked his wife and children in the eyes and told them what he did that day. Thus, he avoided doing anything that he would be ashamed of."

10 years later LUMCON had a small cadre of resident scientists, a new, spacious lab, and 2 research vessels.

After 10 years in the "outback", Boesch was ready for new challenges. The University of Maryland Center for Environmental Science (UMCES) was looking for a new director, and Boesch was the perfect candidate – smart, young but experienced, energetic, and with a strong scientific background.

UMCES is about the same size as VIMS but split between 4 campuses. Boesch spent the next 27 years there. He had a distinguished tenure, teaching, researching, serving on state and federal committees, and advising several governors. He retired in 2017.

Like Hargis, Boesch, has been a leader on the national and international stage, and is still active.

Scientific Progress

19th century biogeographer Alexander von Humboldt, looking back on his prolific career, quipped that there are 3 stages of scientific progress. For any new theory, first deny that it's true, then deny that it's important, and finally, credit the wrong person.

The Linear Model

Boesch observed what he calls a "linear model", where scientists come up with a new finding, perhaps unpleasant, and notify technical advisors. The advisors pass it along to bureaucrats at state or federal agencies, who in turn, inform their managers. The managers either act on their own or inform the politicians, who enact a solution. "That's the food chain," says Boesch, "And that could not be farther from the truth."

In Boesch's view, progress comes in spurts: in response to a lawsuit, a high-profile policy debate, a major hurricane, or in the case of fisheries, a financially ruinous year.

The science is often murky. Scientists are accustomed to continuously questioning themselves. Consensus on an issue may change as technology improves and more studies are done. For politicians, acting on this sort of knowledge is risky, considering that after having your name bandied about by the press, fairly or unfairly, someone else will be competing for your job in another year or so.

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The Crescendo Model

One of Boesch's peers, Ann Swanson, executive director of the Chesapeake Bay Commission, has a slightly different take. According to her, there are 3 stages: crisis, crescendo, consensus. In response to a crisis there is media coverage and public outcry, which builds into an emotional crescendo, followed by political negotiation that leads to consensus for corrective action.

For science to play a part, someone must make the case in layman's terms. Often this is someone from an advocacy NGO, like the Chesapeake Bay Foundation, The Nature Conservancy, Wetlands Watch, or the James River Association. They employ scientists to keep up with current events and to lobby for their interests. However, while pursuing their advocacy missions, some less reputable groups have been known to cherry-pick which science to promote.

Wetlands, Beaches, and Seagrass

28 - Marsh at sunrise https://www.flickr.com/photos/vims

A New State Mandate – Protecting Wetlands and Shorelines

In 1972 the General Assembly recognized that legislation was needed to prevent ongoing wetlands destruction by dredging and filling. In a farsighted move, they passed a wetlands act that mandated permits for any project that would disturb wetlands. The permits would be issued by the VMRC and newly established county wetlands boards. VIMS provided technical assistance before, during and after the bill was passed.

This legislation required VIMS to conduct and maintain an inventory of tidal marshlands. Using topographic maps, aerial photos, and ground survey instruments, VIMS field personnel mapped and documented all state wetlands, county by county. It was, needless to say, a huge project, and unprecedented anywhere in the world.

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29 - Aerial Photo of Tidal Wetlands *https://www.flickr.com/photos/vims_photos/29868660617/*

A few years later, in response to beach erosion at Virginia Beach, the General Assembly mandated that the inventory be expanded to include the entire shoreline, all 10,000 miles! The combined inventory became the *Coastal Inventory Program* and continues to be updated periodically.

In the 1990s, ground surveys became more accurate as GPS survey instruments became available. A surveyor's day would begin by preparing and launching a small boat. Then they would follow the shoreline, getting in as close as possible, all the while repeatedly clicking a button to record position. Shoreline characteristics were noted. Back in the lab, the analysts would connect the dots to map the shoreline.

Over the years as technology improved, the VIMS team started using digital aerial photographs and *Geographic Information Systems (GIS)* software. After 2000, aerial imagery became so detailed, it was no longer necessary to do field work. For example, they can now count the stones in a breakwater, whereas in the old days, they were lucky if they could see the breakwater at all.

Local, regional, state, and federal officials use this data to assess permit applications, and to prepare planning documents. The data is available online.

30 - Ryan Schloesser retrieves a buoy lost in an Eastern Shore marsh https://www.flickr.com/photos/vims_photos/24498784614/

In 1980, after successfully inventorying tidal shorelines, VIMS was tasked with expanding the inventory once again, to include non-tidal wetlands. This initiative was never funded, and it extended the range of VIMS responsibilities from the coastal plain to the piedmont and mountains of Virginia.

The VIMS group has been much in demand, occasionally taking on research projects in neighboring states. They have had to limit this practice in order to meet their responsibilities in Virginia.

In 1992, recognizing the quality of the VIMS surveys, Maryland contracted with VIMS to map their Bay coast in the same manner. VIMS also partnered with the National Oceanic and Atmospheric Administration (NOAA) to develop a coastal inventory for several Gulf states.

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As a result of a court ruling in 1998, which was later overturned, the right to ditch non-tidal wetlands was upheld and as a result, more than 2,500 acres of non-tidal wetlands in Virginia were ditched for development, and additional acres of isolated wetlands were destroyed.

In May 2023, the US Supreme Court ruled that the EPA no longer has jurisdiction over non-tidal wetlands. This removed federal protection from approximately half of all wetlands in the continental United States. However, Virginia's wetlands are still protected by the Nontidal Wetlands Act of 2001.

The VIMS *Center for Coastal Resource Management* published a comprehensive review of their past 50 years in their Summer 2023 newsletter.

31 - Paddling through the East Coast's northernmost bald cypress forest. https://www.flickr.com/photos/vims_photos/26625959005/

Carl Hershner

"There is no greater service than service to the government and citizens of the Commonwealth." Carl Hershner, 2020.

For someone who came to VIMS not knowing what he wanted to be when he grew up, Carl Hershner took on perhaps VIMS' greatest challenge - guiding the management of Virginia's wetlands and seashores.

Hershner grew up in Pennsylvania and attended college at Bucknell. During the summers, he worked as a lab technician at an EPA field lab in Annapolis. When he came to VIMS as a grad student in 1971, he found himself back in a chemistry lab doing water quality assays. In 1972 Hurricane Agnes brought heavy rains, and VIMS devoted all its resources to research the effects of the big storm. Water quality was super important – the flooding and runoff was taking a toll on the flora and fauna.

It was during field work in the salt marshes with Ken Moore and others that Hershner decided to expand his horizons. It's hard to convey the experience of visiting a salt marsh for the first time. Most people have never experienced it, but visitors to Chincoteague get a feel for it as they motor along the causeway just inches above brownish green *Spartina* marshes and sinuous streams that the locals call "guts". It's true wilderness, almost completely devoid of humans, with fiddler crabs, oysters, minnows, barnacles, mosquitoes, greenhead horseflies; and sometimes-noisy marsh hens, seagulls, and ducks; and lots of mud. Unlike freshwater marshes, you can walk on *Spartina* marshes, but one false move and you're up to your knees in muck.

32 - Carl Hershner *https://www.waterwayguide.com/latest-news/news/9861/virginia-institute-of-marine-science-new-video-series-takes-a-deeper-dive-into-solutions-for-shorelines-much-more*

The first research projects Hershner worked on dealt with the effects of oil spills. "So I set upon a multi-year project to see what happened when one repeatedly dumped oil all over a marsh. As hard as this may be to believe today, killing a couple of marshes in the name of science made a lot of sense at the time, and I learned a tremendous amount about both the pollutant's effects and the basic biology of wetlands."

He later studied the effects of the herbicide atrazine, which was thought to be a reason for the decline of seagrass.

In 1978 he joined the VIMS Wetlands Department. He worked with newly established local wetlands boards, which were tasked with assessing and granting permits. All this was new, so there were lots of questions. The only qualification to be a board member was willingness to serve.

During his early years at VIMS, as if Hershner wasn't busy enough, he took on a leadership role as a volunteer medic at the Abington Rescue Squad. He recruited and trained several VIMS personnel as EMTs and drivers.

Hershner worked with the team that was mapping and cataloging county wetlands. Hershner and geologist Suzette Kimball (who later became director of the U.S. Geological Survey) were consulted about beach erosion in Virginia Beach. They recommended that unvegetated shorelines be added to the wetlands inventory, to provide guidance for regulatory decisions. Their proposal was accepted, but with less funding than requested, and VIMS was now tasked with inventorying all shorelines.

During his early years at VIMS, as if Hershner wasn't busy enough, he took on a leadership role as a volunteer medic at the Abington Rescue Squad. He recruited and trained several VIMS personnel as EMTs and drivers.

Hershner is the kind of guy who is friends with everyone he meets. Directly across from Maury Hall, was a mobile home owned by a Mrs. Riley, know to all as "Ma". Mrs. Riley lived there with her grandson, Ken, who suffered from dwarfism. Mrs. Riley, despite her own physical ailments, kept house and cooked for the two of them, and frequently entertained and fed graduate students, who, in turn, would run errands for Ken and her. She often told stories about growing up on the water, including one about her pet pig that rode around on the bow of her boat. Sadly, one day the swine was taken from her, without notice, for culinary purposes. Hershner was a good friend to Mrs. Riley and Ken.

Seagrass

33 - Bo Lusk sampling eelgrass beds. https://www.flickr.com/photos/vims_photos/52387664457/in/album-72177720302449217/

Marine life thrives in seagrass. It's a fertile nursery habitat for all sorts of tiny fish and crabs. Blue crabs hide in it when they mate and molt, to protect the soft and vulnerable female. It is a critical habitat for sheltering juvenile and adult bay scallops. Striped bass and speckled trout swim above the grass, feeding on the critters that emerge. During winter migrations, waterfowl feed on it.

The horizontal stems, "rhizomes", and roots stabilize sediment and the long, slender leaves dampen wave energy. The large surface area of the leaves supports prolific micro-algae production. Seagrass sequesters carbon as it carries out photosynthesis, absorbing carbon dioxide and generating oxygen – so

important for bottom dwelling animals. It also reduces ocean acidification, which may be a problem for aquaculture in the future.

For all these reasons, submerged aquatic vegetation is regarded as an indicator of ecosystem health - the canary in a coal mine. Wherever there is seagrass there's clean water and healthy marine life.

Submerged aquatic vegetation is regarded as an indicator of ecosystem health.

Bob Orth

34 - Bob Orth

After graduating from Rutgers, where he worked 2 summers for oyster biologist "Hurricane Hal" Haskin, Bob Orth came to VIMS as a grad student. For his masters' thesis project, Orth surveyed the fauna of seagrass beds. From VIMS he went to the University of Maryland for his PhD, where he witnessed the decimation of seagrass by Hurricane Agnes in 1972.

At this time Congress began funding a research initiative to investigate the ecology of the Bay. Orth conducted the SAV portion of the research and reported the damage from Hurricane Agnes. On the basis of this and related findings, researchers concluded that the Bay was in trouble. In 1983 the Chesapeake Bay Program was founded as a regional partnership between federal agencies, surrounding states, universities, and NGOs. The program's ambitious goal was to restore the ecological health of the Bay.

When Orth returned to VIMS, he focused on seagrass restoration. At that time eelgrass was the most abundant seagrass in the lower Bay. A major milestone was when Orth figured out how to propagate eelgrass from seeds, which is much easier than from seedlings.

For their first experiments with seed propagation, Orth's team cruised through shallow areas in a skiff, casting out seeds as they went along. Where the seeds sprouted and grew, the path of the boat could be seen in aerial photographs. Once an area was sparsely seeded, the grass spread out to fill in the gaps. To express his thanks to his funding agency, Orth seeded an area spelling out "NOAA" in large letters, and to everyone's delight, it was clearly visible in the following year's aerial photographs. The Virginia Coastal Zone Management Program Manager, Laura McKay, called it "eco-grafitti".

In 1978 Orth began annual aerial surveys of Bay grasses that continue today. Each year a small aircraft logs 2,500 miles flying 181 standardized routes. It's a laborious and tricky business. The photos must show seagrass if it exists; so anything impairing the view is problematic: sun glint, choppy waves, turbid or too-deep water. Also, tides have to be taken into consideration. Often they have to call a local scientist or riverkeeper, someone who has been out on the water, to find out if the water is clear. Satellite imagery can sometimes be used to fill in the gaps, but it's not detailed enough to be used exclusively.

Back at the lab, GIS specialists prepare updated maps from the photographs - another labor-intensive task. At the end of each year VIMS publishes statistics and identifies trends.

Orth's attempts to restore seagrass in the Bay have been frustratingly unsuccessful. There was a nice upward trend for a few years prior to 2019, but then came a big die-off. Currently the total acreage is about the same as the 30-year average, with some eelgrass being replaced by widgeon grass, a thinner and less bio-diverse habitat. A recent study by Maryland and Virginia researchers found that widgeon grass has supplanted eelgrass as the dominant seagrass in the Bay, primarily due to its higher temperature tolerance and ability to repopulate blighted areas from seed. There is concern that eelgrass may not continue to survive in the Bay given global warming trends – Virginia is at the southern end of its geographical range.

On the seaside of the Eastern shore, however, it has been a different story. In the 1920s eelgrass was abundant, but a few years later was almost completely wiped out by disease. Orth heard of a single patch surviving near Wreck Island, and from that he collected seed and started planting nearby areas. His strategy worked!

Subsequently, with funding from Virginia CZM, Orth partnered with The Nature Conservancy (TNC) scientists Barry Truitt and Bo Lusk, and together, they scaled up the process by building a seed curing facility. Seed collection and dispersal is now done by VIMS and a TNC team led by Lusk and Brittany Collins. Each spring, a corps of eager volunteers don wetsuits, masks, and snorkels and brave the still-cold water to gather seed-bearing shoots.

The success of the coastal bay seagrass restoration project is unrivaled anywhere else in the world, and Orth and TNC have received many awards.

35 - De Havilland Beaver, VIMS first aerial survey aircraft https://www.flickr.com/photos/vims_photos/15483803610/

Now there are 10,000 acres of healthy eelgrass behind Wreck, Cobb, and Hog islands. That's 15 square miles, almost the size of Manhattan Island. The success of this seagrass restoration project is unrivaled anywhere else in the world, and Orth and TNC have received many awards.

Orth has also been recognized for his leadership and service to the scientific community. He has served his local community - he was elected to the Gloucester County Board of Supervisors and served for several years. He was also a member of the Abingdon Rescue Squad, the Gloucester High School Athletic Boosters Club, and coached his kids' athletic teams.

He's a good-natured fellow, even when he's kidded about his love of grass – seagrass, that is.

Shoreline Erosion Control

(Graphics in this section are from Hardaway and Byrne, 1999.)

Shoreline property owners can be faced with difficult decisions about how to protect their property. VIMS marine geologists seek to understand the physical and geological processes that govern shoreline erosion, and provide technical support to the VMRC, local wetlands boards, and landowners.

In 2020 the Wetlands Act was amended to make "living shorelines" the default control method, where plants, sand, or rock are used to reinforce the shoreline. If implemented properly, these can resist erosion and provide habitat. One of the problems with vertical erosion-control structures is that there is not much room for tiny plants and animals to grow.

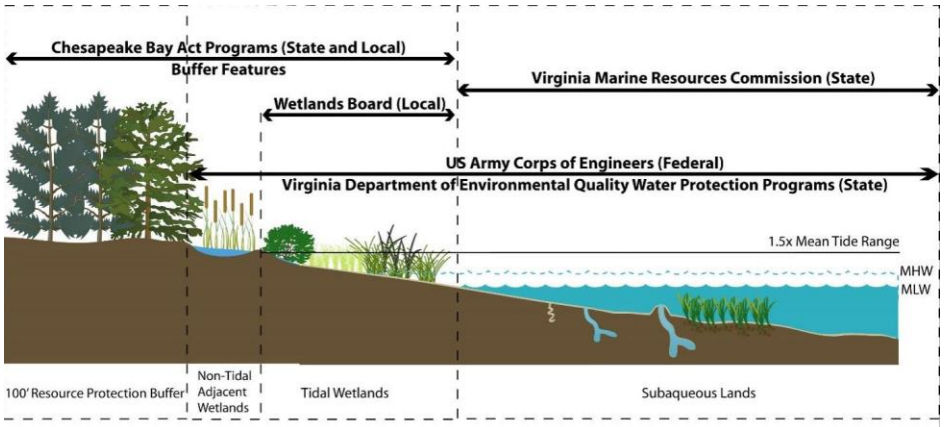
In 2020 the Wetlands Act was amended to make "living shorelines" the default erosion control method, where plants, sand, or rock are used to reinforce the shoreline.

Figure 28

Kingsmill on the James, James City County, Va. Shore protection system utilizing headland, breakwaters, beach fill with wetland vegetation, bank grading with upland vegetation, a revetment, and an interfacing low-crested breakwater.

VIMS provides a wealth of resources to local wetlands boards and municipal planners: consultancy, an annual workshop, a comprehensive *Shoreline Management Handbook*, and a well-designed website. In Virginia, municipal and rural planners are required to take into consideration sea level rise.

Shoreline management issues can be complex, as shorelines fall into overlapping jurisdictions. A recent Supreme Court ruling removed non-tidal wetlands from the jurisdiction of the Army Corps of Engineers.



Virginia Shorezone Jurisdictions: legally defined shoreline resources and the relevant local, state and federal authorities. Note that some authorities cross resource boundaries and most resources have at least two responsible regulatory authorities. Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/), University of Maryland Center for Environmental Science.

For landowners compelled to control erosion, or for those taking a proactive approach, there is a program administered by local Soil and Water Conservation Districts (SWCD) called the *Virginia Conservation Assistance Program* (VCAP) that currently (2022) reimburses homeowners 80% of the cost of approved projects, up to $30,000. Homeowners and businesses can request assistance, free of charge, from the Shoreline Erosion Advisory Service .

The Eastern Shore Barrier Islands

Virginia's Eastern Shore has the longest stretch of undeveloped barrier islands in the US. Most of the islands in this 70-mile coastal wilderness are owned by TNC and have been designated a UNESCO Biosphere Reserve. The last of these islands to have private homes was Cedar Island and those were swallowed up by the ocean or removed by 2015. Previous settlements have met the same fate, but the

islands in their natural state provide a valuable habitat for migrating birds, and the pristine coastal bays are excellent sites for aquaculture.

36 - One of the last Cedar Island beach houses. https://www.flickr.com/photos/vims_photos/13433960605/

VIMS geologist Chris Hein has been studying these barrier islands, marshes, and coastal bays; seeking to understand the underlying geological processes. His crew has been working with historical maps, aerial photos, and satellite imagery to document erosion and deposition. They take core samples and deploy ground penetrating radar to study historical sedimentation. In one of his recent publications, Hein and Giulio Mariotti of Louisiana State University predict that erosion rates will increase in the next 50 years, whether or not sea level rise continues. (Video link - Changes in the barrier islands in recent years.)

37 - Erosion rates in meters/year. The first number is the average for the last 150 years, the second, the last 30 years. VIMS After Hours Presentation, Jan 2019

Ecological Monitoring of the Eastern Shore Coastal Bays and Wetlands

The coastal bays that lie between the barrier islands and the mainland are high salinity, which indicates that the water is primarily ocean water, rather than freshwater runoff from land. This is good for water quality, as fresh water runoff can be high in nutrients and sediments. The northernmost county, Accomac, has poultry operations that many feared would degrade water quality, but VIMS studies of streams that feed into the coastal bays has, so far, not shown significant levels of pollutants.

With a burgeoning aquaculture industry, there is concern that there may be future impacts to water quality. Tp keep an eye on this, VIMS maintains continuous water quality monitors at two sites, one at Willis Wharf at a large clam hatchery, and the other at the ESL seawater labs. The data is published online.

Dick Snyder and P. G. Ross have laid the groundwork for long term ecological monitoring at ESL. An analogy in the medical world is the annual physical exam, where vital signs and blood tests are routinely taken, and the physician examines the patient looking for changes that could impact overall health. The Ecological Management Program (EMP) has standard testing and observation protocols, and each year a detailed document is published that summarizes the results. They trawl, they tow plankton nets, they deploy seines, and they collect sediment samples. Back at the lab they identify and count the fish, invertebrates, and macro algae. They monitor microalagae, oyster spatfall; and marsh die-back as observed from drone photography. The program provides opportunities for students, staff, interns, and visiting scientists to gain experience in ecosystem research, and the data is useful for planning and applying for funding for future research.

William and Mary

The Graduate School

The first marine science graduate program was offered in 1940 in the William and Mary Biology Department - a master's degree in Aquatic Science. In 1959, at the VFL, a Department of Marine Science was established and offered an M.A. degree in Marine Science. In 1963 a joint program was established with the University of Virginia, with PhD degrees in biological oceanography and fisheries biology. In 1975 UVA moved its marine science graduate programs from VIMS into their own, newly established Department of Environmental Sciences.

The VIMS School of Marine Science now offers M.S. and Ph.D. degrees in Marine Science, and a Masters of Public Policy in partnership with the College of William and Mary.

38 - Nalani Schnell teaches larval morphology https://www.flickr.com/photos/vims_photos/13434415494/in/album-72157715261609603/

Linda Schaffner

Linda Schaffner, recently retired Associate Dean of Academic Studies, credits her mentors for her success as an academic and a researcher. Her first mentor, Leland Pollock of Drew University, a distinguished invertebrate ecologist, took her to the Woods Hole Marine Biological Lab for a summer field course, and encouraged her to do a semester at the University of Miami where she took a course in marine biology and as she put it, "got my first feel for the marine lab vibe."

She entered graduate school at VIMS in 1976, to study benthic ecology under Don Boesch. In her words, "a dirty job, but hey, someone has to do it." To those who may wonder why someone would devote a career to studying bottom-dwelling organisms, Schaffner points out that, "Despite what they say in the popular press, the most expansive benthic habitats in most estuaries, including Chesapeake Bay, are comprised of soft sediments. This was true in the historic past and is true today. And as any former student of one of my courses knows, what lies beneath is not a featureless, boring habitat. It's a complex

environment characterized by cryptic organisms and myriad processes that play major roles in ecosystem function."

Working for Bob Diaz, "(she) absolutely earned the nickname 'box core Linda' "for hours upon hours of tedious microscope work, going through hundreds of offshore sediment samples, identifying and counting critters. She was hailed as "the Mud Queen", a high honor among her peers, who wore "Born to Pick" T-shirts. She got her PhD in 1987 and has been on the VIMS faculty ever since. In 2011 she was promoted to Associate Dean of the School of Marine Science. At the VIMS grad school, the Associate Dean does the heavy lifting, as the Dean is also the Director and has lots of other duties.

Schaffner has taught classes, mentored grad students, and conducted research. She teamed up with the VIMS geologists to investigate the interplay between sediment transport processes and benthic communities. One of their findings was that many benthic animals are much more tolerant of seabed disturbances than was expected.

Two of Schaffner's most successful initiatives have been a 10-week Summer Intern Program for undergraduates, and the Hall-Bonner Program for Minority Doctoral Scholars, a partnership with Hampton University and Old Dominion University.

Schaffner has served in leadership positions in several national organizations and received many honors for teaching and research.

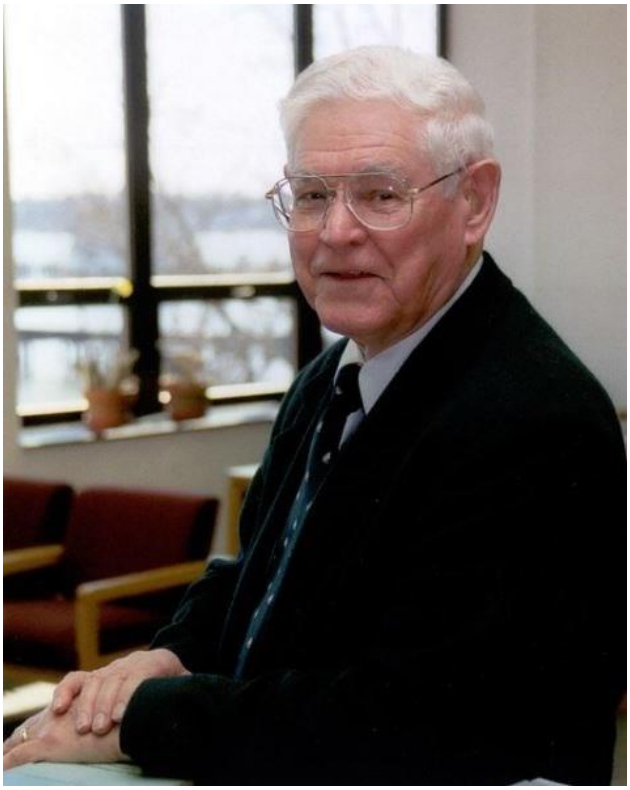
Payback

In 1978, three years after the Hargis grand larceny trial, the VIMS board was dissolved, and VIMS was assigned to report to William and Mary's president and Board of Visitors. Two years later Hargis stepped down as director. "I got the message from the president that it might be a good idea if I went back to the bench so I said, OK, I will, because I'm not going to permit anything untoward to happen to the institute, with my baby."

There are two schools of thought as to why Hargis lost his job. Vengeance was one. The other was financial mismanagement. Or maybe he was just tired of the fight.

There are two schools of thought as to why Hargis lost his job. Vengeance was one. The other was financial mismanagement. Or maybe he was just tired of the fight.

Hargis' Legacy



39 - Hargis in retirement *https://www.flickr.com/photos/vims_photos/15049419503/*

When Hargis became director in 1959, the lab had 6 scientists and 26 support staff. In 1981, when he stepped down, the institute had 71 scientists, 400 support staff, and was funded by 24 state and federal agencies. VIMS had become a major research, educational, and advisory institution. During Hargis' tenure, there was no dredging of the James River, no new oil refinery, and no new toxic chemical spill. Virginia's wetlands, shorelines, and seagrass had been surveyed, mapped and categorized; and served as a model of responsible stewardship of public lands. Also, crabs, shellfish, and finfish were being routinely surveyed and monitored.

Sixteen years after Hargis stepped down, he was honored with the Mathias Medal from the Virginia and Maryland Sea Grant programs for applying science to public policy. In 2003 he received two honors: the Thomas Jefferson Medal for Outstanding Contributions to Natural Science, from the Virginia Museum of Natural History; and the VIMS Lifetime Achievement Award. Shortly afterwards, the General Assembly named the VIMS library after him. He was a frequent library user and supporter.

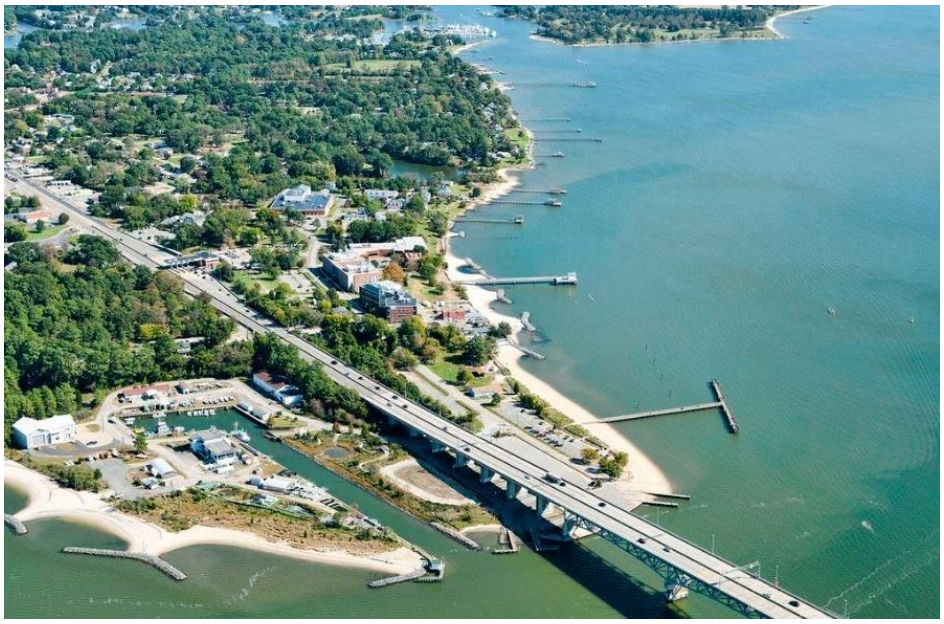
Hargis died in 2008. His greatest legacy may have been his unflinching support of science in public policy. His top-down leadership style wouldn't work well today, according to Don Boesch. Individual scientists now bring their own funding, and with that, a degree of autonomy. Hiring decisions are made by committees of managers and peers. Major reports are authored by teams of scientists, to reduce the harassment of individuals.

As we have seen, harassment has happened at VIMS: the state police investigation of Hargis; the death threats to Hugget, and the criticism of John Lucy for his observations of the menhaden fishery. But to be

an objective purveyor of science to public discourse, it is inevitable that people will be angry, and often from multiple sides of an issue. The courage these scientists displayed has unfortunately become more rare, yet they are the ones that built VIMS reputation.

His greatest legacy may have been his unflinching support of science in public policy.

40 - Hargis Library https://www.flickr.com/photos/vims_photos/50160513731/in/album-72157715299093722/



41 - VIMS Campus: https://www.flickr.com/photos/vims_photos/10405960763/

The Takeover

Calming the Waters

Biologist Frank Perkins, for whom the "Dermo" oyster pathogen, *Perkinsus marinus*, was named, was appointed acting director of VIMS while a search committee looked for his successor. A year later, when a suitable candidate was not found, Perkins was appointed director.

Perkins didn't have the charismatic personality of Hargis, but that was OK because what was needed was a steady hand on the tiller, someone to get the financial house in order and better coordinate with William and Mary. There was no more showing up in Richmond at meetings when you weren't invited.

As Don Boesch observed, we were entering an era of semi-autonomous researchers, committees, and further division of labor. The Director's role would be as an administrator, a dean, and lobbyist, not inclined to make trouble for the board, the governor, or the General Assembly.

William and Mary was able to increase funding almost each year of Perkins' 10-year term. Federal funding had declined, and most of the money was now coming from the state. In return VIMS was asked to do more advisory work.

Perkins didn't have the charismatic personality of Hargis, but that was OK because what was needed was a steady hand on the tiller, someone to get the financial house in order and better coordinate with William and Mary.

The Chesapeake Bay Program

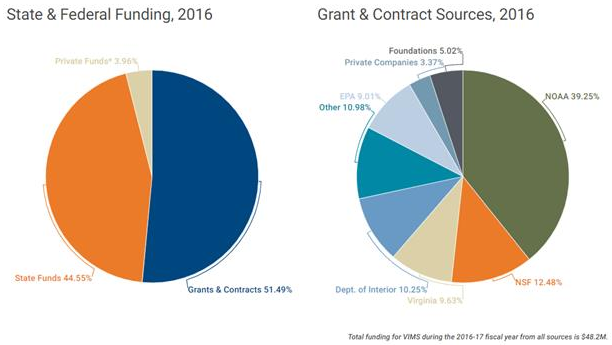
Much of the new research was part of U.S. EPA's Chesapeake Bay Program, an agreement between federal, state, and local government agencies; and NGOs; with the goal of restoring the Bay ecosystem. This required monitoring fish, shellfish, seagrass and wetlands.

Despite Maryland and Virginia's history of disagreeing on crab regulations, in 1996 they established a Bi-State Blue Crab Advisory Committee to work together to address declining harvests, but the committee disbanded in 2003 after Virginia failed to appropriate their share of the funding. However, in 2008, they both agreed to reduce landings by 34 percent. In Maryland, they shortened the fall crabbing season and in Virginia, they outlawed the winter crab dredge season.

The Budget

Under new leadership, it was time to improve infrastructure, the campus, and the fleet. Several new buildings were built, including Waterman's Hall with an aquarium and museum exhibits in the lobby. More and more scientific work was being done on computers, and the centralized systems and personal computers needed to be periodically upgraded. It was the dawn of the era of molecular biology and DNA analysis. Scientific equipment was becoming more sophisticated and needed repair and periodic upgrades. All this required consistent funding.

Fast forward to 2016. Slightly less than half of VIMS budget is now from state funds, and slightly more than half is from grants and contracts.



Behind the Scenes

One of Perkins' innovations was to establish a foundation for private donations in 1982. The first leader was George Roper. A native of Norfolk, Roper graduated from the University of Virgina in 1951, and joined the Army and trained as an electrician apprentice. In 1953 he joined the family business, *Norfolk Shipbuilding and Drydock* Corp, founded by his grandfather in 1914. Roper was an influential leader and a major benefactor to Tidewater Community College, William and Mary, and VIMS.

Roper was also a driving force in another of Perkins' initiatives, the Marine Science Development Council. This was a group of eastern Virginia business and community leaders who provided guidance for long term planning.

The men and women of the Foundation and Council deserve a lot of credit for their political and financial support. Roper, the Masseys, the Nunnallys, Steve Johnsen, Marshall Acuff, and Jim Rogers - the list goes on and on.

The graduate school added faculty and new courses at Gloucester Point and at William and Mary's undergraduate school. The campus was improved with new buildings and equipment. More funding came from the state's general fund, a more stable source, so it was easier to retain good people. And now there was a foundation that provided private funding, and just as importantly, political support.

The men and women of the Foundation and Council deserve a lot of credit for their political and financial support, which ushered in a much-needed period of stability.

42 - Mark Luckenbach with the VIMS Council on an Eastern Shore field trip. https://www.flickr.com/photos/vims_photos/24761756979/

Partner Universities

University of Virginia

The UVA Anheuser-Busch Coastal Research Center is a field lab located in the seaside town of Oyster on the Eastern Shore, and managed by the Department of Environmental Sciences in Charlottesville. It has lab space, boats, a conference room and can sleep up to 24 visitors. According to John Porter it's a great place to work. "You sit down over dinner; you sit on the screened porches – fostering that level of interaction is a really critical part" of the center.

The lab is home to the Virginia Coast Reserve *Long-Term Ecological Research Program*. Its goal is to gather long term datasets to document changes in plants, animals, and topography. Most recently they have been engaged in studying "blue carbon" - storage of carbon in coastal marine habitats.

Old Dominion University

The ODU Department of Ocean and Earth Sciences offers BS and MS degrees in Ocean and Earth Science and PhD degrees in Oceanography. Two of the founding fathers died recently.

William Dunstan was a chairman of the department for many years. As a young researcher, he and a coworker demonstrated that nitrogen, not phosphorus, was the limiting nutrient for phytoplankton in Long Island waters. This was an important contribution to our understanding of wastewater pollution.

Larry Atkinson was a physical oceanographer who conducted deep sea research all over the world. He served as a leader on many national and international committees and boards. He was managing editor of the journal *Oceanography* and editor of the *Journal of Geophysical Research-Oceans*. John Bane, of the University of North Carolina, recalled a paper Atkinson published in 1971 on nutrients in North Carolina coastal waters. "(It is) now a classic and a foundational work. When we finally met in person, it was ... a surprise to find such a young man behind the name and reputation." Atkinson was in his 20s when he wrote the paper.

Perhaps Atkinson's greatest tribute is from his obituary. "…the superpower which he will be most remembered for, was his amazing ability to bring together people from all over the world for common goals and purposes, which he did his entire career."

Virginia Tech

The Virginia Seafood Agricultural Research and Extension Center in Hampton provides technical assistance to the seafood industry to ensure quality and safety, and promote innovative processing and packaging technology. They have an aquaculture research facility where they are currently growing finfish.

Virginia Tech also has a research station in Painter, Va., on the Eastern Shore, that focuses on improving agricultural practices; including reducing nutrient runoff from agriculture important for maintaining coastal water quality.

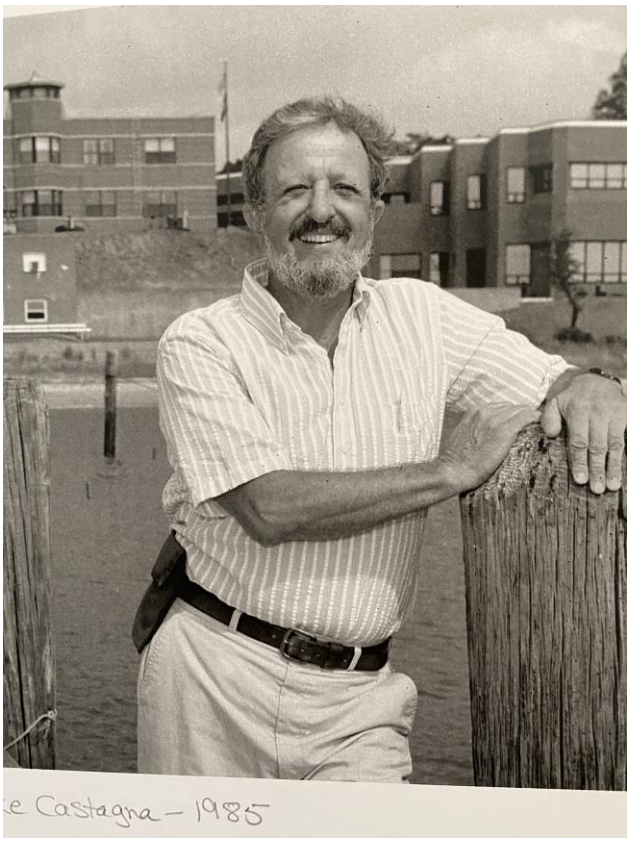
Aquaculture

The first attempts at aquaculture in Virginia were during WWII, at Wachapreague. Two researchers working for Dupont opened a field station to grow ribbed mussels as a source of vitamins. Ribbed mussels are abundant and grow at the base of salt marsh cordgrass (Spartina alternaflora). Unlike related blue mussels, ribbed mussels are not generally eaten; as they tend to be muddy and have an inferior flavor. At the time, they had been harvested in the wild as a vitamin supplement for poultry feed. During WWII, when international trade in industrial chemicals was disrupted, they were a potential source of vitamin D for submariners, who were cooped up indoors for extended periods. Aerial photos show their experimental plots, but we don't know how successful they were in their quest for vitamin D.

43 - Farming oysters https://www.flickr.com/photos/vims_photos/52266192165/in/album-72177720301080705/

In the 1950s when MSX invaded, and in the 1980s, when the Dermo pathogen (*Perkinsus marinus*) set in, the oyster industry collapsed. Hargis and his team investigated but had no solutions.

Salvation



44 - Mike Castagna https://www.vims.edu/esl/_docs/crest_spring2004.pdf

Like Hargis, Mike Castagna served in WWII in the Pacific theatre, and took advantage of the GI Bill to attend college after the war. Castagna went to Florida State University and swam on the All-Navy swim team. He was about to graduate when he got called back to active duty in Korea, where he served as a medic. In Korea he also scuba-dived and participated in a project to compile Navy dive tables, which are still used to time descents and ascents, to avoid decompression sickness.

Castagna returned to Tallahassee to finish undergraduate work and went on for a master's degree. Upon graduation he moved to St. Augustine where he worked at *Marineland*, swimming with dolphins and serving as a veterinary technician. In 1956 he moved to Boothbay Harbor. ME, to work for the Bureau of Commercial Fisheries (BCF). During that time, as a Naval Reservist, he went to Key West for underwater demolition training. At the age of 30, he was the oldest trainee. They called him "Grandpa", but he finished the program at the top of his class.

In 1958 he transferred to a small BCF lab in Franklin City, near Chincoteague. He studied the local ecology and was well oriented when Hargis, a former classmate at Florida State,offered him a job in nearby Wachapreague, where VIMS had recently built a 1-story brick building with offices, two dorm rooms, and laboratory space. The year was 1962.

Castagna, gregarious by nature, made friends with local fishermen. He worked with Hargis, looking for ways to control oyster drills. They also tried, without success, to develop disease-resistant oysters.

He began studying shellfish life cycles by growing them in the lab. He and his team worked with 60 species, and found that hard clams, *Mercenaria mercenaria*., held the most promise as an aquaculture product. They were not vulnerable to disease, and, ironically, the small ones – the size of a silver dollar - are tastier and sell for more than the large ones. That reduced the growth period,

They grew larvae in rows of 20-gallon galvanized garbage cans, the big ones, like Oscar the Grouch lives in. To maintain a continuous flow of seawater, and to minimize the number of pumps, the cans were lined up and connected by siphon hoses. Saltwater plumbing was always a challenge – pipes and valves would clog up with fouling organisms if not flushed out daily with fresh water.

In a greenhouse they grew phytoplankton to feed the larvae, which they raised in tubs in an abandoned oyster shucking house that served as a hatchery. They improvised continuously, using low-cost materials. As Castagna would say, “There’s no reason to spend two dollars on a valve if pinching a hose will work just as well”. A heat exchanger was improvised from a whiskey barrel and salvaged copper tubing.

They improvised continuously, using low-cost materials. As Castagna would say, “There’s no reason to spend two dollars on a valve if pinching a hose will work just as well”.

Castagna led by example. He pitched in with everyone else in Friday afternoon cleanups. There was a spirit of cooperation; team members filled in wherever they could help, regardless of their job title.

Once the hatchery was successful, it was time to “plant” the fingernail-sized clams on nearby mud flats to grow to market size. Keeping predators away was a challenge. After trying different methods, the solution was to cover the beds with netting.

At this point they had a complete system and were ready to go public. Castagna and John Kraeuter published a Manual for Growing the Hard Clam *Mercenaria* and offered a short course on clam aquaculture, affectionately known as "clam college". Several students went on to establish commercial hatcheries, aqua-farms, and packing sheds on the Eastern Shore.

Like the Wright brothers first aircraft, the system was rudimentary, but it proved the concept and paved the way for others to refine the concepts and procedures. The long-suffering shellfish industry now had a viable business opportunity, and they seized it. In 2021, the industry brought in $58 million to Virginia coffers, with 99% of landings coming from the Eastern Shore.

Castagna’s team hosted visiting scientists and students from all over the world. On one occasion, Castagna took a visiting foreigner to a nearby barrier island in a small boat. To go ashore, they had to wade through shallow water. It was warm enough to go barefoot on the sandy bottom. As Castagna took off his shoes, the foreigner proceeded to strip naked. Concerned about how this might look to the locals, Castagna tossed him a towel. The visitor caught it, rolled it up and put it on his head.

The Great Oyster Comeback

45 - Teaching moment with Stan Allen https://www.flickr.com/photos/vims_photos/40687106910/

It must have been frustrating to Hargis that after all the years of research by him and his team, there was no breakthrough in the oyster disease problem. However, there was help in the offing, from a young grad student from Foxboro, Massachusetts.

After college, Standish Allen spent 2 years working construction, waiting for his girlfriend to join him in Maine, where he entered the University of Maine's Masters program in Aquaculture. A little over a year into the program, in an unheated attic, reeking of seaweed and marsh mud, the 25-year-old was able to breed the first *triploid* oyster. Eventually, this would prove to be a very big deal, but not yet.

In an unheated attic, reeking of seaweed and marsh mud, the 25-year-old was able to breed the first triploid oyster.

Most plants and animals are *diploid*, with 2 sets of chromosomes, but breeders of both plants and animals have developed organisms with 3 (triploid), 4 (*tetraploid*) and 6 (*hexaploid*) sets. Most of these are larger, grow faster, and some - the triploids, are infertile. This means no seeds, like in bananas and watermelons; and in oysters, it means they can be harvested in summer months, as they are not emaciated from spawning. Fast growth is important; obviously to get to market faster, but also to avoid disease. These plump, cultured, triploid oysters are now the most sought after by restaurants and connoisseurs.

But it would take 30 years for the triploids to be a commercial success.

To breed the first triploid, a toxic chemical, cytochalasin B, had to be added immediately after the eggs meet up with the sperm. Unfertilized oyster eggs are diploid, and one set of female chromosomes is eliminated during fertilization. The chemical interferes with this process, and the egg keeps both sets of female chromosomes. Along with the single set from the male, this makes 3 sets, a triploid.

For the process to work, the timing must be precise, the water temperature must be perfect, and the eggs and sperm must be at just the right stage of development.

Allen published his results but did not think to apply for a patent. Later, in 1984, at the University of Washington, as a PhD student, Allen and coworker Sandra Downing created a triploid Japanese Oyster. This time they applied for a patent for the process *and the oyster itself*. Since the process had already been published in Allen's 1979 paper, the Patent Office denied the request, but announced that genetically altered animals could be patented. It was a landmark decision in American patent law.

Next Allen and Downing applied for a patent for a different process to create triploids, and this time they were successful. Later, in 1993 at Rutgers, Allen and former grad student friend, Ximing Guo, applied for a patent for a tetraploid oyster, and that was also granted. This was super important, as it is way too difficult to breed triploids the way Allen initially did it. The easiest way is to breed normal oysters (diploids) with tetraploids (2 cross 4 -> 3) and that is the key to how modern hatcheries work. Tetraploids can reproduce, so they can be kept and cultured in hatcheries as broodstock - oysters cultured to produce seed.

These plump, disease-resistant, triploid oysters are now the most sought after by restaurants and connoisseurs.

46 - Hatchery scientists Joana Sousa and Jess Moss Small ttps://www.flickr.com/photos/vims_photos/50210948806/in/album-72157715436320973/

In an effort to revive the oyster industry, in 1997 the General Assembly appropriated funds for an oyster breeding facility at Gloucester Point and funds to lure Allen away from Rutgers. The Aquaculture Genetics and Breeding Technology Center (ABC), as it was called, was housed in an existing building next to the boat basin, just inches above sea level and subject to flooding. There was no heating or cooling, so it was like working in a garage. Allen became the first director.

Similar to Mike Castagna's quest, the goal was to develop a process for commercial aquaculture. For oysters, the challenge was harder because of disease. By this time, breeders had been successful in developing oysters that were resistant to MSX, but not to Dermo. Dermo is a pathogen that accumulates as the oysters grow. It is not harmful to human consumers, but it kills wild oysters around the age at which they fully mature, around 2 1/2 years. Triploid oysters can better resist Dermo because their average age of maturity is 1 ½ years. Also, they are heartier in the summer, as they don't expend energy in reproducing,

At this time, researchers had been experimenting with Pacific and Japanese oysters. It was critical to prevent the non-native oysters from escaping into local waters, to prevent infestation by another non-native pathogen. One solution was to quarantine the oysters at a separate facility. At Topping, VA, near the mouth of the Rappahannock River, the Kaufman Aquaculture Center was built primarily for this purpose, with private funding.

The Asian oysters did well in lab tests, so Allen's team proceeded to conduct field grow-out tests. For these tests, they bred infertile triploid oysters. Mark Luckenbach's team tested these in Wachapreague.

It is a very rare phenomenon, but it is possible for a triploid to reproduce. During experimentation with non-natives, Allen's team had to ensure that the triploids were not reproducing. This involved checking thousands of oysters to see if they were producing gametes. Needless to say, this was tedious work.

The triploid Asian oysters did well in field tests, so a lot of people were excited about the prospect of introducing them. However, VIMS advisory personnel were concerned that they could displace the native oysters. Several federal agencies shared that concern, and also concluded that the Asian oysters were a potential carrier of human pathogens. Many considered the Asian oyster an inferior product compared to the native Virginia oyster. Consequently, they were banned.

At this point, the native *Crassostrea virginica* was the only option. After all the experimentation with Asian oysters, they had the expertise, materials, and field test sites to test the native oyster.

Crassostrea virginica ranges from the Gulf Coast to Maine, so out-of-state oysters with potentially unique genetics were brought in for breeding and testing, to see if they were disease resistant. A Louisiana transplant did well and has been among the successful contributors to the breeding stock.

In the end, the triploid native oyster proved to be a viable commercial species.

47 - Baby Oysters: https://www.flickr.com/photos/vims_photos/45687656505/

There are now 5 field test sites, ranging from low salinity at the Choptank River in Maryland, to the Potomac, the Rappahannock, the York, and finally the high-salinity Lynnhaven River. VIMS provides several varieties of broodstock for each of these salinity regimes.

Allen, a thoughtful lecturer, speaks of his oysters as farm animals. As such, he likens his breeding work to that of agronomists who developed the high-yield crops of today. Asked about any worries he might have about introducing these cultivars to local waters, Allen responded that you could make a case for harvesting only farmed oysters, and letting the native oysters grow undisturbed, to restore the Bay's reefs, to provide habitat, to filter water, and to anchor and stabilize sediments.

Allen, a thoughtful lecturer, speaks of his oysters as farm animals.

48 - Stan Allen with his oyster breeding team https://www.flickr.com/photos/vims_photos/8342024803/

Bay Scallops

49 - : Bay Scallops https://www.flickr.com/photos/vims_photos/7314848388/

Along with hard clams, bay scallops were one of the first shellfish that Mike Castagna and his crew studied as candidates for aquaculture. They brought in scallops from other areas, even a separate species from Texas, to develop the broodstock. They demonstrated that a production hatchery was feasible, but at that time, it was not profitable to grow them at the price point set by wild harvests.

Bay scallops are a challenging species for aquaculture. They have a short life span, about 1.5 years. They can be an annual aquaculture crop, but given the short life span, a single bad year can be a major setback to natural restoration efforts. Unlike clams and oysters, bay scallops are mobile, propelling themselves by squirting out jets of water from gaps in their shell. These gaps cause them to dry out in storage, much faster than hard clams. Also the shells are thin, which is good for jet propulsion, but requires careful handling during harvesting.

Dick Snyder's team at the ESL has been growing juvenile bay scallops in the lab for both aquaculture and natural restoration. In an effort to restore wild populations, they have been deploying spawning cages, juveniles, and larvae (veligers) in the now-thriving eelgrass beds. The goal is to reach a threshold population density at which adults are in close enough proximity to ensure that their eggs are fertilized, and the population sustained. ESL, the VIMS Seagrass Lab, and TNC partner each year to collect census data on these "planted" scallops.

In 2023 the Virginia CZM Program received a $2.2 million award from NOAA, through the Bipartisan Infrastructure Law "Climate-Ready Coasts" initiative, to provide a grant to VIMS for eelgrass and bay scallop restoration in Burton's Bay, just offshore from Wachapreague.

VIMS is also assisting commercial growers to develop aquaculture methods, providing seed and helping with marketing. One entrepreneur uses something called a lantern net, a series of stacked nets that hang from a single rope.

Restoring and culturing Bay scallops is a work in progress. It's an exciting time to be in aquaculture.

Virginia is currently leading the East Coast in shellfish aquaculture, and nationwide only behind Oregon and Washington.

Top 10 Virginia Fisheries

In 2021, clams were the top species, 99.9% from Eastern Shore aquaculture.

The oyster aquaculture industry continues to grow steadily, supplementing sustainable wild harvest which is managed by VMRC - assisted by VIMS.

Virginia is currently leading the East Coast in shellfish aquaculture, and nationwide only behind Oregon and Washington. Mike Osterling credits this to three factors:

- Regulatory environment favorable to growers
- Motivation of local entrepreneurs
- Research support from VIMS

SPECIES	METRIC TONS	DOLLARS (MILLIONS)
Clam, quahog, northern	2967	57.9
Menhaden	136691	46.6
Crab, blue	7840	33.5
Oyster, eastern	1648	30.3
Scallop, sea	865	29.6
Flounder, summer	811	4.4
Spot	677	3.8
Bass, striped	510	3.8
Withheld for confidentiality	1674	2.0
Catfish, blue	1411	1.8

50 - Top 10 Virginia commercial fisheries, year 2021.

Who ya gonna call?

51 - Karen Hudson https://www.vims.edu/people/hudson_kl/photo/hudson_k_200x200.jpg

When shellfish growers have a problem, who to call? Karen Hudson!

Karen Hudson, VIMS' shellfish aquaculture specialist, is the marine counterpart of a state agricultural extension agent. If she can't answer the questions herself, she can call on parasitologist Ryan Carnegie and others to investigate.

Hudson has gained the trust of the growers. That has paid off. Growers participate in surveys that enable her to prepare a comprehensive annual report on the industry. This has been key to winning support from the General Assembly.

VIMS has recently made major upgrades to its aquaculture research capabilities. For estuarine research, they relocated the Aquaculture Genetics & Breeding Technology Center to the new, state-of-the-art Acuff Center for Aquaculture. For high salinity work, they rebuilt the ESL Castagna Shellfish Research Hatchery & Nursery - now there are two modern seawater labs in Wachapreague. Bill Walton was hired as the aquaculture coordinator to bring expertise from commerce, regulatory, and scientific areas of the field.

The threat to growers is all too real. For years, oyster farmers from the Gulf Coast to the Chesapeake Bay have reported mortalities ranging from 30% to 60%. In the past, natural die-offs have occurred for environmental reasons, like heavy rains from Hurricane Agnes in 1972 that brought about big changes in salinity. Low dissolved oxygen or harmful algae blooms can also cause natural losses, but none of these factors has been identified as causing oyster farm die-offs. VIMS has recently received a $300 thousand grant to investigate this. They suspect that the problem may lie in the genetic composition of broodstock. Hopefully they can breed new strains that are invulnerable to these die-offs.

Modeling

The state of the art in modeling has come a long way since the massive concrete scale models of yesteryear. Now, of course, it's all done on computers.

John Boon

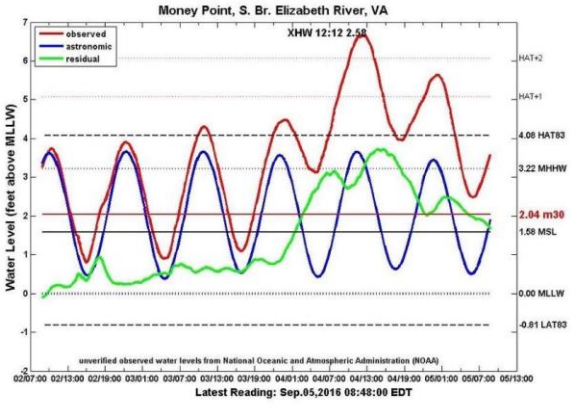
52 - John Boon http://www.youtube.com/watch?v=bz14Ikk3AKM

Marine geologist John Boon has been retired since 2002, but you'd never know it. Since retirement he has written a book on tides, developed a website with sea level rise predictions for 48 locations in US coastal waters, developed a website with accurate short-term tide predictions, and spearheaded the development of several mathematical models.

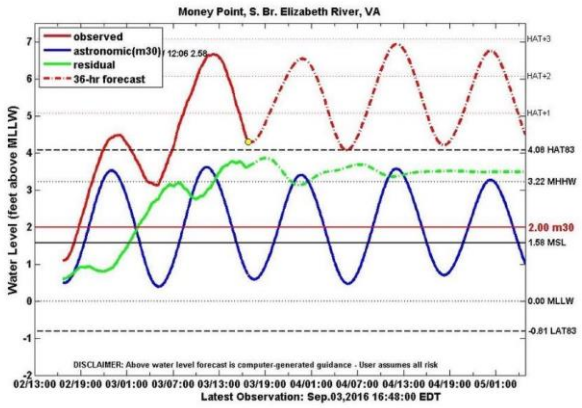
One of Boon's papers about Hurricane Isobel, entitled The Three Faces of Isabel*: Storm Surge, Storm Tide, and Sea Level Rise*, hints at Boon's fondness for film noir.

The times of high and low "astronomical tides", can be predicted years in advance, as they depend on the orbits of the moon and the sun. But that's not the whole story - tides can be heavily influenced by stormy weather. Winds can force water in or out of the Bay, and water levels rise as atmospheric pressures fall.

In the long run, tides are also influenced by sea level rise.



53 - Observed (red) vs. predicted (blue) astronomical tides, tropical storm Hermine https://www.flickr.com/photos/vims_photos/28888217043/



54 - Observed (red) vs. predicted (red dotted), showing spot-on prediction
ttps://www.flickr.com/photos/vims_photos/29510457005/

There are many websites that forecast tides, but Boon's site, called Tidewatch, is unique in that it takes into account meteorological forecasts. It predicts the next 36 hours, so it's always using the latest weather forecast. When a storm is approaching, Tidewatch is the best source for tide and flooding predictions. You can view the forecasts for individual tide stations, or you can click on a map and view a pop-up graph for your location, which can be anywhere in coastal Virginia. This is useful for those who live in frequently flooded areas – they can plan whether to move their cars and what roads to avoid on the way to work. At some point, hopefully, trip-routing applications like Google Maps will use it to help motorists avoid flooded roads.

For major events, residents can "prepare for coastal flooding, whether that involves gathering sandbags, moving possessions to higher ground, adjusting mooring lines for their boat, or choosing an evacuation route."

As if all this wasn't enough for a retiree to take on, Boon played a major role in planning and developing fluid dynamics models for the Bay, as we will soon see.

Catch the King

55 - Tidal Flooding in Norfolk https://www.flickr.com/photos/vims_photos/46382769794/

For 39 years *Virginian Pilot* Reporter Dave Mayfield had been reporting on climate change and felt like his reporting was falling on deaf ears. However, living in Norfolk, people were already experiencing sea level rise whenever there was a particularly high tide, during calm weather.

In 2016 he got an idea for a way to improve the flood predictions – crowdsourcing - crowds of people spreading out all over Norfolk and recording flood boundaries with their cell phones. It would document, precisely, where to expect frequent flooding in the future.

It would require a crowd of people because it would have to be done within a narrow the time frame centered on the maximum high tide.

Mayfield was surprised when his managers approved, and it immediately caught on with VIMS, WHRO Public Media, and Wetlands Watch – a non-profit organization devoted to the restoration and protection of wetlands.

It works by having the volunteers download an app on their cell phones that records the exact location at the push of a button. On a day when an exceptionally high tide is expected, they walk along the high-water lines, clicking as they walk.

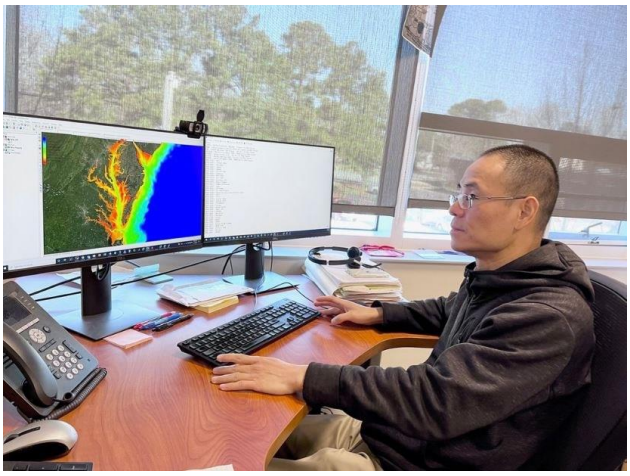
Exceptionally high astronomical tides, “king tides”, are what scientists call perigean spring tides. They occur about 6 times a year. In its first year, the event, called *Catch the King*, drew 700 volunteers who recorded 60,000 data points. It turned out to be a social occasion also, a chance for concerned neighbors to get to know each other. And it proved to be a teachable moment - elementary and high school classes incorporated it into their curricula.

Mayfield was surprised when his managers approved, and it immediately caught on with VIMS, WHRO Public Media, and Wetlands Watch.

SCHISM

VIMS had good reason to support *Catch the King*. Over the years John Boon and Harry Wang had developed mathematical models to predict tide heights. They seized this opportunity to develop a model to predict flooded areas.

They recruited Joseph Zhang, who, over the past decade or so, had developed an innovative fluid dynamics model. The model, called SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model) uses a spatial grid with variable cell size, tailored to fit the geography. Earlier models used checkerboard-like, rectangular grids. SCHISM uses triangles and quadrangles of varying sizes to conform to irregularly shaped rivers and coastlines. The model uses a single grid to simulate the coastal ocean with large cells, the Bay with medium-sized cells, and the rivers with small cells.



56 - Joseph Zhang https://www.flickr.com/photos/vims_photos/51828419186/

Models like SCHISM are at the heart of modern scientific research. They incorporate our understanding of the physical, chemical, and biological properties of natural phenomena.

The model has been extensively tested. It successfully simulated flooding from Hurricane Katrina in New Orleans, Hurricane Harvey in Galveston, and flooding events in Portugal, Japan, Taiwan, and other locations.

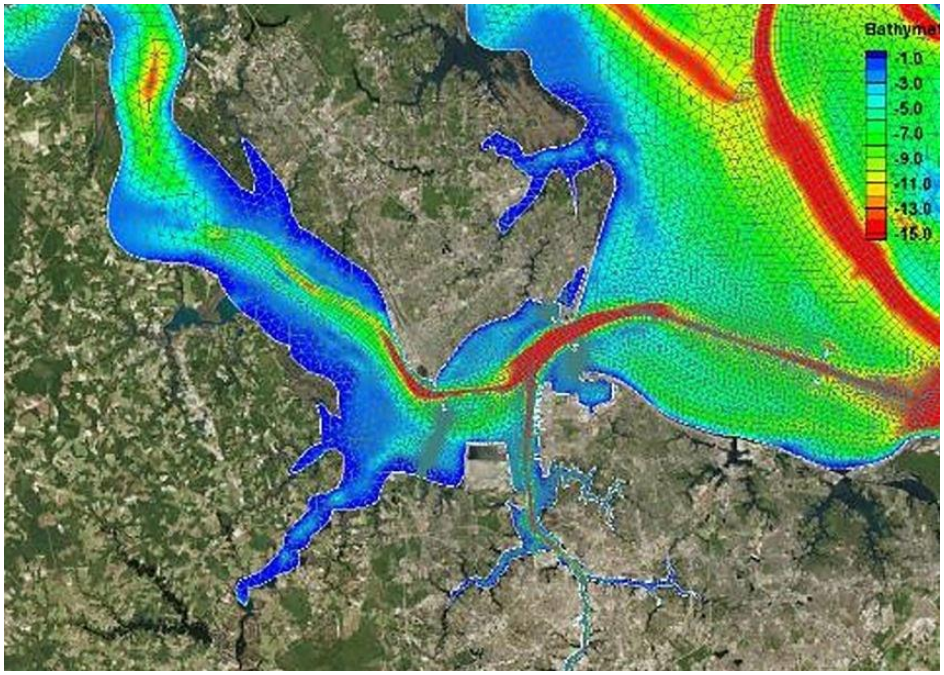
When grid sizes are small, there must be lots of them to cover the spatial area of interest. For the current Chesapeake bay model, there are 45,000 grid cells. To run a 1-year simulation it computes several quantities (water level, water currents, salinity, temperature, etc) at each location, at several depth layers. Using a 2-minute time step for, let's say, 10 calculations at 10 depths, the total number of calculations for a 1-year model run would be:

260,000 time steps x 45,000 grid cells x 10 calculations x 10 depths =

1,170,000,000,000 calculations

That's a lot of math. And that is why these models require supercomputing centers.

To start this model, initial conditions of water currents, salinity, temperature, and nutrient concentrations, etc. are provided, along with tide and weather data. After the first time-step, only updated tide and weather data are required. The model predicts currents, flood levels, salinity, temperature, nutrient concentrations, suspended sediments, and ocean wave heights.



57 - SCHISM Grid *https://www.flickr.com/photos/vims_photos/51828533458/*

Joseph Zhang got his BS degree from Beijing University, then his masters and PhD from the University of Wollongong, Australia. He developed SCHISM from an earlier model developed at Oregon Health Sciences University. Zhang and collaborators from around the world have been continuously refining the model. It's "open-source", freely available to the public along with its source code.

Models like SCHISM are at the heart of modern scientific research. They incorporate our understanding of the physical, chemical, and biological properties of natural phenomena. Models can be tested by "hindcasting", comparing simulations to events that took place in the past, where we know the outcome. If the models perform well, they can be used for "what if" analyses. For example, Bay models can address the following question: how much nutrient-reduction would result from improved wastewater treatment plants, more efficient farming practices, or cleaner septic systems? Think of 3 "dials" that can adjust inputs for each simulation. Questions like this would be impossible to answer without modeling.

SCHISM has been chosen by the EPA for its next generation Chesapeake Bay model. One of the advantages of SCHISM is that it is modular and is designed to accommodate additional user-provided calculations related to water circulation. An example of this is the VIMS Tidal Marsh Model that

simulates changes in marshlands under different sea level rise scenarios. For small patches of marshland, the grid cells are as small as 1 meter in some places.

SCHISM has been chosen by the EPA for its next generation Chesapeake Bay model.

StormSense

Flood models are becoming more and more important as time goes on, due to sea level rise.

The StormSense project focuses on urban areas. In Norfolk, water level sensors have been mounted on bridges and along waterways. These are powered by solar panels and transmit data to VIMS where it is fed into the StormSense flood model. This model (another SCHISM plug-in) incorporates land elevation data derived from radar (Lidar) overflights. The surface elevation data includes the size and shape of buildings, so that the model can account for the resistance of the terrain to flooding. It can identify which buildings are likely to flood given different sea level rise scenarios.

The current version of the Tidewatch Map app is driven by SCHISM with 1,500,000 grid-cells, 13 vertical layers, and a 6 minute time step. In the city, the grid cells are 3-feet wide.

Flood models are becoming more and more important as time goes on, due to sea level rise.

Other VIMS Models

In the future, we will probably see models for SAV and shellfish. It would be great for testing proposed management practices.

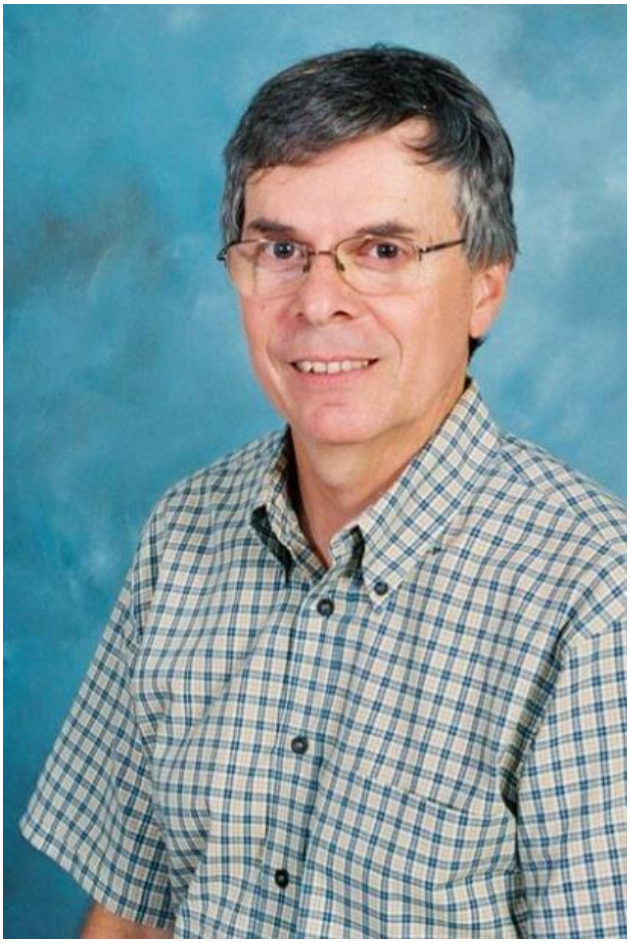
Chesapeake Bay Environmental Forecast System

We now have a model to predict dead zones - areas with too little oxygen to support life. The same model has an experimental capability to predict harmful algal blooms (HABs).

It's called the Chesapeake Bay Environmental Forecast System (CBEFS), and it also forecasts salinity, temperature, dissolved oxygen, and acidification. All are short-term forecasts - 48 hours into the future. A series of color-coded maps is published daily on the website.

This information can be useful to aquaculture operations. In the event of poor water quality, hatcheries can suspend water intake, and postpone spawning and harvesting. During HAB blooms, health departments can consider beach closures. The data can also be used by fishermen to locate the best fishing spots, away from dead zones.

Bob Diaz



58 - Bob Diaz *https://www.flickr.com/photos/vims_photos/8342722240/*

Like Don Boesch, Carl Hershner and Linda Schaffner, youngster Bob Diaz had an affinity for mud and worms. Diaz attended LaSalle College in Philadelphia and took a night-shift job monitoring dissolved oxygen at the Conowingo Dam near the mouth of the Susquehanna River. When oxygen levels got too low, he was to notify the Dam manager to start releasing water, thereby aerating the water for the shad and herring below. The first incident occurred at around 3 AM, and when Diaz called, the Dam manager thought it was a Dam hoax. Reluctantly, Diaz then called his manager, who wasn't happy to get the Dam call, but in another half hour or so the water started flowing and the fish began jumping "in approval".

Diaz came to VIMS as a graduate student in 1968. After earning his PhD, he joined the faculty. He worked with Linda Schaffner and others on hypoxia in the York River. One of their early achievements was to deploy an oxygen monitor from a data buoy that transmitted the results to shore every 30 minutes – an innovation at the time.

In 1976, on a research cruise off the coast of New Jersey, Diaz observed an anoxic event from water flowing into the ocean from the Hudson River. It resulted in an estimated $570 million loss to commercial and recreational fisheries.

Along the Gulf Coast there are times when fish, crabs, and shrimp appear in abundance in shallow water close to shore. In Alabama, locals call it the Mobile Bay Jubilee and feast on a bounty of fresh, delicious

seafood. It was once viewed as a minor miracle. In recent years the cause was discovered - a depletion of dissolved oxygen in deep water.

They found that the number of dead zones has increased worldwide by more than a third since 1995, and that dead zones now rank with over-fishing, habitat loss, and harmful algal blooms as global environmental problems.

In 1995, Diaz published an article with Swedish colleague Rutger Rosenberg on the ecological impacts of hypoxia. They coined the term "dead zones" to describe deep hypoxic zones where only the most resilient worms can survive. They found that these areas occur around the world and are increasing in frequency and magnitude. It's caused by excess nutrients that trigger an algae bloom at the surface and a subsequent bacterial bloom near the bottom. It's the bacterial bloom that consumes the oxygen. The biggest dead zone in the US forms on the Gulf Coast, and the second largest forms in Chesapeake Bay. Sometimes the causes are natural, like at the mouth of the Mississippi river, but in most cases it is exacerbated by manmade pollutants: wastewater and runoff from urban areas and agriculture of plants and livestock.

There was a shortage of striped bass in the Bay during the 1970s and 1980s, attributed mostly to overfishing, but also declining water quality, oxygen depletion, and disease. After regulations were established to restrict the catch, the fishery mostly recovered.

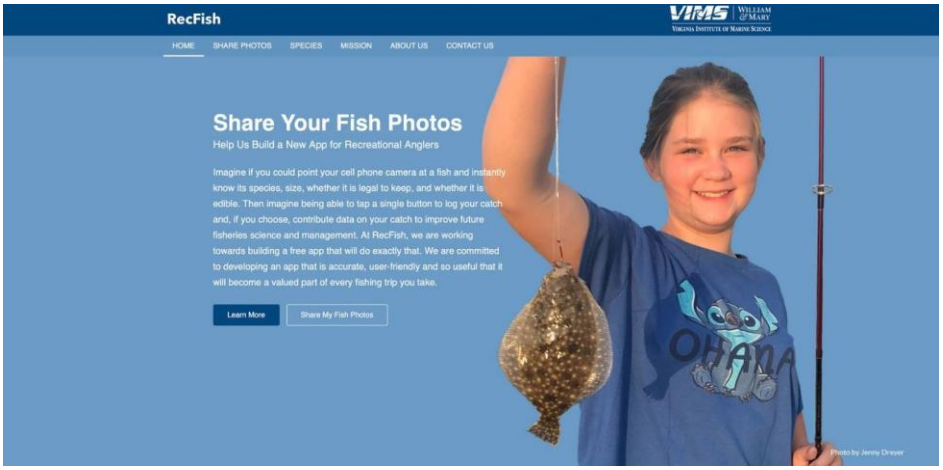
In 2005, Diaz and Rosenberg published their findings about the worldwide expansion of dead zones in the journal *Science*. They found that the number of dead zones has increased worldwide by more than a third since 1995, and that dead zones now rank with over-fishing, habitat loss, and harmful algal blooms as global environmental problems. A dead zone underlies much of the main-stem of Chesapeake Bay each summer, occupying about 40% of its area and up to 5% of its volume.

Diaz's global dead-zone database now appears as a layer in Google Earth.

Diaz retired in 2013 after a fruitful career in which he mentored 75 grad students, served in leadership roles in national and international organizations, advisory services, and as a spokesperson for VIMS. In 2010 he joined the ranks of Hargis, Musick, and Burreson when he was honored by the Virginia Science Museum with the Outstanding Scientist Award.

Diaz's global dead-zone database now appears as a layer in Google Earth.

RecFish



59 - https://www.flickr.com/photos/vims_photos/51020302077/

Birdwatchers have excellent phone apps to help identify birds in the field. Simply take a picture, submit, and if the picture is detailed enough, the app will identify it. If it's a new species for you, click and it's added to your life list. More importantly, your picture is added to a database, catalogued, and made available to researchers and the public. For users, it's convenient – there's no need for field guides or notebooks. For the rest of us, the data reveals what both sexes look like at all ages, and when and where species normally occur. It also enables estimates of abundance and migration patterns.

VIMS has developed a similar app for anglers. *RecFish* is now available on mobile devices and as a website. The initial version is not fully functional, as it can only recognize a few species. It takes several thousand pictures of each species to "train" the machine learning software - software also used for facial recognition and optical character readers. So, the goal of this first version is to gather pictures. As more and more are added, identification skill will improve.

The goal is to identify each fish, estimate size and weight, and determine if it is legal to keep. Future enhancements may include whether it is edible, legal regulations, and the citation size and weight. One possible enhancement - virtual fishing tournaments. Like the birder databases, this one will add to our knowledge of the appearance of both sexes at all ages, migration patterns, abundance, and will yield size and weight statistics.

The goal of the App is to identify each fish, estimate size and weight, and determine if it is legal to keep.

VIMS has been doing trawl surveys since 1965, but only in waters deeper than 9 feet. While the data is invaluable for managing fisheries, it misses shallow waters - important fish habitats of grass beds and oyster reefs. Only the Juvenile Striped Bass Survey samples shallow water.

There are approximately 300 fish species that regularly occur in the Bay, but only about 30 year-round residents. The rarer the species, the more important the pictures are. Anglers are not inclined to pose with throw-back fish, but by photographing them they will be doing a good deed. Those who prefer to not reveal the location of their favorite fishing spot can provide an approximate location or no location at all.

More and more anglers, like birders, are content to observe without harming the animals. For anglers, this is catch and release. Injuries to fish can be minimized in several ways, for example, by using barbless hooks, leaving the fish in the water while carefully removing the hook, and releasing promptly. Catch and release mortality can be significant - for striped bass, mortality of 10% is estimated.

The State of the Bay

Invasive species

Invasive species are non-native species that move into an area and displace native species, potentially disrupting the ecosystem. Some have no known predators and "take over" an ecosystem.

Some invasives, harmful as they are to the natural ecosystem, have desirable attributes. Think of Chincoteague ponies, domestic cats (bird, reptile, rodent, and insect predators), and fragrant honeysuckle.

As we saw earlier, MSX probably came from transplanted Asian oysters. Rapa whelks, thought to have been introduced from ship ballast water, were discovered in the Bay in 1998. Native to East Asia, they are a threat to clams and oysters. They grow to a size that is too large for predators of the two native whelk species. Ironically, in the Hampton Roads area, the whelks have been suffering from a chemical found in boat paint; but are slowly recovering since the chemical has been banned.

In the '70s and '80s, Blue catfish were introduced into Tidewater rivers by the Virginia Department of Game and Inland Fisheries. They now range outside these rivers all the way to the mouth of the Bay where they have been caught in pound nets. They displace native fish like shad and herring, and feed on small crabs and fish. Osprey populations have benefited, which, of course, is a good thing.

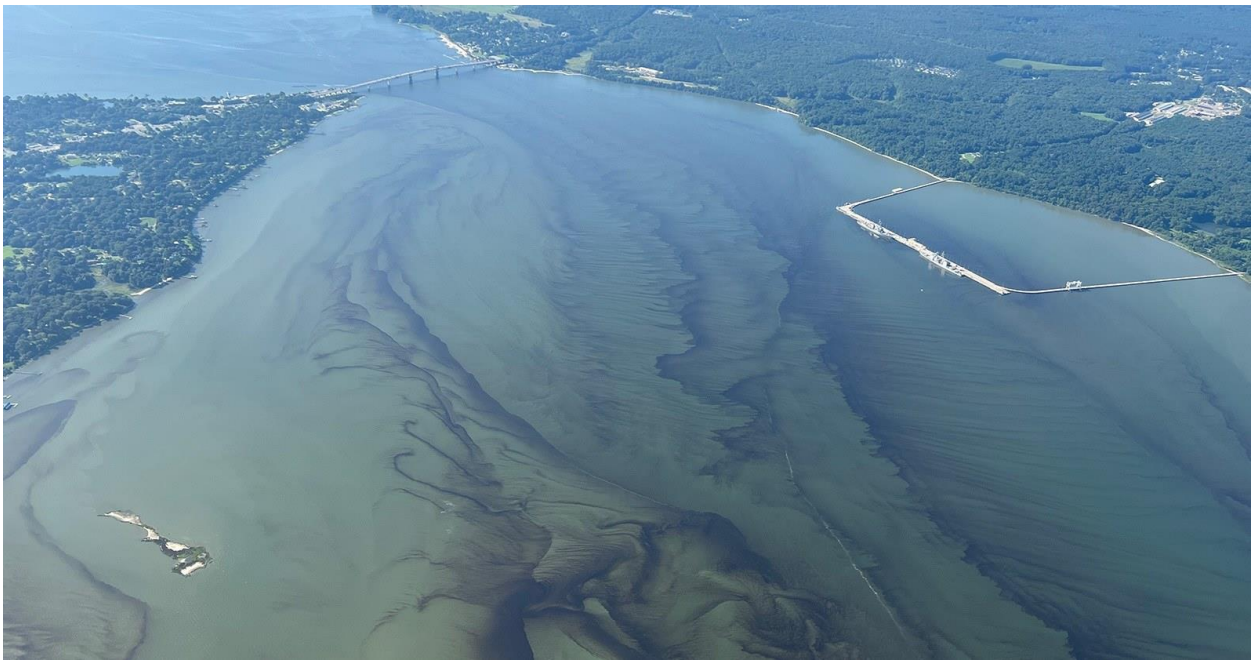
Phragmites australis is a tall native grass that can grow up to 14 feet high. In colonial times a variety was introduced for use in thatched roofs, and has become invasive. It often takes over disturbed soils and can displace native plants in established marshland. It has been regarded as a nuisance species and steps have been taken to control it. However, it has been shown to provide habitat for some bird species, and according to VIMS scientist Matt Kirwin, it's good for ecological resilience because of carbon sequestration, improving water quality by taking up nitrogen, and building up marsh elevation to keep up with sea level rise.

The red macroalgae, *Gracilaria vermiculophylla* has become abundant in the Bay, its tributaries, and the Eastern Shore's coastal bays. The jury is out on whether it's good or bad. In still waters it has a tendency to bunch up and block sunlight, but In other areas it helps vegetate areas previously occupied by seagrass and serves as a nursery habitat. During WWII, Harold Humm, who later authored The Marine Algae of Virginia, surveyed Atlantic coastal waters looking for marine algae from which agar could be extracted – a critical bacteriology lab supply previously sourced from Japan. Humm established an agar factory at Beaufort, NC, that operated during the war, processing *Gracilaria verrucosa* and *Gracilaria foliifera*.

As we will see in the next section, several species of microalgae are invasive. One of the biggest problems with invasives is that they can "sneak up" on us. At any time, an unknown species may invade and wreak havoc, and unless other areas have experienced it, there may be no known remedy.

Some invasives, harmful as they are to the natural ecosystem, have desirable attributes.

Harmful Algal Blooms



60 - source: VIMS.edu

Harmful algal blooms (HABs) have caused serious problems in most Atlantic and Gulf states. Blooms have closed beaches, closed fisheries, and necessitated seafood product recalls. So far (2023) we are lucky in Virginia that no one has gotten sick from Chesapeake Bay shellfish.

In 2021 Kim Reece gave an overview lecture on HABs, summarized below.

HABs are phytoplankton, microscopic plants: dinoflagellates, diatoms, and cyanobacteria. Mostly they're beneficial, an important food source. But they become problematic when they produce toxins, or when they "bloom" – have a population explosion. After a bloom they die and sink to the bottom and are consumed by bacteria, thereby depleting dissolved oxygen.

Blooms are usually dominated by a single species. There are several toxin-producing species in Virginia waters. For some of these species, there are strains that never produce toxin. The ones that do produce toxins, may not do so all the time.

Every species has optimal environmental conditions. Researchers are working to understand the relative importance of temperature, salinity, nutrients, wind patterns, sediment resuspension, and light penetration.

There are several toxin-producing species in Virginia waters. For some of these species, there are strains that never produce toxin. The ones that do produce toxins, may not do so all the time.

Some species reproduce by “cysts”, which can lay dormant in sediments for years. When the conditions are right, they can bloom. VIMS and the Virginia Department of Health have a joint project to map *Alexandrium* cysts.

Other states have found that the best ways to mitigate HAB blooms is by monitoring and issuing early warnings.

Monitoring is done in a variety of ways. Optical microscopes are still used, but nowadays there are instruments that can identify and count microorganisms in water samples either in the lab, or in the case of a "flow cytobot", in the water at a buoy station. These instruments funnel tiny particles single-file through a transparent tube where they can be photographed and counted. Similarly, cytometry focuses a laser on individual particles and characterizes them based on scattered light or fluorescence. (Stan Allen uses cytometry to identify triploid oyster larvae.)

Lab tests can be used to identify DNA from different organisms. It’s another way to determine the mix of species in a sample.

Remote sensing - aerial photos from a drone, aircraft, or satellite can be used to identify and quantify blooms.

Two species are so common on the western shore, they have been given nicknames. *Alexandrium monilatum* and *Margalefidinium polykrikoides* are “Alex and Marge”, a not-so-fun couple. Since 2007 Marge blooms first and then it's typically followed by Alex. Of course, ladies first.

Alex has one redeeming feature, bioluminescence. It glows at night whenever it’s disturbed. A glowing boat wake on a moonless night is an unforgettable sight.

For swimmers, the Virginia Department of Health (VDH) cautions, “If the water is discolored, murky, has an odor, or if there appears to be a film on the water surface, swimming is not advised for human or pets. When in doubt, stay out!”

VIMS has partnered with DEQ, ODU, and VDH to monitor HABs. The coalition is called the HAB Task Force.

So far (2023) we are lucky in Virginia that no one has gotten sick from Chesapeake Bay shellfish.

Plastics

61 - Rob Hale https://www.vims.edu/newsandevents/topstories/2019/_images/plumeri_2019/hale_r_275.jpg

VIMS chemist Rob Hale was the lead author of a 2020 publication about microplastics that was recognized by the *Journal of Geophysical Research: Oceans* as highly significant towards our understanding of the Earth and the solar system. Hale emphasizes that plastics are truly a global problem. In the oceans, plastic waste concentrates in large oceanic gyres, notably "the garbage patch" in the North Pacific. Plastic waste is also found along shorelines all over the world.

Microplastics are tiny particles that were either manufactured that way or broken apart from larger pieces. Popular synthetic "fleece" garments shed multitudes of particles every time they are washed and worn. Plastics are so durable that we tend to think of them as inert, but, unfortunately, some plastics, like polystyrene foam, are infused with toxic agents to enhance their properties. Examples are flame retardants and UV inhibitors. But even the inert particles can have detrimental effects, such as displacing food particles in filter feeders, thus reducing their growth rates.

Hale is concerned about changes in chemical properties as the particles weather and age. He is especially concerned about toxicity of the tiniest particles, nanoplastics.

Microplastics ingested by marine animals can end up on our dinner plates. Investigators report that the highest concentrations are found in filter feeders - mollusks (clams, oysters and scallops).

Hale emphasizes that plastics are truly a global problem.

The consensus is that manufacturers need to find biodegradable substitutes or stop producing all but the most essential products. Kirk Havens has been consulting with Virginia Tech researchers on a biopolymer called PHA (polyhydroxyalkanoate) for escape hatches in crab and lobster pots. PHA can degrade in nature and is currently being developed into netting and rope. It may become the material of choice for oyster bags (used in shoreline erosion barriers), clam aquaculture netting, landscape netting for newly planted slopes, and shotgun shell "wads" that cradle shot pellets and are expelled when fired. Hunters are required to pick up their empty shell casings, but the wads are harder to retrieve - they typically travel 20 to 50 yards. Wads have been found in shorebird stomachs, and they are a big problem for cranberry growers. Virginia Tech researchers are also investigating PHA for netting used to bind hay and straw bales. Cows often eat the netting, which accumulates in their stomachs.

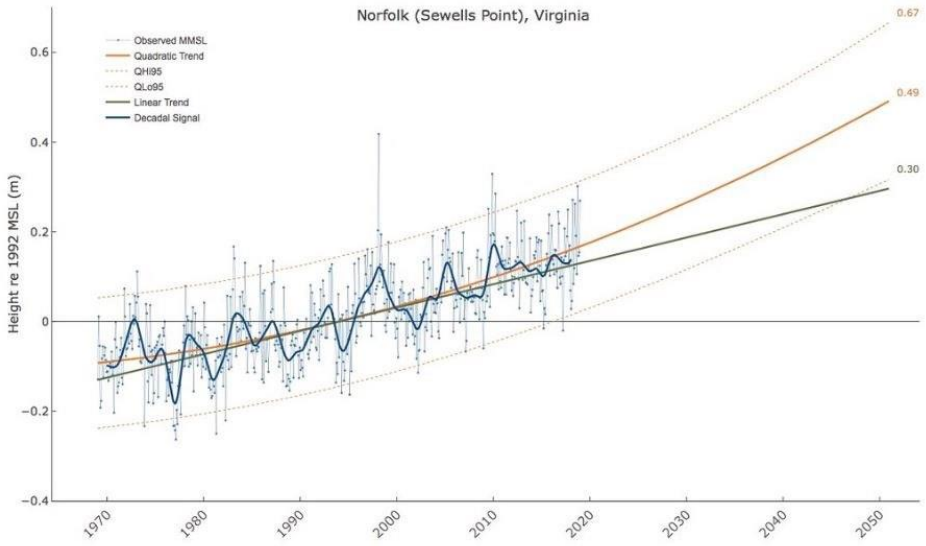
Havens has been consulting with Virginia Tech researchers on a bio-degradeable polymer for escape hatches in crab and lobster pots. This material may prove to have a host of other uses.

Global Climate Change

The primary cause of global climate change is the greenhouse effect, brought on primarily by increasing concentrations of carbon dioxide in the atmosphere. Even if we reduce the burning of fossil fuels, it will take decades to purge the carbon dioxide out of the system. So we are stuck with global warming trends for the foreseeable future.

VIMS has a website, AdaptVA, that addresses climate change and how to mitigate the impact.

Sea Level Rise



62 - Graph of sea Level at Sewells Point, Norfolk https://www.flickr.com/photos/vims_photos/32235271377/

In the global ocean, sea level is rising due to melting glaciers and expansion of warming water. What exacerbates the problem in Eastern Virginia, is land subsidence. This is caused by large quantities of ground water removed by two paper mills, and isostatic rebound - a lingering result of glaciers retreating. As the weight of the retreating ice decreased, the (Canadian) land underneath rose - and distant land (Virginia) fell.

Rising sea levels have implications for wetlands. Scientists disagree on the impact. Some say that wetlands will "drown", others think they will survive by accumulating peat from sedimentation and decaying vegetation. A recent VIMS study found that the rate of 10mm per year was a "tipping point" – above 10 the marshes drown, below 10, they survive.

We have already seen sharp declines in wetlands bird populations in coastal Virginia. Take, for example, seagull populations. There were 55,000 nesting pairs of gulls in 1993, but only 20,000 in 2018. This decline has been attributed to marsh habitat loss.

According to a recent VIMS study, by 2100 sea level rise in the Chesapeake Bay region will claim an additional 600 square miles of upland, mostly rural forests and farm fields. That's 4 times the area of upland inundation than what we have seen since 1840, when reliable records were first available. The challenge will be for landowners and rural counties to adapt to the loss of uplands.

Some scientists think that wetlands will "drown" with sea level rise, others think they will survive by accumulating peat from sedimentation and decaying vegetation.

Warming Bay waters

Warming Bay waters may soon be as problematic as sea level rise. A 2022 report from the Chesapeake Bay Program's *Scientific and Technical Advisory Committee* concluded that the current Bay cleanup strategy, focused on nutrients and sediments, doesn't account for the negative impact of rising water temperatures on marine life. Some of the current mitigation measures, namely detention ponds, increase stream temperatures. Efforts to reduce warming, such as planting trees along streams and in urban areas, haven't been meeting goals. Runoff from urban heat islands is also part of the problem.

We are seeing declines in eelgrass in Bay waters, at least partly due to warming Bay waters. Blue mussels and surf clams are becoming scarce - they are moving north along the coast. White shrimp and pinfish are moving into Virginia waters from North Carolina.

The consensus is that, going forward, we need to prioritize temperature along with nitrogen, phosphorus, and sediments.

Species distributions are changing. Five years ago, Virginia did not have a shrimp fishery.

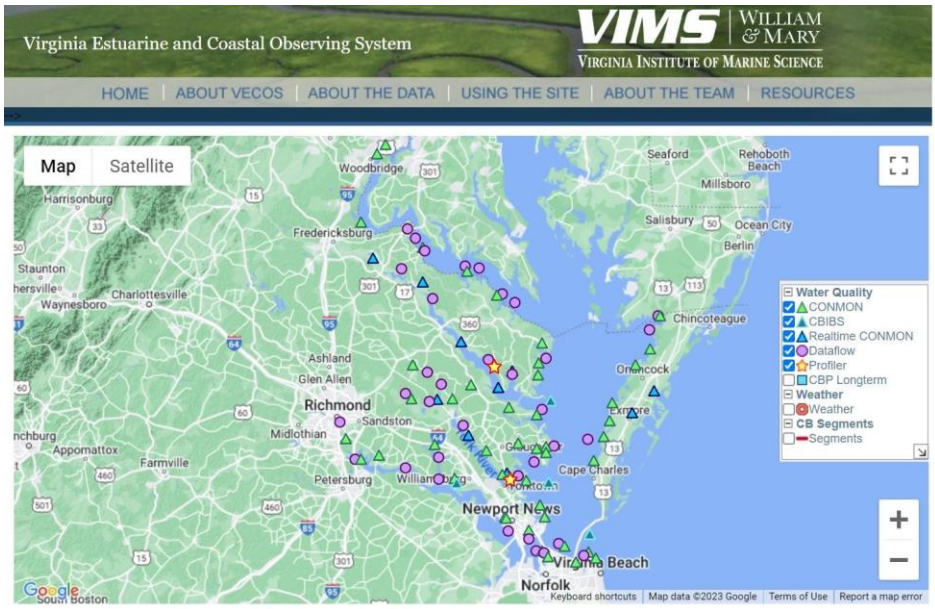
Acidification

Another impact to Virginia fisheries is acidification. More carbon dioxide in the atmosphere means more in the oceans, which makes the water more acidic. This is a potential long-term problem for shellfish, as it makes it more difficult to grow shells. Fresh water is naturally acidic; rainfall certainly is. This may ultimately be more of a problem for open ocean critters, rather than for those adapted to the fluctuating acidity of estuaries.

Report Cards

The Chesapeake Bay Foundation and the University of Maryland Center for Environmental Science issue annual reports on the Bay and its watershed.

Water quality is obviously an important component of the evaluation criteria. VIMS partners with the Virginia Department of Environmental Quality, the EPA Chesapeake Bay Program, and the Hampton Roads Sanitation District, to collect and distribute water quality, meteorological, and oceanography data. A list of data sources is here, and the data is available online.



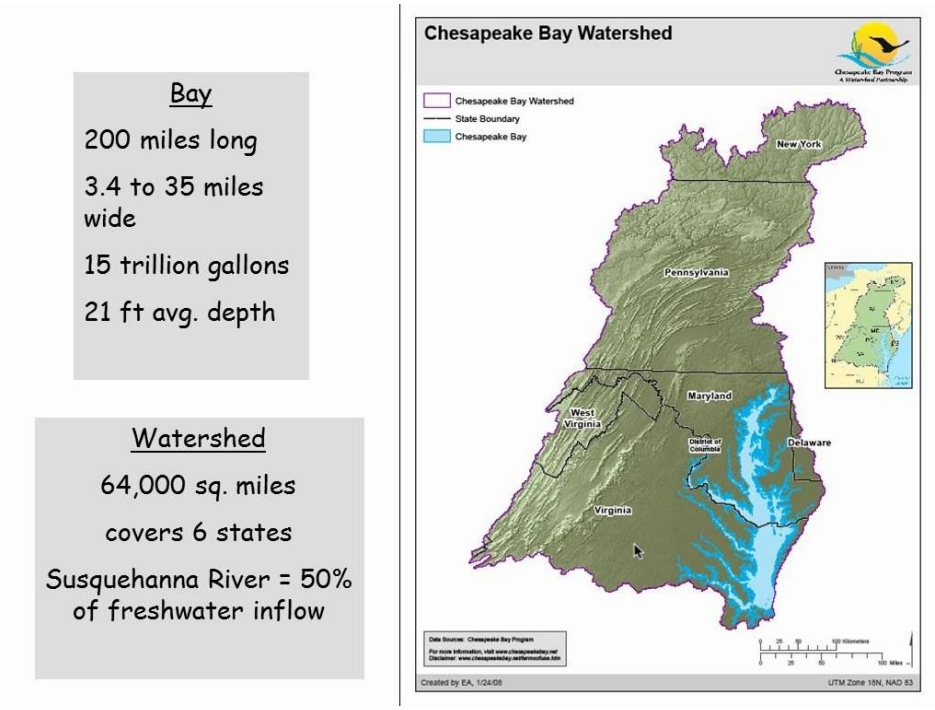
63 - Stations for water quality, meteoroligical, and oceanographic data. [*http://vecos.vims.edu/Default.aspx*](http://vecos.vims.edu/Default.aspx)

VIMS issues two report cards: Chesapeake Bay dead zones and Sea Level changes at 32 locations along the Atlantic, Gulf, and Pacific coastlines, including Alaska.

The Big Picture

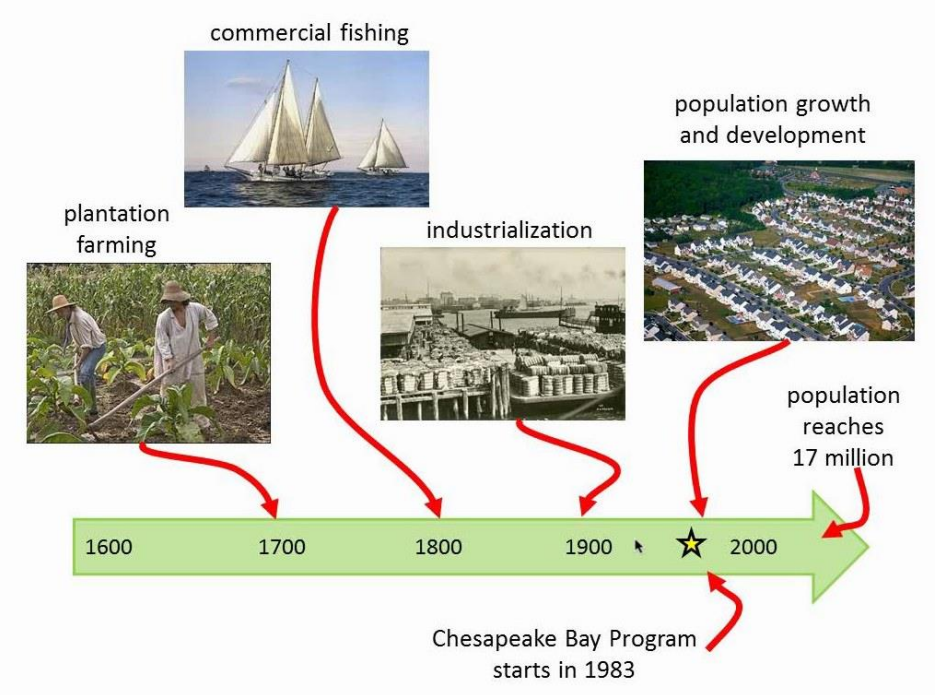
64 - Satellite image of Bay and it's tributaries [*https://www.flickr.com/photos/vims_photos/49090957008/*](https://www.flickr.com/photos/vims_photos/49090957008/)

In 2015, to lead off VIMS 75th anniversary commemoration, Carl Hershner gave a talk on the "Chesapeake Bay: Then, Now, and Next", summarized below.



The watershed of the Bay is huge. For every acre of Bay surface, there are 14 acres of watershed. This ratio, watershed to bay area, is the largest of any estuary in the world.

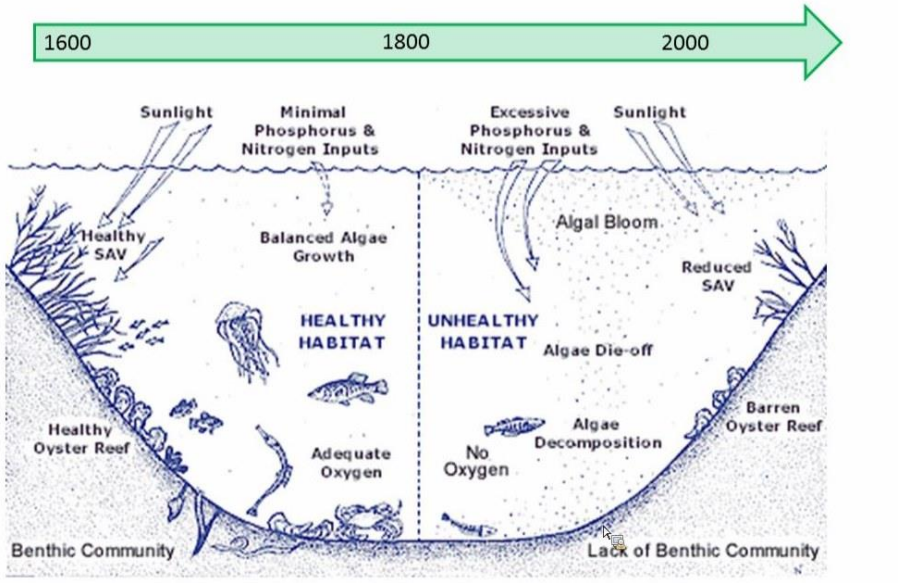
Bay health is heavily dependent on what goes on in the watershed. There are currently 17 million residents, continuously developing the land, and enjoying a pleasant quality-of-life.



Looking at the timeline above, the forested environment started changing when European settlers arrived and began clearing land for farming. As the land was cleared, runoff increased, carrying sediments into the rivers. Before that, runoff was mitigated by vegetation and beaver dams. The problem with sediments is that they settle before they are swept out to sea, smothering oyster reefs and covering sandy bottom habitats with silt. Suspended sediments increase turbidity and reduce the sunlight available to seagrass. Less seagrass means less habitat, less photosynthesis, and less oxygen produced near the bottoms.

Large scale commercial fishing began in the 1800s and for the first time, as we saw with oysters, we experienced overfishing of key populations.

Industrialization brought on faster development, and mass-produced fertilizers, herbicides and pesticides. Nutrients from agricultural runoff and municipal wastewater cause algae to bloom in surface waters. This leads to a chain of events: seagrass suffers from lack of sunlight, the algae eventually die and sink to the bottom where bacteria consumes them, thereby depleting the dissolved oxygen at the bottom. This process is called eutrophication.



The opposite of eutrophic is oligotrophic, which was the case when John Smith first arrived. The water was clear, and seagrass, shad, sturgeon, and oysters were thriving.

The first indications of trouble came when shad and sturgeon disappeared, and oyster harvests declined. For the first time, people noticed blue-green algae blooms in the Potomac.

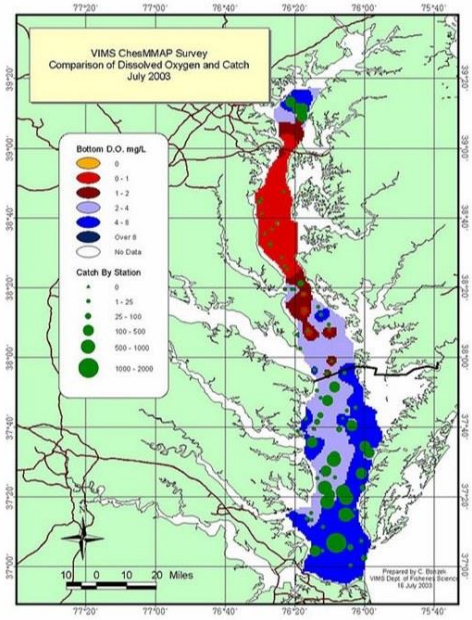
Evidence of trouble

Collapse of shad and sturgeon fisheries

Declining Oyster harvest

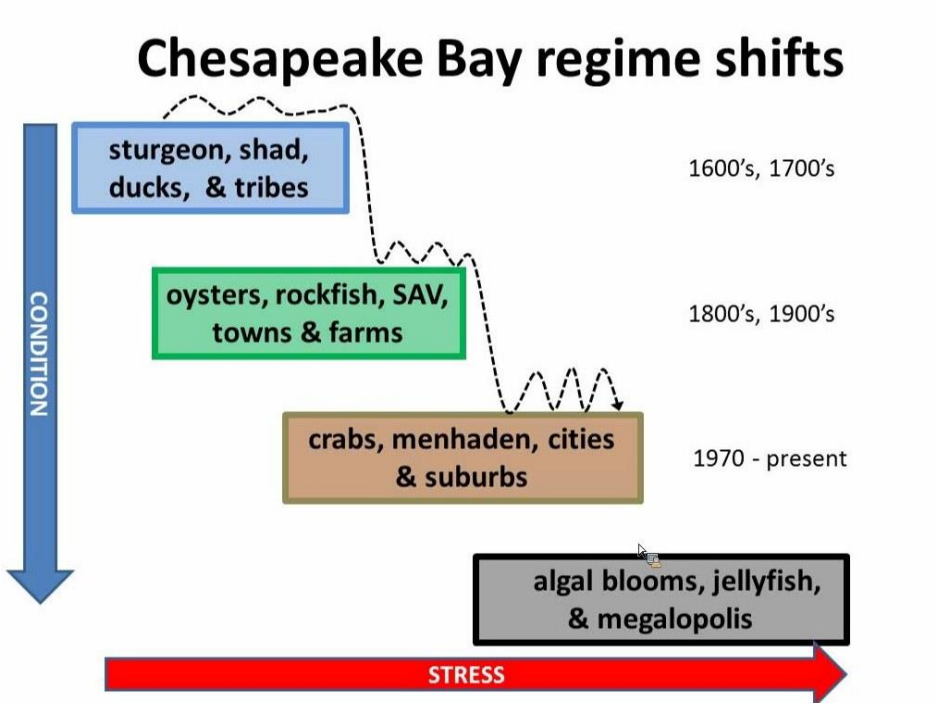
Blue-green algae blooms in the Potomac

Hypoxia

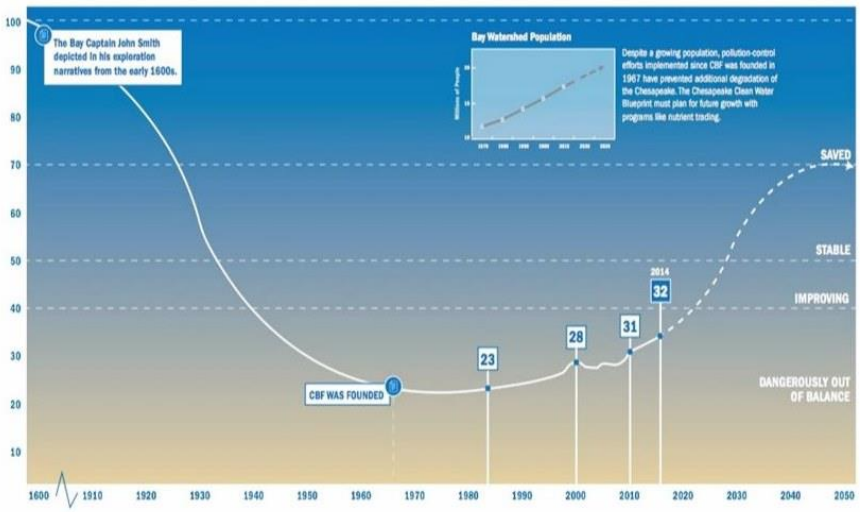


Later, when oysters, rockfish, and SAV declined, people again took notice.

Scientists speak of ecological regime changes, defined as major, persistent changes in the ecology of an area. Hershner defined 4 regimes, shown below. Currently we are in the "crabs, menhaden, cities and suburbs" regime. The 4th and final regime, with algal blooms, jellyfish, and bacteria; is where we will be if current trends continue.

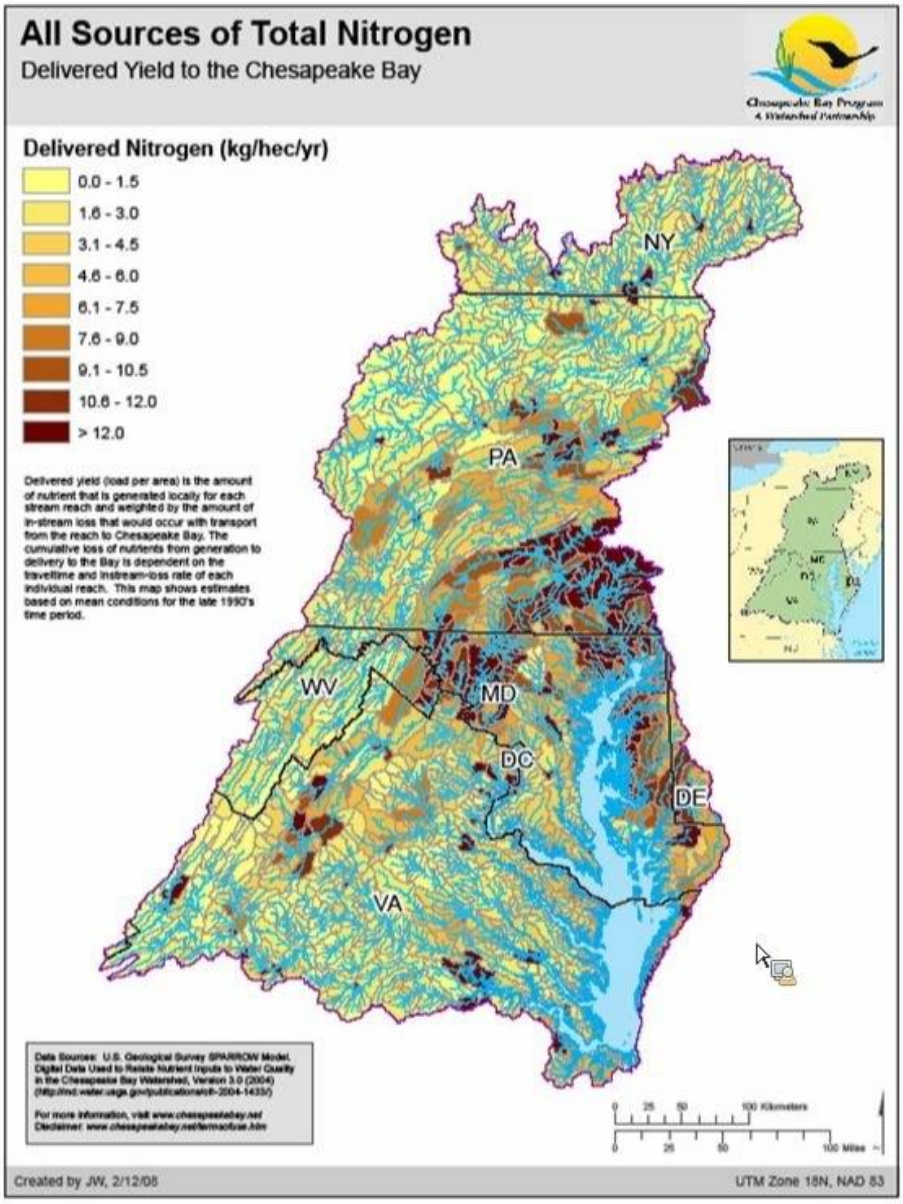


In 1998 the Chesapeake Bay Foundation issued its first State of the Bay report. CBF scientists evaluated 13 indicators (listed below the next figure) in three categories: pollution, habitat, and fisheries. The benchmark of 100% was taken to be the state of the Bay when John Smith arrived.

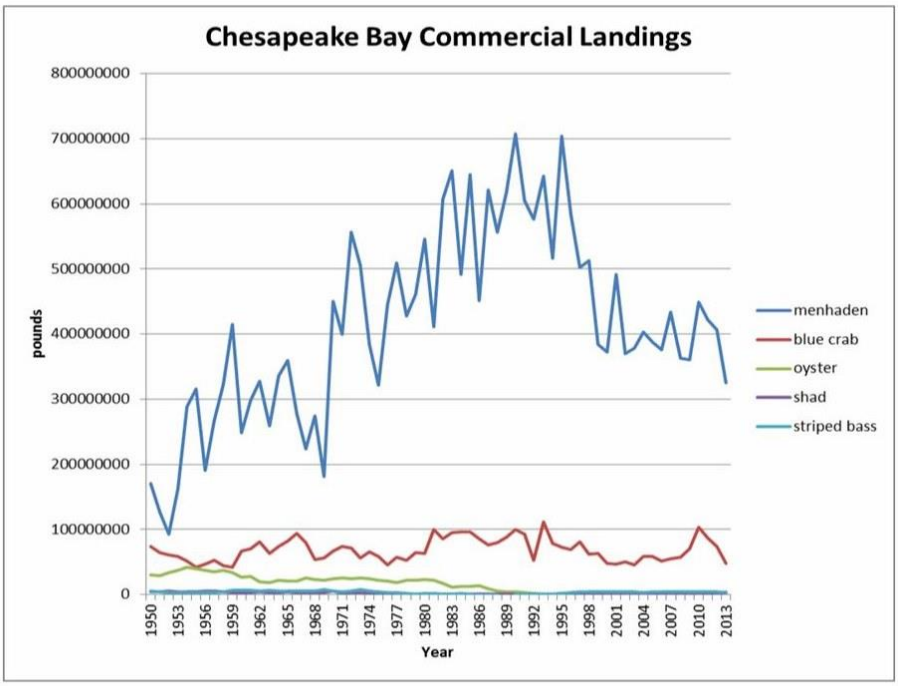


dissolved oxygen	oysters	underwater grasses
phosphorus	rockfish	wetlands
nitrogen	blue crabs	resource lands
water clarity	shad	forest buffers
toxics		

In 1983 the states met and agreed to work together to improve the Bay. This was the start of EPA's Chesapeake Bay Program. One of the first conclusions was that the Bay was in trouble, and the states needed to take action to restore it. Nitrogen pollution was identified as the most serious problem. The map below shows the largest sources of nitrogen entering the Bay, mostly in Maryland and Pennsylvania.

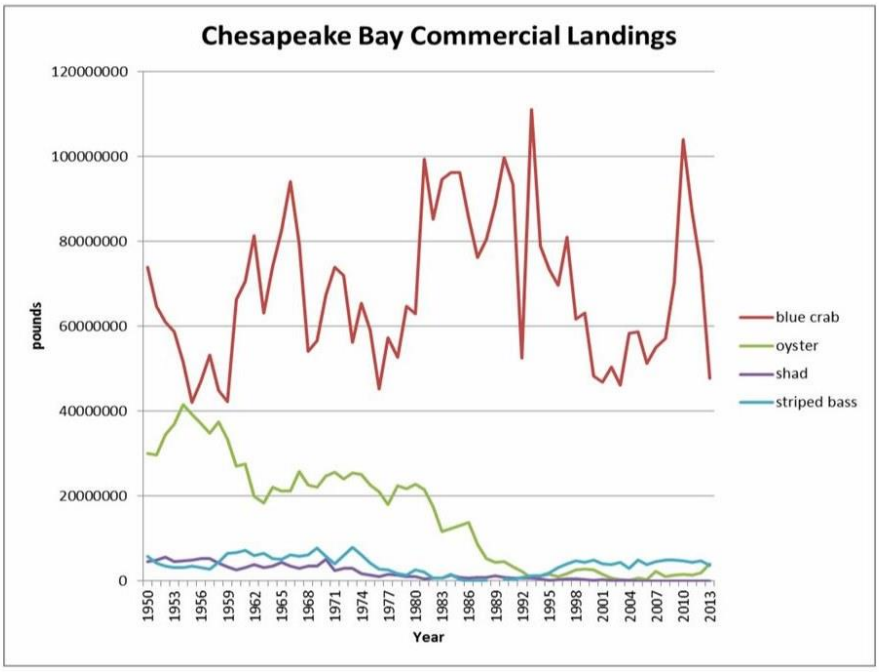


Menhaden is the largest fishery, by tonnage, as shown below. Crabs are the second largest.



https://www.st.mfs.noaa.gov/st1/commercial/landings/annual_landings.html

Below is the same data with Menhaden removed, to show more detail for the other fisheries.

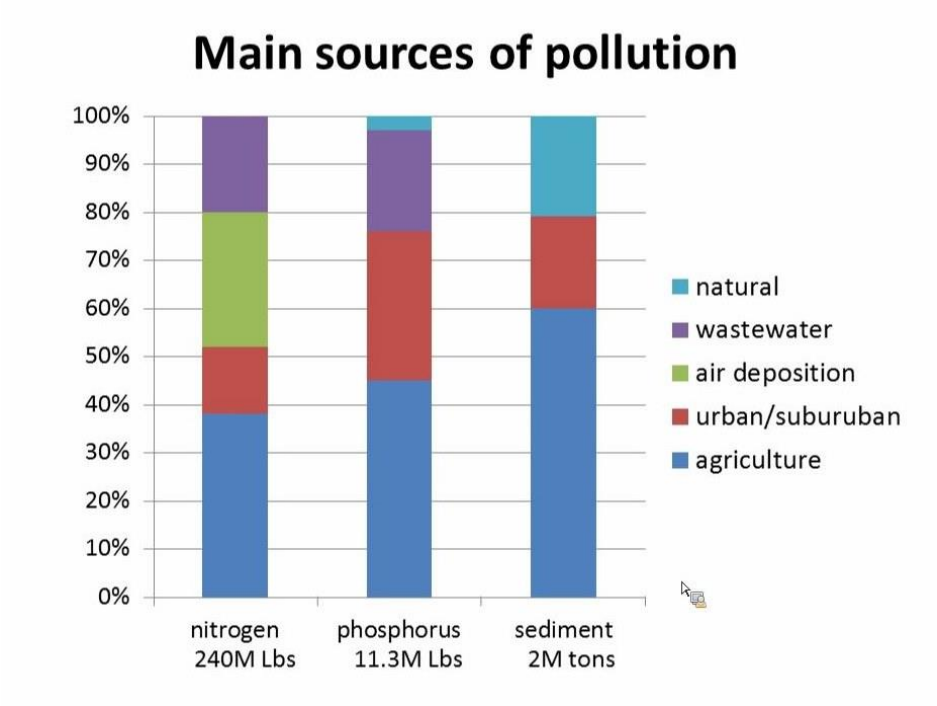


https://www.st.mfs.noaa.gov/st1/commercial/landings/annual_landings.html

Oysters, shad, and striped bass bottomed out starting around 1980. Since then, striped bass and oysters have recovered.

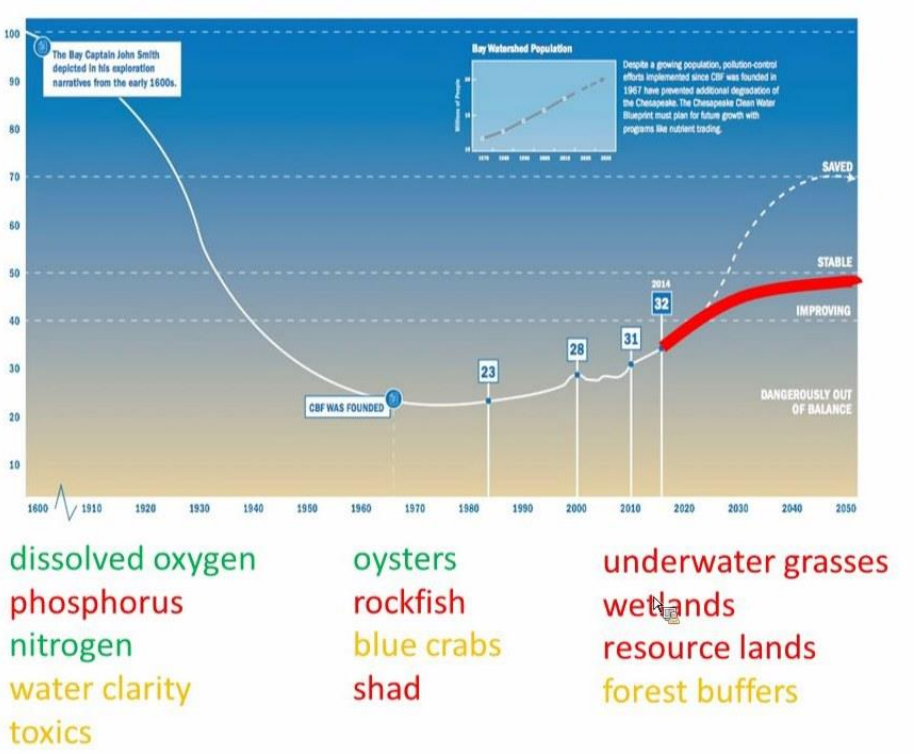
Nutrient pollution has proven to be difficult to reign in. We've made a lot of progress in improving wastewater treatment, but agriculture is a different story - it is now the major source and difficult to reduce.

A somewhat surprising source of nitrogen is from the atmosphere: vehicle exhaust fumes and emissions from power plants that burn fossil fuels.



Given the increasing levels of environmental stress, Hershner argues that we can't get back to the John Smith regime, and it's unlikely we'll be able to go back to the wild oyster - rockfish -SAV regime.

In the diagram below, on the vertical axis, the CBF goal is 70%. Hershner argues that a more realistic goal is 50%. Hershner color-coded the 13 CBF indicators: red = highly unlikely, yellow = unlikely, and green = possible.



Hershner concludes, “For effective public policy, for the appropriate use of limited public resources, …we need to rethink what the end goal should be for this system. We may have to come to grips with a Chesapeake Bay that is always going to be cloudy. It just won't be producing jellyfish and we hope it will be producing clams and oysters. They may come from aquaculture as opposed to wild harvests.”

“But it can still be a system that serves us very well. It just won't be one that it looked like back in the early ‘70s and ‘50s. When we think about climate change, one of the two big drivers… we know the temperatures have increased and are going to increase, and sea level is coming up and we expect it to continue coming up”.

According to Hershner, the other big driver is population and development in the watershed. When we consider these challenges, and that the people living in the watershed have a good quality of life, we may conclude that despite our best efforts, we may be limited in how much we can improve the Bay. Therefore, we need to rethink what we consider to be success.

Our task going forward is to identify the most cost-effective and sustainable interventions. Fortunately, our models are state-of-the-art and enable us to do the what-if analyses that will assist us in making wise decisions.

A recent (2023) report from the Chesapeake Bay Program’s Scientific and Technical Advisory Committee reached similar conclusions. We should strive for a healthier Bay, but it won't be the Chesapeake of the past.

All things considered, the outlook for the Bay may not be so bad after all.

"We may have to come to grips with a Chesapeake Bay that is always going to be cloudy. It just won't be producing jellyfish and we hope it will be producing clams and oysters. They may come from aquaculture as opposed to wild harvests."

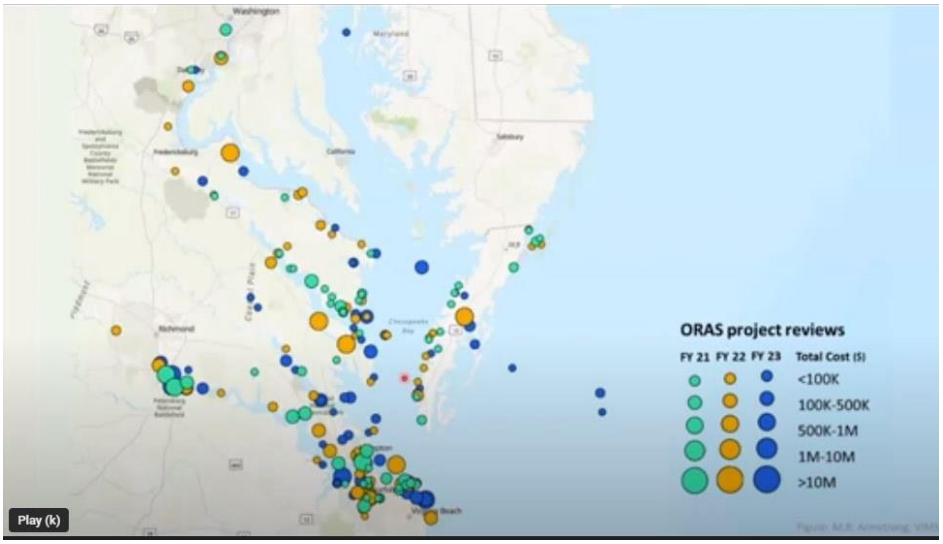
Advisory Services

VIMS now has an Office of Research and Advisory Services (ORAS) that responds to requests from the General Assembly, the governor, state agencies, local wetlands boards, marine and coastal-related private industries, and federal agencies. They also provide personnel and training to support the management of wetlands and seagrass.

Two VIMS advisors attend monthly meetings of the Virginia Marine Resources Commission where the commission rules on permits and regulations. They respond to questions from the Board as its members weigh VMRC staff recommendations and public input.

Perhaps the most valuable service VIMS provides at VMRC meetings is as an honest broker to provide scientific opinions on issues that can be highly contentious. The December 2022 meeting that considered tighter regulation of menhaden fishing in the Bay drew the largest crowd ever – the VMRC auditorium was overflowing with concerned Northumberland and Northampton County residents.

Emily Hein recently gave a talk on current projects. The map below shows the locations and sizes (in dollars) of projects for the three years ending in 2023.



Perhaps the most valuable service VIMS provides at VMRC meetings is as an honest broker to provide scientific opinions on issues that can be highly contentious.

The largest ongoing project is the Hampton Roads Bridge Tunnel Expansion. VIMS modelers simulated the impact of the proposed project on currents, water quality, plant and animal life. Fortunately, the impacts were minimal. One of the issues was the installation of steel pilings, which when driven into the bottom, vibrate in such a way that is hazardous to marine life. One of the recommendations was to start with soft blows, slowly increasing the intensity so that finfish could flee the area.

An example of a recently completed project is the construction of gapped breakwaters just north of the Savage Neck Dunes Reserve on the Bay in Northampton County. The project was mostly successful in protecting the property owners' shoreline, but it increased erosion at the Savage Neck Dunes Reserve – despite beach nourishment intended to prevent it.

Hein, Lyle Varnell, and Mark Luckenbach are also on-call for disaster response, such as oil spills, plane crashes, and ship fires. In March 2022 there was a crash of a Navy Hawkeye radar aircraft in a coastal bay near Chincoteague. Salvage personnel were able to offload the aviation fuel and recover the wrecked aircraft; and with VIMS guidance, there was only minimal damage to eelgrass beds.

Marine Advisory Program

VIMS has a related group of marine scientists that focus on a wide range of topics: aquaculture, commercial and sport fishing, marine education, marine business, and seafood technology and safety. This group is dedicated to advisory services; they represent VIMS at public meetings and events.

Public Education

In addition to William and Mary graduate and undergraduate degree programs, VIMS provides internships at the college and high-school levels. For college students, there are summer intern research and field courses at Gloucester Point and at Wachapreague. At Gloucester Point there is an Oyster Aquaculture Training program that prepares students to work at hatcheries or start their own business.

66 - Ryan Bethea - after VIMS Oyster Aquaculture Training, he started his own oyster company https://www.flickr.com/photos/vims_photos/50210946626/

For 10 lucky high school juniors and seniors from the Northern Neck, Rappahannock Community College (RCC) and Virginia Tech offer an annual 3-week course in Aquaculture. Also for this age group, VIMS has a Governor's School program for high achievers.

VIMS educators provide the Bridge, a web-based clearinghouse of digital classroom resources, and the *Virginia Scientists and Educators Alliance* that works with graduate students to create K-12 lesson plans. They also offer a summer field course for Virginia middle and high school teachers at Wachapreague.

For 10 lucky high school juniors and seniors from the Northern Neck, Rappahannock Community College (RCC) and Virginia Tech offer an annual 3-week course in Aquaculture.

67 - https://www.flickr.com/photos/vims_photos/15484025530/https://www.flickr.com/photos/vims_photos/15484025530/

As mentioned above, the VIMS *Center for Coastal Resources Management* offers Tidal Wetlands workshops in the spring and fall for members of citizen Wetlands Boards and other interested parties. The Chesapeake Bay National Estuarine Research Reserve at VIMS offers a Coastal Training Program for grades K through 12.

VIMS has many other public programs, including open houses, After Hours lectures, and an occasional grad students' presentation at a local brewery or distillery - *A Scientist Walks into a Bar*.

The VIMS website provides a wealth of information, without which, this document could not have been written.

Finally, the Hargis Library provides physical and electronic access to marine science literature from VIMS and worldwide.

Acknowledgements

I (George Mapp) have recently been writing for the *Citizens for a Better Eastern Shore* newsletter. I have an MS degree from VIMS (1982), but I've been away from marine science for many years. I haven't kept up with VIMS and all they have accomplished over the years, so I thought I would write an article, and it grew into this document, available online at:

https://bit.ly/VIMShistory

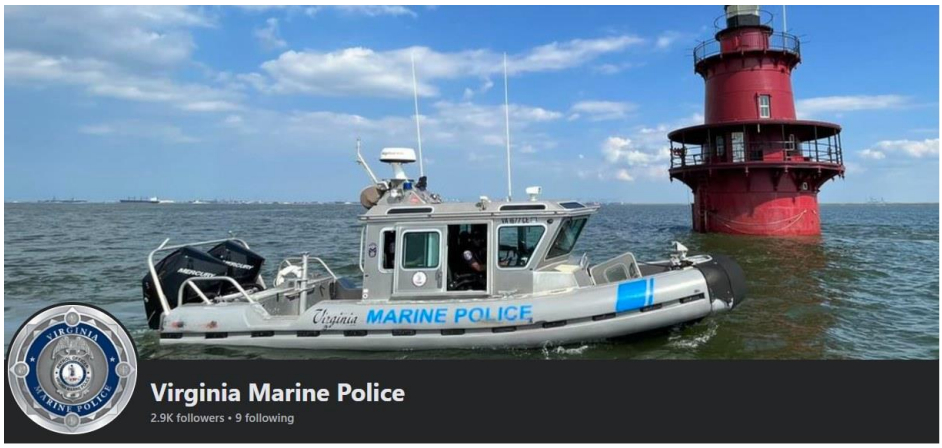
I chose the web format because it's easy to distribute the document, including color photos, to anyone who shares my appreciation for the scientists, educators, and staff members who work diligently to understand, describe, and document the intricacies of our natural marine environment.

I am grateful to Carl Hershner, Bill Rue, and Laura McKay for their advice and encouragement; and I particularly thank Dick Snyder for his many comments and corrections. Any remaining errors are, of course, mine alone.

I welcome your comments - email me at gmapp0@gmail.com.

Appendix

The Virginia Marine Resources Commission



68 - https://www.facebook.com/VirginiaMarinePolice

In 1875 the General Assembly established a Fish Commission to study and recommend legislation to the Governor and General Assembly. Over the years the Commission was granted more and more authority over fisheries, bottoms, wetlands, shorelines, dunes, and beaches. The agency was renamed the Virginia Marine Resources Commission (VMRC) in 1968.

VMRC regulates saltwater fisheries. Offshore species and species that range across state boundaries may also be regulated by NMFS or the ASMFC. State fisheries that violate ASMFC or NMFS regulations or catch limits may be shut down by the U.S. Secretary of Commerce.

The 8 VMRC Board members are appointed by the governor to 4-year terms. The commissioner is also appointed by the governor and may be replaced anytime. One board member has to be a commercial fisherman and another, a recreational fisherman.

VMRC currently has approximately 150 employees, with 33 in Fisheries Management, 11 in Shellfish Management, and 14 in Habitat Management. These employees work with stakeholders, the public, and with regional and national fishery management groups (ASMFC and NMFS).

VMRC **monthly board meetings** are held in Hampton, open to the public, with opportunities for public comments. Examples of agenda items are shoreline permit appeals (forwarded from local wetlands boards) and public hearings for changes in fisheries catch limits or season schedules. Each agenda item is presented by a VMRC staffer, with staff recommendations. VMRC staffers and VIMS Advisory personnel are available to answer questions. A representative from the Attorney General's office is available to address legal issues. VMRC can make formal requests to VIMS to present expert testimony at future meetings.

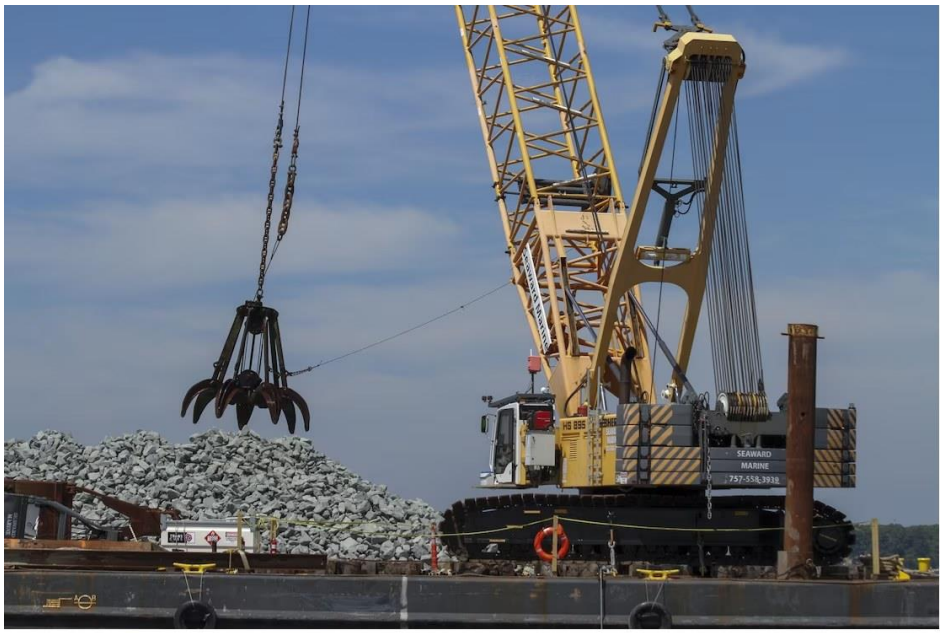
A critically important part of fisheries management is stakeholder and public participation. Accordingly, VMRC has 9 **Management Advisory Committees**: Aquaculture, Crab, Finfish, Commercial Fisheries, Recreational Fisheries, Menhaden, Saltwater Fisheries, Shellfish, and Seaside Eastern Shore Oyster Replenishment. VMRC staffers facilitate committee meetings, either in-person or online or both. All meeting agendas and minutes, and some video recordings, are published on the VMRC website.

Each committee is composed of board members with diverse backgrounds, from communities impacted by their decisions. Members discuss the issues, hear public comments, and submit recommendations to the monthly VMRC Board meetings, where the commissioners vote to accept, modify, or reject them.

Committee chairmen can be VMRC Board members, VIMS advisors, or other members – not VMRC staffers. Facilitating the meetings may entail presiding in partnership with the chairman. It's an understatement to say that this requires a lot of patience, as some speakers digress and exceed their allotted time. Was it Mark Twain who said, "People who love sausage and respect the law should never watch either one being made"?

VMRC has 5 divisions, 3 of which are related to fisheries. The other 2 are Law enforcement and Administration.

Habitat Management



69 - Piankatank River Oyster Recovery Project *https://www.nao.usace.army.mil/PiankatankOyster/*

According to Virginia law, the state owns bottomlands below Mean Low Water. The Baylor survey of 1884 is still used to delineate public oyster grounds. VMRC can lease areas outside of the Baylor grounds to private parties for shellfish cultivation, so long as it is not covered by submerged aquatic vegetation. Leaseholders can hold onto to a lease indefinitely if they pay rent on time, and they have a transfer right. Transfers have sold for hundreds of thousands of dollars.

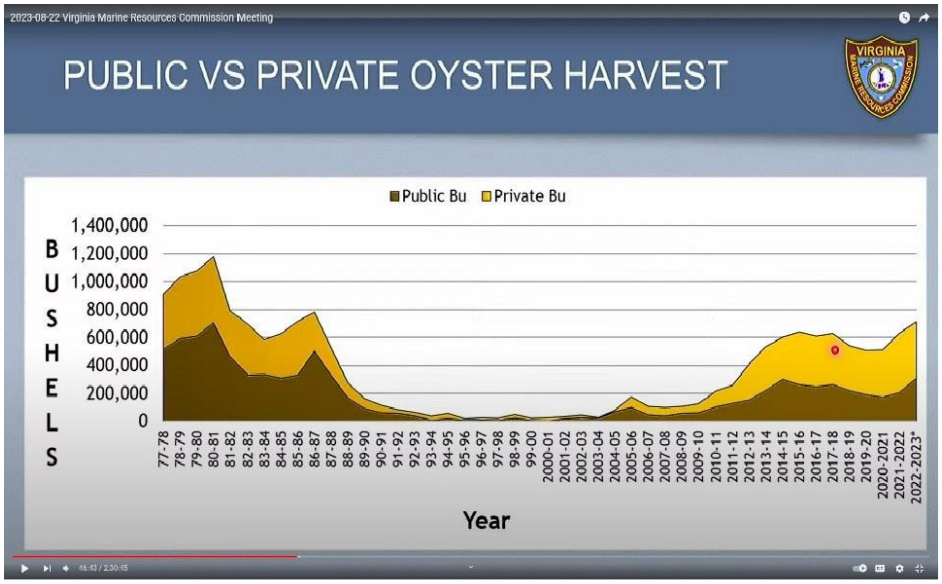
Conflicts with waterfront property owners are becoming more frequent as aquaculture takes up more bottomland. Homeowners have objected to arrays of floating or tidally-exposed cages, complaining that they are a hazard to navigation and recreation, and they interrupt scenic views and lower property values.

VMRC manages a public oyster reef replenishment program with participation by VIMS, USACE, the Rice Rivers Center at Virginia Commonwealth University, CBF, TNC, and others. For example, over 400 acres in have been restored on the Piankatank River by spreading granite rock over the bottoms to provide surfaces for oysters to grow.

There is also a program to help private lessees improve their bottomland, administered by the U.S. Department of Agriculture.

Not all restoration projects have been successful. Recently a project on the Lynnhaven River that used recycled paving concrete was ordered by VMRC to remove 190 barge loads of material because of complaints from landowners about asphalt, rebar, metal wires, and plastic. Also, VIMS found low levels of polyaromatic hydrocarbons. PAHs, a toxic material, in the asphalt and concrete. The project was halted, and the sponsoring organizations were ordered to remove the material.

Shellfish Management



70 - https://www.youtube.com/watch?v=hf58Z9SLNlg

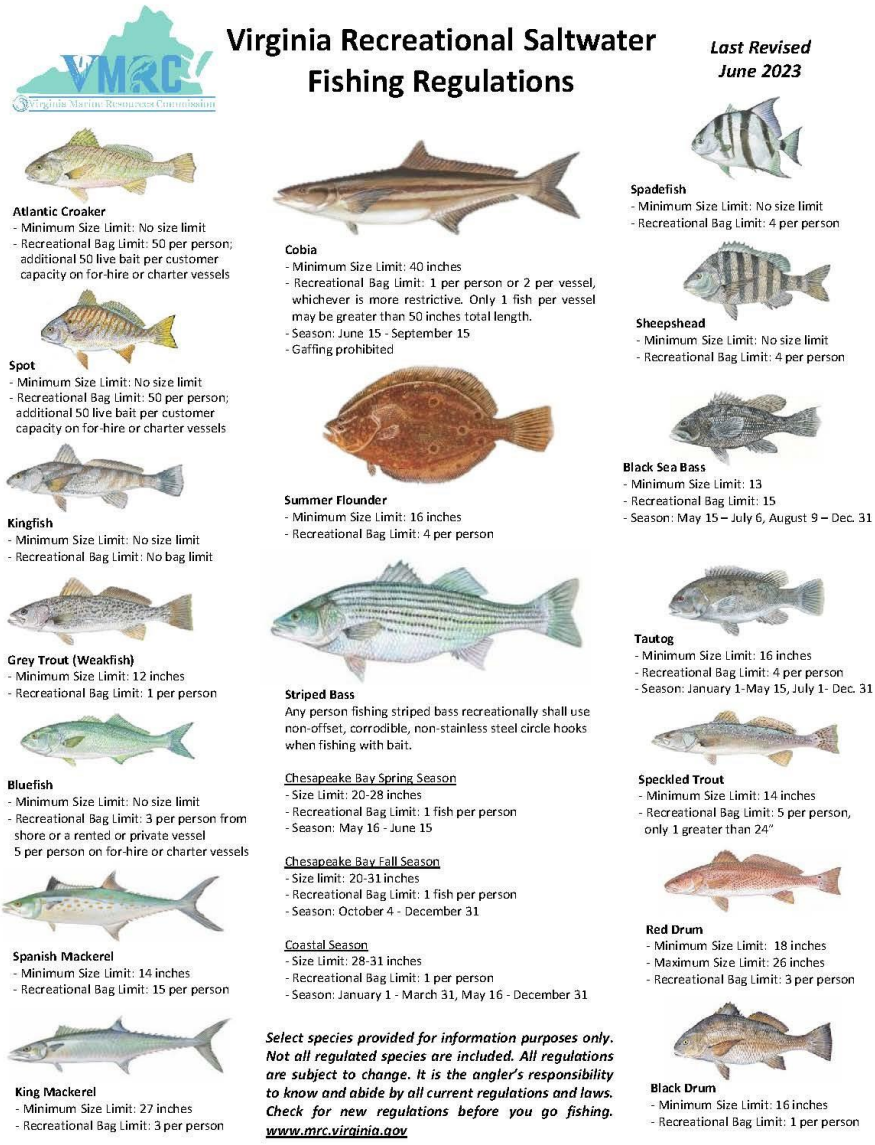
VMRC issues licenses for commercial fishing. Some fisheries can only support a limited number of fishermen. For these fisheries, there are limits on the number of active licenses. Some new licenses may be available after a waiting period; some may be purchased from an existing license holder.

For shellfish, regulations are so complicated that online training is required. Not only are there rules as to when and where you can fish, but also there are health department regulations to guard against pathogens like Vibrio. In summer months, the catch must be shaded from direct sunlight, and must be offloaded from the boats by 10 AM. These regulations are important for seafood that is eaten raw.

The strict oyster regulations are also important to sustain the wild (non-aquaculture) fishery, which has recovered from severe declines in the 1990s.

VMRC also regulates commercial and recreational crabbers: size, season, time of day, and possession limits. They also set aside sanctuary areas that cannot be fished, and "harvest areas" that can be fished at designated times only.

Fisheries Management



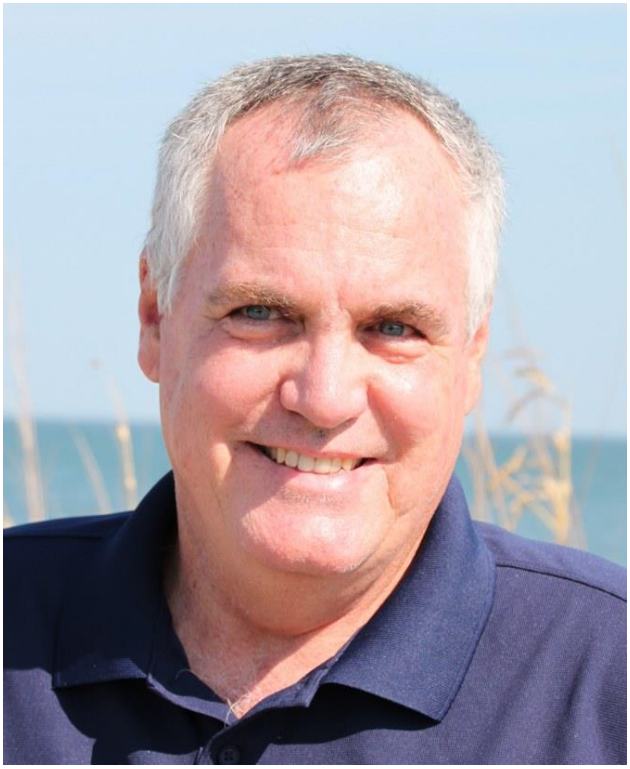
71 - https://www.facebook.com/photo/?fbid=661904162642835&set=pb.100064697708625.-2207520000

For recreational fisheries, VMRC establishes catch limits and license requirements. The Department of Wildlife Resources publishes the regulations and sells the licenses. VMRC offers an informative Angler's Guide online. VMRC also manages an annual Saltwater Fishing Tournament, and awards commemorative citations for record catches.

VMRC participates in the NMFS Marine Recreational Information Program whereby staffers interview anglers as they unload their daily catch. They record the number of fishermen, they weigh and measure the fish, and they record information about fish that were released. The individual reports are confidential.

VMRC also conducts age and growth studies, a program they took over from Old Dominion University. Each year personnel process hundreds of fish otolith and scale samples.

Pat Geer



72 - https://www.mrc.virginia.gov/FM-Chief.shtm

"Nobody (who) goes into fisheries management does it to get rich. We do it because we have a passion for fisheries, and I will say that about all my staff. I mean they all have a strong passion. We're dedicated to the job we do, and we do the very best we can." Pat Geer, 2022 (Video link)

Pat Geer was a seasoned fisheries manager when he joined VMRC in 2018.

After completing his master's degree at Old Dominion University, he joined the Fisheries group at VIMS where he served for 14 years in a variety of project management roles including the *Juvenile Fish and Blue Crab Survey.* For the next 16 years he worked at the *Georgia Department of Natural Resources* - for 8 of those years as the Chief of Marine Fisheries. He came to the VMRC in 2018 and was promoted to Chief of Fisheries Management the following year.

A long-term member of the ASMFC, Geer is also the designated state official from Virginia on the NMFS Mid Atlantic Fishery Management Council.

As fisheries chief, Geer manages commercial and recreational saltwater fisheries. Aside from collecting landings and related statistics, preparing management plans, and setting catch limits, his division issues commercial fishing licenses and bottomland leases. To regulate fishing pressure, some licenses are restricted, available only by lottery or purchase from a previous owner. Similarly, some bottomland leases are only available by purchasing from a previous lessee. Complex issues arise when license fees or lease rents are not paid on time.

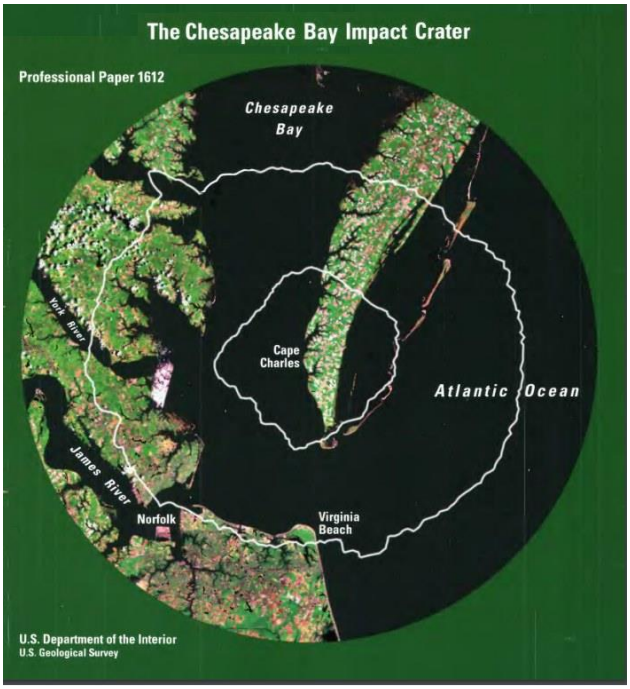
Geer is concerned about the future of some of the traditional fisheries, like crabbing and oystering. Many watermen are getting old, as are their boats and gear. Operating costs are going up and licenses can be difficult to obtain. To recruit young fishermen, there is now a *Commercial Waterman's Apprentice Program* for young people, 12 years and older.

We are fortunate to have Geer as the leader of this organization. He has just the right amount of experience, patience, expertise and moxie, and is the voice of reason at many drawn-out meetings.

Moreover, Commissioner Jamie Green, the board members, and staffers do a good job of running VMRC meetings. They carry out their duties above board, with integrity and fairness. It's a good example of democracy in action.

The Bolide

By 1970, Luis Alvarez had achieved more than most scientists could dream of – he had recently won the Nobel Prize in Physics. At that time his son, Walter, was grappling with a puzzle that had long eluded geologists, something called the K-T boundary -- a half inch layer of clay sandwiched between older sediments known to have dinosaur fossils and younger sediments without. What could have caused the dinosaurs to go extinct? Walter discussed this with his dad, who up until that point had little interest in geology.



73 - https://pubs.usgs.gov/pp/1612/report.pdf

The two approached a friend at Berkeley who had developed a new technique to analyze clay particles. They found a surprisingly high concentration of iridium, an element rare on earth but abundant in space. That led them to conclude that a meteorite impact followed by a “nuclear winter” had triggered the demise of the dinosaurs.

This did not sit well with paleontologists. Aside from not appreciating a crack by Alvarez comparing them to stamp collectors; one of the first big, fundamental debates in the 1800s was how geologic changes occurred. Was it by a series of catastrophic events, or was it slow, gradual change, like erosion? By 1900 "catastrophism” had been rejected. What the early scientists had no way of knowing was the extent of destruction of a comet or meteor strike, and that was provided by the Hubble space telescope in 1994. A series of comet fragments impacting the planet Jupiter delivered a destructive blast way more powerful than expected, equivalent to hundreds of nuclear weapons. NASA astronomer Heidi Hammel described it as a "punch in the gut", a wakeup call that the earth could be next.

So if dinosaurs died off from an impact, where was the crater? Luis Alvarez died before it was discovered – a 100 mile wide, 12 mile deep crater buried off the Yucatán Peninsula in Mexico.

In 1999, US Geological Survey scientists found "shocked quartz" in deep wells drilled in Eastern Virginia. This is a mineral found only in impact craters. To confirm this was an ancient crater, they were able to convince Texaco to share their proprietary seismic profiles, from which the crater could be detected. They were able to piece together the boundaries of a 35-million-year-old, 50-mile wide crater buried under sediments in the lower Chesapeake Bay, centered on the town of Cape Charles. It’s the largest known impact crater in the US and Canada.

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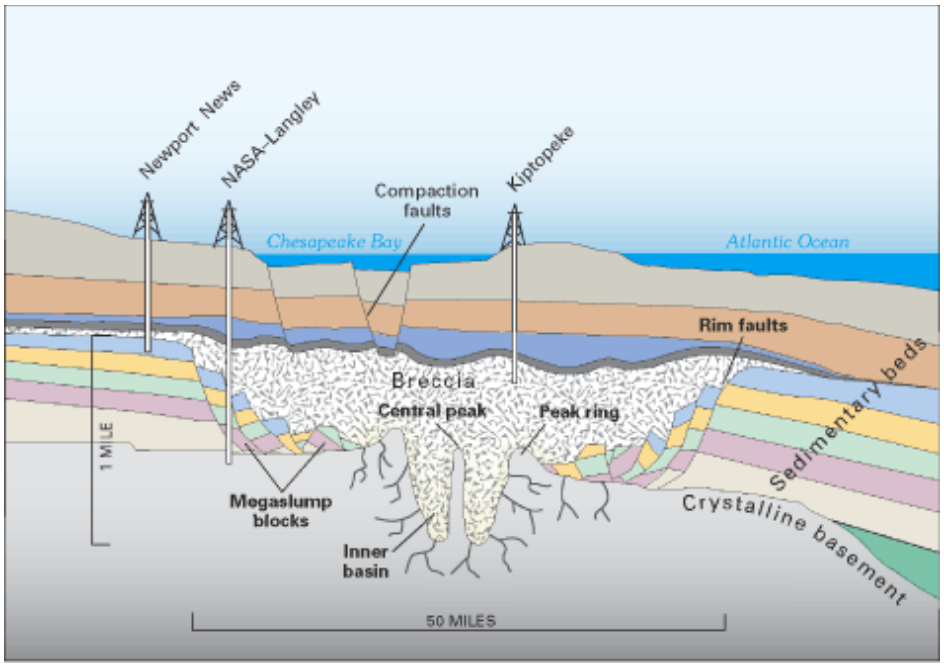

74 - Cross section of the buried impact crater. https://commons.wikimedia.org/w/index.php?curid=407254

The impact, from a comet or meteorite, disrupted aquifers and left a lasting depression that formed the mouth of the Chesapeake Bay. The discovery explained layers of hard granite and pools of salty water found in nearby deep wells. At first geologists thought some of the current land subsidence could be attributed to the crater, but later concluded that after 35 million years, too much time had passed for subsidence to still be active.

VIMS geologists had been studying the geological history of the Bay, to help understand sedimentation and erosion processes. Their research focused on the most recent 100 thousand years or so, which, in geologic time, is like yesterday. It was a time of multiple ice ages with the rise and fall of sea level, when the Virginia portion of the Eastern Shore peninsula was formed. The rising Chesapeake Bay is an example of what geologists call a "drowned river valley" – the river being the Susquehanna.

The Codfish Ball

"All the Swordfish love to play. Every clam is here today.

To shell-a-brate this holiday at the Codfish Ball.

Shark and Salmon play backgammon till the break of day.

And each Seahorse is here of course, this is the place where the plaice all play!"

From At the Codfish Ball, by Sidney Mitchell

75 - Releasing hatchery cobia: *https://www.flickr.com/photos/vims_photos/7314895970/*

By George

https://www.etsy.com/hk-en/listing/603705387/signed-print-of-my-new-yorker-cartoon