OCEAN HEALTH & HARMFUL ALGAL BLOOMS

Ocean Conservation & Ms. Foster's Elderly Advice

Aldo Leopold once said that "*conservation is a state of harmony between men and land*" - but for many of us it is the water. It is water that quenches our thirst and can even calm our souls when gazed upon from a beach chair or a casting platform on a skinny-water skiff. Substitute beer for water if you care to, but remember beer is also mainly water (~95%). Our emotions are bathed in water and our sins washed away. It also excites us when it erupts with life and a targeted leviathan runs wild at the end of a purposefully connected line. For some living entities, up to 90% of that organism's body weight is made of water - fish weigh in at about 80% water and that's an important number to understand when headed to the certified scale. Fish are practically water swimming in water. For an adult human, water content is down to about 60%, with the brain and heart at 73%, lungs 83%, skin 64%, muscles and kidneys 79%, and even our bones at approximately 31%. It is no wonder we are so connected to it – we are literally more than half water. The importance of water cannot be overstated, but it is quickly forgotten until we are about to run out of it, it is polluted beyond use, or it is raining cats and dogs and the creek is about to rise.

Water is what makes life possible on this planet. It is where we want to be and in many instances the reason we need to be there. It is the nature of water, its structural chemical design in both form and its ability to transform, that make all known forms of life possible. It is ultimately the biological answer for the need of a universal solvent. It sounds obvious, but it is water that makes it possible to chase fish recreationally along our coasts. Not just water, but it is clean water that we need to make this happen. Ask a member of Captains for Clean Water (https://captainsforcleanwater.org) who are focused on Everglades Restoration, Nutrient Pollution, and Water Policy. They have watched water quality degradation and the loss of habitat in Florida first hand, and up close, while practicing their life's passion as a Guide or Charter Captain. They have watched fish and marine mammals go belly-up and have stormed the state capital peacefully with environmental improvement demands in hand. They kept a vigilant watch from the guest balconies of the state capital in Tallahassee Florida while lawmakers cast their votes on important water management budgets. The Coastal Conservation Association is another grass roots group focused on Water Quality, Fisheries, and Habitat Restoration. Without clean water, and healthy coastal habitats, a way of life in Florida and other coastal states is threatened both for Charter Captains and the rest of us that depend on those critical resources.

The world's oceans are also one of the primary depositories of biodiversity on Earth. They represent over 90% of the habitable space on this planet we call home and contain well over 250,000 species. The oceans, and the many species that inhabit them, are crucial to a healthy functioning planet. Together they supply about half of the oxygen we breathe and absorb approximately 26% of the carbon dioxide we release into the atmosphere. Our oceans also feed over three billion people who are dependent on fish and other seafood as a vital protein source in their diet. I believe we all recognize how important water is to our survival, but I have to wonder why we continue to use the oceans and other water bodies as dumping grounds for our own waste? This question reminds me of some well-intended elderly advice given to me as a kid by my grandmother Verba Foster. She convinced my adolescent-self that a shower was much better than a scrub in the tub, and did it without a loud

demanding command, or a "*because I said so*." All she had to do was ask me this one simple question: "*Little-John, why do you want to wash your face with the same water you're sitting in*?"

Ocean Dumping

Dumping waste into water bodies is a poorly thought-out activity that has finally come home to roost for many countries. If Ms. Foster was still around, I'm certain this is exactly how she would call it. Oceanic waters and coastal environments have been used historically for the dumping of chemical and industrial wastes, radioactive waste, trash, munitions, sewage sludge, and contaminated dredged material. It was often said "dilution is the solution to pollution" and it was thought that the oceans were vast enough to dissipate any potential problems. That simple solution obviously did not work out well. To help curtail the negative impacts of ocean dumping, Congress enacted the Marine Protection, Research and Sanctuaries Act (MPRSA) in 1972. I'm old enough to remember its debut and was nerdy enough at that time to appreciate that legislation. I still do. It declares that "it is the policy of the United States to regulate the dumping of all materials which would adversely affect human health, welfare or amenities, or the marine environment, ecological systems or economic potentialities." This legal achievement has certainly helped, but our oceans continue to face major threats that include global climate change, pollution, habitat destruction, invasive species, and a dramatic decrease in ocean fish stocks. More than 80% of ocean pollution comes from land-based sources that include mercury, plastic waste, manufactured chemicals, petroleum waste, municipal discharge of treated sewage, agricultural runoff, and biological threats like harmful algal blooms (HABs). Remember HABs, it's ultimately where we are headed in this piece. Although we hear much in the recent news about problems with plastics in the world's oceans, it is nutrient pollution that remains the largest pollution problem we have in most of our coastal rivers and bays of the United States - and it is predicted to intensify. It sounds mundane, but believe me, it is not. Remember - HABs.

Nutrient Loading to Coastal Waters

If you go to the United States Environmental Protection Agency (USEPA) web site for Nutrient Pollution (https://www.epa.gov/nutrientpollution/issue) you will find an aerial photograph of a toxic cyanobacteria (i.e., blue-green algae) bloom taken by Mr. Bill Yates on the Lower St. Johns River near Jacksonville FL. Bill is a Southern photographic artist and a friend. He and his family have called the banks of this large American river/estuary home for most of their lives. This image, amongst other documentation of surface toxic algal scums, is a stark visual reminder of what plagues many of our coastal waters today. It represents a natural biological response to excessive nutrient loading to our surface waters. Algae, including the various species that produce toxins, from lakes to oceans, are a natural component of ecosystems. The production of toxins by algae is a natural part of the ecology of some algal species. However, massive HABs driven by human and agricultural waste is not a natural ecological phenomenon. The caption under Bill's photograph reads "Too much nitrogen and phosphorus in the water can have diverse and far-reaching impacts on public health, the environment, and the economy." The image, as a responsible reminder of the continuing problem, is credited to Mr. Yates, but the words are from the USEPA. As a nation, we are aware of the problem. The USEPA states that "nutrient pollution is one of our most widespread, costly, and challenging environmental problems, and is caused by excessive nitrogen and phosphorous in the air and water." I am a retired scientist who now likes to fly fish for tarpon and other big predatory fish in the Gulf of Mexico. From the tower in my boat I have to agree with both Bill's visual reminder and the government's assessment of the situation. Nutrient pollution to surface fresh and estuarine waters, and the subsequent production of toxic HABs, are some of the primary environmental threats we face considering that harmony we seek both with the land and the water.

HABs

Nutrients are also natural components of coastal waters, but they can pollute surface- and ground-water when present in excessive amounts. Nutrient pollution (i.e., Cultural Eutrophication) can lead to significant economic consequences and serious environmental and human health impacts. Excessive nutrients in water bodies can also be linked to toxic algal blooms (e.g., see Bill's photo) that impact water quality, degrade aquatic habitats, and limit dissolved oxygen in water needed by fish, invertebrates and other aquatic life. The decay of large algal blooms can cause fish kills due to organic decomposition and the loss of dissolved oxygen in water. Many algal blooms can produce bioactive compounds that are toxic to fish, wildlife, and humans if they are exposed to tainted waters during recreational activities, consume contaminated fish or shellfish, or drink water that has not been properly treated to remove toxins. Excessive nutrients can also contaminate groundwater resources used for drinking water. Excessive nitrogen (e.g., nitrate) in groundwater can also be a concern for infants. Elevated levels of nitrogen in the air, and its deposition to surface waters, also represent unique health problems for humans and impacts to aquatic and terrestrial habitats. The primary sources of excessive nitrogen and phosphorus include agriculture, stormwater, wastewater, fossil fuels, and home domestic waste that include fertilizers, yard and pet waste, and some types of soaps and detergents.

There's always an odd exception to the general rule, particularly in oligotrophic (i.e., low nutrient) marine waters, but it is often a simple narrative that describes the occurrence and impacts of HABs in surface waters: 1. Excessive nutrients from human sources enter a water body; 2. Excessive nutrients cause algae to replicate beyond normal background concentrations (i.e., they form a bloom); 3. The algae produce toxic compounds that are harmful to wildlife and other animals; 4. Algal toxins can be bioaccumulated by shellfish and other aquatic species; 5. Degradation and decay of the algae cause a loss of dissolved oxygen in the water column resulting in fish and invertebrate kills; and 5. Algal toxins in the water can cause wildlife and other animals to become sick and/or die. Moreover, the USEPA tells us that "drinking, accidentally swallowing, or swimming in water affected by a harmful algal bloom can cause serious health problems including: rashes, stomach or liver illness, respiratory problems, or neurological effects. No one likes to say it out loud, but algal toxins can also be lethal to wildlife, humans, agricultural livestock, and all too often those family pets that take a dip into a contaminated lake to retrieve a stick or a ball.

A review of HABs in the U.S. by Woods Hole Oceanographic Institute (Donald Anderson et al. in 2021) found that an analysis of the data collected over the past 30 years suggests overall there is a significant increasing trend in all HAB events. Part of the expansion is credited to increase awareness, research, and monitoring efforts. Other contributing factors include geographic species dispersion to new areas, new poisoning syndromes and impacts, and stimulatory effects of human activities such as nutrient pollution, aquaculture, and ocean warming. They warn that resource managers and public health officials are in need of new approaches to monitor and manage a growing diversity of algal species and toxins at the scale and nature of the national problem.

Algal Toxins & Human Health Effects

Algal toxins can affect human health. That is no great mystery within scientific and public health circles, or communities that have suffered major toxic algal bloom events, or had shellfish harvests curtailed following the bioaccumulation of algal toxins - but that information can be politically sensitive. Authorities never want to cause the public to panic if bad news hits their desk without a quick rebuttal or an easy solution. That's just my personal perspective and experience having lived that life as an Environmental Scientist many years ago. There may be some political merit in that approach for some, but I like the facts straight up and delivered right away. It may be better to educate and give everyone an equal opportunity to be aware of the possible risks and allow them to implement appropriate personal safeguards. For example, if the water has toxic algae in it, and the local authorities post a warning of such event, we are duly warned and can decide to keep Grandma Foster, the kids, and the dog out of the water until the coast is literally clear.

Algal toxins in recreational waters, drinking water supplies, or in contaminated seafood are opportunities for potential human exposure and poisoning syndromes. Although cyanobacteria have likely been around since near the beginning of time on Earth, they are first reported in 1878. However, the incidence, intensity, and impacts of

cyanobacteria blooms has increased in fresh water and marine ecosystems. Cyanobacteria blooms occur in water bodies that are subject to accelerated nutrient loading and may be enhanced by elevated temperatures. They represent a serious threat to natural ecosystems and human health given the toxins they produce that include hepatotoxins (e.g., microcystin, nodularin, cylindrospermopsin) and neurotoxins (e.g., anatoxin-a, saxitoxin). Cyanobacteria toxins are also known to persist as they move from freshwater to estuarine and coastal ecosystems. For example, microcystins have been found to move from rivers and lakes into coastal ecosystems, where they accumulated in bivalves, and subsequently consumed by sea otters that died due to liver necrosis. This event represents the bioaccumulation of algal toxin in bivalves, as well as crabs and snails, representing a novel new human health threat that is poorly understood in marine ecosystems. Given the increasing impacts related to toxic cyanobacteria in fresh water, and their discharge to marine systems, it is likely that the accumulation of algal toxins in marine food webs may become a more common occurrence.

Common cyanobacterial toxins found primarily in fresh water and some estuarine environments include microcystin, cylindrospermopsin, anatoxin, guanitoxin (formerly known as anatoxin-a(S), Saxitoxin, Nodularin, and Lyngbyatoxins. The USEPA and U.S. Centers for Disease Control (CDC) describe these toxins as follows:

Microcystin-LR
USEPA: Microcystins are the most widespread cyanobacterial toxins and bioaccumulate in common aquatic vertebrates and invertebrates such as fish, mussels, and zooplankton. Microcystins primarily affect the liver (i.e., hepatotoxin), but can also affect the kidney and reproductive system. There is inadequate information to asses the carcinogenic potential of microcystins in humans.
CDC: Abdominal pain, headache, sore throat, vomiting and nausea, dry cough, diarrhea, blistering around the mouth, and pneumonia

Cylindrospermopsin
USEPA: The primary toxic effects of this toxin are damage to the liver and kidney. Following EPA Guidelines for Carcinogen Risk Assessment, there is inadequate information to assess carcinogenic potential of cylindrospermopsin.
CDC: gastrointestinal symptoms, including vomiting and bloody diarrhea, as well as fever and headache.

Anatoxins
USEPA: Anatoxins bind to neuronal nicotinic acetylcholine receptors affecting the central nervous system (i.e., neurotoxins). There are multiple variants, including anatoxin-a, homoanatoxin-a, and anatoxin-a(s). There is no information available on the carcinogenicity of anatoxin-a in humans or animals or on potential carcinogenic precursor effects.
CDC: neurologic symptoms, including numbness, tingling, burning sensation, drowsiness, salivation, and speech disturbances.

Saxitoxins
USEPA:Saxitoxins are representative of a large toxin family referred to as the Paralytic Shellfish Poisoning (PSP) toxins. When toxigenic marine dinoflagellates are consumed by shellfish, toxins concentrate and are delivered to consumers of the shellfish. These toxins have also been reported in freshwater cyanobacteria.
CDC: Exposure to saxitoxin most commonly occurs following ingestion of certain fish that contain it in their tissues. Ingestion of saxitoxin can cause numbness of the oral mucosa as quickly as 30 minutes after exposure. In severe poisoning, illness typically progresses rapidly and may include gastrointestinal (nausea, vomiting) and neurological (cranial nerve dysfunction, a floating sensation, headache, muscle weakness, parasthesias and vertigo) signs and symptoms. Respiratory failure and death can occur from paralysis

Other human poisoning syndromes, following the consumption of contaminated shellfish from estuarine and marine environments, include paralytic, diarrhetic, neurotoxic, amnesic, and azaspiracid shellfish poisoning. Most are caused by biotoxins produced by a collection of algae called dinoflagellates. The exception is amnesic shellfish poisoning (i.e., domoic acid) produced predominately by diatoms. The following toxins produced by marine algae are described by the U.S. Centers for Disease Control as follows:

Azaspiracid

Azaspiracid toxins produced by *Protoperidinium* spp. that accumulate in bivalve shellfish (scallops, mussels, clams, and oysters) cause AZP. Humans are exposed by eating these contaminated shellfish. Contaminated shellfish are most often from Europe and Japan. Signs and symptoms include nausea, vomiting, diarrhea, abdominal pain, chills, headache, and fever. These usually start within 24 hours after exposure and last for days.

Brevetoxin
Brevetoxins are a group of similar neurotoxic compounds which are tasteless and odorless. Although toxicity can result from inhalational, dermal, or oral exposure, the most common route of exposure is by oral ingestion of contaminated shellfish. Illness from oral ingestion is characterized by a combination of gastrointestinal and neurologic signs and symptoms. Gastrointestinal symptoms include abdominal pain, vomiting, and diarrhea. Neurologic signs and symptoms include paresthesias, reversal of hot and cold temperature sensation, vertigo, and ataxia. Inhalational exposure may cause respiratory symptoms such as cough, dyspnea and bronchospasm (1-4). Brevetoxin can also cause illness in aquatic wildlife.

Ciguatoxin
Ciguatera fish poisoning (i.e., ciguatera) is an illness caused by eating fish that contain toxins produced by a marine microalgae called *Gambierdiscus toxicus*. People who have ciguatera may experience nausea, vomiting, and neurologic symptoms such as tingling fingers or toes. They also may find that cold things feel hot and hot things feel cold. Ciguatera has no cure. Symptoms usually go away in days or weeks but can last for years. People who have ciguatera can be treated for their symptoms.

Domoic Acid
Domoic acid produced by diatoms (*Pseudo-Nitzschia* spp.) that accumulate in bivalve shellfish (scallops, mussels, razor clams [*Siliqua patula*], oysters, Dungeness crab viscera) causes ASP. Humans are exposed by eating contaminated shellfish. Contaminated shellfish are most often from temperate waters and are mostly found in temperate waters of North America, South America, and Northern Europe. Signs and symptoms include: Gastrointestinal: nausea, vomiting, diarrhea, abdominal cramps; Cardiovascular: arrhythmias, hypotension, or hypertension; Neurological: paresthesias, enhanced hot and cold sensations, burning in the teeth or extremities, confusion, memory loss (potentially chronic amnesia), disorientation, and seizures/coma in severe cases, although rare; Respiratory: shortness of breath, excessive secretions, pulmonary edema, and possibly paralysis; and Signs and symptoms usually occur within 24 hours and vary by organ system and severity of illness.

Okadaic Acid
Okadaic acid, dinophysistoxins, or pectenotoxins produced by dinoflagellates (*Dinophysis*, *Prorocentrum lima* spp.) that accumulate in bivalve shellfish (scallops, mussels, clams, and oysters) cause DSP. Humans are exposed by eating these contaminated shellfish. Contaminated shellfish are most often from Europe and Japan and are found worldwide, but especially in Europe and Japan. Signs and symptoms include nausea, vomiting, diarrhea, abdominal pain, chills, fever, and headache. Signs and symptoms are usually mild and occur within 2 hours after exposure. Onset and severity of illness are based on the amount of toxin ingested. Signs and symptoms are self-limited and resolve in 3–4 days.

Saxitoxin
See description above.

Dinophysistoxin
Diarrhetic shellfish poisoning (DSP) is an acute gastrointestinal illness caused by consumption of bivalve mollusks that have accumulated okadaic acid (OA) or related dinophysistoxins through filter feeding. DSP toxins are produced by several species of marine dinoflagellates from the genera *Dinophysis* and *Prorocentrum* (*1*–*4*). Symptoms of DSP include nausea, abdominal pain, vomiting, diarrhea, headache, chills, and fever (*5*). Onset occurs 0.5–4 hours after consumption of contaminated food, and symptoms last up to 72 hours; treatment is supportive. To date, no sequelae have been reported, but speculation has suggested that chronic exposure may increase risk for gastrointestinal cancers.

AW Calendar Days

As a graduate student at the University of New Orleans, I spent many days swimming transect lines along the bottom of Lake Pontchartrain – not a true lake, but a semi-enclosed body of estuarine water with two narrow connections that ultimately led to the Gulf of Mexico. We were conducting research to elucidate the current state of submerged aquatic vegetation (i.e., critical habitat) in the estuary and the possible stressors leading to the slow demise of this natural resource. When we lose aquatic habitats, particularly in estuaries, we lose critical nursery grounds for many of the recreational species we like to chase with rods and reels both near- and off-shore.
I was the lucky volunteer in search of an education that was tasked with the 'field crawl'. It involved slithering along the bottom of a turbidly dark urbanized estuary, holding my breath while following a measured tape, and recording every instant the tape would intercept a particular species of underwater plant. It wasn't fun and I certainly didn't get any hint of this opportunity from watching the Jacques Cousteau films on television as a kid. Looking back over an older, wiser shoulder, that work appears somewhat dangerous today as I recall alligators, snakes, a water spout, someone shooting over my head with a rifle, and a very close call with a flying pelican. I recorded those field days on a calendar in the university laboratory with an AW (Ass Wet). Sometimes the AW included a C for cold and an FC for the obvious. However, that field work was important, because in part it coincided with a major state and federally coordinated push to turn dirt and help reduce the rate of wetland loss that was occurring in south Louisiana.

One of those projects was a proposed diversion of Mississippi River Water to the Lake Pontchartrain estuary that later would be deemed problematic. Potentially toxic cyanobacteria (blue-green algae) blooms occurred on the lake following the release of nutrient rich river water into the estuary. It wasn't just an environmental problem, but a political issue as well given the bigger restoration picture and funding. State and federal funding are tax dollars at work and that often result in controversy in one form or another. That diversion project ultimately stalled indefinitely for environmental reasons. I would later go on to serve on the first Florida Harmful Bloom Task Force and watch the politically laced catcalls of Bloom and Doom transition into multiple State of Emergency declarations by Florida Governors and the temporary closure of swimming beaches and drinking water treatment plants - all due to toxic algal blooms. As I write this piece, there has been a cyanobacterial bloom on Lake Okeechobee, a growing *Sargassum* belt in the Caribbean Sea, a recent closure of a drinking water treatment plant due to an algal toxin in finished drinking water, and a Red Tide event in the Gulf of Mexico that resulted in fish kills and economic impacts to local beachside communities. Bloom and Doom be damned – it is, and has been, a real and relevant environmental issue that unfortunately is not easily resolved.

Impacts to Florida's Waters: Nutrients & Fecal Bacteria
This gets a bit technical and is loaded with legal code references, but hang with me to the end of the paragraph where it all comes together. The Florida Department of Environmental Protection (FDEP) and the USEPA have known for many years what the primary issues are that drive the degradation of surface waters in Florida. I'm certain there have been many changes and rumblings since, but according to the USEPA, and a rule published in the Federal Register (December 6, 2010), the EPA promulgated numeric water quality data for nitrogen/phosphorus pollution to protect aquatic life in lakes, flowing waters, and springs within the State of Florida. The criteria apply to Class I and Class III waters in order to implement the State's narrative nutrient provision. Florida Administrative Code, provides that "[i]in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna." In the FDEP 2020 Integrated Water Quality Assessment for Florida: Sections 303(d) and 305 (b), and 314 Report and Listing Update, "the analyses indicate that the main impacts to Florida's ground and surface waters are from nutrients and fecal indicator bacteria (FIB). Out of all of that legal code and analysis – it is important to recognize that Florida and the EPA agree that it is nutrient loading and fecal bacteria that are the primary impacts to surface and ground waters within the state. Having those two disparate agencies agree on anything is difficult at best – but in this case they do.

Probabilistic analyses of the state's lake and flowing water resources by FDEP, using 2016 to 2018 data, indicate that nutrient enrichment is most prevalent in lakes and canals, while fecal indicator bacteria are most prevalent in streams. Data analyses of water quality trends show that nutrient loads may be decreasing in flowing surface waters, lakes were found to have slightly increasing total phosphorus (TP) (i.e, nutrient indicator), and a more pronounced increase in Chlorophyll-*a* (i.e., algae indicator). Total Maximum Daily Load's (TMDLs) must be developed for waterbody segments placed on FDEP's Verified List of Impaired Waters. TMDLs establish the maximum amount of a pollutant that a waterbody can assimilate without causing exceedances of water quality standards. As of January 10, 2020, FDEP has adopted a total of 447 TMDLs. Of these, 262 were developed for dissolved oxygen, nutrients, and/or un-ionized ammonia, 179 were developed for bacteria, and 5 were for other parameters that include iron,

lead, and turbidity. In addition, the state has adopted a statewide TMDL for mercury, based on fish consumption advisories affecting over 1,100 waterbody segments. Florida's Basin Management Action Plan (BMAP) Program is a framework for water quality restoration, containing local and state commitments to reduce pollutant loading through current and future projects and strategies.

While we wait on the physical results following the TMDL and BMAP processes, HABs continue to occur in highly visible and inconvenient places about the state. Let's start with intermittent blue-green algae blooms in Lake Okeechobee where surface toxic scums have been moved simultaneously down both the Caloosahatchee River, to the Gulf of Mexico, and the St. Lucie Canal, to the Atlantic Ocean. The ACOE releases water from Lake Okeechobee for flood protection when it reaches alarmingly high levels. Unfortunately, the released water can carry toxic cyanobacterial scums with it to each coast if present in the lake during openings. Following one of these events, a State of Emergency was declared by the Florida Governor, and beaches closed on both coasts, during the Fourth of July weekend celebrations in 2016. The algae blooms were so severe the event became known as Toxic Summer and the Guacamole Coast. Florida and the Army Corps of Engineers are now more aware of the problem and have implemented monitoring and restoration initiatives. If you go to the FDEP Bluegreen-Algae Dashboard (https://floridadep.gov/AlgalBloom,) you can report a bloom, get answers to FAQs, see a map with sampling locations, and get a count of algal bloom observations and toxin analyses results from around the state. On Sunday July 16, 2023 the 30 day+ count for algal blooms reported was 2,042. Another notable HAB event occurred during May 2021 when an algal toxin (i.e., Cylindrospermopsin) produced by a species of blue-green algae (i.e., *Cylindrospermopsis raciborskii*) was detected in raw water samples from Clear Lake and in finished drinking water at the West Palm Beach Water Treatment Plant. Earlier that month, it was reported that the city had shut down taps flowing into the main supply of drinking water after finding blue-green algae in canals connected to Lake Okeechobee.

The above examples are just a few in a long and growing list the are causing significant issues for the state and water managers. Add to that list the problems with Red Tide and subsequent fish and wildlife kills along the coasts and it's a recipe for a perfect storm. Let's not forget that Red Tide can cause human health effects as well when aerosolized into the air during rough surf conditions or if people choose to swim in it. Unfortunately, Florida is not alone in its problems with nutrient enrichment and toxic algal blooms. It is an issue in most coastal states, but also includes places like Montana, Michigan, Wisconsin, and Oklahoma to name a few. It's also a global issue that includes the occurrence of cyanobacterial toxins and marine toxins in water and seafood from many other countries and on most continents. See Table 1 for a list of Cyanobacterial and other marine algal toxins.

Everglades Restoration & Send It South

The Captains for Clean Water organization in Florida is leading an effort they call the 'Send It South Campaign'. They support Everglades Restoration and the need to send more water south from Lake Okeechobee to the Everglades and Florida Bay. Without it, the organization and others believe that water quality, aquatic habitats, and other natural resources would continue to decline due to an ecological imbalance that has occurred from those areas not receiving enough fresh water. Their stated solution is to support improved operations, such as the Lake Okeechobee System Operating Manual (LOSOM), and new Everglades restoration infrastructure, like the EAA Reservoir. In short, they are also ready to buy-in and support the expense necessary to implement environmental restoration.

Following a report to Congress in 1999, that signaled the environmental decline of south Florida, a strategy called the Comprehensive Everglades Restoration Plan (CERP) was enacted to restore portions of the Everglades, Lake Okeechobee, the Caloosahatchee River, and Florida Bay. The restoration plan was needed to correct ecosystem damage incurred over the past 50 years. It was initially planned to take 30 years and cost $7.8 billion to complete, but following its approval and signing into law in 2000, the plan has been compromised and slowed to a crawl at times by politics and funding. In September 2008 the National Research Council (NRC) signaled "scant progress" in restoration because of problems in budgeting, planning, and bureaucracy. The NRC report stated "Ongoing delay in Everglades restoration has not only postponed improvements—it has allowed ecological decline to continue." It is without doubt that such a large and uncharted restoration effort at this scale will provide plenty of room for mistakes. It encompasses over 18,000 mi^2 and includes hundreds of projects that are focused on restoration of quantity, quality,

timing, and delivery of water. Hydrological restoration, water quality improvement, habitat protection and restoration, invasive species management, water supply planning and conservation are all part of the south Florida project. Florida Everglades restoration is a huge undertaking, it will be riddled with mistakes and delays, but it has buy-in at all levels and it may ultimately be worth the effort.

Everglades restoration may be a monumental task, but it is not alone given the rapid loss of wetlands in nearby Louisiana. Over the past 84 years, annual wetland loss in Louisiana has ranged from a high of 32 mi^2 to a more moderate 10.8 mi^2. In December 2022, the USACOE announced the signing of a Record of Decision to approve permits for the Mid-Barataria Sediment Diversion project in Louisiana. It is not the most glamorous title for the largest individual restoration project in history, but it is designed to preserve local ecosystems and leverage the use of natural solutions to build on and strengthen acres of wetlands in the Barataria Basin. The diversion project will be adaptively managed to ensure effective operations of the sediment diversion to help restore and achieve an ecologically functional delta.

Harmony

Natural systems are resilient – they do not give up. Bioresilience can occur at many different scales, from changes in DNA in insects to amphibians that can repair damaged cells, and even ecosystems that can adapt to widescale changes that are often the result of human activity. In the natural world, having the ability to adapt to change can be a matter of life and death.

In September 1986, the prominent biologist E.O. Wilson introduced the term "biodiversity" into our collective vocabulary. He described how "biological diversity is being irreversibly lost through extinction caused by the destruction of natural habitats." He claimed that action was needed and there was a need to protect key species and the unintended destruction of an ecosystem that sustains us all. He also said that "we are locked into a race. We must hurry to acquire the knowledge on which a wise policy of conservation and development can be based." That's good advice. However, good policy must be followed by appropriate actions. It is one thing to identify and understand a problem through policy, but it is something very different to implement actions that feel as though you are having to move mountains. The costs to implement restoration efforts are significant and policy must be satisfied by public understanding and approval given potential rewards. There's a great example of this public buy-in, or maybe better stated their approval to buy land for habitat and water quality improvements. Following toxic algal scum events during the Toxic Summer in Florida, the local residents gathered for a photograph on the beach. It was an aerial photo of all concerned who had realized what they believed needed to be done to help resolve the problem. Using their bodies, as a kind of ink upon the sand, they spelled out the following on the beach to make their approval of Everglades Restoration apparent to all: BUY THE LAND!!. The land they referred to was in use by agricultural interests within the project area, but desperately needed for restoration purposes. Those words, made of living human anatomy, was a message to the world that it was time to use their tax dollars to correct the problem - and they approved. They signaled their approval to the heavens because it had a direct impact on their lives and it was the harmony that they longed would return.