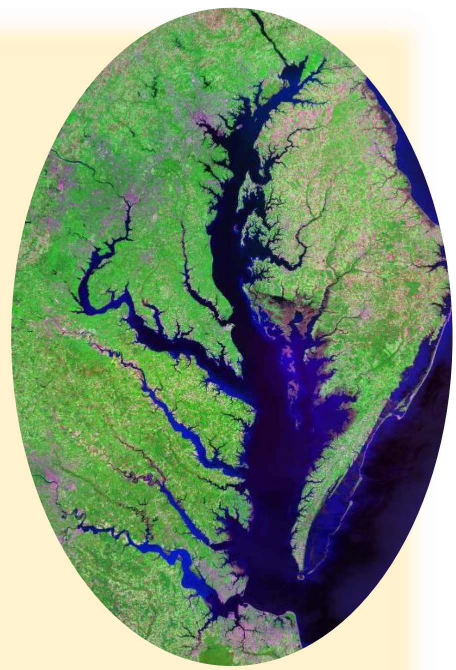
MODULE 4

Air & The Chesapeake Bay

Dead Zones, Deposition, and Nitrogen Pollution

Module Overview



The Chesapeake Bay is a natural treasure: it provides innumerable resources and ecosystem services to the living things in its watershed, especially humans. Yet the Bay is also a fragile ecosystem that has been inundated with pollution of all kinds. One of the oft-overlooked sources of pollution to the Bay is air pollution, which contributes a significant amount of nutrient pollution to its waters. In this Meaningful Watershed Educational Experience (MWEE) based module, students start by investigating a fish kill in the Bay, tracing the cause of this phenomenon back to algae blooms and nutrient pollution. Then they continue to work backwards to understand the sources of this nutrient pollution. Along the way they learn about watersheds and airsheds, and collect data on atmospheric deposition. Using this information, they build a model of pollution to the Bay, which they draw upon to create and implement an action plan to combat pollution. As a culmination of their investigation, students present their model and findings to local stakeholders.

Anchor phenomenon: A large area of dead fish floating in the Chesapeake Bay.

Pacing

- 12 activities (1 optional) including action project and presentation
- Approximately 12-13 class periods (plus 1 optional) plus time for action project and presentation (4+ class periods)

When to Teach This Module

Finding the right place within a science scope and sequence to investigate air pollution with students can be tricky. Below you will find some information about the module that can help you decide where this it might fit into your own plans for student leaning:

- **Connection to Ecosystems**: Air pollution can have a tremendous effect on the health of ecoystems, including the Chesapeake Bay. With activities focused on algae blooms, dissoved oxygen, and modeling cause-effect relationships in the Chesapeake Bay, this module would fit well as part of an ecoystem unit, especially in connection with food webs and energy transfers.

- **Connection to Human Impacts on Earth Systems**: Because this module focuses specifically on how *pollution* affects the Chesapeake Bay, it would work well as an addition to a unit on human impacts on earth systems by exploring the mechanism of how human activities affect ecosystems.

- **Meaningful Watershed Educational Experience (MWEE):** This module fulfills a component of the Cheseapeake Bay Agreement that all students in 6-8th grades experience a Meaningful Watershed Eductational Experience. To learn more about MWEEs, see the Teacher Background Information section below.

Timing Notes

The timing for this module can be tricky due to a few specific activities. Keep the following things in mind when planning out the schedule for the module:

- Activity 3 (Algae in a Bottle) is an experiment that runs for two weeks. There are a few different options for when to run the experiment that are noted in the activity itself. The activity also works well during a time when students will be in and out of normal class (ex. during holidays, testing, etc.), as long as they have intermittent times to check in with their results.

- Activity 11 (Measuring Wet Deposition of Nitrogen) requires rainwater. You can adjust when to lead this activity based on when it rains, or you can collect and freeze rainwater. See the activity itself for details.

- Activity 12 (Doing our Part) is a action project that requires some advance planning and additional time and resources to complete. Make sure to plan well enough ahead, and to provide enough class time to complete the project.

- Activity 13 (Presenting the Chesapeake Bay) is based on student presentations that will require some advance planning time and class time to complete, especially if you want students to present for an authentic audience.

Standards Overview

Middle School NGSS standards alignment:

Performance Expectations

Focus PE:

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

Science & Engineering Practices

Focus SEP: Constructing explanations and designing solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
- Construct an explanation using models or representations.
- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.

Focus SEP: Developing & Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and/or use a model to predict and/or describe phenomena.
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

Background SEP: Planning and carrying out investigations

Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

Disciplinary Core Ideas

Focus DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Background DCI: ESS3.C: Human Impacts on Earth Systems

Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

Crosscutting Concepts

Focus CCC: Cause and Effect: Mechanism and Prediction – Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Focus CCC: Systems and System Models – A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

NGSS 5th Grade Standards alignment

Performance Expectations:

Focus PE: 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. [Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [Assessment Boundary: Assessment is limited to the interactions of two systems at a time.]

Background PE: 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Science & Engineering Practices

Focus SEP: Constructing explanations and designing solutions

The goal of *science* is the construction of theories that provide explanatory accounts of the material world.
The goal of *engineering* design is a systematic approach to solving engineering problems that is based on scientific knowledge and models of the material world.

Focus SEP: Developing & Using Models

Science often involves the construction and use of models and simulations to help develop explanations about natural phenomena.
Engineering makes use of models and simulations to analyze systems to identify flaws that might occur or to test possible solutions to a new problem.

Background SEP: Planning and carrying out investigations

A major practice of *scientists* is planning and carrying out systematic scientific investigations that require identifying variables and clarifying what counts as data.
Engineering investigations are conducted to gain data essential for specifying criteria or parameters and to test proposed designs.

Disciplinary Core Ideas

Focus DCI: ESS3.C: Human Impacts on Earth Systems

Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

Background DCI: ESS2.A: Earth Materials and Systems

Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean
supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)

Crosscutting Concepts

Focus CCC: Cause and Effect: Mechanism and Prediction – Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain new contexts.

Background CCC: Systems and System Models – Defining the system under study – specifying its boundaries and making explicit a model of that system – provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Virginia Standards of Learning (SOLs) alignment

Science & Engineering Practices	
5.1 (b)	Planning and carrying out investigations. The student will… • collaboratively plan and conduct investigations to produce data • take metric measurements using appropriate tools
5.1 (d)	Constructing and critiquing conclusions and explanations. The student will… • construct and/or support arguments with evidence, data, and/or a model
5.1 (e)	Developing and using models. The student will… • develop models using an analogy, example, or abstract representation to describe a scientific principle or design solution
6.1 (b)	Planning and carrying out investigations. The student will… • independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate, and include the safe use of chemicals and equipment • take metric measurements using appropriate tools
6.1 (d)	Constructing and critiquing conclusions and explanations. The student will… • construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)
6.1 (e)	Developing and using models. The student will… • use, develop, and revise models to predict and explain phenomena
Content Standards	
6th Grade 6.8	The student will investigate and understand that land and water have roles in watershed systems. Key ideas include: a) a watershed is composed of the land that drains into a body of water; c) the Chesapeake Bay is an estuary that has many important functions; d) natural processes, human activities, and biotic and abiotic factors influence the health of a watershed system.
Life Science LS.8	The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time. Key ideas include: b) changes in the environment may increase or decrease population size; c) large-scale changes such as eutrophication, climate changes, and catastrophic disturbances affect ecosystems.
Life Science LS.9	The student will investigate and understand that relationships exist between ecosystem dynamics and human activity. Key ideas include: b) changes in habitat can disturb populations; c) variations in biotic and abiotic factors can change ecosystems.
Biology BIO.8	The student will investigate and understand that there are dynamic equilibria within populations, communities, and ecosystems. Key ideas include: d) natural events and human activities influence local and global ecosystems and may affect the flora and fauna of Virginia.
Earth Science ES.11	The student will investigate and understand that the atmosphere is a complex, dynamic system and is subject to long-and short-term variations. Key ideas include d) human actions, including economic and policy decisions, affect the atmosphere.

Common Core State Standards alignment

Literacy Standards	
RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
WHST.6-8.1	Write arguments focused on discipline-specific content.
WHST.6-8.1B	Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research.
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
Math Standards	
6.SP.B.5	Summarize numerical data sets in relation to their context

5E Module Flow

Activity 1 (Engage): The Dead Zone
Timing: 30 minutes
Purpose: Introducing the anchor phenomenon
- ✓ Students will make observations of the anchor phenomenon
- ✓ Students will ask questions to better define the anchor phenomenon
- ✓ Students will develop preliminary hypotheses about what causes dead zones

Activity 6 (Explore/Explain): Rain, Pollution, and Watersheds
Timing: 45 minutes
Purpose: Building background knowledge about watersheds, and how they transfer pollution to the Chesapeake Bay
- ✓ Students will be able to define watershed, geosphere, and hydrosphere, and explain how they connect
- ✓ Students will be able to describe how land-based nutrient pollution gets into the Chesapeake Bay
- ✓ Students will know that some pollution gets into the Bay when it washes off the land

Module Materials

Activity 1 (Engage): The Dead Zone

- ❒ Handouts: Phenomenon Observations, Hypotheses, and Questions
- ❒ Materials needed: “Clues” board with sentence strip about the dead fish
- ❒ Optional materials: none

Activity 2 (Explore): Introducing the Chesapeake Bay

- ❒ Handouts: I see & hear, I think, I wonder: The Chesapeake Bay (with teacher guide), About the Chesapeake Bay reading
- ❒ Materials needed: Projector & speakers, Chart paper (or other way to display document)
- ❒ Optional materials: none

Activity 3 (Explore/Explain): Algae in a Bottle

- ❒ Handouts: Algae in a Bottle experiment procedure, Data collection sheet, Analysis & summary sheet
- ❒ Materials needed: Materials for Algae in a Jar experiment (see below), Dissolved oxygen test kit, Additional glassware (ex test tubes) so multiple students can test at the same time, For clues board: “Lots of algae in the Bay before fish died”, Algae in a Bottle Teacher Guide
- ❒ Optional materials: none

Activity 4 (Explain): Algae: The Silent Killer

- ❒ Handouts: Reading: Algae & Dissolved Oxygen (double-entry journal)
- ❒ Materials needed: Computer & projector, Word wall words: dissolved oxygen, algae, algae bloom, decomposer
- ❒ Optional materials: none

Activity 5 (Explain): Where is the Pollution Coming From?

- ❒ Handouts: Where is the Pollution Coming From?
- ❒ Materials needed: Computer & projector
- ❒ Optional materials: none

Activity 6 (Explore/Explain): Rain, Pollution, and Watersheds

- ❒ Handouts: Watershed Notes sheet
- ❒ Materials needed: Plain paper (enough for all students, Spray bottle(s) with water (one or more), Water-soluble markers (see below for more details) – enough for all students, Paper towels for cleanup, Crumpled Paper Watershed teacher guide, Word wall words: watershed, geosphere, hydrosphere, Computer & projector
- ❒ Optional materials: none

Activity 7 (Explore): How do Gases Get Into Liquids? (optional)

- ❒ Handouts: Disappearing salt
- ❒ Materials needed: Salt, Cups of water, Stirrers, Bottle of carbonated beverage (ex. soda), Word wall words: dissolve
- ❒ Optional materials: none

Activity 8 (Explain): Air Pollution in the Chesapeake Bay

- ❒ Handouts: Welcome to the Airshed
- ❒ Materials needed: Word wall words: airshed, dry deposition, wet deposition; Blank paper (enough for all students); Spray bottle(s) with water (one or more); Chocolate pudding mix in small cups; Cotton balls; Water in small cups
- ❒ Optional materials: none

Activity 9 (Explain): Modeling Pollution in the Chesapeake Bay

- ❒ Handouts: none
- ❒ Materials needed: Computer & projector, Pre-printed/written parts of the Chesapeake Bay pollution model (these can be on paper or on sentence strips) including lots of arrows, Extra paper and markers to add components to the model
- ❒ Optional materials: none

Activity 10 (Explain): What's Going on in our Airshed?

- ❒ Handouts: Nitrogen Air Pollution
- ❒ Materials needed: Computer & projector, Animated nitrate maps (downloaded from http://nadp.slh.wisc.edu/maplib/ani/no3_conc_ani.pdf), Animated ammonium maps (downloaded from http://nadp.slh.wisc.edu/maplib/ani/nh4_conc_ani.pdf), Sentence strips for Chesapeake Bay pollution model: nitrate, ammonium, power plants, agriculture, cars, trucks, etc.
- ❒ Optional materials: none

Activity 11 (Explore): Measuring Wet Deposition of Nitrogen

- ❒ Handouts: Nitrogen Deposition in Rainwater
- ❒ Materials needed: Nitrate and ammonia test kits (see note on materials), Additional glassware (ex. small beakers) to allow for multiple groups to test at the same time if necessary, Rainwater collectors (ex. jars), Distilled water (to use as a control), Safety & cleanup materials (safety goggles, paper towels, etc.), Tips for Measuring Nitrogen Deposition in Rainwater (teacher guide)
- ❒ Optional materials: none

Activity 12 (Elaborate): Doing Our Part

- ❒ Handouts: none
- ❒ Materials needed: Vary depending upon project chosen
- ❒ Optional materials: none

Activity 13 (Evaluate): Presenting the Chesapeake Bay

- ❒ Handouts: Student Presentation Rubric
- ❒ Materials needed: Student Presentation Planning Guide
- ❒ Optional materials: vary depending upon presentation type(s) chosen

Cost considerations

Unlike most of the other On the Air 2020 activities, this module contains a few different activities that have more significant costs. Algae in A Bottle (Activity 3) can be done with several recyclable materials, but it also requires fertilizer and a dissolved oxygen test kit. Measuring Wet Deposition of Nitrogen (Activity 11) requires at least one test kit for nitrate and/or ammonium. In addition, the action project (Activity 12) may require additional materials depending on what you and your students choose to do.

Below are a few suggestions to help manage some of these costs if they are a concern:

- **Create a Donors Choose page with the required materials**. Everything that is needed for the module can be purchased online, so creating a way for donors to provide the materials can be very straightforward.

- **Ask for donations from local stores**. The dissolved oxygen test kit (Activity 3) is sold at most pet stores and aquarium shops. The fertilizer (Activity 3) can be found at many garden stores or nurseries (just make sure to get the proper fertilizers). Materials for action projects (Activity 12) can often be found at local retailers.

- **Reach out to local environmental organizations**. There are many local branches of groups such as The Sierra Club and the Audubon Society who may be willing to provide funding for small projects such as this.

- **Apply for a mini-grant.** In the past, the Chesapeake Bay Trust (CBT) has offered small grants (up to $5,000) for schools to conduct MWEEs. Other organizations offer similar grants. The CBT MWEE grant page is here: https://cbtrust.org/grants/environmental-education-mini/ and Bay Baypack's funding page which lists lots of similar funding opportunities is here: http://baybackpack.com/funding

What is a MWEE?

This module is designed as a MWEE or Meaningful Watershed Educational Experience, as defined by the Chesapeake Bay Watershed Agreement. Students in Maryland, DC, and Virginia are expected to complete at least one MWEE during their middle school education.

If you are new to MWEEs, the information below will help you understand why certain elements of the module are written as they are. There are lots of MWEE resources available online which you may find helpful to access during the module, especially towards the end during the student presentation and action project activities. Links to a few of these resources are below.

The following information comes from the Chesapeake Bay Program's "An Educator's Guide to the Meaningful Watershed Educational Experience"

What is a MWEE?
MWEEs are learner-centered experiences that focus on investigations into local environmental issues that lead to informed action and civic engagement. Both teachers and students play important roles in the MWEE by working together in partnership. Teachers present unbiased information and assist students with their research and exploration, while students go through the inquiry process and ultimately take action to address the issue. Four essential elements and four supporting practices build upon each other to create this comprehensive learning experience for students

What are the parts of a MWEE?
The MWEE consists of four essential elements that describe "what students do." These elements promote a learner-centered approach that emphasizes the role of the student in actively constructing meaning from the learning experiences. Throughout the process students have time for reflection, allowing them to refocus on how what they are learning and experiencing affects the driving question of their investigations. The four elements are Issue Definition, Outdoor Field Experiences, Synthesis & Conclusions, and Stewardship & Civic Action.

To learn more about MWEEs, check out these resources:

- An Educator's Guide to the Meaningful Watershed Educational Experience: https://www.cbf.org/document-library/education/teachers-guide-to-meaningful-watershed-education-experience.pdf. This is the definitive guide to MWEEs.

- Bay Backpack: http://baybackpack.com/. This website has innumerable resources for learning more about MWEEs, as well as ideas for creating action projects, teaching resources centered on the Chesapeake Bay, field studies, and funding ideas

- The National Oceanic and Atmospheric Administration (NOAA) supports MWEEs through grants and training experiences. Check out their MWEE website at: https://www.noaa.gov/education/explainers/noaa-meaningful-watershed-educational-experience

- The Chesapeake Bay Foundation is one the largest supporters of MWEEs in the area through training and field experiences. Check out their MWEE page, which includes links for trainings, field experiences, and resources here: https://www.cbf.org/join-us/education-program/mwee/

Teacher Background Information

Nutrient Pollution

Nutrient pollution is one of America's most widespread, costly and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water.

Too much nitrogen and phosphorus in the water can have diverse and far-reaching impacts on public health, the environment and the economy. Photo credit: Bill Yates

Nitrogen and phosphorus are nutrients that are natural parts of aquatic ecosystems. Nitrogen is also the most abundant element in the air we breathe. Nitrogen and phosphorus support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water.

But when too much nitrogen and phosphorus enter the environment - usually from a wide range of human activities - the air and water can become polluted. Nutrient pollution has impacted many streams, rivers, lakes, bays and coastal waters for the past several decades, resulting in serious environmental and human health issues, and impacting the economy.

Excess nitrogen in the air can impair our ability to breathe, limit visibility and alter plant growth.

Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. Large growths of algae are called algal blooms and they can severely reduce or eliminate oxygen in the water, leading to illnesses in fish and the death of large numbers of fish. Some algal blooms are harmful to humans because they produce elevated toxins and bacterial growth that can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water.

Nutrient pollution in ground water - which millions of people in the United States use as their drinking water source - can be harmful, even at low levels. Infants are vulnerable to a nitrogen-based compound called nitrates in drinking water. Excess nitrogen in the atmosphere can produce pollutants such as ammonia and ozone, which can impair our ability to breathe, limit visibility and alter plant growth. When excess nitrogen comes back to earth from the atmosphere, it can harm the health of forests, soils and waterways.

Source: Nutrient Pollution, US EPA, https://www.epa.gov/nutrientpollution

Nitrogen Dioxide Basics

What is NO_2 and how does it get in the air?

Nitrogen Dioxide (NO_2) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NO_x). Other nitrogen oxides include nitrous acid and nitric acid. NO_2 is used as the indicator for the larger group of nitrogen oxides.
NO_2 primarily gets in the air from the burning of fuel. NO_2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment.

Effects of NO_2

Health effects

Breathing air with a high concentration of NO_2 can irritate airways in the human respiratory system. Such exposures over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing), hospital admissions and visits to emergency rooms. Longer exposures to elevated concentrations of NO_2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. People with asthma, as well as children and the elderly are generally at greater risk for the health effects of NO_2.

NO_2 along with other NO_x reacts with other chemicals in the air to form both particulate matter and ozone. Both of these are also harmful when inhaled due to effects on the respiratory system.

Environmental effects

NO_2 and other NO_x interact with water, oxygen and other chemicals in the atmosphere to form acid rain. Acid rain harms sensitive ecosystems such as lakes and forests.

The nitrate particles that result from NO_x make the air hazy and difficult to see though. This affects the many national parks that we visit for the view.

NO_x in the atmosphere contributes to nutrient pollution in coastal waters.

Source: Basic Information About NO_2, US EPA, https://www.epa.gov/no2-pollution/basic-information-about-no2#What%20is%20NO2

Additional Information

Nutrient Pollution

- The EPA website on nutrient pollution has excellent information about sources and solutions, effects, action projects at home and in the community, and policy information. Access the main nutrient pollution site at: https://www.epa.gov/nutrientpollution for links to all this information

Air Pollution and the Chesapeake Bay

- The Chesapeake Bay Foundation's Interactive Slideshow "The Unseen Traveler" has excellent information on how air pollution from specific sources affects the Chesapeake Bay. Access the slideshow at: https://www.cbf.org/issues/air-pollution/the-unseen-traveler.html

Dead Zones, Dissolved Oxygen, and Nutrient Pollution

- Chesapeake Bay Dead Zones (animated) https://www.youtube.com/watch?v=zJ4I0fDq3MI

NOx in the News

- The Volkswagen diesel emissions scandal allowed cars to emit more than 40 times the legal limit of nitrogen dioxide into the air. Learn more about the scandal from BBC new here: https://www.bbc.com/news/business-34324772

Air Quality Champion in Our Commuity

Photograph courtesy of Chesapeake Quarterly, a magazine from Maryland Sea Grant. Credit: Michael W. Fincham.

Name: Dr. Lewis Linker
Title: Modeling Coordinator and Team Leader for Science & Analysis
Organization: U.S. Environmental Protection Agency, Chesapeake Bay Program Office

How does your work relate to air quality?
I lead a team that creates models and simulations of the Chesapeake's airshed, watershed, and estuary so decision-makers can make a plan for how to clean up the Chesapeake Bay watershed and tidal waters. The plan is called a Watershed Implementation Plan (WIP) and it's a road map of all the actions we all need to do, from New York to Virginia to get healthy and safe air and waters in the Chesapeake region. Without computer simulations of the airshed and watershed we wouldn't know what a restored Chesapeake looks like or what would be the best way to get there. By problem solving, and communicating, we help decision-makers to deal with challenges like population growth and climate change in the Chesapeake region.

What motivates you to come to work every day?
Restoring the Chesapeake Watershed and Bay is a really, really big deal to me. When I was growing up, the Rouge and Cuyahoga rivers were catching on fire, the Potomac River next to the Nation's Capital stank in the summer heat, and the Chesapeake seemed to be in a death spiral. Now it's all coming back, very slowly, bit-by-bit, but coming back, and it's very satisfying that my Modeling Team has played our very small part in the Chesapeake recovery. Also, I know that my Modeling Team depends on me to do my job and to support them every day, and I depend on them too, so that's a big motivator - being there to support a team with an important mission.

What education and career path did you pursue to have the position that you have today?
My early career path was all over the place! At first, I thought I would go into medicine and I completed a biology and chemistry undergraduate degree at Towson State. Then I became very interested in marine biochemistry research. In the end, I decided that I really wanted to do something that had more promise of immediate, concrete, and significant results that I could point to, so I switched to environmental engineering and I have made that my career ever since. It now sounds all very thought out and methodical, but at the time it really was more of a hot mess! Ultimately though, my broad diversity of technical and scientific training prepared me well for a modeling background. I guess it shows that you never know how it's going to finally turn out. But if you are fortunate enough to really go after learning something that interests you, and if you can find a way for that learning to make a contribution to the general public, then things will turn out alright.

What is your workspace like?
Our Modeling Team works with computer simulations of air and water quality, so really our office can be anywhere! We could work on the far side of the moon as long as we had a good internet connection (and good snacks, of course!). Our Modeling Team runs our experiments and tests just like other scientists, but they are all run in a virtual computer space. In fact, our Airshed Model is simulated in North Carolina, the Watershed Model is done in Annapolis, Maryland, and our Estuary Model was run by in Vicksburg, Mississippi. So our Modeling Team is really all over the place - but not yet on the far side of the moon!

What accomplishment are you most proud of?
When my two boys were very young, they knew my work was to clean up the Bay. So naturally they assumed that once I got to work, I put on an orange jump suit, picked up a bag, and started cleaning up the Chesapeake Bay. Even though my Modeling Team is very accomplished, and have received many awards, I'm most satisfied in being able to join with my Team and with the all of the citizens in the watershed to "pick up a bag" in order to clean up the Chesapeake's airshed and watershed.

Glossary

acid rain – rainfall made sufficiently acidic by air pollution that it causes environmental harm, typically to forests and lakes. The main cause of acid rain is combustion of fossil fuels, which produces waste gases that contain sulfur and nitrogen oxides, which combine with water vapor to form acids. Other forms of acid precipitation are also possible.

airshed – an area of land that shares a common air flow. The Chesapeake Bay nitrogen airshed is the area of land where most of the nitrogen air pollution to the Chesapeake Bay comes from

algae (singular alga) – simple, nonflowering, and typically aquatic organisms of a large group that includes the seaweeds and many single-celled forms. Algae contain chlorophyll but lack true stems, roots, leaves, and vascular tissue

algae bloom - a rapid increase in the population of algae in an aquatic system

ammonium $(NH_4)^+$ – an ion that is related to ammonia (NH_3). Both ammonium and ammonia are common air pollutants that are produced from agriculture and industry.

brackish – slightly salty, like the mixture of river water and seawater in estuaries

dead zone – a low-oxygen, or hypoxic, area of water that can be deadly to aquatic life

decomposer – an organism that breaks down dead or decaying organisms

deposition – the process by which substances are "deposited" on the land or in the water. In the case of air pollution, deposition refers to air pollution from the atmosphere is deposited on land or in the water

dissolve – (as a substance) to become incorporated into another substance so as to form a solution. Most commonly, when a solid or gas is dissolved into a liquid

dissolved oxygen – oxygen molecules that are dissolved in and which is available to living aquatic organisms.

dry deposition – the process by which air pollution is deposited directly from the atmosphere, either as a gas or a solid

ecosystem – a biological community of interacting organisms and their physical environment

estuary – a partially enclosed, coastal water body where freshwater from rivers and streams mixes with salt water from the ocean. Estuaries, and their surrounding lands, are places of transition from land to sea.

eutrophication – an excessive amount of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and may cause the death of animal life from lack of oxygen.

fish kill – the sudden and unexpected death of a number of fish or other aquatic animals such as crabs or prawns over a short period of time and often within a particular area in the wild.

food web – a model showing how energy and matter are transferred in an ecosystem by indicating what organisms eat or are decomposed by other organisms

geosphere – the solid components of Earth in comparison to the hydrosphere, atmosphere, and biosphere.

hydrosphere – all the waters on or below the earth's surface, such as aquifers, lakes, and seas. Sometimes hydrosphere is also used to refer to water vapor in the form of clouds.

menhaden – a common fish found in the Chesapeake Bay. Also known as mossbunker and bunker

MWEE (Meaningful Watershed Educational Experience) - an investigative or experimental project that engages students in thinking critically about the Chesapeake Bay watershed

nitrate $(NO_3)^-$ – an ion that is a common component of fertilizers. Nitrate often forms when nitrogen dioxide (an air pollutant) reacts with other pollutants and dissolves in water vapor. Nitrate is common component of nutrient pollution.

nitrogen – an element found abundantly in the Earth's atmosphere. When combined with oxygen, nitrogen forms nitrogen oxides (NO_x), a common form of air pollution and a contributor to nutrient pollution

nitrogen dioxide (NO_2) – a highly reactive gas that is a common air pollutant. Nitrogen dioxide primarily comes from burning fossil fuels in power plants, cars, trucks, and other vehicles.

nutrient pollution – the process where too many nutrients, mainly nitrogen and phosphorus, are added to bodies of water and can act like fertilizer, causing excessive growth of algae.

phosphate $(PO_4)^{3-}$ – an ion that is a common component of fertilizers. Phosphate is a common component of nutrient pollution.

phosphorus – a metallic element that commonly combines with oxygen to form the phosphate ion. In this form, phosphorus is a common contributor to nutrient pollution

rain gauge – a device for collecting and measuring the amount of rain which falls

runoff – water flowing across the ground's surface, which often carries things with it

sediment – sand or stones that are carried into a body of water (or onto land) from wind, water, or ice

watershed – an area of land that drains into a specific body of water

wet deposition – the process by which air pollution is deposited by mixing with precipitation