Teacher: Grae Carter	Date: August 7th, 2025
Class Type: ICT + GenEd	Grade: 7th!
Time Frame: ~ 45min - a unit.	

Lesson Overview

Students will explore the connections between New York City's history, its harbor ecology, and the role of technology in environmental restoration. The lesson begins with a look at the historical importance of oysters in New York Harbor, including Indigenous stewardship, immigrant labor, and environmental injustice. Students will then learn about the biology and ecological function of oysters, including how they clean water and build reef habitats.

This lesson allows students to understand not only the biological importance of these organisms, but also how science and technology can be used to address issues of access, equity, and environmental justice. The use of AI-assisted labeling reflects an emerging area of ecological research that students can take part in directly.

As a marine science teacher with a background at the NY Harbor School, I bring personal investment to this work. I am collaborating with researcher Mehmet Kerem Turkcan to train a model that will recognize species in harbor videos. This project reflects my commitment to integrating research, restoration, and culturally relevant teaching. I want students to see themselves as part of the harbor's future and as contributors to meaningful science.

After building background knowledge, students will be introduced to a beginner-friendly explanation of artificial intelligence, focused on how scientists and educators use tools like CVAT (Computer Vision Annotation Tool) to train computers to recognize patterns in images. Students will use a simplified version of the CVAT interface to identify and count oysters in photo trays from the classroom tank system. This hands-on activity will help students apply species identification skills and understand how AI can be used to solve real-world problems, including restoring the health of the harbor.

The lesson blends marine biology, environmental justice, and introductory AI concepts to help students see themselves as scientists, technologists, and stewards of New York City's waterways.

Objectives/Aims:

- Use computer vision tools to explore environmental problem-solving
- Identify key species in NYC waterways including oysters, tunicates, algae, and signs of human interaction
- Understand the ecological role of marine species in habitat restoration
- Connect scientific research to local history, labor, and environmental justice in New York City's waterfront communities

New York State Science Standards (Middle School – Life Science & Technology):

- MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and

nonliving parts of an ecosystem.
- MST Standard 5: Technology – Students will use technological systems and tools to access, process, and communicate information to address problems.

Next Generation Science Standards (NGSS – Middle School):
- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution.
- MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process.
- MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Common Core State Standards (Grades 6–8):
- CCSS.ELA-LITERACY.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.
- CCSS.ELA-LITERACY.WHST.6-8.2: Write informative/explanatory texts, including the narration of scientific procedures or technical processes.
- CCSS.MATH.PRACTICE.MP4: Model with mathematics.

New York State Intermediate-Level Science Content Standards (Grades 5–8):
- Standard 1: Scientific Inquiry – Students will use mathematical analysis, scientific inquiry, and engineering design as appropriate to pose questions, seek answers, and develop solutions.
- Standard 4: The Living Environment – Students will understand and apply scientific concepts related to the interdependence of living organisms, biodiversity, and ecosystems.
- Standard 7: Interdisciplinary Problem Solving – Students will apply knowledge and thinking skills from science, mathematics, technology, and other areas to address real-world issues and make informed decisions.

Key Vocabulary and Concepts:
- ★ **Oyster** – A filter-feeding bivalve mollusk that helps clean the water and creates reefs that support marine life.
- ★ **Tunicate** – A sea-dwelling invertebrate that filters water and attaches to surfaces like rocks, docks, or oyster cages.
- ★ **Algae** – Simple aquatic organisms that photosynthesize; they can be helpful in ecosystems or harmful when they grow out of control.
- ★ **Oyster spat** – A young oyster that has just attached to a surface where it will grow into an adult.
- ★ **Oyster reef** – A structure made up of living oysters and their shells that provides habitat, improves water quality, and protects shorelines.
- ★ **Filter feeder** – An organism that feeds by straining small particles, such as plankton or detritus, from the water.
- ★ **Bioindicator** – A species whose health or presence helps scientists understand the condition of an environment.
- ★ **Species identification** – Recognizing and naming organisms based on their physical traits or behavior.
- ★ **Native species** – A plant or animal that naturally belongs in a specific ecosystem or region.
- ★ **Invasive species** – A species introduced to a new area that causes harm to native ecosystems or outcompetes native organisms.

- ★ **Benthic zone** – The bottom layer of a body of water, including the sediment where many marine organisms live.
- ★ **Brackish water** – A mix of freshwater and saltwater, often found in estuaries and harbors.
- ★ **Estuary** – A body of water where freshwater from rivers meets and mixes with saltwater from the ocean.
- ★ **Hudson River** – A major river in New York State that flows south into the Atlantic Ocean.
- ★ **New York Harbor** – The natural harbor at the mouth of the Hudson River; once home to billions of oysters and now the focus of restoration.
- ★ **Urban ecology** – The study of how organisms interact with each other and their environment in urban settings like cities and harbors.
- ★ **Runoff** – Water that flows over land after rain or snow, often carrying trash, oil, or pollution into nearby waterways.
- ★ **Stormwater** – Rainwater that does not soak into the ground and flows into drains, rivers, or the ocean, sometimes picking up pollution.
- ★ **Water quality monitoring** – Testing water to measure its cleanliness, chemical levels, temperature, or bacteria content.
- ★ **Marine debris** – Human-made trash found in the ocean or large bodies of water, such as plastic bags, bottles, or fishing gear.
- ★ **Image annotation** – Labeling parts of a digital image to identify what is present, such as animals or objects.
- ★ **AI model (Artificial Intelligence model)** – A computer program that learns from data and can recognize patterns, like identifying species in a photo.
- ★ **CVAT (Computer Vision Annotation Tool)** – A digital tool used to label images and videos so that AI models can learn how to identify different objects.
- ★ **Computer vision** – A field of computer science focused on teaching computers how to "see" and understand images and video.
- ★ **Citizen science** – Research done by regular people, including students, who collect or analyze scientific data as part of larger projects.
- ★ **Community science** – A form of citizen science that focuses on projects that benefit and involve local communities.
- ★ **Environmental justice** – The principle that all people, regardless of race or income, deserve equal access to a clean and healthy environment.
- ★ **Environmental stewardship** – Taking care of the environment through responsible decisions, actions, and care for future generations.
- ★ **Restoration** – The process of repairing or rebuilding a damaged ecosystem.
- ★ **Ecosystem restoration** – A larger, planned effort to bring back the health and function of an entire ecosystem, such as New York Harbor.
- ★ **Biodiversity hotspot** – A place with a large number of different species that is also at risk of habitat loss or environmental damage.
- ★ **Shell recycling** – Collecting used oyster shells from restaurants or homes and using them to help build new oyster reefs.
- ★ **Harbor Estuary Program** – A government-supported initiative to restore, protect, and monitor the NY–NJ Harbor Estuary system, including its wildlife and water quality.

Materials & Resources:

- Phones or computers with internet access to use the CVAT interface
- Custom marine organism dataset, featuring images of oysters, tunicates, algae, and hands
- Easy-to-use species identification key (simplified version of the Billion Oyster Project ID key)
- Teacher-created slide presentation introducing key species and visual ID features
- Film: *Take Back the Harbor* (2018), available on classroom device or via student phones for select segments
- Many posters, class creations, etc.

Safety Practices:

- All students will be required to wear gloves when handling live oysters or other marine organisms, whether working at Billion Oyster Project field sites or in the classroom.
- In the classroom, oysters are housed in water tanks and a modified "filing cabinet" system. Students must follow all teacher instructions when interacting with these systems.
- Gloves must be worn during any direct contact with the tank water, oyster shells, or filtration equipment.
- Students will wash their hands before and after wearing gloves and avoid touching their faces during activities.
- Observation is prioritized over handling. Students will use tools or pointing when possible instead of direct contact.
- Sharp shell edges and tank components will be identified in advance. Students will be reminded not to reach blindly into tanks or drawers.
- Phones used for identification or CVAT work should be kept dry and used with clean hands away from water stations.

Preparation for Teaching Diverse Students:

- Students will receive scaffolded examples of each organism
- Visuals and multilingual labels will be used where possible
- Groupings will be mixed and culturally responsive examples will be used
- Content will be linked to local neighborhoods and student identities

Cultural context:

- This lesson connects scientific skills to NYC history and racial equity. Students will learn how working-class, immigrant, and Black New Yorkers historically contributed to oyster harvesting and harbor work and how restoration efforts today aim to reconnect marginalized communities to marine ecosystems. The use of AI modeling allows students to see how technology and justice overlap in environmental science.

Prior Knowledge:

- Students have learned about NYC waterways and local species through BOP materials
- Students are exploring the importance of oysters as filter feeders and reef-builders

Prior Lesson:	**Followup Lesson:**
● Lab Safety	● BOP Project symposium

• Students practiced species ID using printed ID keys and discussed oyster reef functions	• Students will complete their own annotations and participate in a CVAT simulation to track oyster appearances in the sample sites

Lesson Overview/ Abstract:

- This lesson introduces students to AI-based tools (like CVAT) that are being used in partnership with scientists (such as Mehmet Kerem Turkcan and local NYC teachers) to identify key marine organisms like oysters, tunicates, algae, and human hands in underwater videos. Students will observe labeled examples, learn identification features, and reflect on the ways this work helps restore the harbor and empowers community engagement in marine science.

Time	Activity	Materials	Rationale
5 min	**Do Now:** Name three things that make oysters important to the NYC Harbor. Write them on the whiteboard.	Paper, pens; prior-knowledge prompt on board	Activates prior knowledge of oyster ecology, water filtration, shoreline protection, and cultural history
10 min	**Mini-Lecture & Timeline Walkthrough:** Overview of oyster history in NYC (Dutch regulation → CS3 era). Show vertical timeline poster.	Projector or printed timeline; slides with key dates; pointer https://www.welikia.org/?utm_campaign=44819_0425%204.22.2025%20Earth%20Month&utm_medium=email&utm_source=dotdigital&dm_i=7T8J,YKZ,2HCYWQ,4D2Y,1 https://www.si.edu/newsdesk/releases/indigenous-peoples-have-shucked-billions-oysters-around-world-sustainably	Situates students in the arc from 1658 regulations, 1927 harvest ban, to modern restoration; connects past exclusions to present equity and infrastructure efforts
10 min	**CS3 Smart Streets Connection:** Demonstrate how urban sensors (from CS3) monitor water level, salinity, and flow at oyster restoration sites. Discuss how smart-street data informs reef placement.	Laptops/tablets with CS3 dashboard; sample sensor data; Internet access (or offline CSV)	Shows real-world technology integration—how CS3 data guides oyster reef design, improves stormwater management, and strengthens coastal resilience

15 min	**Hands-On Oyster ID & Counting with CVAT:** In pairs, students upload sample Harbor images to CVAT, use Billion Oyster Project keys to tag oyster clusters, count tagged oysters.	Laptops with CVAT login; Billion Oyster ID keys handout; sample image dataset; gloves (if viewing live samples)	Engages students in authentic citizen-science: applying infrastructure monitoring tools to marine biology, reinforcing species ID, data collection skills, and project stewardship
5 min	**Group Debrief & Reflection:** How did smart-streets data and oyster infrastructure work together? What did you learn about equity and environmental justice in NYC oyster history?	Whiteboard or chart paper; markers	Encourages metacognition: linking history, technology, and restoration; highlights social justice dimensions and students' role as future stewards

Lesson Assessments
Follow-Up Assignment: ● Students will annotate 20 images, labeling key ecological features and noting any AI-generated insights, then write a 3- 4-sentence reflection on how AI and scientific methods can partner to address local environmental challenges.
Additional Accommodations for Students: ●
Methods of Assessment: ● How did oyster labor connect to racism, immigration, and class in NYC's past? ● How have Asian American and Indigenous communities been included - or excluded - from environmental work in NYC? ● Who is the Hudson for today - and who still doesn't have access?

Nansemond Indian Nation: Restoring Connections Through Oysters

In the Engineering and Science Education sessions, we talked a lot about making science real and relevant, especially when it connects with local communities. That idea stuck with me. I built this lesson so my students could use actual engineering tools like CVAT to study something happening right outside our classroom: oysters in New York Harbor.

Instead of just learning about AI or marine life in theory, students are doing hands-on annotation and contributing to a dataset that supports reef restoration. We explored systems thinking in the sessions, and I wanted students to see how water quality, biodiversity, technology, and history are all connected.

I also thought carefully about cultural relevance. I included NYC's labor history, stories of Black and Indigenous

oystering communities, and current restoration projects. This gives students a way to see themselves in science and understand the impact of their work.

Oh My AI! *Using Artificial Intelligence to Study Marine Life*
Artificial Intelligence (AI) allows us to teach computers to "see" and identify objects in photographs. In this project, we're using a tool called CVAT (Computer Vision Annotation Tool) to help recognize species found in New York Harbor, including oysters, tunicates, algae, and more.
How CVAT Works:

1. Students draw boxes or outlines around organisms in real images.
2. Each outlined object is labeled—for example, "oyster" or "tunicate."
3. The labeled data trains a computer model to recognize these organisms in new images.

Why It's Important:

- AI speeds up the process of monitoring oyster reefs and marine ecosystems.
- It helps researchers and students gather large amounts of ecological data.
- It combines science, technology, and environmental justice in real-world applications.

Your Role:
By participating in this process, you are contributing to local conservation science and helping develop tools that support habitat restoration in New York City's waterways.

Oysters in New York City
Pre-1600s: Indigenous Stewardship
The Lenape people, the original stewards of the NYC area, sustainably harvested oysters and other shellfish for thousands of years. Oysters were a staple food and deeply embedded in Lenape spiritual, cultural, and ecological knowledge (Kurlansky, 2006). Shell middens (heaps of discarded shells) along the Hudson and East Rivers show centuries of harvest and reverence for marine life. Lenapehoking - the ancestral homeland - included what is now Manhattan, Brooklyn, Queens, Staten Island, and parts of New Jersey.

1609–1700s: Colonization and Exploitation
1609: Henry Hudson arrives; European colonists begin large-scale oyster harvesting and disrupt Indigenous lifeways. Dutch and British colonists begin exporting oysters commercially and regulating beds (the first Dutch colonial oyster laws date to 1658). Enslaved Africans were used as laborers in the waterfront economy. In New Amsterdam, over 40% of households owned enslaved people in the 1600s (NPS, 2020). Enslaved workers were forced to haul oysters, build piers, and labor in fish markets, often alongside poor white and Indigenous laborers.

1700s–1800s: Immigrant Labor and Working-Class Food
Oysters become a democratic staple - sold by street vendors to both elites and the working poor (Kurlansky, 2006). Irish, Italian, and Afro-Caribbean immigrants worked in oyster beds, piers, and fish markets across Red Hook, Mott Haven, Greenpoint, and Lower Manhattan. Free Black oystermen fished the Bronx River, Harlem River, and Jamaica Bay. In places like Tappan (now Rockland County), Black families combined farming and oystering traditions (NPS, 2020). These communities faced growing restrictions, including racist laws denying dock permits and licenses, even when they held generational ecological knowledge.

Asian American Interactions with Oysters
Although Asian Americans - particularly Chinese immigrants - arrived in NYC in growing numbers beginning in the late 1800s, discriminatory policies such as the Chinese Exclusion Act of 1882 limited their access to traditional

waterfront labor (Takaki, 1993).
Still, Chinese Americans and other Asian immigrants contributed significantly through adjacent work:

- Seafood markets in Chinatown sold oysters and shellfish as part of Asian culinary traditions (Wu, 2014).
- Asian New Yorkers helped shape demand for oysters as part of cross-cultural seafood cuisines.
- In other coastal U.S. cities (like San Francisco and Seattle), Asian immigrants were heavily involved in aquaculture and shellfish farming - labor and knowledge that connects historically to modern oyster restoration efforts.
- Today, Asian American students and scientists are part of the Billion Oyster Project and harbor ecology programs, representing a growing legacy of environmental stewardship.

Mid-1800s–Early 1900s: Overharvesting and Public Health Crises
By the late 1800s, New York Harbor was one of the most productive oyster ecosystems on Earth, with billions of oysters naturally filtering water (Billion Oyster Project, 2024). Floating river baths were installed along the Hudson and East Rivers, and New Yorkers swam and bathed in the same waters (Gotham Center, 2018). Mass immigration from Europe and Asia fueled demand for cheap oyster labor; poor housing and sanitation issues rose near waterfronts.

1880s–1920s: Multiple typhoid and cholera outbreaks were traced to raw oysters harvested from contaminated water.
1927: New York City banned commercial oyster harvesting due to rising public health concerns - without directly addressing pollution (Kurlansky, 2006).

1970s: Pollution, Decline, and Activism
By the 1970s, the Hudson River was declared "biologically dead" in several areas due to sewage, PCBs, and toxic waste.
1966: The Hudson Riverkeeper organization was founded - the first citizen-led environmental watchdog group in the U.S. Riverkeeper held corporations and government agencies accountable, successfully sued polluters, and helped enforce the Clean Water Act (Riverkeeper, 2024). Their work laid the foundation for today's oyster reef recovery and modern environmental justice movements.

1980s–2000s: Recovery and Regulation
1986: The New York State Department of Environmental Conservation (NYSDEC) designated most NYC waterways as "uncertified for shellfishing", which is still the legal classification today (NYSDEC, 1986). Water quality slowly improved due to enforcement of the Clean Water Act, new treatment plants, and citizen activism.
Indigenous-led environmental advocacy began to gain recognition again, advocating for land acknowledgments, rematriation, and cultural inclusion in restoration efforts.

2010s–Today: Restoration and Justice
2010: The Billion Oyster Project (BOP) was launched with a goal of restoring 1 billion oysters to New York Harbor by 2035. Harbor School students, many from working-class, immigrant, and BIPOC communities, grow oysters in tanks, monitor reef sites, and study urban ecology hands-on (Billion Oyster Project, 2024).
2015–present: The NYC Department of Environmental Protection (DEP) invests in green infrastructure, expanding CSO (Combined Sewer Overflow) control systems.

Indigenous Initiatives Today

- The American Indian Community House (AICH) and the Lenape Center work on Indigenous environmental sovereignty, including water, food, and land restoration projects.
- In 2022, the Lenape Center partnered with NYU and city parks agencies to support rematriation and cultural education.
- BOP and other harbor educators now integrate Lenape knowledge and history into oyster restoration programs (Lenape Center, 2023; AICH, 2023).
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Laws and Milestones

Year	Law	Description	Citation
1658	Dutch Oyster Regulation	The colonial government of New Amsterdam issued North America's first known oyster regulation to control overharvesting. While framed as environmental management, these early laws excluded Indigenous communities from resources they had sustainably used for generations.	Kurlansky, 2006
1790	Naturalization Act of 1790	Limited citizenship to "free white persons." This excluded enslaved Africans, Indigenous people, and Asian immigrants from naturalization, restricting their legal rights, land ownership, and ability to work in regulated trades like oystering.	Ngai, 2004
1700s - 1800s	Black and Afro-Caribbean Oyster Labor	Enslaved and later free Black workers labored in NYC's oyster economy, harvesting, shucking, and selling shellfish, especially along the Harlem River, Jamaica Bay, and Bronx River. Despite their expertise, Black oystermen were increasingly pushed out by racist zoning laws and denied licenses and waterfront access.	NPS, 2020; Kurlansky, 2006
1800s - 1900s	Latino and Afro-Caribbean Waterfront Labor	As migration from Puerto Rico, the Dominican Republic, and the West Indies increased, Afro-Caribbean and Latinx workers found work in fish markets, canneries, and harbor cleanups. However, language barriers and racial discrimination often excluded them from ownership or leadership roles in marine industries.	Peña, 2015
1882	Chinese Exclusion Act	Banned Chinese laborers and denied Chinese immigrants the right to naturalization, barring them from many jobs, including regulated waterfront labor. While some worked in seafood markets and kitchens, they were shut out of licensed shellfish work.	Takaki, 1993
1899	Rivers and Harbors Act	First federal regulation of dumping into navigable waters. Though limited in scope, it established the federal government's right to protect waterways — a foundation for future environmental justice movements.	EPA, 2024
1924	Immigration Act of 1924	Enforced racial quotas favoring Northern and Western Europeans. Asian, African, and Latin American immigrants were largely excluded	Ngai, 2004

		from legal immigration and naturalization, limiting access to fishing licenses and trade unions.	
1927	NYC Oyster Ban	After repeated typhoid outbreaks linked to contaminated oysters, the city banned all commercial harvesting in local waters. This destroyed many small oystering businesses, disproportionately harming Black, Brown, and immigrant workers who relied on local marine industries.	Kurlansky, 2006
1943	Magnuson Act	Repealed the Chinese Exclusion Act, allowing Chinese immigrants to naturalize and enter labor markets legally — including marine and environmental jobs. Symbolic, but opened doors for later Asian American participation in environmental work.	Lee, 2015
1965	Immigration and Nationality Act (Hart-Celler Act)	Ended racial quota systems, allowing increased immigration from Asia, Latin America, and Africa. Opened opportunities for a more racially diverse environmental workforce in NYC and nationwide.	Tichenor, 2002
1966	Hudson Riverkeeper Founded	A coalition of mostly white commercial and recreational fishers founded the first waterkeeper group. Though initially limited in diversity, Riverkeeper's work sparked a citizen-led environmental justice model that inspired later BIPOC participation.	Riverkeeper, 2024
1972	Clean Water Act	Landmark law requiring sewage and industrial pollution controls. Enabled water restoration in NYC and laid the legal groundwork for modern oyster reef restoration and environmental equity.	EPA, 2024
1986	NYS Shellfish Classification	NYSDEC classified NYC waterways as "uncertified for shellfishing." These restrictions persist today and have historically impacted marginalized communities who relied on shoreline subsistence fishing and shellfish gathering.	NYSDEC, 2023
2010	Billion Oyster Project Begins	A citywide initiative to restore 1 billion oysters to NY Harbor by 2035. The project partners with public schools, including many serving Black, Brown, and immigrant youth — reconnecting students to ecology, research, and maritime careers.	Billion Oyster Project, 2024
2020s	Indigenous-Led Partnerships	The Lenape Center and American Indian Community House partner with public agencies and schools to bring Indigenous land/water stewardship into environmental education and restoration projects.	Lenape Center, 2023; AICH, 2023

Sources

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