CAPE COD REGIONAL STEM NETWORK

From Wreck to Museum
Whydah Pirate Museum

https://www.discoverpirates.com/

Science [Physical Science] Grade 8

This unit connects the history of Cape Cod's maritime past, the wreck of the Whydah and the real-world application of chemistry to recover and preserve the artifacts found off the coast of Wellfleet. Students will identify examples of chemical and physical changes, the composition of artifacts and sea-water. They will analyze their interactions and predict how the artifacts will react after long exposure to sea-water and explore various methods to stop these chemical reactions and preserve the artifacts. At the end of the unit students will create a basic recovery and conservation plan for artifacts recovered from concretions.

This material is based upon work supported by the National Science Foundation under Grant No. 1347610. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Please provide us some background information on the unit development. In order to help others who are interested in this topic understand a bit more about what you created, we will write a short introduction to each unit and provide some images, in addition to posting the completed units on the Cape Cod Regional STEM Network website (www.capecodstemnetwork.org). Please help us by answering the questions below after you have completed your unit.

1. Who helped to create this unit?

Names	School (Grade/course taught)
Beth Knittle	Barnstable Public Schools
Marie Zahn	Whydah Pirate Museum

2. What were some sources of inspiration for this unit?

The Whydah Museum is a world class museum with working lab where visitors can see the recovery and conservation process at work.

3. In your own words, what are you hoping students learn—big picture—through this unit?

Chemistry has real world applications outside the theory of the classroom and image of a scientist in a lab with test tubes and beakers. Chemistry plays a role in preserving history and creating art.

4. What might students find exciting in this unit?

Students will find the connection between Cape Cod history, pirates, treasure hunting, and science exciting.

5. What science standards or real-world content did you strive to emphasize?

Grade 8 Physical Science and the problem-solving process of real world science applications

6. How would you say that this unit "matters" to the STEM community? Or to our community on Cape Cod? Or to the larger community?

Real science, world history and a first-class museum are not things we need to look elsewhere. We have them right here in our own backyard on Cape Cod.

7. What's the most important lesson you learned as you created this?

Not particularly a lesson learned by emphasized how much science, the process, is really a creative endeavor. It based on knowledge and skills yet there is still a bit of trial and error, practical experience and multiple approaches to solve problems. Science is in many ways an art.

8. **Anything else you would like fellow teachers or others to know about this unit?**

Incorporating a field trip to the museum to identify artifacts and see recovery and conservation in action would be extremely beneficial. The field trip fits best between lesson 6 and 7. If a visit is impossible, the unit can be completed using the included resources.

Table of Contents

	Page
Title Page and Overview	1
Background Information	2
Stage 1 Desired Results	4
Stage 2 Evidence	5
Stage 3 Learning Plan	5
Lesson 1: Ship Wrecks on Cape Cod	8
Lesson 2: Characteristics of Ocean Water	10
Lesson 3: A Pirates Life Reacts with the Sea	12
Lesson 4: Concretions and the Work of the Archaeologist	15
Lesson 5: The Work of the Archaeologist	17
Lesson 6: Pulling it all Together	19
Information to Support Teacher Learning	21
List of Unit Resources	
Lesson 1	22
Lesson 2	30
Lesson 3	33
Lesson 4	41
Lesson 5	44
Lesson 6	46

Stage 1 Desired Results

MA STE Standards

8.MS-PS1-1. Develop a model to describe that (a) atoms combine in a multitude of ways to produce pure substances which make up all of the living and nonliving things that we encounter, (b) atoms form molecules and compounds that range in size from two to thousands of atoms, and (c) mixtures are composed of different proportions of pure substances.

8.MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

8.MS-PS1-5. Use a model to explain that atoms are rearranged during a chemical reaction to form new substances with new properties. Explain that the atoms present in the reactants are all present in the products and thus the total number of atoms is conserved.

ELA

W 8.1 2. Write informative/explanatory texts (e.g., essays, oral reports, biographical feature articles) to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

ESSENTIAL QUESTIONS

EQ 1. How do various materials react after a long exposure to sea-water?

EQ 2. How are historical artifacts preserved for future generations?

UNDERSTANDINGS

Student will understand ...

U1. The composition of seawater and it physical and chemical properties.

U2. The relations between atoms, elements, compounds and mixtures.

U3. Various elements and compounds have different physical and chemical properties particularly their reactivity with salt water.

U4. The difference between chemical and physical change.

U5. The role science plays in discovering and preserving history.

TRANSFER

Students will be able to independently use their learning to...

T1 Predict the reactivity of chemicals

T2 Research and apply information to predict the behavior of materials in sea-water

T3. Communicate understanding of concepts in writing and through discussion.

	Cross-Curricular Connections History Grade 8 **Topic 1. The philosophical foundations of the United States political system** Supporting Question: *What were the roots of the ideas that influenced the development of the United States political system*

Stage 2 Evidence

Formative Assessment Ideas:

Individual/groups notes (Google Doc)
Compiled class notes (Google Doc)
Shipwreck Summary Sheets
Seawater and Freshwater Investigation
Composition of Sea-water Chart
Whydah Artifact Data Sheets

Summative Assessment Ideas:

Students will be writing an article on the recovery of artifacts from the Whydah and the work of the archaeologist.

Stage 3 Learning Plan

Summary of Key Learning Events and Instruction

- Recommendation for teachers to read the overview from Methods of conserving archeological material from underwater sites by Donny Hamilton http://nautarch.tamu.edu/CRL/conservationmanual/ConservationManual.pdf This will lay the foundation for guiding students through these lessons.
- Recommend using a shared google doc to collect class data. Student can complete their work in groups or pairs and then add their data to update doc(s) throughout the unit to get the larger picture.

Introductory Lesson	**Constructing Lesson**	**Practice Lesson**	**Assessment Lesson**
Lesson that introduces the content. More teacher directed	Lessons that engage students in building and linking together understanding. Guided/collaborative. Student/teacher or partners/small group	Lessons or activities that students can complete relatively independently	Formative: Check-ins along the way to see if students "get it" Summative: Students showing what they know, when you feel they are ready

Stage 3 Learning Plan

Summary of Key Learning Events and Instruction

Lesson Name	**Type** (Introductory, Constructing, Practice, and Assessment)	**Content Addressed**	**Standards Included** (by number)
1. Shipwrecks on Cape Cod	Introductory	Brief history of shipwrecks on Cape cod, what a shipwreck could tell us about history. How do we learn from these time capsules?	
2. Characteristics of Ocean Water	Constructing	Compare fresh and salt water. Identify the components of sea-water and identify if element, compound or mixture.	8MS-PS1-1
3. A Pirate's Life Reacts with the Sea	Constructing	Review properties of ocean water. Create a list of objects that pirates may have used on the ship. What are these objects made from? Element, compound, mixture? How will they react with sea-water.	8MS-PS1-1 8MS-PS1-2 8MS-PS1-5
4. Concretions	Practicing	What are concretions? How are concretions are formed, from physical and chemical changes?	8MS-PS1-1 8MS-PS1-2 8MS-PS1-5
5. The Work of the Archaeologist	Constructing	Process stabilization of the chemical reaction, extraction methods and preservation.	8MS-PS1-1 8MS-PS1-2 8MS-PS1-5

6. Pulling it all together	Practice/Assessment	Based on previous lessons, collected data and information students create conservation plans for possible objects found in shipwrecks, describing what happens to an artifact from wreck to museum.	ELA W 8.1.2

Lesson 1: Shipwrecks on Cape Cod

Overview of the Lesson: What will students be doing?
This lesson is designed to help students connect the rich maritime history of Cape Cod and its many shipwrecks to history and science. These wrecks are glimpses to the past. How do we learn from these time capsules?
Time (minutes): 50 mins

Standard(s): What standards (s) will be the focus of the lesson?

-
-

Essential Question(s): What essential questions will be addressed in this lesson?

- What can shipwrecks tell us about the past?

Science Objectives

-

Language Objectives and/or Targeted Academic Language

- Archeologists
- Marine

Anticipated Student Pre-conceptions/Misconceptions (optional)

Instructional Materials/Resources/Tools

- National Parks Service Shipwrecks https://www.nps.gov/caco/learn/historyculture/shipwrecks.htm
- The Mystery of Cape and Islands ship wrecks. https://www.weneedavacation.com/Cape-Cod/Articles/Shipwrecks/
- Sparrow-Hawks remains carefully studied http://plymouth.wickedlocal.com/news/20180115/sparrow-hawks-remains-carefully-studied-for-age-place-of-origin
- Map of Cape Cod shipwrecks (Optional)
- Shipwreck Summary Sheets

Assessment: How will you know that the students got it?
Completed shipwreck summary sheets
Discussion and teacher observation

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. **Obtaining, evaluating, and communicating information**

Lesson Overview:

- Students will learn about the many ship wrecks on Cape Cod, what object may be left behind and what they might tell us about the past.

Opening/Engagement: 15 mins

1. Have students read articles about shipwrecks around Cape Cod, and note or underline ideas or words that caught their attention.
2. Ask students to summarize what they read. Discuss readings bring out key ideas; many shipwrecks, over centuries, glimpse into different time periods

During the Lesson: 25 min

3. Assign small groups information about different wrecks (shipwreck summary sheets). Ask students to brain storm what these shipwrecks might teach us about the past. If computers are available student could read about their ship online.
4. Groups complete shipwreck summary sheet
5. Students might need some guiding questions if they appear stuck.
    - What are some objects the people on board need for everyday use?
    - What were the ships made from?
    - Think about the time period the ship was active?
    - Were they carrying cargo?
    - What was the ship's purpose?
    - Where was the ship coming from, going to?
    - Why do some object survive to be discovered in the future and some do not?

Lesson Closing: 10 min

6. Have groups report back about their ship, what objects might be left behind and what they think the ships could tell us.
7. Ask them students to think about how we can gather and collect that information.
8. Note that we are going to explore how chemistry and science help us learn from these wrecks

Instructional Tips/Strategies/Suggestions for Teacher: What other ideas would you like to highlight? What grouping strategies are important?

What are adjustments for struggling learners, enrichment, or for students who are English Learners?

Lesson 2: Ocean Water

Overview of the Lesson: What will students be doing? All the shipwrecks we looked at in the previous lesson are all surround in ocean water. In this lesson we will explore the nature of ocean water and how might impact the artifacts left behind. **Time (minutes):** 50 mins
Standard(s): What standards (s) will be the focus of the lesson? 8.MS-PS1-1. Develop a model to describe that (a) atoms combine in a multitude of ways to produce pure substances which make up all of the living and nonliving things that we encounter, (b) atoms form molecules and compounds that range in size from two to thousands of atoms, and (c) mixtures are composed of different proportions of pure substances.
Essential Question(s): What essential questions will be addressed in this lesson? • What are the key differences between sea-water and fresh water?
Science Objectives • Measure some of the properties of fresh and sea-water.
Language Objectives and/or Targeted Academic Language • Salt • Density • Reactivity
Anticipated Student Pre-conceptions/Misconceptions (optional)
Instructional Materials/Resources/Tools • Sea-Water and Fresh Water Investigation (located in resources) • Fresh water (tap will do) • Sea-water • Steel wool • Jars/containers • Vegetable oil

- Depression slides
- Hot plate
- Microscope or dissecting scope
- Blue and green food coloring

Assessment: How will you know that the students got it?
Complete Sea and Fresh Water Investigation
Discussion and Observation

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. Developing and using models
3. **Planning and carrying out investigations**
4. **Analyzing and interpreting data**
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. **Obtaining, evaluating, and communicating information**

Notes about Science and Engineering Practices included:

Lesson Overview:

- Student will perform 3 investigations to explore the differences in salt and fresh water. This should be done in groups. Depending on class situation each group can complete all 3 investigations or each group can be assigned one investigation and results shared with the class.

Opening/Engagement: 10 mins

1. All objects from a shipwreck are exposed to salt water. What impact might this have in preserving or destroying these objects?
2. Let's investigate the properties of Sea (Salt water)

During the Lesson:30 mins

3. Have students complete the Sea-water, Fresh water Investigation.

Lesson Closing 10 mins

4. Review the finding of the investigation by asking different groups to report on their results
5. Ask students to predict what the results of the reactivity investigation.

Instructional Tips/Strategies/Suggestions for Teacher: What other ideas would you like to highlight? What grouping strategies are important?

What are adjustments for struggling learners, enrichment, or for students who are English Learners? A video alternative to demonstrate the rusting experiment and also explains the chemistry of rusting. https://www.youtube.com/watch?v=jQoE_9x37mQ

Lesson 3: A Pirate's Life Reacts with the Sea

Overview of the Lesson: What will students be doing? In this lesson students will be taking a closer look at what gets left behind in a shipwreck (artifacts) and what is in sea-water to predict what will happen to the artifacts after 300 years in the ocean. **Time (minutes):50 mins**
Standard(s): What standards (s) will be the focus of the lesson? 8.MS-PS1-1. Develop a model to describe that (a) atoms combine in a multitude of ways to produce pure substances which make up all of the living and nonliving things that we encounter, (b) atoms form molecules and compounds that range in size from two to thousands of atoms, and (c) mixtures are composed of different proportions of pure substances. 8.MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. 8.MS-PS1-5. Use a model to explain that atoms are rearranged during a chemical reaction to form new substances with new properties. Explain that the atoms present in the reactants are all present in the products and thus the total number of atoms is conserved.
Essential Question(s): What essential questions will be addressed in this lesson? • How will artifacts react after long term exposure to sea-water?
Science Objectives • Given the composition of an artifact determining if it is element, compound or mixture • Research the reactivity of the material. • Predict the reaction of the material/artifact after long exposure in salt water

Language Objectives and/or Targeted Academic Language

- Density
- Salinity
- Corrosion
- Oxidation
- Compound
- Mixture
- Element
- Atom

- Ions
- Salt
- Gases
- Alloy
- Oxidation

Instructional Materials/Resources/Tools

- Reading: Ocean Water and Metals
- Whydah Artifact Tool Kit for Educators
- Whydah Artifact class data sheet (and Teacher resource supplement)
- Computer access to research material reactivity
  Reactivity Series of Metals https://www.bbc.com/education/guides/zqjsgk7/revision/1
  Periodic Table - Elements - http://www.webelements.com/

Assessment: How will you know that the students got it?
Completed artifact data sheet

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. Developing and using models
3. Planning and carrying out investigations
4. **Analyzing and interpreting data**
5. Using mathematics and computational thinking
6. **Constructing explanations (for science) and designing solutions (for engineering)**
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Notes about Science and Engineering Practices included:

Lesson Overview:

- Student will examine the result of the reactivity investigation; they will review the characteristics of ocean water the role it played in the corrosion of metal.
- They will explore the history and wreck of the whydah
- Identify the composition of recovered artifacts and predict how they reacted to long term exposure to sea-water**.**

Opening/Engagement:

1. Ask students to examine their results of the reactivity investigation and add the data to their investigation sheets.
2. Ask a student to summarize the reactivity investigation.
3. Have students read/review the ocean water and metals reading.

During the Lesson:

4. Introduce students to the wreck of the Whydah – the only authenticate pirate treasure in the world found right here of the coast of Cape Cod
5. Student will look at specific items recovered from the wreck and conduct some research on these items to determine composition, label as mixture, compound element and predict how they would have reacted with sea water.
6. Complete provided student/group data collection sheet

Lesson Closing

7. Ask some students to share their finding with the class
8. Students should add their information the class data sheet.

Instructional Tips/Strategies/Suggestions for Teacher: What other ideas would you like to highlight? What grouping strategies are important? What are adjustments for struggling learners, enrichment, or for students who are English Learners?

Teachers should refer to the Teacher Resource for Artifact Tool Kit.
Some artifacts are made up of single materials such as gold coins; others are compound artifact such as a pistol that is made of wood, iron and brass. When giving artifacts out to students (groups or pairs) you may wish to take into consideration the complexity of the artifacts and its composition to be researched.

Note: Pewter is an alloy, in 1717 the alloy was of Tin and Lead. Modern pewter is an Alloy of Tin, Antimony and Copper

Lesson 4: Concretions

Overview of the Lesson: What will students be doing?
Describe how concretions form, and identify some of the physical, and chemical changes that take place.
Time 50 (minutes):

Standard(s): What standards (s) will be the focus of the lesson?
8.MS-PS1-1. Develop a model to describe that (a) atoms combine in a multitude of ways to produce pure substances which make up all of the living and nonliving things that we encounter, (b) atoms form molecules and compounds that range in size from two to thousands of atoms, and (c) mixtures are composed of different proportions of pure substances.

8.MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Essential Question(s): What essential questions will be addressed in this lesson?

- What are the physical and chemical changes that take place in the debris of the wreck that forms the concretions

Science Objectives

- Identify chemical changes that take place in iron to form a concretion.

Language Objectives and/or Targeted Academic Language

- Concretion
- Encrustation
- Sedimentation
- Decomposition
- Oxidation
- Chemical Change
- Physical Change

Anticipated Student Pre-conceptions/Misconceptions (optional)

-

Instructional Materials/Resources/Tools

- Video: Explore Shares shipwreck treasure with the world https://www.youtube.com/watch?v=cVXavwWFuuw&feature=youtu.be
- Video Notes
- Article Concretion from the Wreck of the Week https://thewreckoftheweek.wordpress.com/tag/concretion/
- Concretion Discussion Guide

Assessment: How will you know that the students got it?
Discussion and Teacher Observation

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. **Constructing explanations (for science) and designing solutions (for engineering)**
7. Engaging in argument from evidence
8. **Obtaining, evaluating, and communicating information**

Notes about Science and Engineering Practices included:

Lesson Overview:

- Students will watch and read about concretions they will use this information and that from previous lessons to discuss the how concretions are formed**.**

Opening/Engagement: 10 mins

- Ask the students what they know about the wreck of the Whydah
- Show the students the video Explorer Shares Shipwreck Treasure with the World https://www.youtube.com/watch?v=cVXavwWFuuw&feature=youtu.be

During the Lesson: 35 mins

- Show video a second time – pausing several times to have students note and discuss what they are seeing. (see video notes)
- In pairs have students Read: Article Concretion from the Wreck of the Week https://thewreckoftheweek.wordpress.com/tag/concretion/
- Based on readings videos and previous lessons have students complete the What is a concretion discussion guide
- Use the guide to have a class discussion around concretion formation.

Lesson Closing 5 min

7. Ask for suggestions on how to “undo” a concretion**?**
Instructional Tips/Strategies/Suggestions for Teacher: What other ideas would you like to highlight? What grouping strategies are important? What are adjustments for struggling learners, enrichment, or for students who are English Learners?

Lesson 5: The Work of the Archaeologist

Overview of the Lesson: What will students be doing? **Student will explore how artifacts are removed from the concretion and conserved by both mechanical and chemical means.** **Time 50 (minutes):**
Standard(s): What standards (s) will be the focus of the lesson? 8.MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. 8.MS-PS1-5. Use a model to explain that atoms are rearranged during a chemical reaction to form new substances with new properties. Explain that the atoms present in the reactants are all present in the products and thus the total number of atoms is conserved. • •
Essential Question(s): What essential questions will be addressed in this lesson? • How does the archaeologist/ conservator “undo” a concretion to find the artifacts left behind in a wreck. •
Science Objectives •
Language Objectives and/or Targeted Academic Language • Void • Cast • X-ray • stabilization • Mechanical Cleaning • Chemical Cleaning
Anticipated Student Pre-conceptions/Misconceptions (optional)

-

Instructional Materials/Resources/Tools

- Read: How to do archaeological conservation https://heritagecalling.com/2018/03/16/how-to-do-archaeological-conservation/
- Read: A conservator's tool kit https://thewreckoftheweek.wordpress.com/tag/concretion/
- Watch: Shipwreck artifact conservation https://www.youtube.com/watch?v=-NLdOOKGrL0
- Read: Archaeological Conservation http://www.staugustinelighthouse.com/LAMP/Conservation/Archaeological_Conservation
- Watch: Using an airbrush to clean leather https://www.youtube.com/watch?time_continue=19&v=Y1qzVR_UkAE
- Teacher resource General Steps for recovering artifacts from a concretion

Assessment: How will you know that the students got it?
Students will create a plan with the basic steps of conservation

Science and Engineering Practices included (put the included ones in bold):

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. **Constructing explanations (for science) and designing solutions (for engineering)**
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Notes about Science and Engineering Practices included:

Lesson Overview:

- Student will watch and read about the conservation process and outline the basic steps.

Opening/Engagement: 10 mins

1. Watch: Shipwreck artifact conservation https://www.youtube.com/watch?v=-NLdOOKGrL0

ghlight the mechanical cleaning of artifacts to remove from the concertation
ghlight the chemical cleaning – electrolysis (Chemical stabilization) to remove the corrosive salt

During the Lesson:30 mins

2. **Have students in groups or pairs review the following information then create a plan for what steps an archaeologist will take once recovering a concretion**

ad: Archaeological Conservation http://www.staugustinelighthouse.com/LAMP/Conservation/Archaeological_Conservation
ad: How to do archaeological conservation https://heritagecalling.com/2018/03/16/how-to-do-archaeological-conservation/
ad: A conservator's tool kit https://thewreckoftheweek.wordpress.com/tag/concretion/

atch: Using an airbrush to clean leather https://www.youtube.com/watch?time_continue=19&v=Y1qzVR_UkAE
Lesson Closing 10 mins 3. Select some students share their plans (teacher resource General Steps for recovering an artifact from a concretion)

Lesson 6: Pulling it All Together

Overview of the Lesson: What will students be doing?
Students will be writing an article on the recovery of artifacts from the Whydah and the work of the archaeologist. Particularly focusing on what happens to an artifact from wreck to being displayed in a museum
Time (minutes):

Standard(s): What standards (s) will be the focus of the lesson?

ELA W 8.1 2. Write informative/explanatory texts (e.g., essays, oral reports, biographical feature articles) to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Essential Question(s): What essential questions will be addressed in this lesson?

- **What happens to an artifact from wreck to museum**

Science Objectives

-

Language Objectives and/or Targeted Academic Language

-

Anticipated Student Pre-conceptions/Misconceptions (optional)

-

Instructional Materials/Resources/Tools

- Students should have access to all previous work and resources completed in this unit
- Questions to think about. This list of questions may help students with creating their articles

Assessment: How will you know that the students got it?
The completed essay/article

Science and Engineering Practices included (put the included ones in bold):

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking

6. Constructing explanations (for science) and designing solutions (for engineering) 7. Engaging in argument from evidence **8. Obtaining, evaluating, and communicating information** **Notes about Science and Engineering Practices included:**
Lesson Overview: • Students will draw upon the material covered in this unit to summarize the what happens to an artifact from wreck to being in the museum
Opening/Engagement: 10mins 1. Ask students to think back to the artifact they first researched back in Lesson 3 and describe what happened to the artifact from wreck to museum. (falls to ocean bottom, surrounded by salt water and sediment, corrosion occurs, concretion formed, concretion recovered, stabilized, artifact recovered, cleaned, all the physical and chemical changes) 2. Ask students to share what skills and knowledge are needed to do such work. (Historians need science too)
During the Lesson: 3. Students will write an article about the recovery of the treasure from the Whydah. They may choose to address 1 artifact or several. 4. Provide students the Questions to think About sheet. Have them do a pre-writing with a partner and verbally answer some of the questions to help them prepare for writing. 5. Move amongst the students to check on progress and ask guiding questions.
Lesson Closing **6.** Select several students to share their writing.
Instructional Tips/Strategies/Suggestions for Teacher: Depending on your student's language and writing skills some students may be encourage to write an article addressing the majority of the ideas covered in this unit, or you may choose to provide a student with a single question to address with their writing. Student could also draw a diagram or make a list of what happens to an artifact.

Information to Support Teaching Learning

What additional resources can support teachers in developing background understanding of content or ideas in this unit?

Ocean Water and Corrosion

CK12 Sea-water chemistry https://www.ck12.org/c/earth-science/seawater-chemistry/
CK12 Valance electrons and reactivity https://www.ck12.org/c/physical-science/valence-electrons/
Optional experiment on what is needed for rust to form http://www.bbc.co.uk/bitesize/standard/chemistry/metals/corrosion/revision/1/
Periodic Table - Elements - http://www.webelements.com/
Why Does Metal Rust? https://www.youtube.com/watch?v=B_em0quwuSw
Reactivity Series of Metals https://www.bbc.com/education/guides/zqjsgk7/revision/1
Read: Alloys https://www.ck12.org/c/physical-science/alloys/lesson/Alloys-MS-PS/?referrer=concept_details
Corrosion Rate in Salt water https://www.youtube.com/watch?v=q-q4cncpsrI
Read Seawater chemistry https://www.ck12.org/earth-science/seawater-chemistry/lesson/Seawater-Chemistry-HS-ES/

Shipwrecks & Whydah

Cape Cod ship wrecks https://www.nps.gov/caco/learn/historyculture/shipwrecks.htm
Video: National Park service 300th anniversary of the wreck of the Whydah https://www.youtube.com/watch?v=MbFY0xo7IGo
A good overview of the history of the Whydah and Sam Bellemy
Whydah Project https://www.discoverpirates.com/whydah-project/
Nat Geo Live Barry Clifford: Pirate Treasure found https://www.youtube.com/watch?v=XZCvZ8ToSj0
National Parks Service Shipwrecks https://www.nps.gov/caco/learn/historyculture/shipwrecks.htm
The Mystery of Cape and Islands ship wrecks. https://www.weneedavacation.com/Cape-Cod/Articles/Shipwrecks/
Sparrow-Hawks remains carefully studied
http://plymouth.wickedlocal.com/news/20180115/sparrow-hawks-remains-carefully-studied-for-age-place-of-origin

Methods of conserving archeological material from underwater sites by Donny Hamilton
http://nautarch.tamu.edu/CRL/conservationmanual/ConservationManual.pdf
Massachusetts Board of Underwater Archaeological Resources https://www.mass.gov/orgs/board-of-underwater-archaeological-resources

List of Unit Resources (in lesson sequence)

Lesson 1

- National Parks Service Shipwrecks https://www.nps.gov/caco/learn/historyculture/shipwrecks.htm
- The Mystery of Cape and Islands ship wrecks. https://www.weneedavacation.com/Cape-Cod/Articles/Shipwrecks/
- Sparrow-Hawks remains carefully studied http://plymouth.wickedlocal.com/news/20180115/sparrow-hawks-remains-carefully-studied-for-age-place-of-origin
- Map of Cape Cod shipwrecks (Optional)
- Shipwreck Summary Sheets (Below)

SS Cherokee Courtesy of the Rich Turnwald collection,muboat.net/allies/merchants/ships/1818.html

Cherokee

Type of Vessel: Passenger ship, Iron

Date of Wreck: 1942

Reason for Loss: Sunk by torpedo from German submarine

Location: 50 miles NE of Province town

Type of things you might find on the ship before it sank.	Do you think they will last after long exposure in the ocean?

The Frances (Wicked Local)Drawing by Larry Nordsby

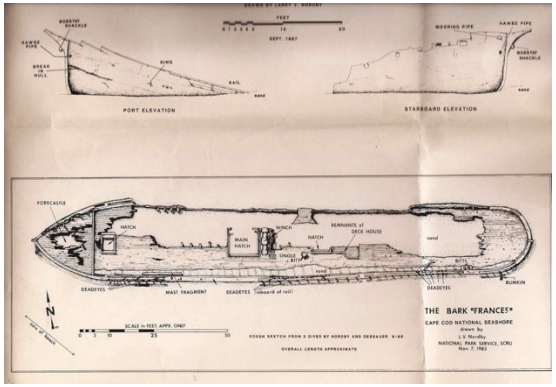
The Frances

Type of Vessel: 3 Masted Bark, Iron

Date of Wreck: 1872

Reason for Loss: ran aground in a storm

Location: Head of the Meadow Truro MA



Type of things you might find on the ship before it sank.	Do you think they will last after long exposure in the ocean?

HMS Somerset exposed 2010 (Boston.com)

HMS Somerset

Type of Vessel: British Frigate, Wood Hull

Date of Wreck: 1778

Reason for Loss: Struck sand bar

Location: Deadman's Hollow, Provincetown

Type of things you might find on the ship before it sank	Do you think they will last after long exposure in the ocean?

Josephine Marie

Type of Vessel: Fishing Vessel, Steel

Date of Wreck: 1992

Reason for Loss: Sunk in storm

Location: Stellwagen Bank, 6 miles off Provincetown

Josephine Marie (Stellwagen NMS)

Type of things you might find on the ship before it sank.	Do you think they will last after long exposure in the ocean?

Kate Harding on Cape Cod beach
(Bill Carter collection)

The Kate Harding

Type of Vessel: 3 Masted British Bark, Wood Hull

Date of Wreck: 1892

Reason for Loss: Stranded on Beach in Storm

Location: North Truro, north of Highland Light

Type of things you might find on the ship before it sank.	Do you think they will last after long exposure in the ocean?

Paul Palmer (Stellwagen NMS)

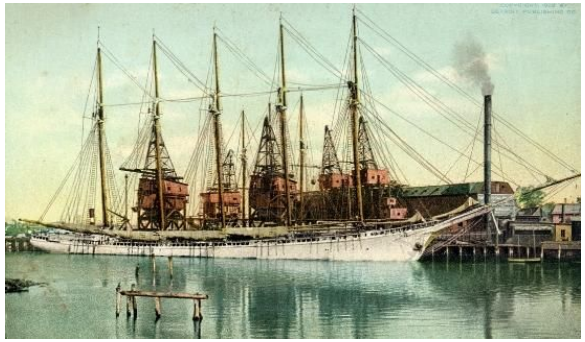
Paul Palmer

Type of Vessel: 5 Masted Schooner, Wood

Date of Wreck: 1913

Reason for Loss: Caught fire then sank

Location: 50 miles NE of Provincetown



Type of things you might find on the ship before it sank.	Do you think they will last after long exposure in the ocean?

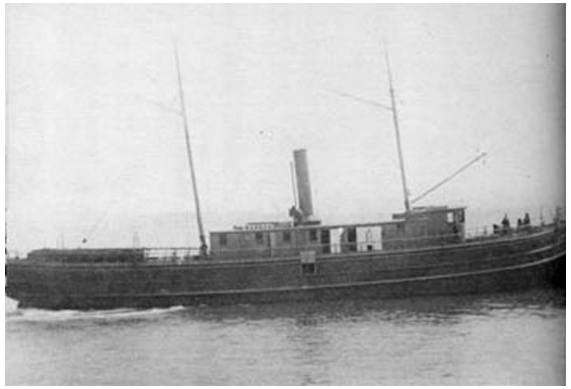
Pentagoet

Type of Vessel: Small steam, wood

Date of Wreck: 1898

Reason for Loss: Sunk in storm

Location: Stellwagen Bank,



Pentagoet (Stellwagen NMS)

Type of things you might find on the ship before it sank.	Do you think they will last after long exposure in the ocean?

Lesson 2

- Fresh water (tap will do)
- Sea-water
- Steel wool
- Jars/containers
- Vegetable oil
- Depression slides
- Hot plate
- Microscope or dissecting scope
- Blue and green food coloring
- Sea and Fresh Water Investigation

CAPE COD REGIONAL STEM NETWORK

Sea Water and Fresh Water Investigation

Name:

Group Members:

You are going to conduct a few experiments to compare some properties of sea-water and fresh water.

Water Density

1. Pour 10 ml of blue, salty water into a test tube.
2. Using a dropper add an equal amount of green fresh water.
3. Draw and label your test tube. Color the water as you see it.

4. Which water was on the bottom, which floated on top?

5. Which type of water has the greater density?

Dissolved Solids

1. Take 2 depression slides, using a wax pencil label one SW and the other FW.
2. Place several drops of sea-water on the depression slide labeled SW and place several drops of freshwater on the depression slide labeled FW.
3. Place the slides on a warm hot plate and let the water evaporate.
4. Look at each slide under a microscope (or dissecting microscope)
5. Sketch your slides?

6. What did you find on each slide?

Reactivity

In this experiment you will be comparing reactivity of salt water and fresh water on iron.
You will need 5 containers, steel wool, fresh water, ocean water, salt and vegetable oil.
The vegetable oil will form a thin layer keeping air from entering.

Label the Jars 1, 2, 3, 4 and 5
Place a small amount of steel wool in each jar
Jar 1: add fresh water to jar
Jar 2: add fresh water to the jar and a small amount of vegetable oil
Jar 3: add salt water to the jar
Jar 4: add salt water to the jar and a small amount of vegetable oil
Jar 5: add salt to the jar

Wait one day and observer changes in each jar

Jar	Contents	Observations
Jar 1	**Steel wool and fresh water**	
Jar2	**Steel wool, fresh water and vegetable oil**	

Jar3	**Steel wool and salt water**	
Jar4	**Steel wool, salt water and vegetable oil**	
Jar5	**Steel wool and salt**	

What conclusions do you come to base on your observations?

Lesson 3

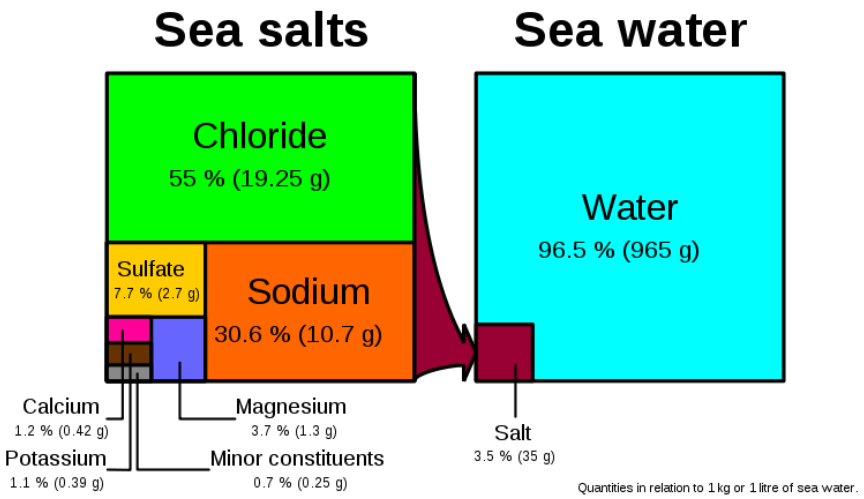
- Reading: Ocean Water and Metals
- Whydah Artifact Tool Kit for Educators
- Whydah Artifact class data sheet (and Teacher resource supplement)
- Computer access to research material reactivity
- Reactivity Series of Metals https://www.bbc.com/education/guides/zqjsgk7/revision/1
- Periodic Table - Elements - http://www.webelements.com/

Ocean Water and Metals

In the sea and fresh water investigating we discovered that ocean water contains dissolved solids. Many of these solids are **salts**. When salts dissolve, they separate into particles called **ions**.

1. Based on the chart below which is the most common ion?

2. Based on the ions present what are two salts found ocean water?



https://commons.wikimedia.org/wiki/File:Sea_salt-e-dp_hg.svg

The measure of the amount of salts in ocean water is called salinity. On average there is 35 grams of salts for every one Kilogram of ocean water. Salinity can vary by location. For example, the salinity of ocean water is reduced in the areas where fresh water rivers enter the ocean and increases where there is a high rate of evaporation such as near the equator or near the poles where water freezes thus concentrating the salts in the water below the ice.

Effects of Salinity

Salinity effects the physical and chemical properties of ocean water. Salt water has a higher **density** then fresh water as you discovered during the investigation. The presence of salt ions lowers the **freezing point** of ocean water. This is why fresh water freezes

before ocean water. Ocean water freezes at 28.58°F (-1.9°C). The presence of ions also allows salt water to carry an electric current better then fresh water.

3. Which ocean water would have the higher density, water from the equator or water from Mississippi river delta?

Gases in Ocean Water

Ocean water also contains dissolved gases, these gases are used by organism in the sea just as land organisms use air. The gases in the ocean come from interactions with the atmosphere at the surface and also are released by the organism in the ocean. The two most common gases are Carbon Dioxide (CO_2) and Oxygen (O_2)

Ocean water and corrosion

Corrosion is the process of **oxidation,** on iron the process of forms rust. Oxidation is the loss of **electrons**. When rust forms the electrons move from the atoms of iron to the atoms of oxygen. The salt ions in salt water help to carry the electrons from one atom to the other. This is called electrochemical corrosion. This is why corrosion of metals happens at a faster rate in ocean water then fresh.

Iron + Oxygen -> Iron Oxide

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

The combination of moisture, oxygen and salt damages metal more so than just rust. This combination eats away at the metal causing it to weaken and fall apart. This is why many iron objects left in sea-water are destroyed over a long period of time. Some metals are more reactive then other. Here is a table of some common metals and their **reactivity** levels.

Metal	Reactivity
Aluminum	Increasing Reactivity ->
Zinc	
Iron	
Nickel	
Tin	
Lead	
Antimony	
Copper	
Silver	
Gold	

4. Name one metal that is more reactive then iron?

5. Name one metal that is less reactive them iron?

Whydah Artifact Data Sheet

Group members:_____

Artifact:_____

Describe the artifact: For example, what was it used for, approximate size, etc.?

Do we use similar objects today, if so what are they made from? Do you think they would survive 300 years in the ocean.?

Complete the table; you may need to do a little research

Materials Found in Artifact	Chemical composition of the Materials	Element, Compound, Mixture	Expected condition when discovered.

Class Data Sheet

Whydah Artifacts

Artifact	Composition	Intensify if Element, compound, or mixture. Include Chemical formulas	Expected condition when discovered.
Gold Fragments, Coins, and Akan Gold			
Silver Coins, Ingot			
Brass Scale Weights			
Lead Scale Weights			
Adze (Axe) and handle			
Medical Syringes			
Pissoir			
Musket			
Grenades			
Sun King Pistol and ribbon			
Shot Pouch			
Buckles, Buttons and Cufflinks			
Cordage - rigging			
Spoon Plate Fork			

Human bone, stocking and shoe			

Teacher Resource
Summary of Metal Conditions found on Whydah
Supplement to the Whydah Artifact Tool Kit

Summary notes based on Methods for Conserving Archaeological Material from Underwater Sites by Donny L Hamilton suggested pages in chart below.

Key work of the conservator in marine archeology is to stabilize the find. In this case stop the corrosive process by using fresh water instead of salt water, often de-ionized water. Then removing salt from objects and treating the recovered objects to prevent further decomposition.

In discussion focus students on the idea of stopping and or undoing the destructive process of exposure of ocean water.

Large concretions/encrustations tend to form around metallic artifacts. These contain the products of metal corrosion, rocks, sediments, clay and marine life. In the case of the Whydah the concretions are primarily a biproduct of the corrosion of iron. Of the metals on the Whydah iron is the more reactive then most. Iron can come from the nails used to build the ships, chests and barrels, as well as, the extra iron plating added to the ship as it was transformed from slave ship to pirate ship.

Recommend conservation procedures
Gold: pg 85
Silver: pg 75
Copper, Brass, Bronze: pg 71
Lead: Tin, Pewter pg 82
Iron: pg 46
Wood: pg 22
Silk: pg 31
Fiber: pg 31
Bone: pg 15
Glass: pg 20
Leather: pg 27
Working with encrustations/concretions pg 44

Artifact	Composition	Element, Compound, Mixture	Expected Condition
Gold Fragments, Coins, and Akan Gold	Gold, Au	Element	Due to low reactivity gold does not corrode though it may be surround in concretion
Silver Coins, Ingot	Silver, Ag	Element	Due to low reactivity Silver does not corrode though it may be surround in concretion. There may be surface oxidation forming a tarnish
Brass Scale Weights	Brass (Alloy) • Copper, Cu • Zinc, Zn	Mixture	Due to low reactivity does not corrode though it may be surround in concretion. There may be surface oxidation forming a tarnish
Lead Scale Weights	Lead, Pb	Element	Due to low reactivity does not corrode though it may be surround in concretion. There may be surface oxidation forming a tarnish
Adze (Axe) and handle	Iron, Fe Wood	Iron: Element Wood: Mixture • Lignin: compound $C_9H_{10}O_2$,$C_{10}H_{12}O_3$,$C_{11}H_{14}O_4$ • Cellulose: compound $(C_6H_{10}O_5)_n$	Due to reactive nature of iron and organic nature of wood. Expect lots of degradation.
Medical Syringes	*Pewter (Alloy) • Tin, Sn • Lead, Pb	Mixture	Due to low reactivity does not corrode though it may be surround in concretion. There may be surface oxidation

			forming a tarnish
Pissoir	Lead, Pb	Element	Due to low reactivity does not corrode though it may be surround in concretion. There may be surface oxidation forming a tarnish
Musket	Iron, Fe Wood		Due to reactive nature of iron and organic nature of wood. Expect lots of degradation
Grenades	Iron, Fe Wood Gunpowder		
Sun King Pistol and ribbon	Brass (Alloy) • Copper, Cu • Zinc, Zn Wood Silk Pigment	Silk: Mixture Primary fibers are the protein Fibroin a compund	Brass- Due to low reactivity does not corrode though it may be surround in concretion. There may be surface oxidation forming a tarnish Wood – Silk – Pigment –
Shot Pouch	Leather	Mixture	
Buckles, Buttons and Cufflinks	Silver Copper Glass Brass (Alloy) • Copper, Cu • Zinc, Zn Pewter (Alloy) • Tin, Sn • Lead, Pb Paste (Leaded Glass)		Due to low reactivity does not corrode though it may be surround in concretion. There may be surface oxidation forming a tarnish
Cordage - rigging	Fiber	Mixture Possibly Hemp	
Spoon Plate Fork	Pewter (Alloy) • Tin, Sn • Lead, Pb		

Human bone, stocking and shoe	Leather Wood Silk Human bone	Bone: Mixture • Calcium Phosphate ($Ca_3(PO_4)_2$Compound) • other materials	

*Pewter in 1717 was an alloy of Tin and Lead. After the mid 1700's lead was no longer used to create pewter it now is an alloy of Tin, Antimony, and Copper.

Lesson 4

- Video: Explore Shares shipwreck treasure with the world https://www.youtube.com/watch?v=cVXavwWFuuw&feature=youtu.be
- Video Notes
- Article Concretion from the Wreck of the Week https://thewreckoftheweek.wordpress.com/tag/concretion/

Video Notes

Explorer Shares Pirate Treasure with the World.

https://www.youtube.com/watch?v=cVXavwWFuuw&feature=youtu.be

0:06 Artifacts, ask student to identify some artifacts?
Coins, compass, buckle, spoon
Ask why are items tagged, labeled and bagged?

0:12 Bringing up a canon, describe the condition of the canon.

0:14 Compare the condition of the canons now.
Note these scenes are filmed in Brewster at Kenneth J Kinkor Center for Research & Archaeology (not open to the public)

1:02 Why do you think the Whydah's bell is stored in water?

1:13 This scene is filmed at the lab at the Yarmouth Museum. This is a large concretion holding many objects. It is continually sprayed with fresh water.

1:20- 1:23 These are examples of concretions. What do you notice protruding from the second concretion at 1:23?

1:26 X-ray is used to see inside the concretion and determine what artifacts it may hold. Looking back at the list of artifacts are there any that might prevent the x-ray from seeing all that is in the concretion? (lead blocks X-rays)

1:45 filmed at Yarmouth Museum

2:00 Archeologist and conservator Marie Zahn mechanically cleaning a concretion

CAPE COD REGIONAL STEM NETWORK

Concretion Discussion Guide

Directions: with your partner please complete the discussion guide to prepare for a class discussion about the formation of concretions.

1. Describe what a concretion looks like? What color are they? Could you see objects in examples, if so what did you see? Are those objects naturally occurring or man-made? list some examples of each.

2. What types of physical changes do your think happened the ship and the objects on the ship during and after the wreck?

3. What material do you think gives the concretion its color? Please describe the chemical change that took place to create that color.

4. Please describe any other chemical changes that could be taking place to the objects in the concretion.

5. What do you think holds it all together?

Lesson 5

- Read: How to do archaeological conservation https://heritagecalling.com/2018/03/16/how-to-do-archaeological-conservation/
- Read: A conservator's tool kit https://thewreckoftheweek.wordpress.com/tag/concretion/
- Watch: Shipwreck artifact conservation https://www.youtube.com/watch?v=-NLdOOKGrL0
- Read: Archaeological Conservation http://www.staugustinelighthouse.com/LAMP/Conservation/Archaeological_Conservation
- Watch: Using an airbrush to clean leather https://www.youtube.com/watch?time_continue=19&v=Y1qzVR_UkAE
- Teacher resource General Steps for recovering artifacts from a concretion

General Steps in Recovering Artifacts from a Concretion

1. Stabilization: This usually means washing and storing in fresh water. This slows down the corrosion that caused by salt water and limits exposure to the air that can cause further decomposition.

2. Examination: X-rays are taken of the Concretion to determine what objects might be inside.

This tell the conservations what might be needed to extract and then preserve the objects. Not all object will be seen, there are usually surprises so slow patient care is taken when removing concretions. Some object such as lead (Pb) block x-rays.

3. Mechanical Cleaning: Done with chisels, hammer, brushes and very small tools. The sediments (rocks, shell, sand and barnacles) are removed. Sometimes an iron object completely rusts away leaving a void which forms a mold. Before removing additional sediment, the mold is often filed to make a cast of the object that was once there.

4. Chemical Cleaning: This process removed the last of the concretion. Steps are now taken to stabilized the individual artifact. This includes removing the salt. With metal object this is often with electrolysis. With non-metal objects sometimes successive fresh water baths remove the excess salts.

5: Preservation: Once the objects are removed, cleaned and stabilized steps are taken to preserve the artifact to prevent further corrosion or degradation. This varies greatly depending on the material the object is composed.

Lesson 6

Questions to Think About

What can a shipwreck tell us about the past?

What shipwreck has the only known pirate treasure?

What skills and knowledge does a marine archaeologist need to do their job?

How does salt water effect the items left behind in a wreck?

What type of objects decay and decompose quickly and are not likely to be left behind.

What metals will corrode easily?

What metals do not corrode easily?

What are examples of physical change? Chemical change?

Why is it important to stabilize a concretions or object once it is recovered?

What is mechanical cleaning? What is chemical cleaning?

How does rust form?

Why does rust form faster in salt water then fresh?

What are the similarities or difference between element compound mixture and alloy?

Special thanks to the Cape Cod Regional Stem Network and the Whydah Pirate Museum for making this unit possible.