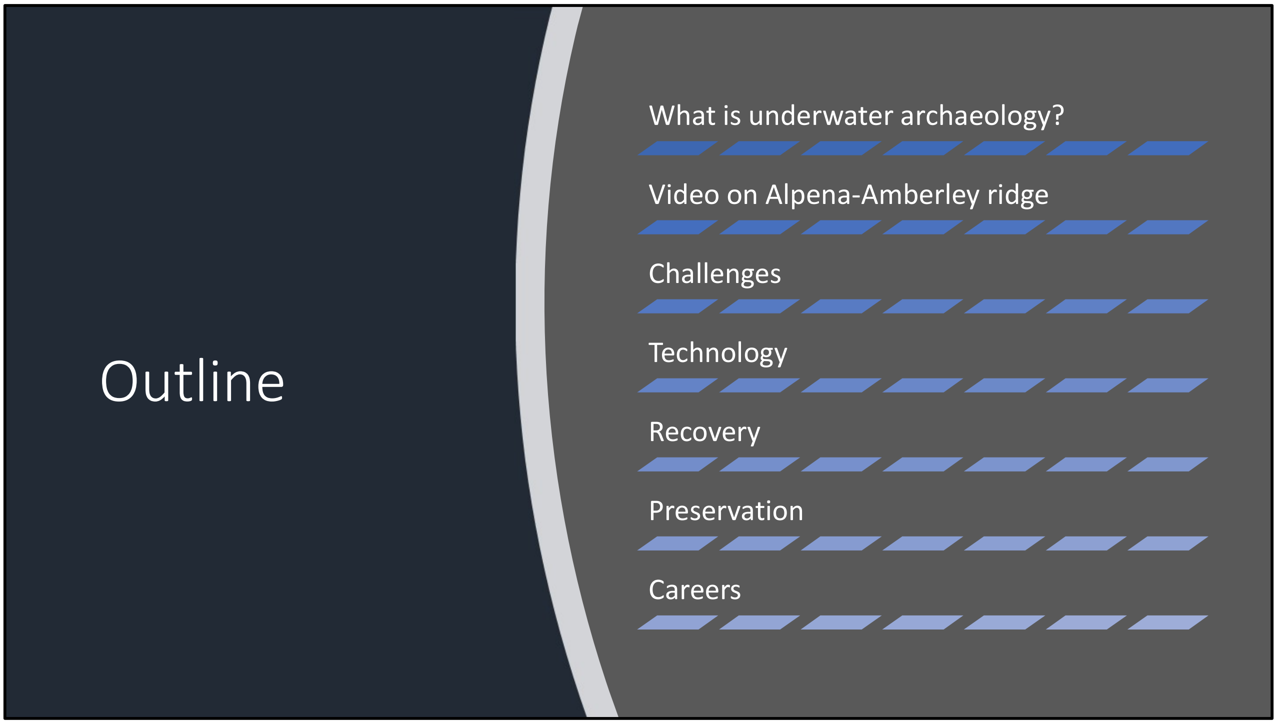
Sonar image of the American vessel USS Hamilton, lost during a gale on 8 August 1813 and lying in some 90 meters deep in Lake Ontario. The cannons are visible on deck, as is a small boat at the stern of the wreck.
Date: 2016:07:28 15:29:45
@ Parks Canada



First we will talk about what exactly is underwater archaeology. Then we will see an example of a site in Lake Huron.

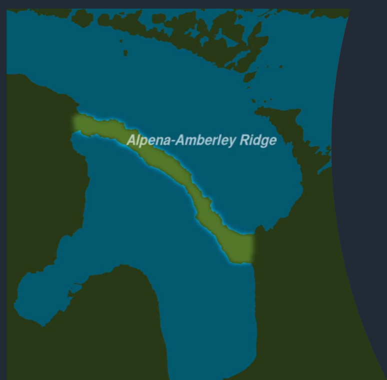
Once you have some idea of what underwater archaeology entails, we will discuss some of the challenges and how we deal with them. Next we will look at the technology that is used in underwater archaeology.

Then we will talk a bit about recovery and preservation of artifacts and finally how would you become an underwater archaeologist.

What is underwater archaeology?

- Study of past human culture through artifacts
- archaeological sites located underwater
  - Rivers, lakes, cenotes, springs, tidal basins, seas, and oceans!
- Includes shipwrecks, plane crashes, human and animal remains, and sunken cities
- The study of shipwrecks is nautical archaeology and may take place on land or under water

Lake Huron Alpena-Amberly Ridge



Video from 2015
https://www.youtube.com/watch?v=BITmXuNkYgU&feature=youtu.be

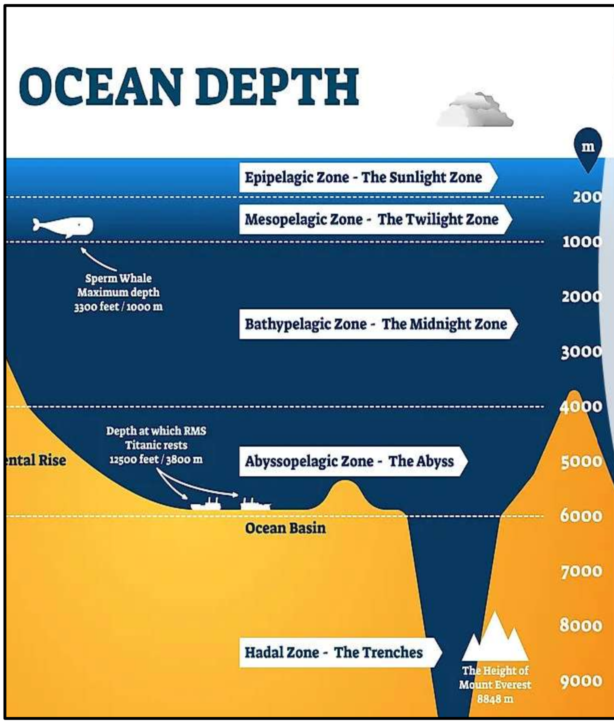
Challenges

- Cold
- Depth
- Communication
- Currents & Visibility

Cold water slows the rate of decay for artifacts, especially organic materials, so many sites are found in cold water. This poses a challenge for divers who want to dive to these sites. The duration of cold water dives is limited by the diver's ability to stay warm enough. One way to do this is by diving with a dry suit, but this is not always enough. It is also possible to supply wetsuits with a flow of hot water to keep divers warm.

These hot water wetsuits have a system of tubing to distribute hot water evenly throughout the suit. Hot water is pumped from the surface and cools as it travels to the diver. These suits are made of crushed neoprene so they do not compress at depth.

Hot water suits are also used when breathing helium mixes because helium conducts heat better than air and will cause the diver to lose heat faster.



Depth

- Some sites are shallow some deep
- Deeper dives have shorter bottom times
- Deeper dives are also riskier and require special gas mixtures
- For really deep use only ROV

Image credit: VectorMine/Shutterstock.com

Open water cert (18m)

Recreational limit (40m)

Deepest SCUBA dive (332m)
Atmospheric Diving System (610m)

ROV (up to 7000m)

Communication

- Waterproof paper for taking notes
- Hand signals
- Acoustic signals (sound)
  - Radio waves attenuate too quickly
  - Transducer -> ultrasound -> receiver -> audible sound
- Data transmission
  - Data can be converted to sound
  - Low data rates
  - AUVs (Autonomous underwater vehicles), some ROVs

One form of communication that needs to take place on an archaeological site is the recording of notes. To do this, divers use a paper that is specially coated or made of plastic to take notes underwater.

The next for of communication is sound between divers or between divers and a boat. Electromagnetic waves such as radio waves are attenuated too quickly underwater to be used for communication so sound waves which travel as pressure waves are used instead. Sound travels about 4x faster in water than air and this varies with the density of the medium and the temperature, but basically humans are not equipped to produce or hear sounds underwater.

Under water communication systems work by using a transducer in a full face diving mask to convert speech to ultrasound. Then the ultrasound signal is transmitted through the water to a receiver that the other diver has. The transducer then converts the ultrasound back into frequencies that we can hear. These systems also allow divers to communicate with a ship at the surface.

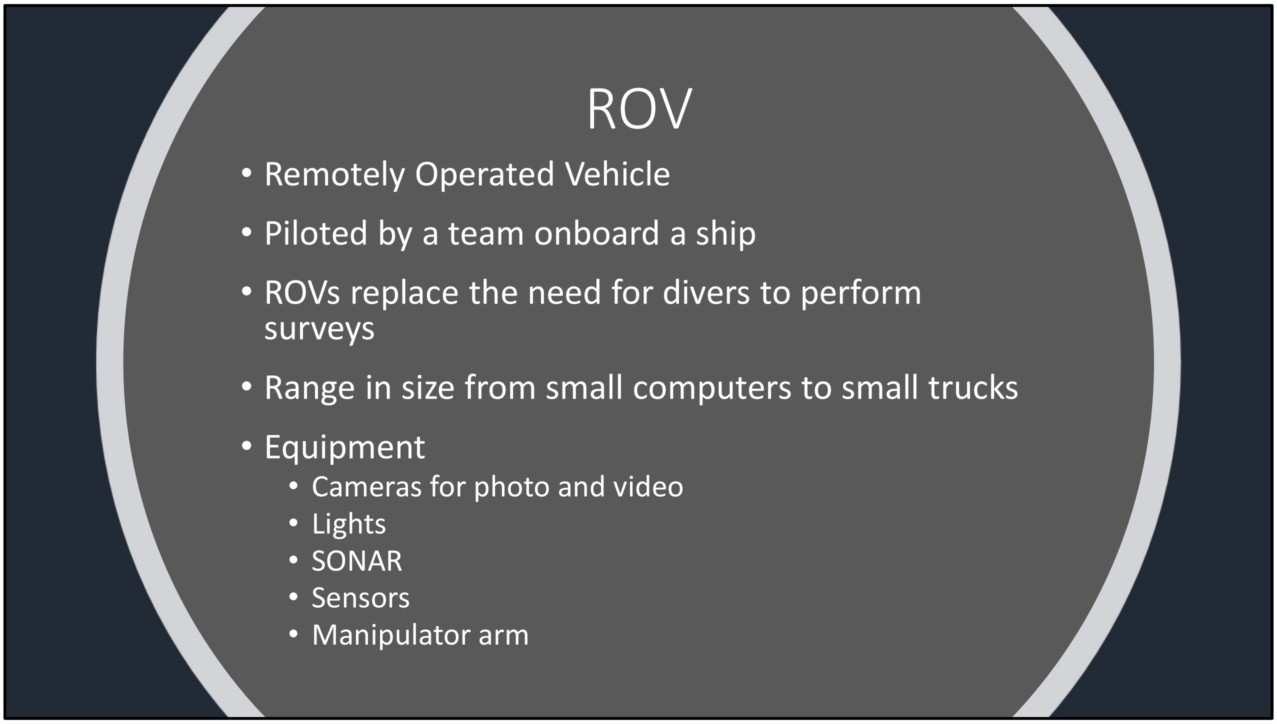
You may also want to transmit data underwater. It is also possible to do thus by converting the digital signal to sound and then back into data but the data rates are very low. Some ROVs transmit data this way and this can be desirable in an environment where you do not want cables but many ROVs transmit data via cables due to the higher rate of data transfer and the enormous amount of data that they collect.

https://dosits.org/people-and-sound/communication/how-is-sounds-used-to-transmit-data-underwater/
https://youtu.be/qheZyVtDzxw

Currents and Visibility

- Currents can move equipment
- Make diving more challenging
- Removing sediment without making visibility worse
  - Small dredges
  - Suction airlift
- Move artifacts

Currents can pose a challenge whether you are diving a site or not. Currents make diving more challenging for divers but also for any equipment since it can cause things to move or be difficult to maneuver. Currents can also affect visibility by kicking up sediment and make it particularly important to remove sediment carefully to avoid ruining the visibility of a site. Sediment is often removed using small dredges or suction airlifts which we will talk about when we look at the process of recovering artifacts. Another issue that currents cause is movement of artifacts. While the obvious concern is that currents can break artifacts it is also important in archaeology to look at the arrangement of objects to learn about the site. For example, the distribution of cargo from a shipwreck can give clues about how the ship sank.



One way to avoid the challenges associated with diving at depth and in the cold is to use ROVs instead of divers.

ROVs are controlled by operators using joysticks at the surface of the water. They are equipped with cameras for still photographs and video. In many cases, they will also have sensors such as for temperature. pH, and salinity and manipulator arms for retrieving objects. They are connected to the ship by a bundle of cables called a tether that includes the electrical cables for sending signals to and from the ship

https://oceanexplorer.noaa.gov/facts/rov.html.

ROV Classification

Micro/mini

<15 kg

~150M

Inspections

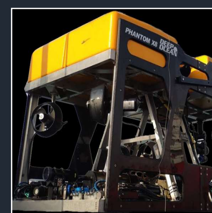
Hard to reach areas

Observation/ Inspection

5 hp

~300M

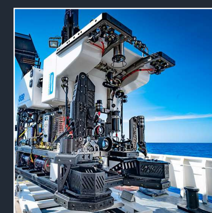
Lakes, rivers, coastal waters



Light work

50 hp

~2000M



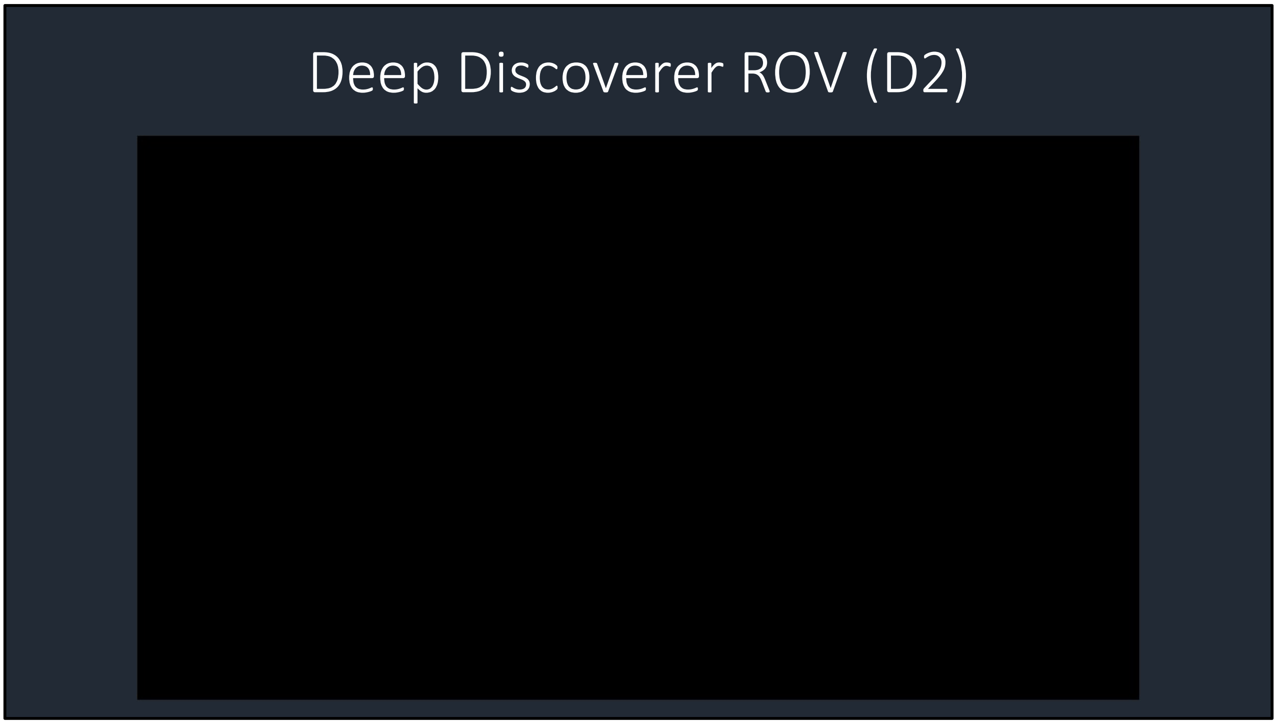
Heavy work

220 hp

3500M – 6000M

Different companies may classify their ROVs differently but this is a general idea of the types of ROVs available.
Observation/Inspection class in the few hundred meter range.

https://www.subsea-tech.com/mini-rov-guardian/
https://www.deeptrekker.com/resources/under
https://www.deepocean.com/rov-phantom-x8.phpwater-rovs



https://oceanexplorer.noaa.gov/facts/rov.html
https://oceanexplorer.noaa.gov/technology/subs/deep-discoverer/deep-discoverer.html

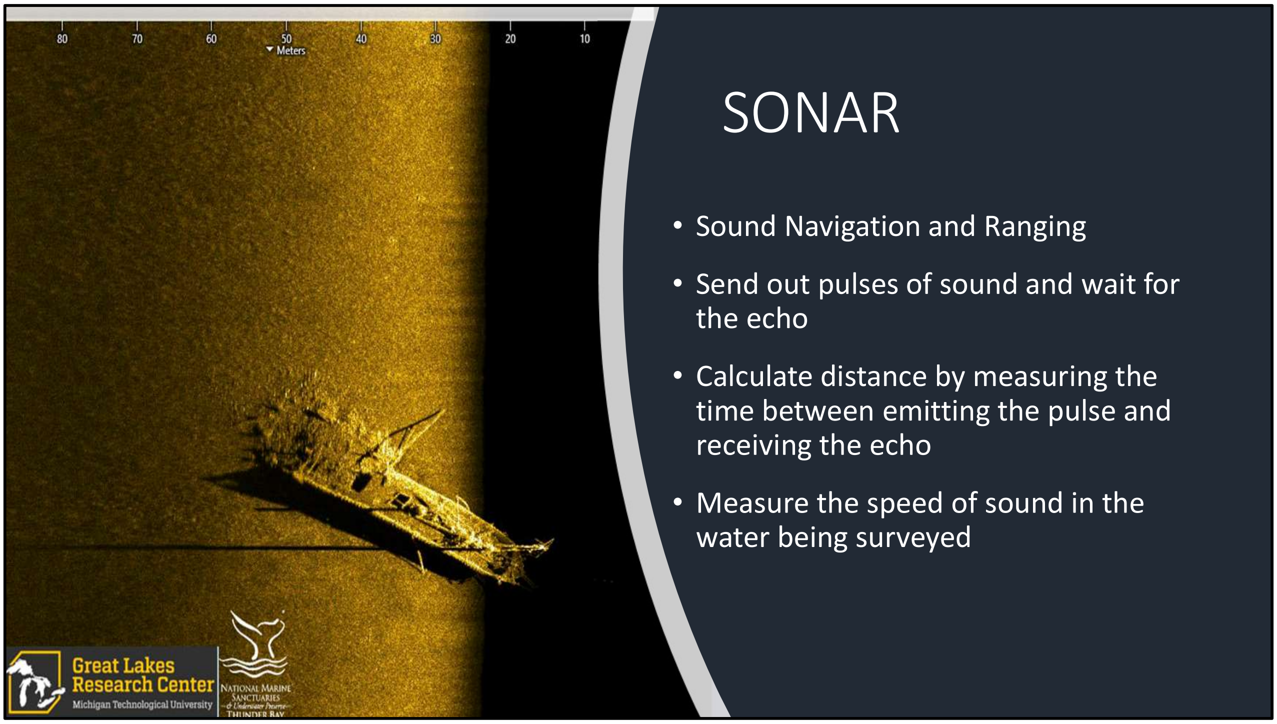
The video explains how the Deep Discoverer is being used for biological and geological surveys but this sort of ROV would be just as capable of sampling and photographic an archaeological site.

Imaging

- Photogrammetry
- An ROV or diver takes hundreds or thousands of images
- Camera moves along a preplanned route and the images overlap
- Every bit of the site needs to be captured at multiple angles and distances
- Software is used to stich the images together into a 3D model
- New Hope Shipwreck Bow

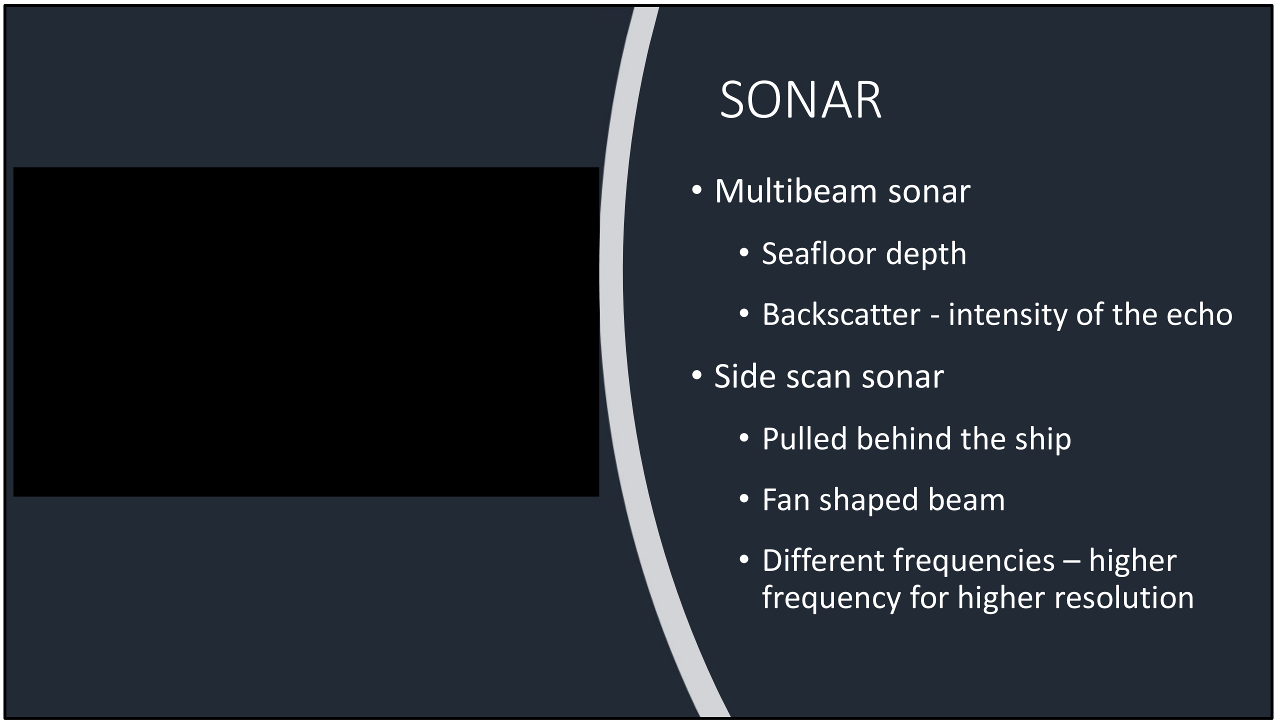
We will start talking about imaging by looking at photogrammetry. We saw that ROVs tend to be outfitted with a number of cameras. This allows them to capture many high resolution images that software can then compile into detailed 3D models to map out an archaeological site.

Two other imaging methods are SONAR and LiDAR.



SONAR stands for sound navigation and ranging. It works by using a transducer to send out a pulse of sound and then waits for the sound to bounce off of objects or the seafloor and return. By measuring how long it takes for the sound to return we can calculate the depth of objects. It is necessary for a ship to first calculate the speed of sound in the water that they are surveying because temperature, salinity, and depth all affect the density of water and therefore change the speed of sound.

https://oceanexplorer.noaa.gov/technology/sonar/side-scan.html
Side scan sonar image of schooner *Typo*, which collided with steamer *W.P. Ketcham* in October of 1899. The schooner, which was carrying a cargo of coal, was rammed in the stern. The sonar image shows the bow and upright foremast, cargo hatches across Typo’s deck, and the broken stern with a pile of spilled coal. *Image Source: Michigan Technological University Great Lakes Research Center. Image courtesy of the Michigan Technological*



Multibeam sonar works by simultaneously sending out multiple sound pulses in a fan shaped pattern. This allows the ship to gather data from directly below it and out to the sides. They are able to measure seafloor depth as well as backscatter which is a measurement of the intensity of the sound echo. Backscatter data can provide information about the composition of different objects, such as whether the seafloor is rocky or muddy. Backscatter from the water column can also provide information about 3D structures such as shipwrecks.

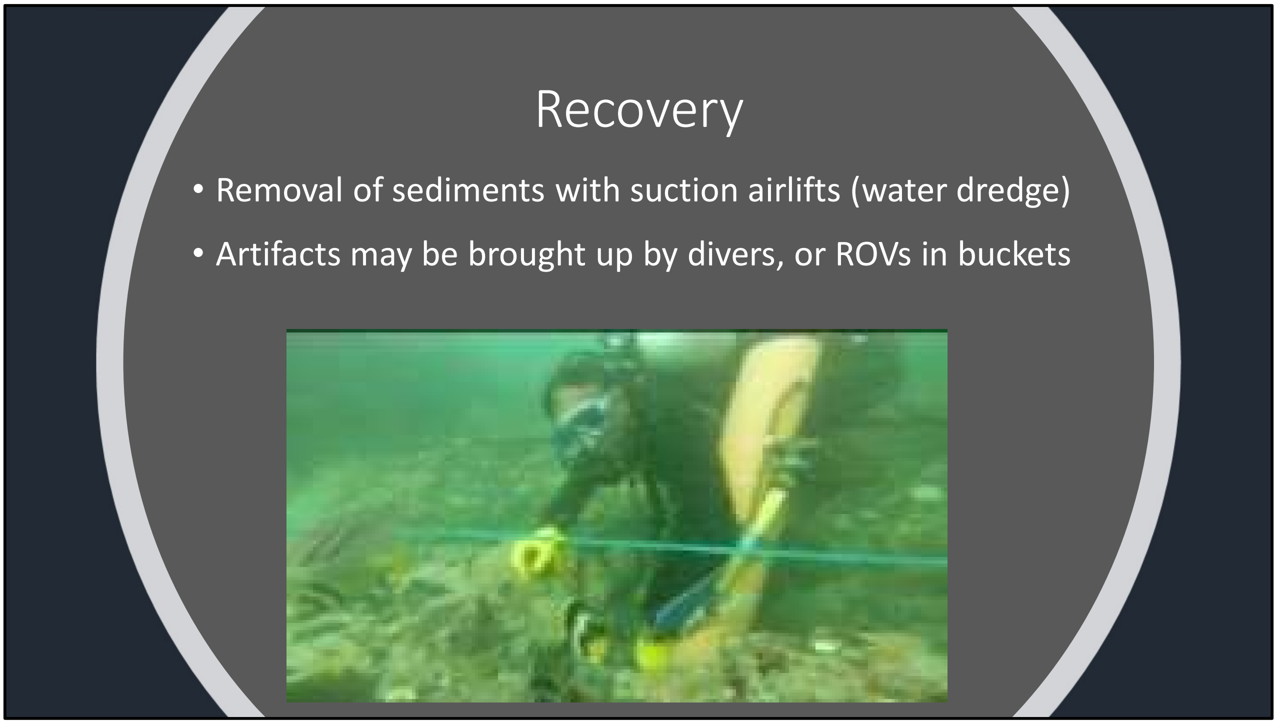
Side scan sonar is similar to multibeam because it has multiple transducer arrays that produce and receive sound signals. They can be mounted to a ship’s hull but are often mounted on a towfish which is an instrument that is pulled behind the ship. The side scan sonar also sends out a fan shaped beam and scans at a constant speed in a straight line. The towfish can record data for different sound frequencies. Low frequency sound captures lower quality image data but covers larger areas and higher frequency sound records smaller areas in greater detail.

Finally, computer programs are used to reconstruct the data into 3D images that are often color coded for depth.
https://oceanexplorer.noaa.gov/technology/sonar/side-scan.html

LiDAR

- Light Detection and Ranging
- Lasers are beamed at the area being surveyed
- Light pulses reflect back and the travel time is measured
- Computers can then construct a 3D map
- Excellent at detecting small anomalies and creating detailed surface maps
- Light travels short distances underwater so this is used close to the object being surveyed

https://www.nationalgeographic.com/culture/archaeology/lasers-lidar-driving-revolution-archaeology/

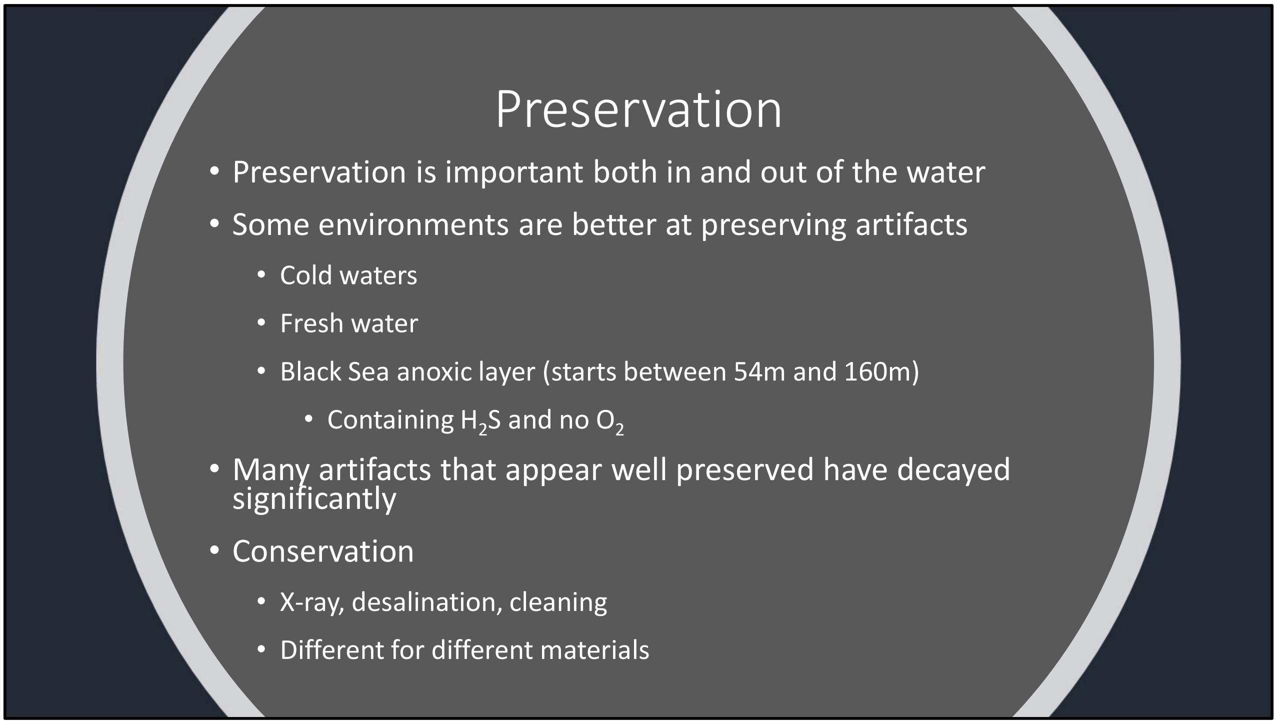


Recovery of artifacts may begin with the removal of sediments. This is done using suction airlifts also known as water dredges. A suction airlift works like a vacuum cleaner to suck up sediment and send it to the surface or dumps it away from the site. This is a video of a diver using a suction airlift to remove san from a site.

https://youtu.be/Vdc0JvLzbXc

Although it is preferrable today to conserve archaeological sites in place, it is possible to raise ships. This is a complicated and expensive process and to give you an idea of what it might look like we have this video of the raising of the Mary Rose in 1982. A British warship that belonged to Henry VIII.

https://youtu.be/5XhbXKE6aTc



The preservation of artifacts is an important part of archaeological study. Differences in environment affect the preservation of artifacts in the water. For example, cold water reduces the rate of decay and corrosion leading to longer lasting wrecks. Fresh water, such as lakes and rivers, can also lead to wrecks that are better preserved than their ocean counterparts. One interesting site is the Black Sea off the coast of Bulgaria. This sea has an anoxic layer below 54-160M that takes up 90% of the sea's volume. The lack of oxygen has lead to incredibly well preserved shipwrecks dating back 2,400 years.

Even wrecks that seem well preserved really are not. Many artifacts are very delicate. For example, wooden artifacts have usually decayed to the point where most of the structure comes from the stiff lignin of the cell walls. When removed from the water the wood is very soft and spongy and if it dried out right away it would shrink and distort. In order to preserve these artifacts, an impregnating substance can be injected into the wood to give it structure and prevent further decay. The water must be removed carefully so that the wood does not shrink or come apart. Then the artifact can be slowly dried without deteriorating.

https://www.nationalgeographic.com/culture/2018/10/black-sea-shipwreck-archaeology-map/

Conservation of metal artifacts

https://youtu.be/-NLdOOKGrL0

https://youtu.be/H2cu_PMwu2s

How to Become an Underwater archaeologist

- Some universities offer degree programs
- Usually requires a master’s degree or PhD
- Organizations offer training for volunteers to assist at various points
  - Save Ontario Shipwrecks (SOS) offers Nautical Archaeology Society (NAS) training on surveying of underwater sites.

https://saveontarioshipwrecks.ca/about/role-and-purpose/

Sources

- https://www.nationalgeographic.com/culture/2018/10/black-sea-shipwreck-archaeology-map/
- https://acuaonline.org/what-is-underwater-archaeology/
- https://www.pc.gc.ca/en/culture/arch/mer-sea
- https://oceanexplorer.noaa.gov/facts/rov.html