

# Great Lakes Conference 2018

## **Autonomous Vehicles for Exploration, Mapping and Environmental Monitoring**

Guy Meadows

Director, Great Lakes Research Center

Robbins Professor of Sustainable Marine Engineering

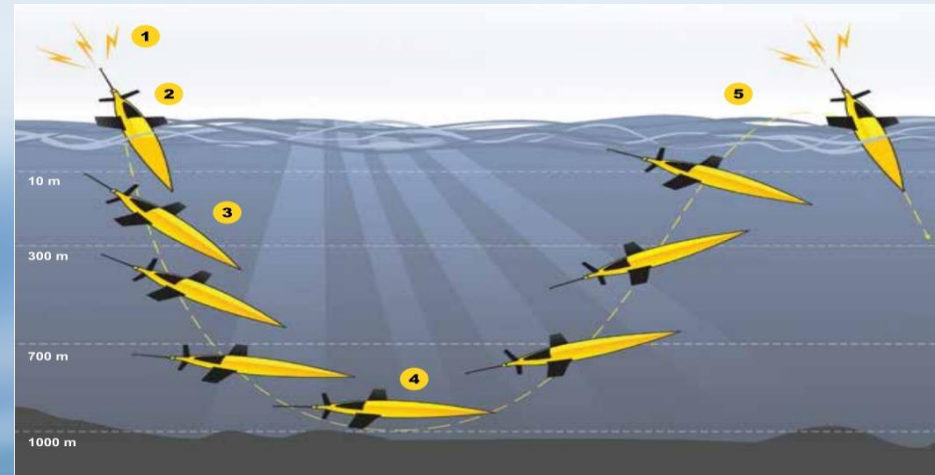
[gmeadows@mtu.edu](mailto:gmeadows@mtu.edu)



Summary of  
Autonomous Marine Vehicles  
used in  
Great Lakes Research  
and  
Time Spent on the Surface

# Autonomous Underwater Vehicles (AUVs)

- Sea Gliders:  
On the surface very little



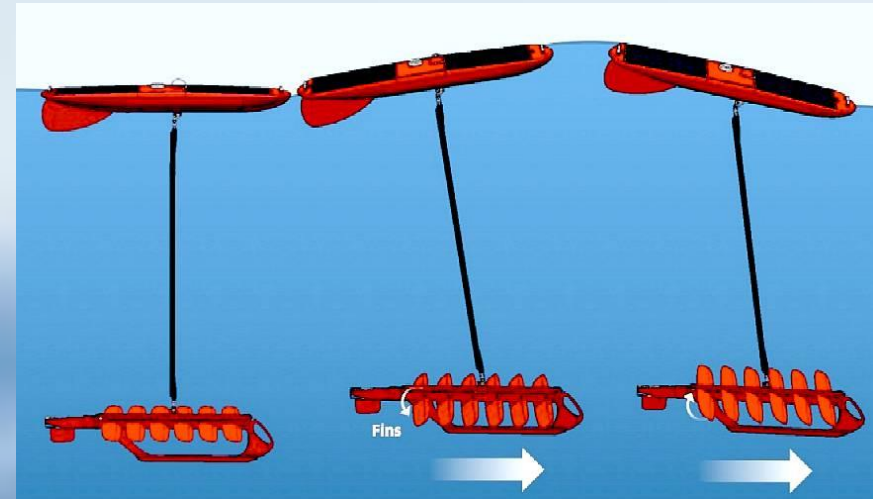
- Autonomous Underwater Vehicles (AUVs)  
Start and end on the surface



# Autonomous Surface Vehicles (ASVs)

- Wave Gliders

Have a surface presence 100%



- Autonomous Surface Vessels (ASVs)

Never leave the surface



# Examples of Great Lakes Efforts

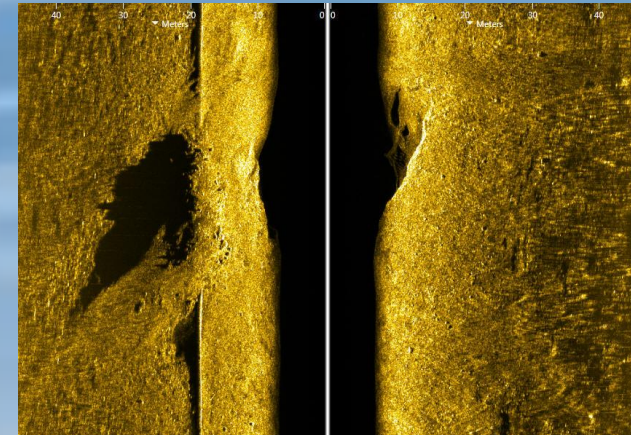
- USGS Wave Glider Winter 2012



- LLO & UM  
Sea Glider



- Mich Tech Iver3/EdgeTech 2205



- CIGLR Water Quality



- Others

# Autonomous Surface Vehicle Workshop

- Solomons, MD (November, 2015)  
Alliance for Coastal Technologies
- Funded by NOAA/IOOS
- Shallow Water Mapping and Water Quality Monitoring
- Aid in Transition of Evolving Technologies from Research Tools to Operational Tools
- Opportunities in the User Market, Performance Parameters, and Cost Considerations



# Workshop Report



## Autonomous Surface Vehicle Workshop

### PROCEEDINGS

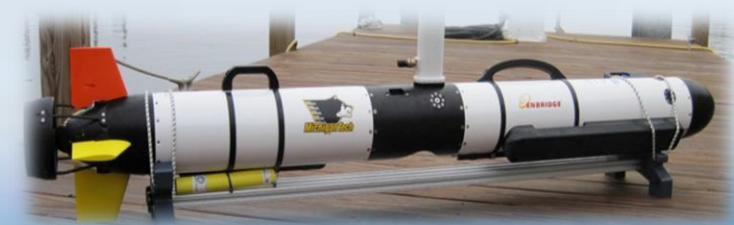


November 18-20, 2015  
Solomons, MD

<http://www.act-us.info/workshops.php>



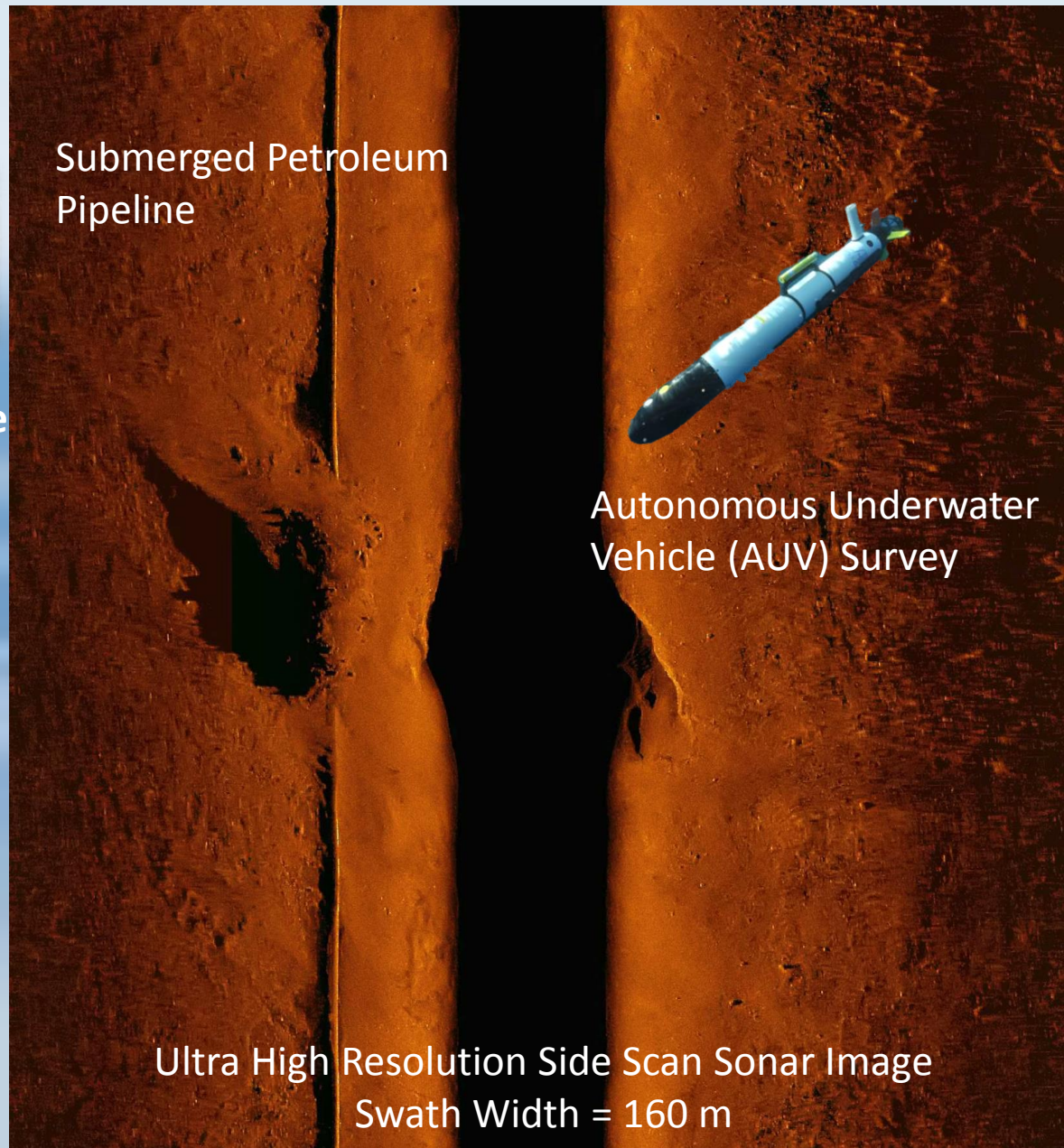
# Advanced Underwater Mapping



Full Autonomous Underwater Vehicle



Remotely Operated Vehicles



Submerged Petroleum Pipeline

Autonomous Underwater Vehicle (AUV) Survey

Ultra High Resolution Side Scan Sonar Image  
Swath Width = 160 m

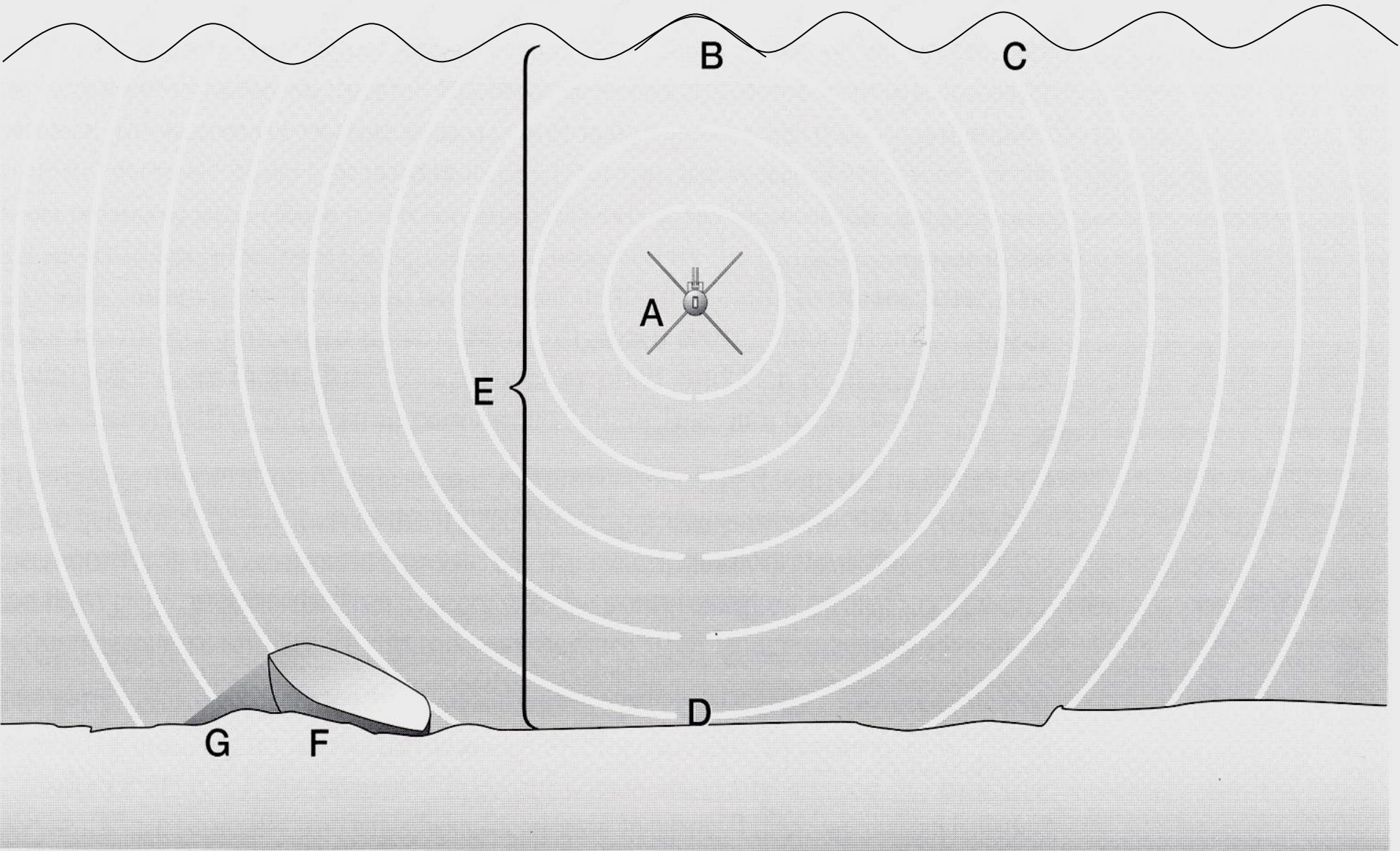


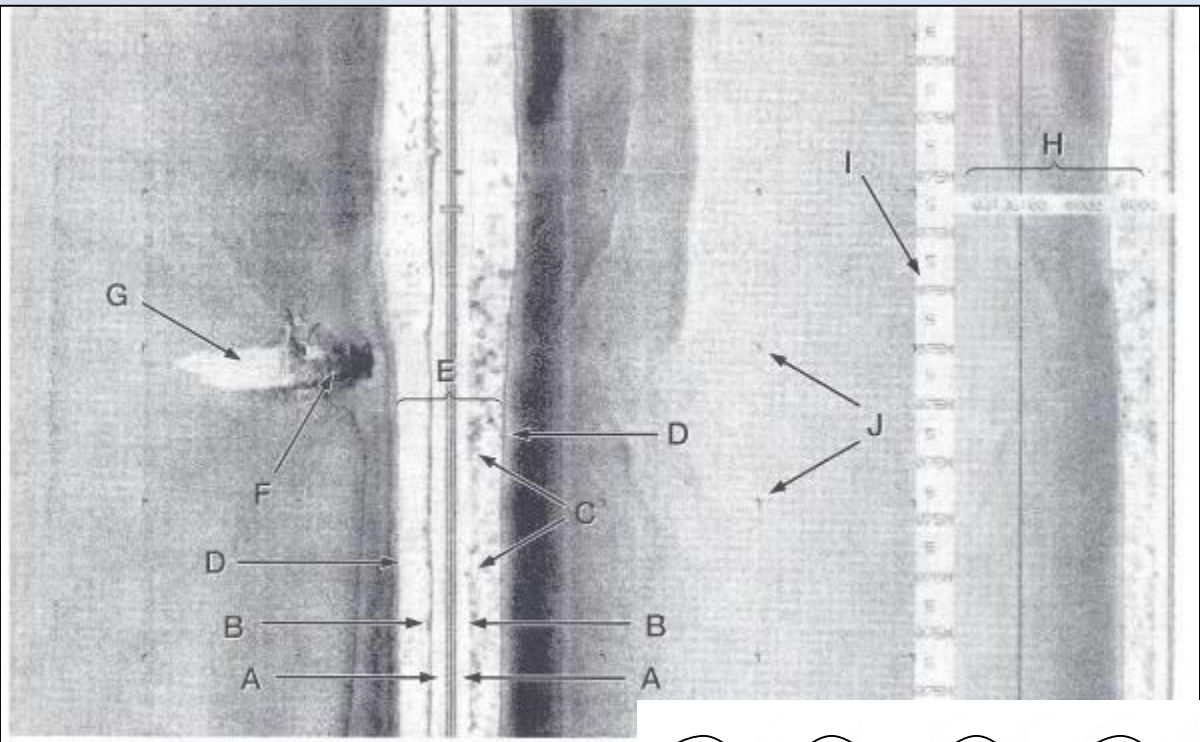
# Autonomous Underwater Vehicle (AUV)



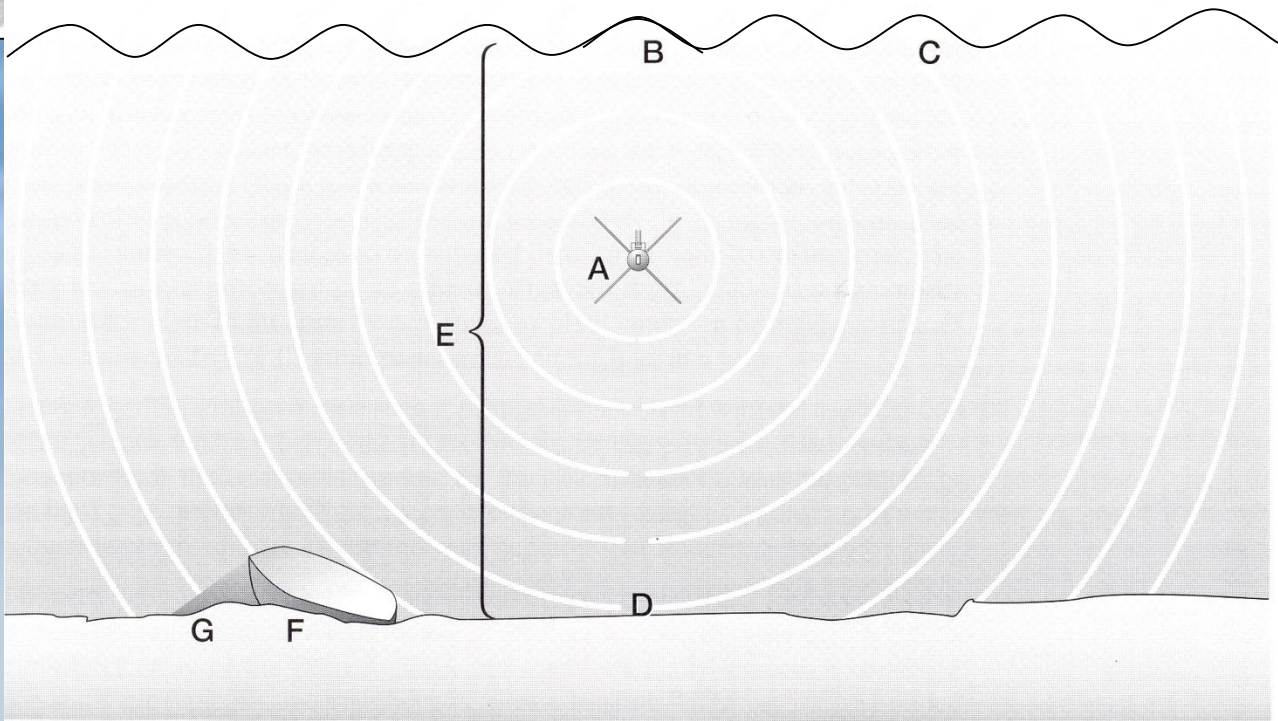
# Side Scan Sonar

## Typical Sound Geometry





- A: Trigger pulse**
- B: First surface return**
- C: Sea clutter**
- D: First bottom return**
- E: Water column**
- F: Sunken fishing vessel**
- G: Shadow**



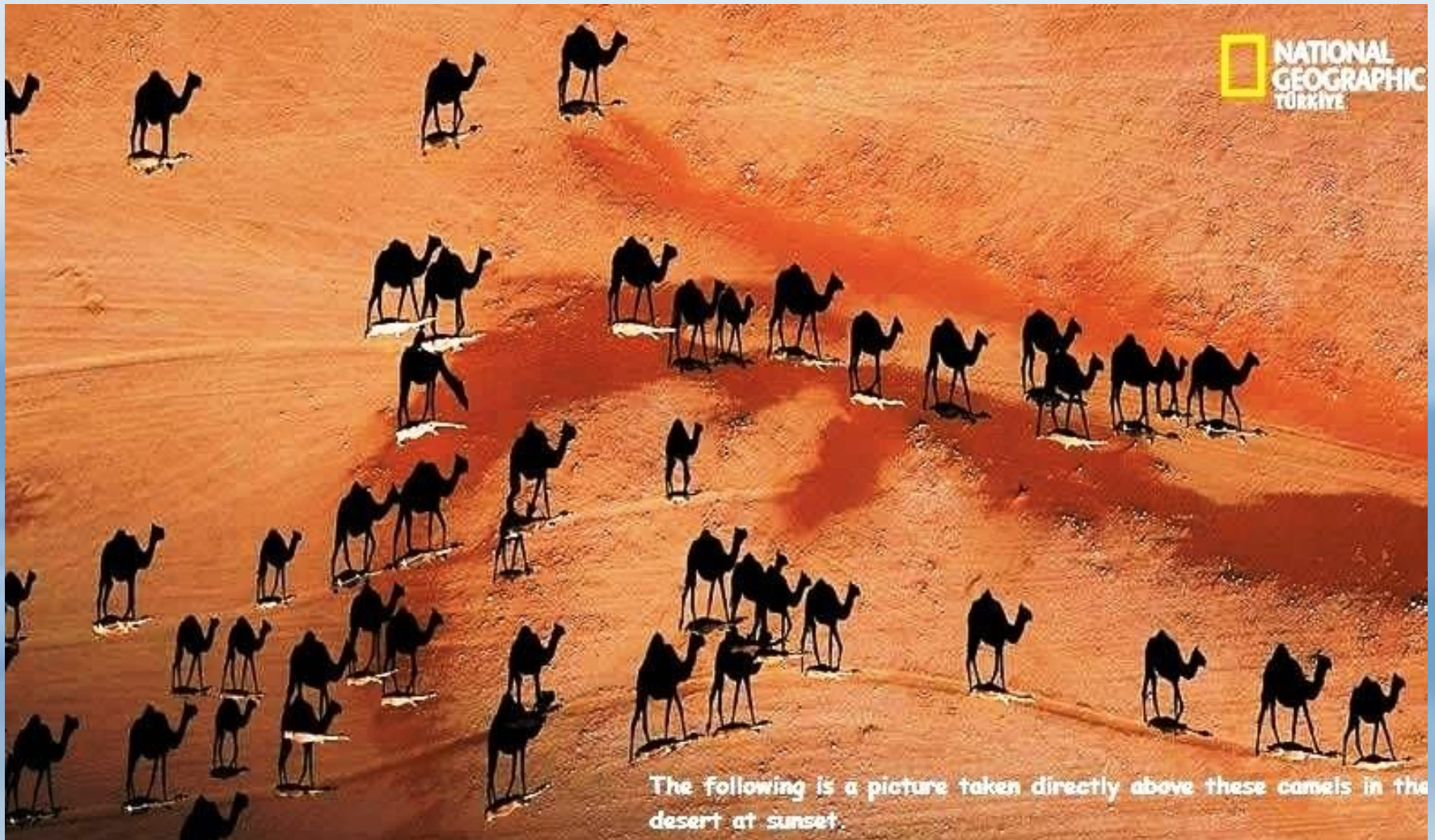
# Side Scan Sonar

## An “Active Remote Sensor”

- Theory of Operation

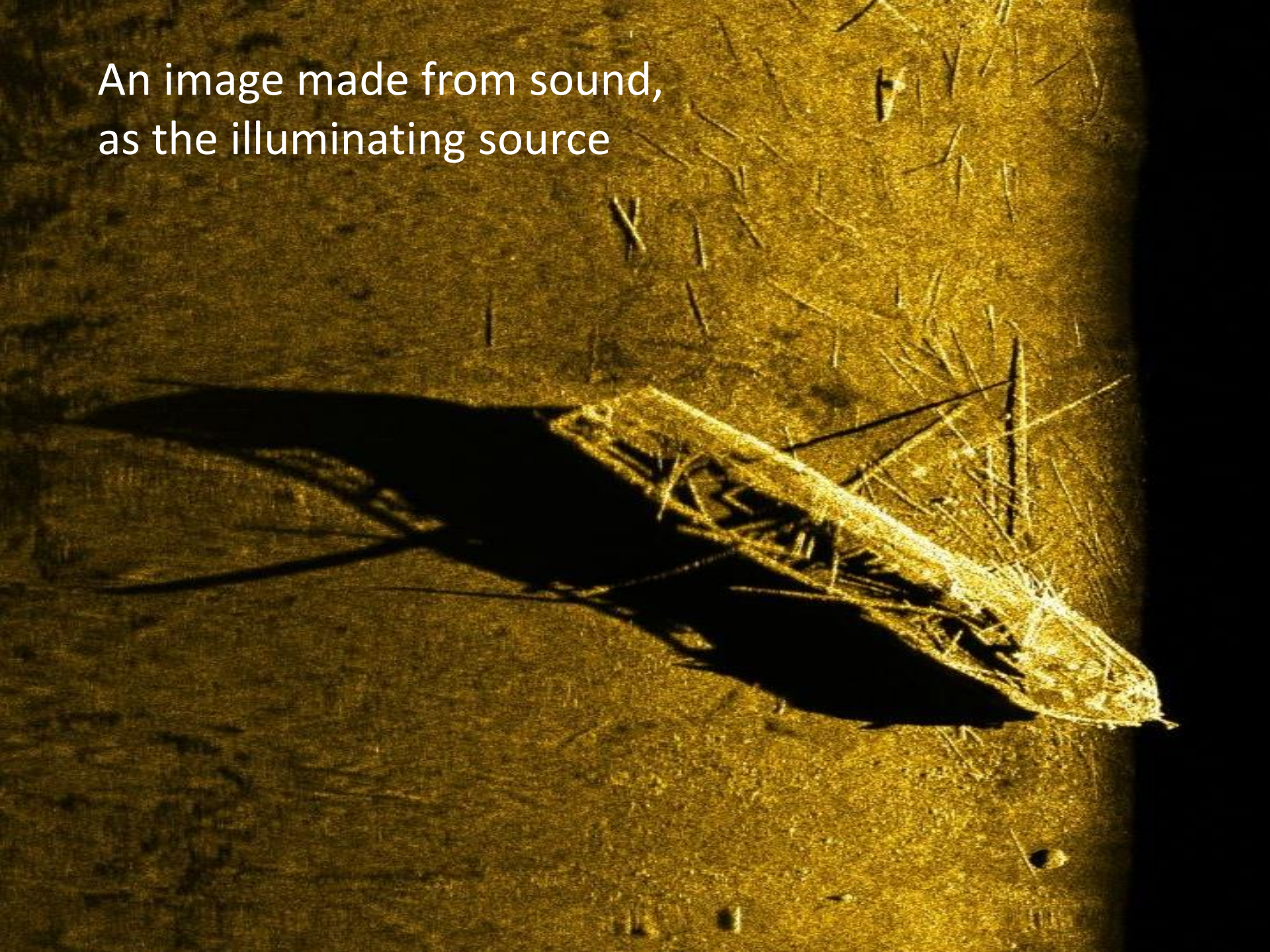


# Result



The following is a picture taken directly above these camels in the desert at sunset.

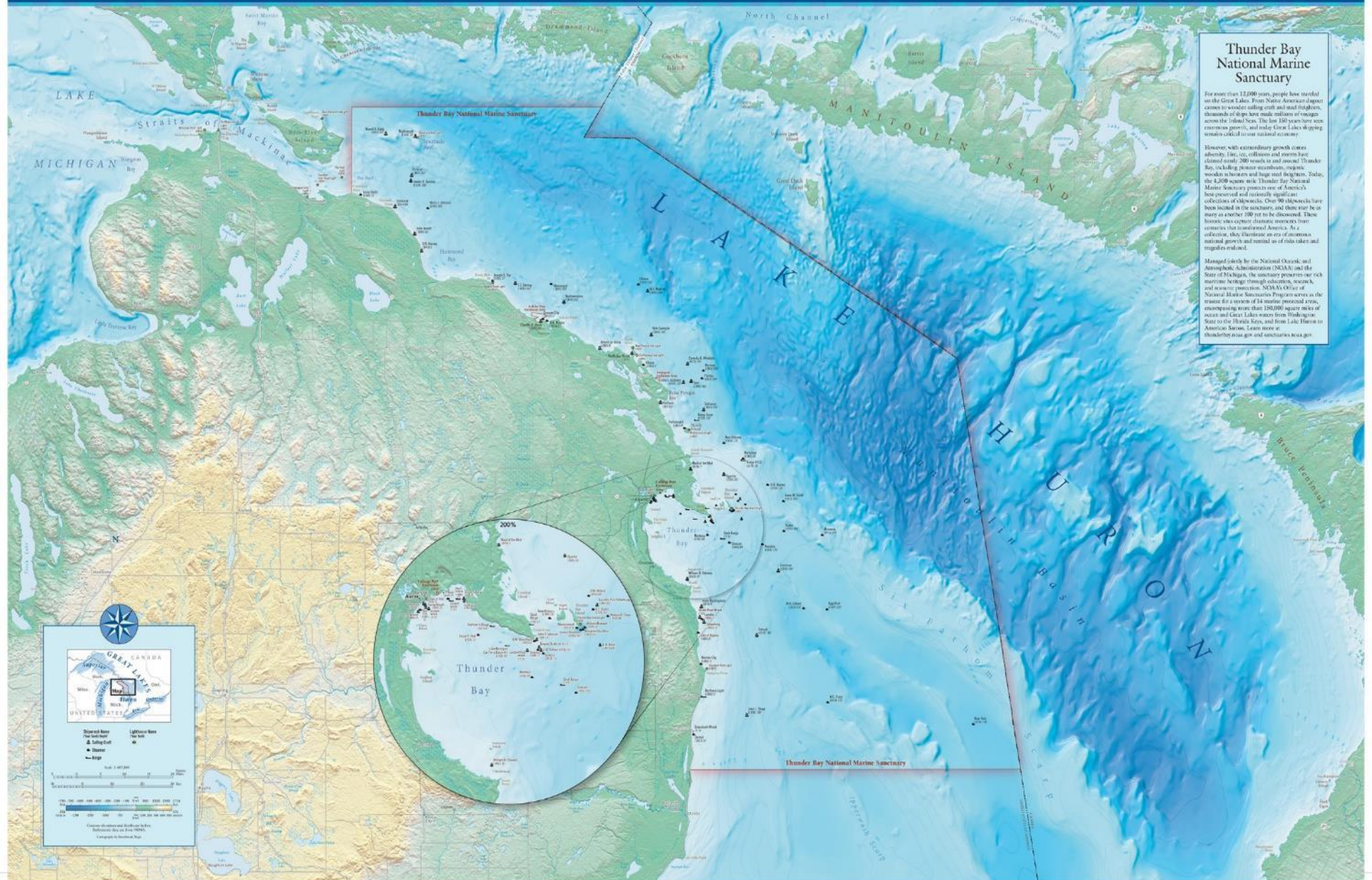
An image made from sound,  
as the illuminating source



# THUNDER BAY NATIONAL MARINE SANCTUARY



Sanctuary Office &  
Great Lakes Maritime Heritage Center  
190 West Washtenaw  
Alpena, Michigan 49717  
616.534.8300  
www.thunderbay.nmra.gov



## Thunder Bay National Marine Sanctuary

For more than 12,000 years, people have traveled on the Great Lakes. From Native American dugout canoes to wooden sailing craft and steel freighters, thousands of ships have made millions of voyages across the inland seas. The last 150 years have seen tremendous growth, and today Great Lakes shipping remains critical to our national economy.

However, with extraordinary growth comes adversity. Over the centuries and more recently, storms have claimed nearly 200 vessels in and around Thunder Bay, including private recreational yachts, wooden schooners and huge steel freighters. Today, the 4,200 square mile Thunder Bay National Marine Sanctuary protects one of America's best preserved and culturally significant collections of shipwrecks. Over 90 shipwrecks have been located in the sanctuary, and there may be as many as another 100 yet to be discovered. These historic sites capture dramatic moments from centuries that transformed America. As a collection, they illuminate an era of enormous national growth and remind us of risks taken and rewards endured.

Managed jointly by the National Oceanic and Atmospheric Administration (NOAA) and the State of Michigan, the sanctuary preserves our rich maritime heritage through education, research, and accurate preservation. NOAA's Office of National Marine Sanctuaries Program serves as the trustee for a system of 14 marine protected areas, encompassing more than 130,000 square miles of ocean and Great Lakes waters from Washington State to the Florida Keys, and from Lake Huron to American Samoa. Learn more at [thunderbay.nmra.gov](http://thunderbay.nmra.gov) and [sanctuaries.noaa.gov](http://sanctuaries.noaa.gov)







Phase I: Over-Water UAS Survey (April)

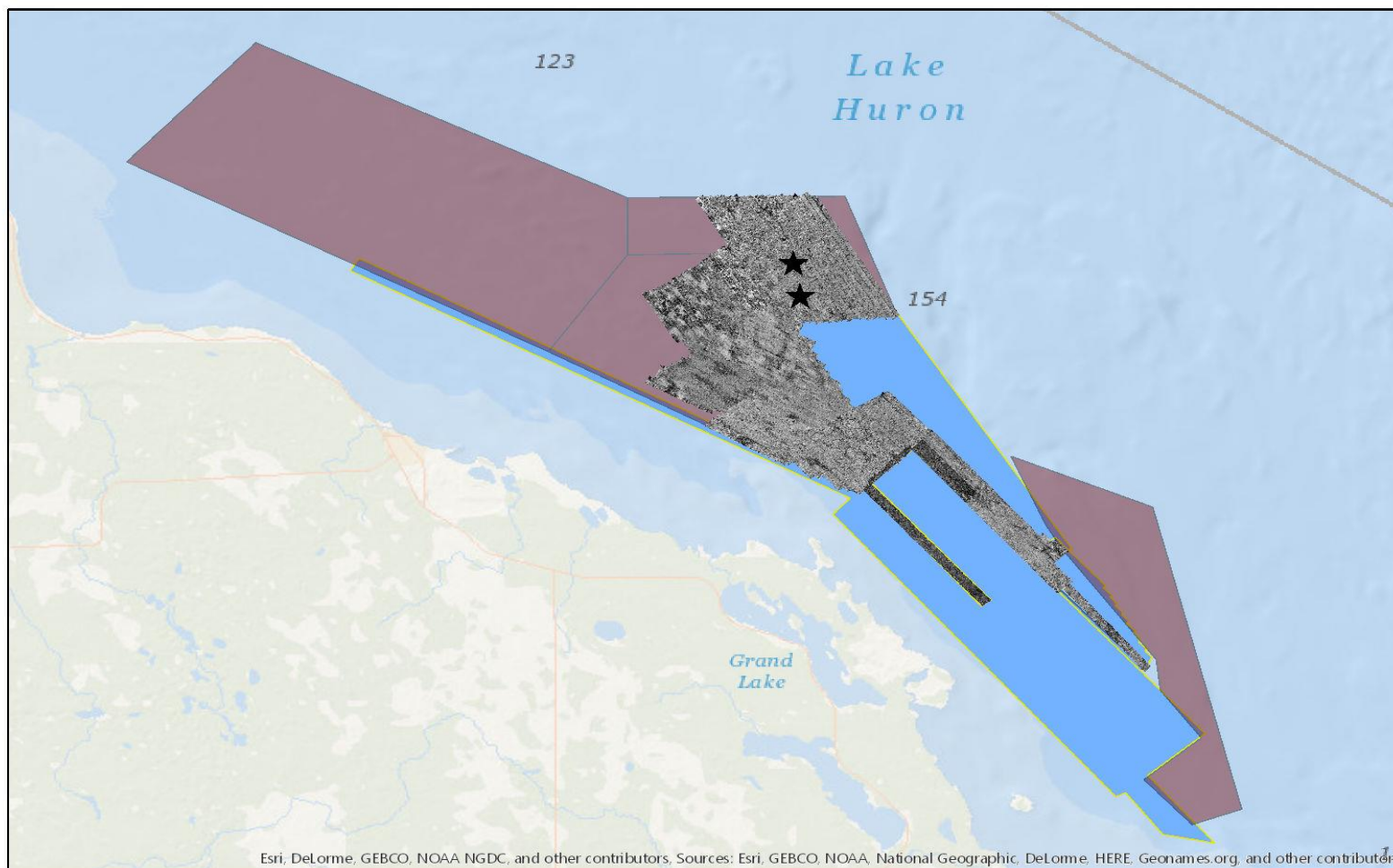
Phase II: Exploratory Sonar Survey (May)

Phase III: Targeted Acoustic Survey via AUV (June)

Phase IV: Diving Operations for Photogrammetric Modeling (July)

Follow-Up Investigation: ROV Mission to Newly Discovered Sites (August)

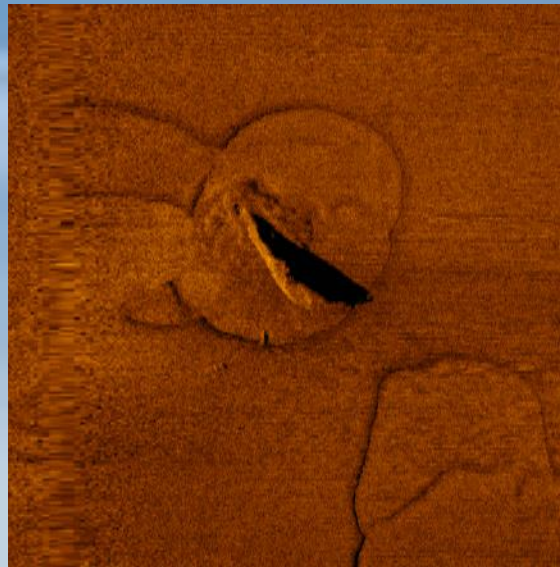
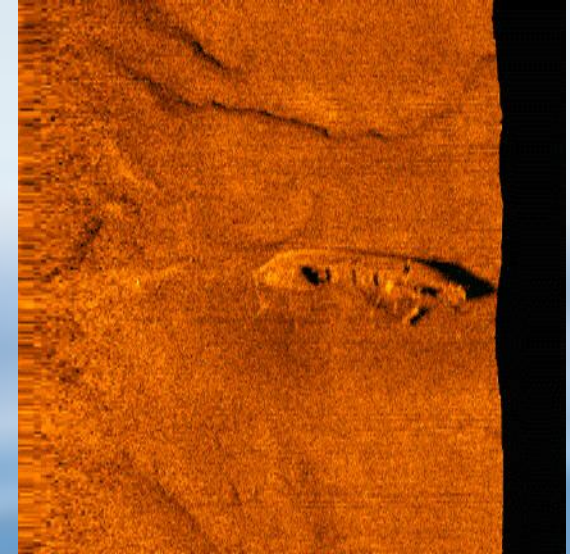
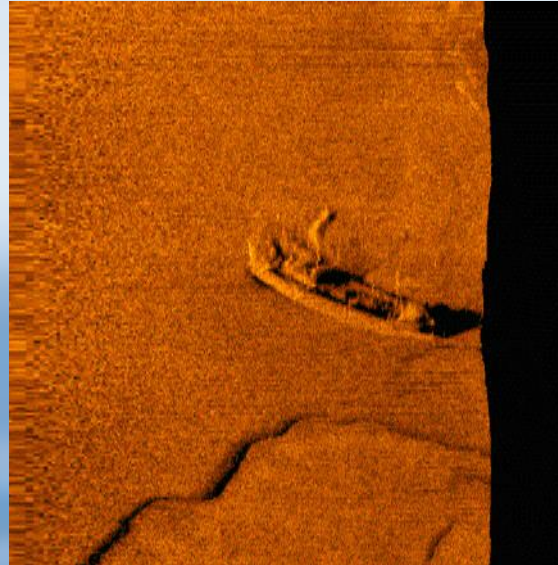
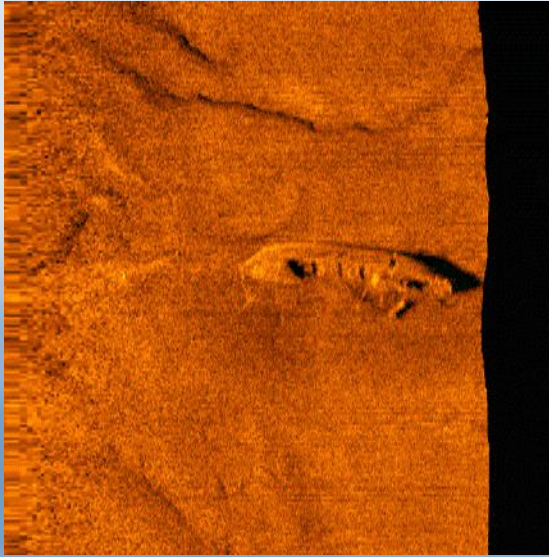
## Area Covered During 2017 Field Operations Nintey-Four Square Miles of Lake Floor Mapped in Six Days



0 2.5 5 10 15 20 Miles

0 3 6 12 18 24 Kilometers

## THUNDER BAY NATIONAL MARINE SANCTUARY

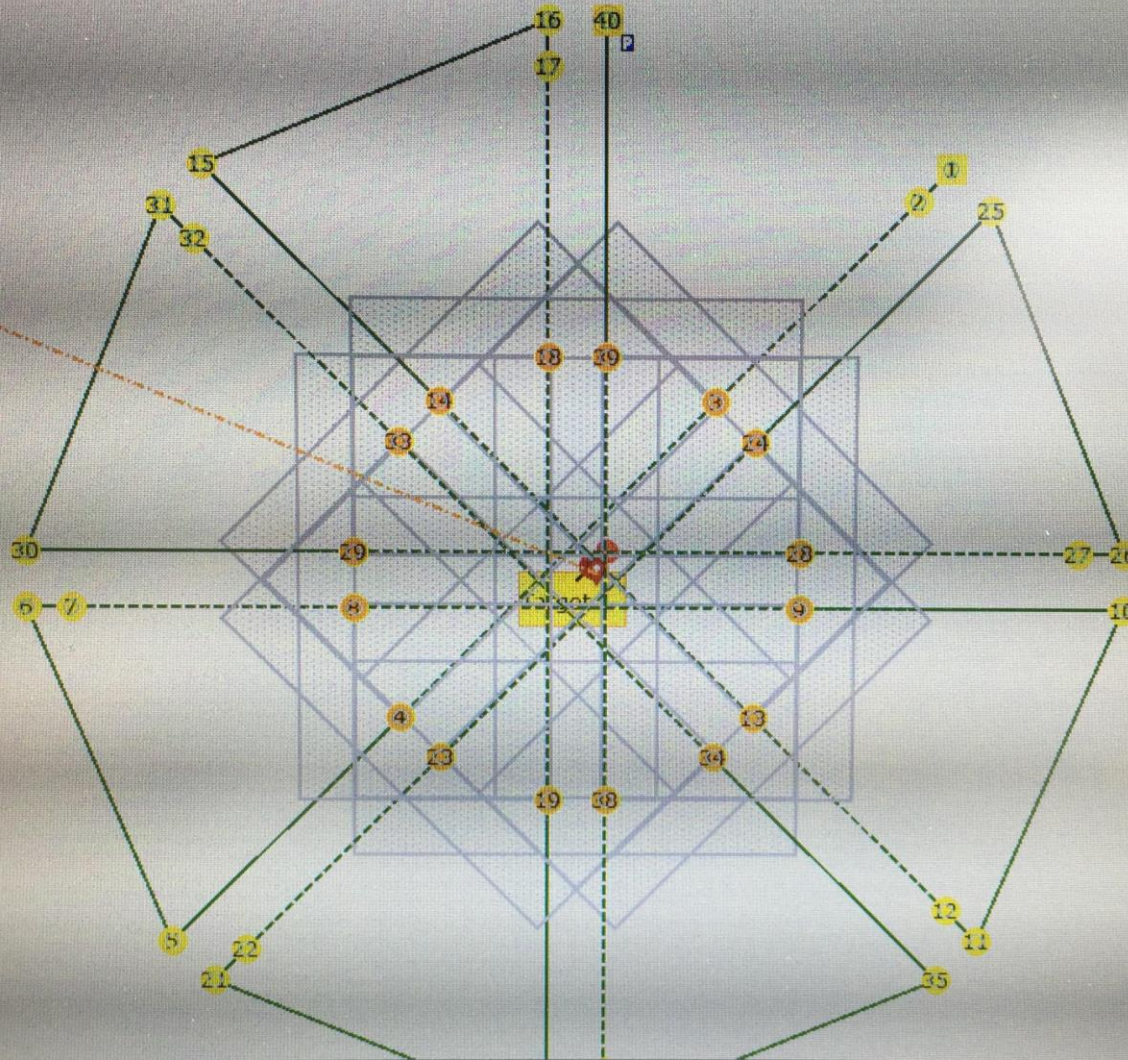


## Phase III: Target Survey with AUV



# Target Identification Pattern

## 16 "looks" at the target



Acom/Rac

- Com  
Serial  
Baud

- Track  
 Enable  
Update P  
 Time  
 Distanc

- Track  
 Enable  
Waypoint  
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Heading:

- Position  
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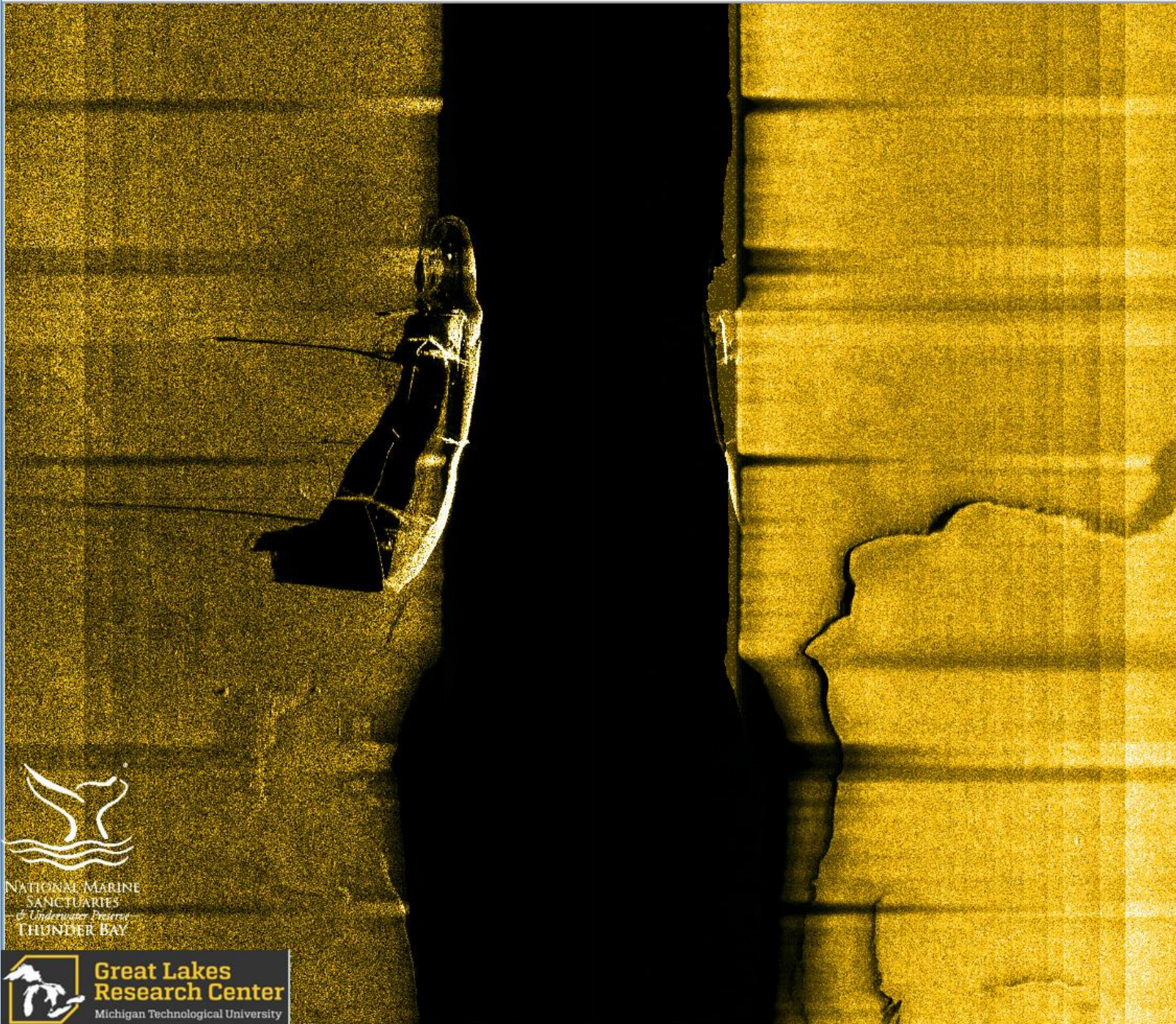
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\$GPGSA,M,3.0  
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INTERNATIONAL MARINE  
ASSOCIATION OF FISHERIES  
21, Boulevard de la  
TERRASSE, RAY

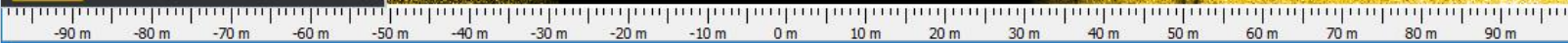


**Great Lakes  
Research Center**  
Michigan Technological University



  
NATIONAL MARINE  
SANCTUARIES  
*Underwater Preserve*  
THUNDER BAY

  
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**S  
Center**  
University

## THUNDER BAY NATIONAL MARINE SANCTUARY

### Ohio

Length: 202 ft

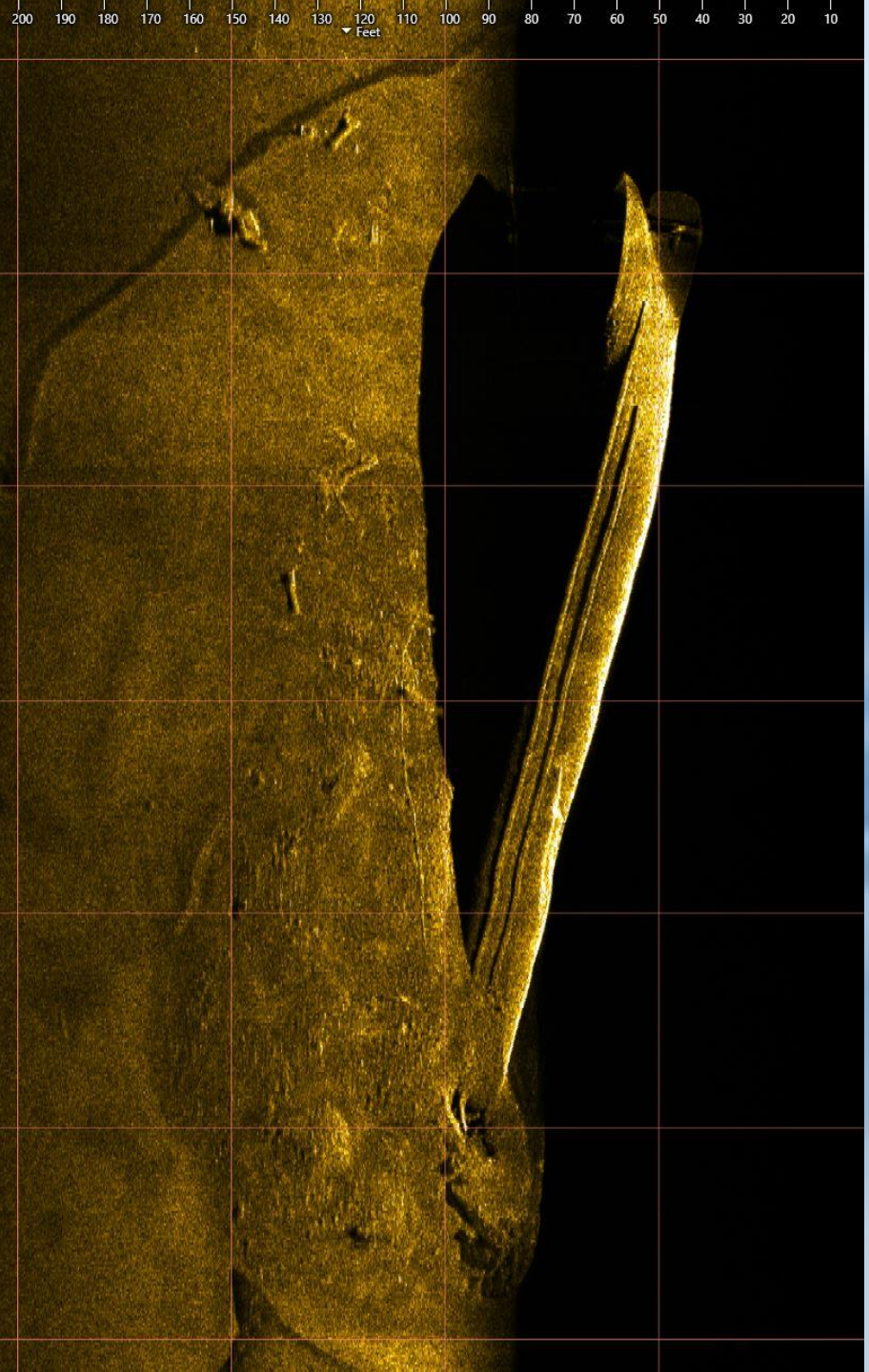
Width: 35 ft

Built: 1873, John F. Squires

Lost: 1894, collision off  
Presque Isle, MI.

Design: Wooden Bulk  
Carrier

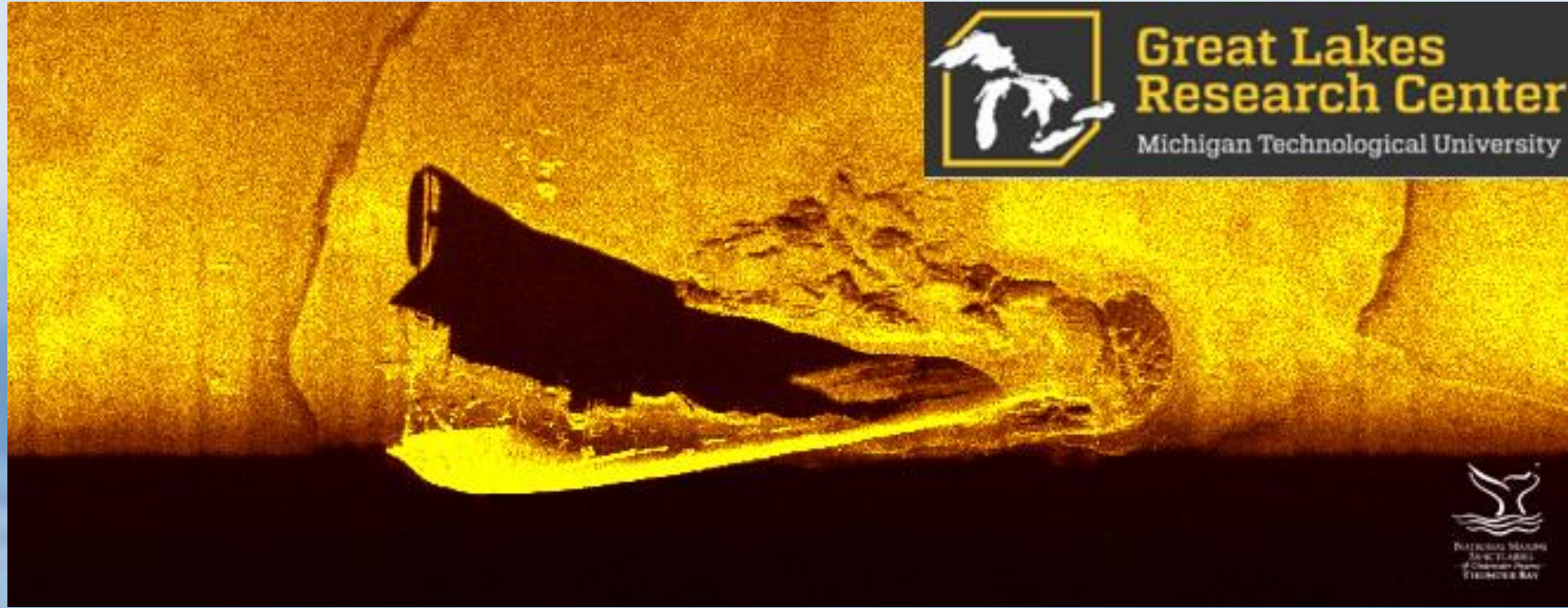






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Research Center**

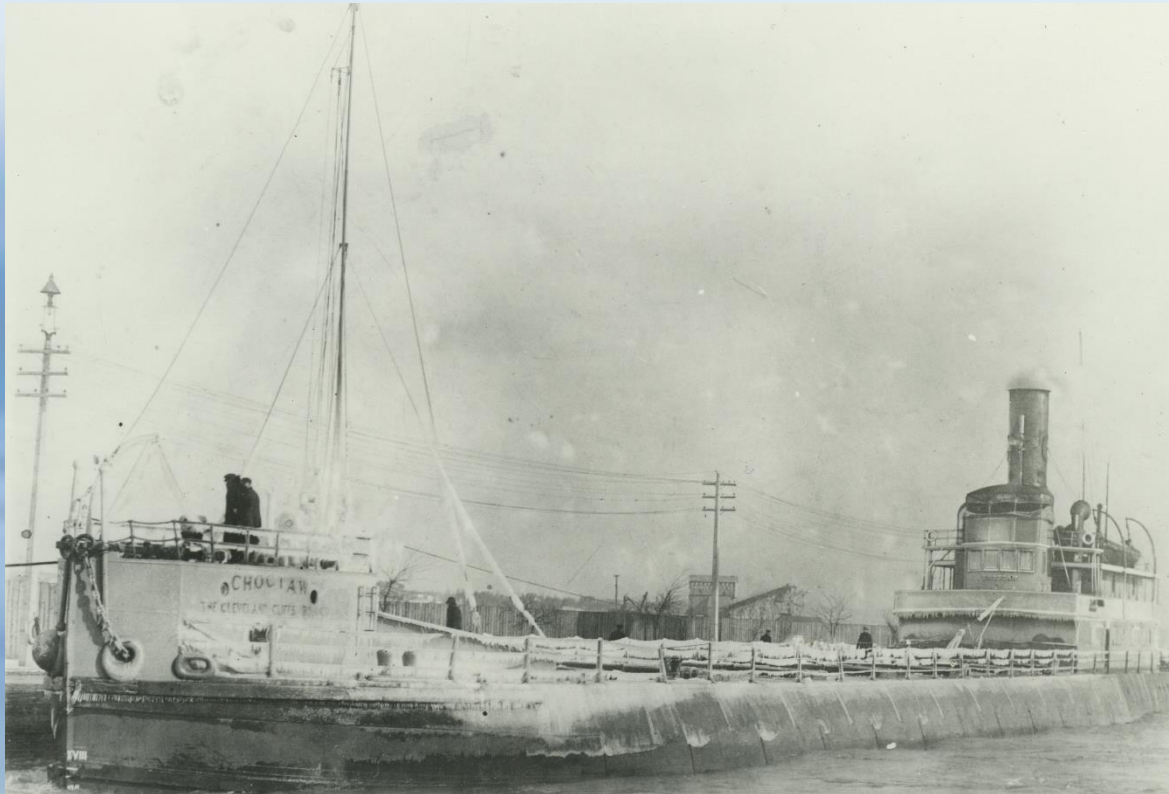
Michigan Technological University



**Great Lakes  
Research Center**

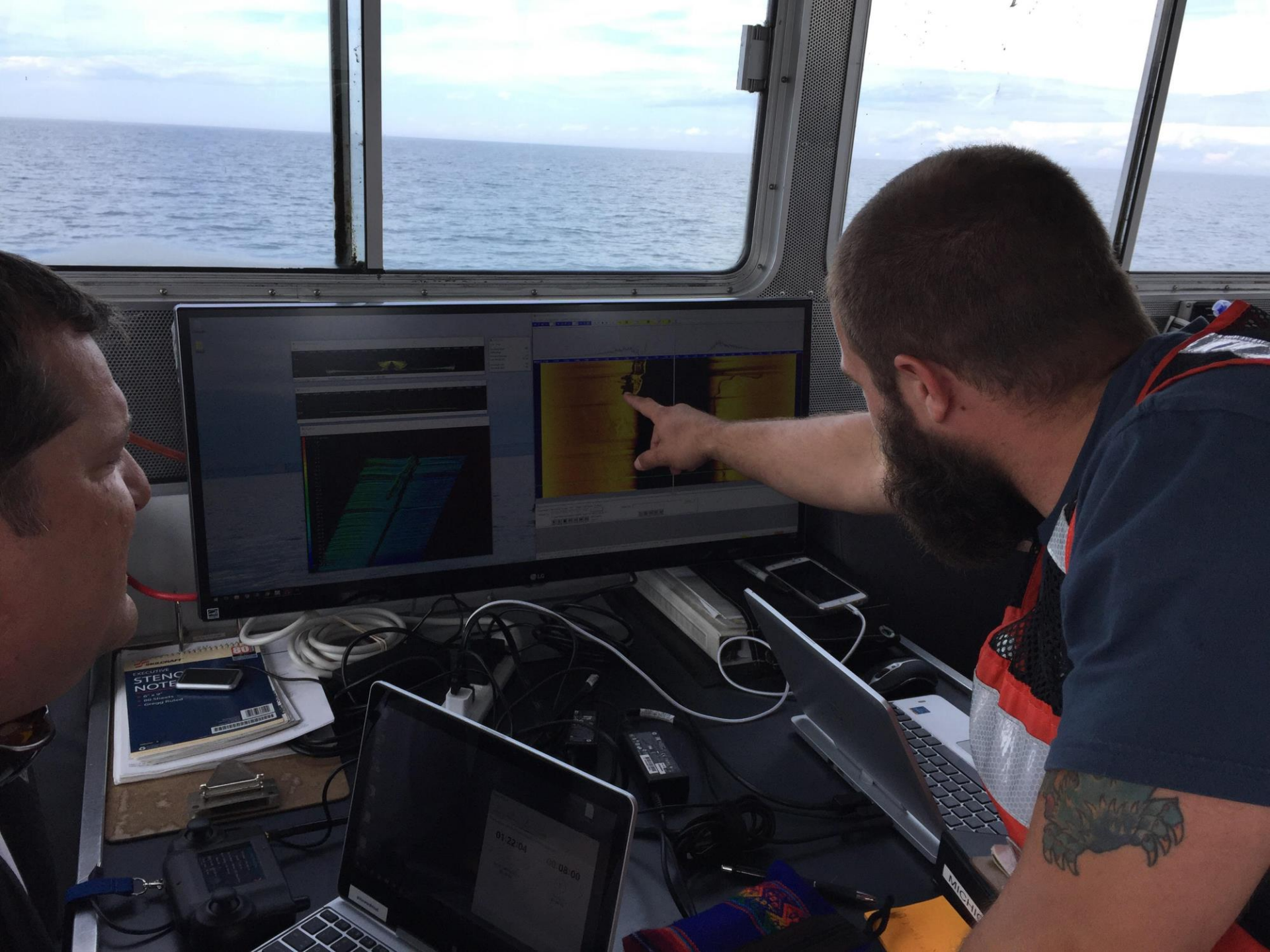
Michigan Technological University

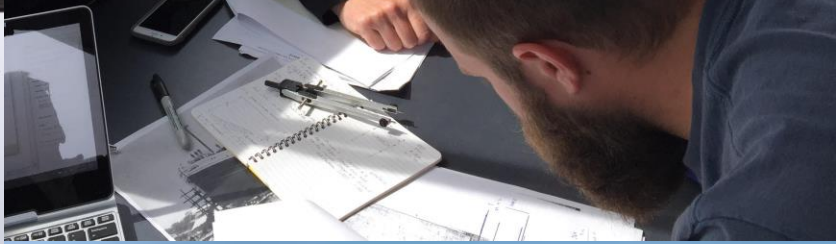
## Choctaw



Length: 267 ft  
Width: 38 ft  
Built: 1892, Cleveland  
Shipbuilding Company  
Lost: 1915, collision off  
Presque Isle, MI.

Design: Bulk Carrier  
Semi-Whaleback  
Straight-back  
Monitor-Style





## THUNDER BAY NATIONAL MARINE SANCTUARY



### John J. Audubon

Depth: 170 ft

Length: 148 ft

Width: 26 ft

Built: 1854

Lost: 1854, collision

Main Features:

Masts/Rigging

Rail Iron

Design: Canal Schooner



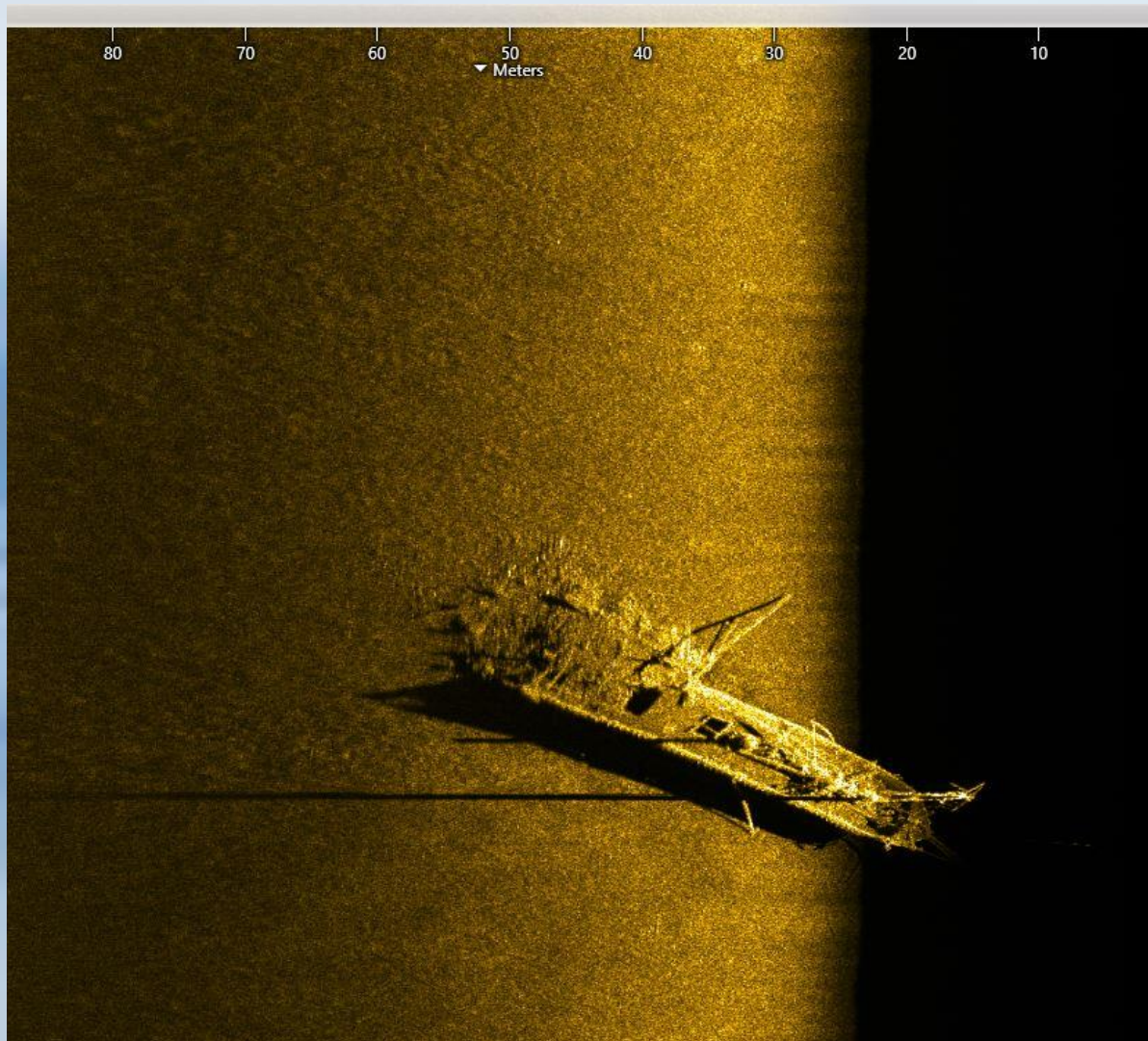
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## THUNDER BAY NATIONAL MARINE SANCTUARY



### Typo

Depth: 160 ft

Length: 137 ft

Width: 26 ft

Built: 1873

Lost: 1899, collision

Main Features:

Fore Mast Upright

Rigging

Smashed Stern

Coal



80

70

60

50  
▼ Meters

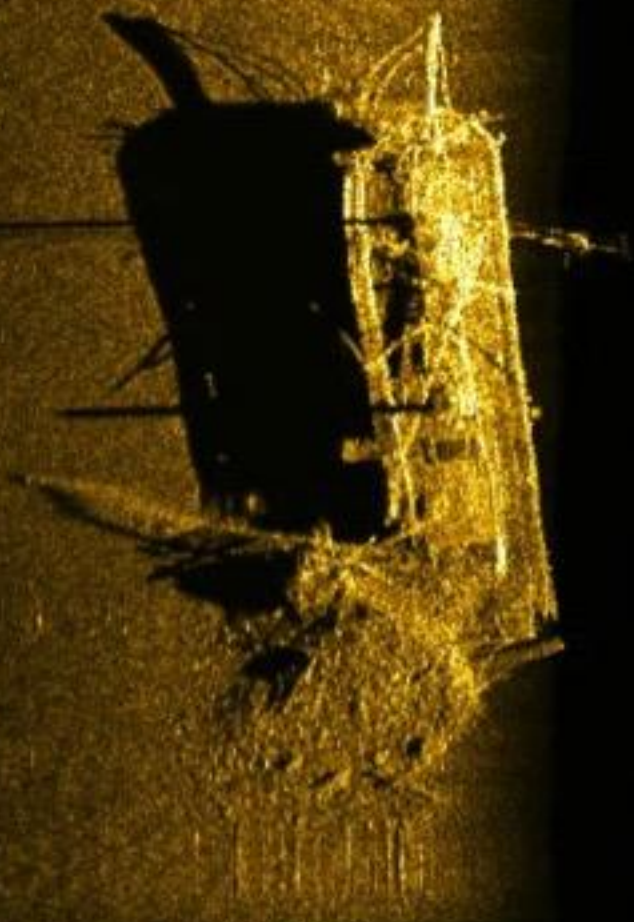
40

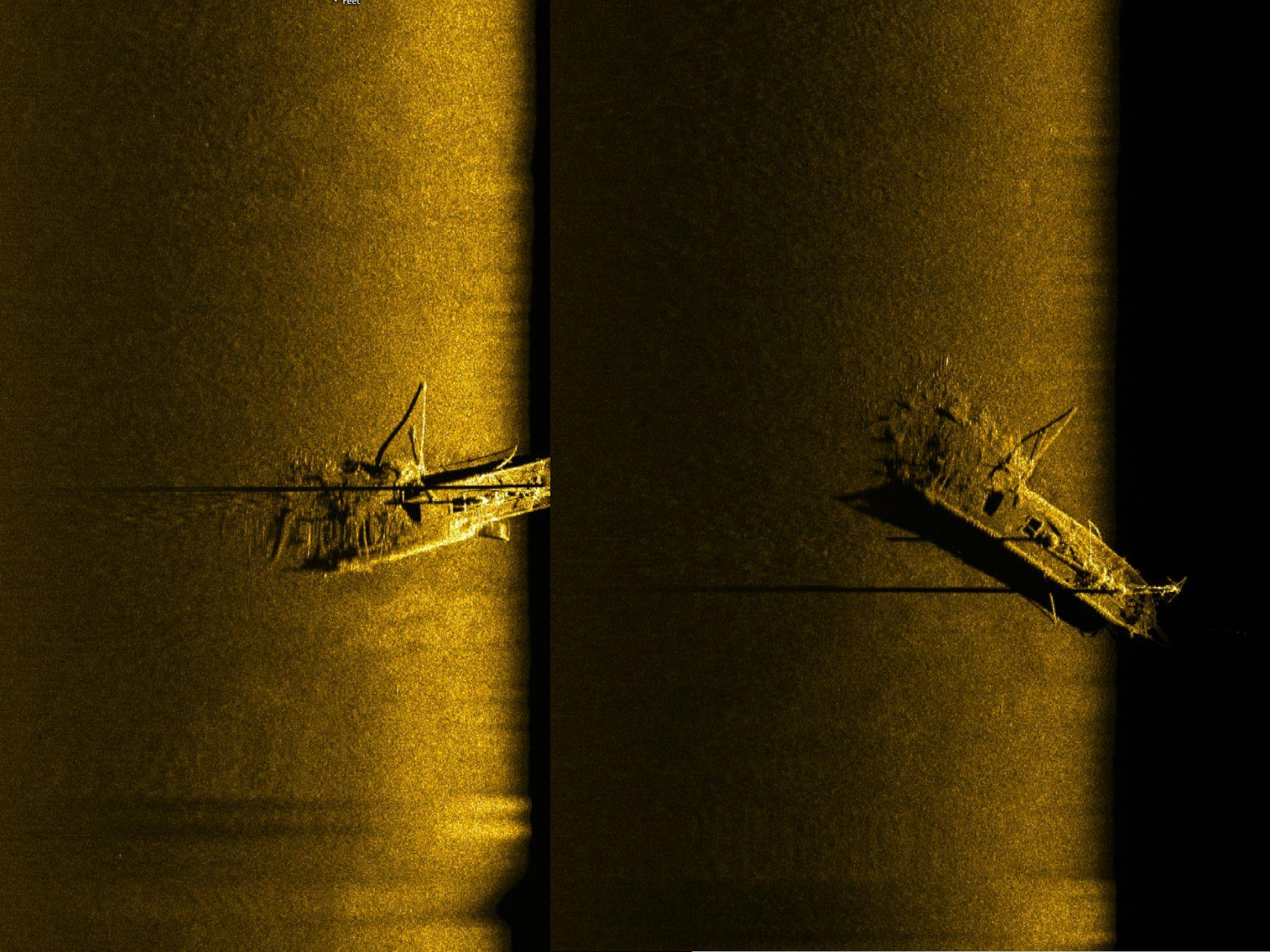
30

20

10

0







## Norman

Depth: 205 ft

Length: 296 ft

Width: 40 ft

Built: 1890

Lost: 1895, collision

Main Features:

Masts/Rigging

Rail Iron

Yawl Boat

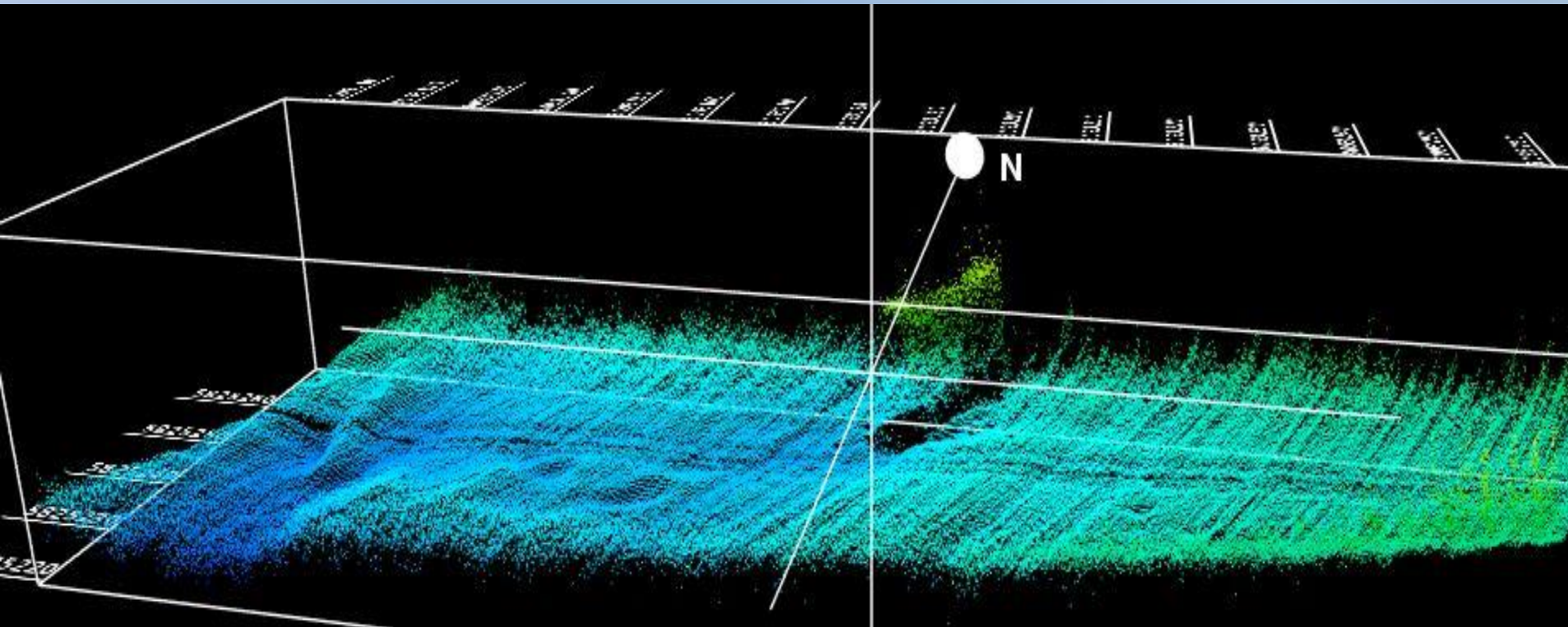
Design: Steel Bulk Carrier



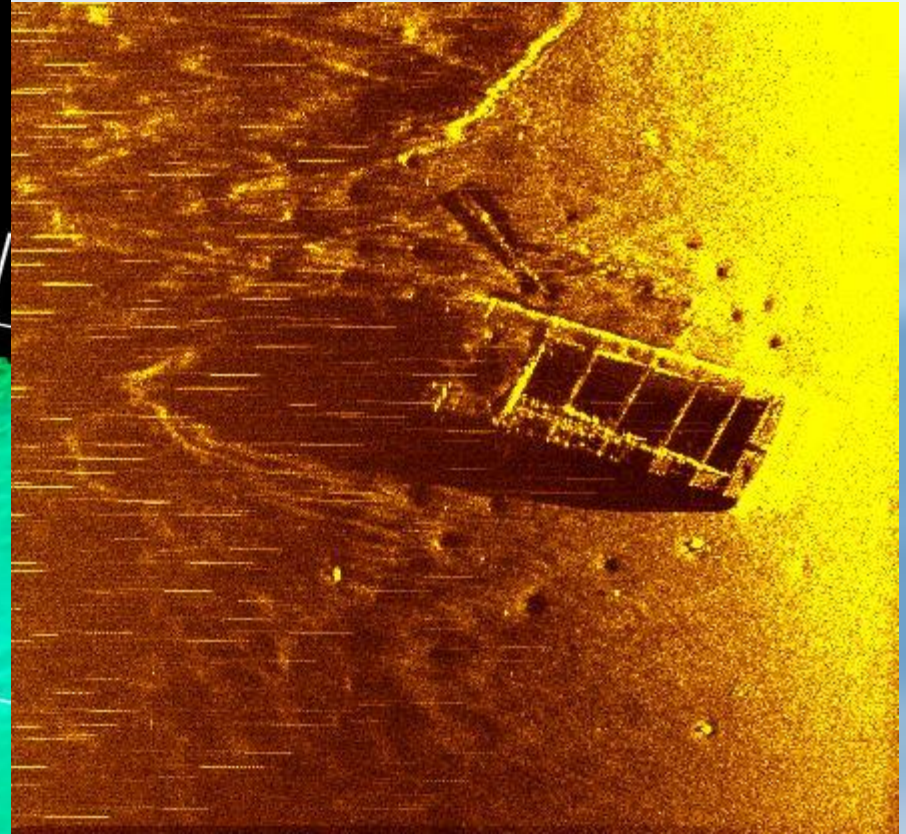
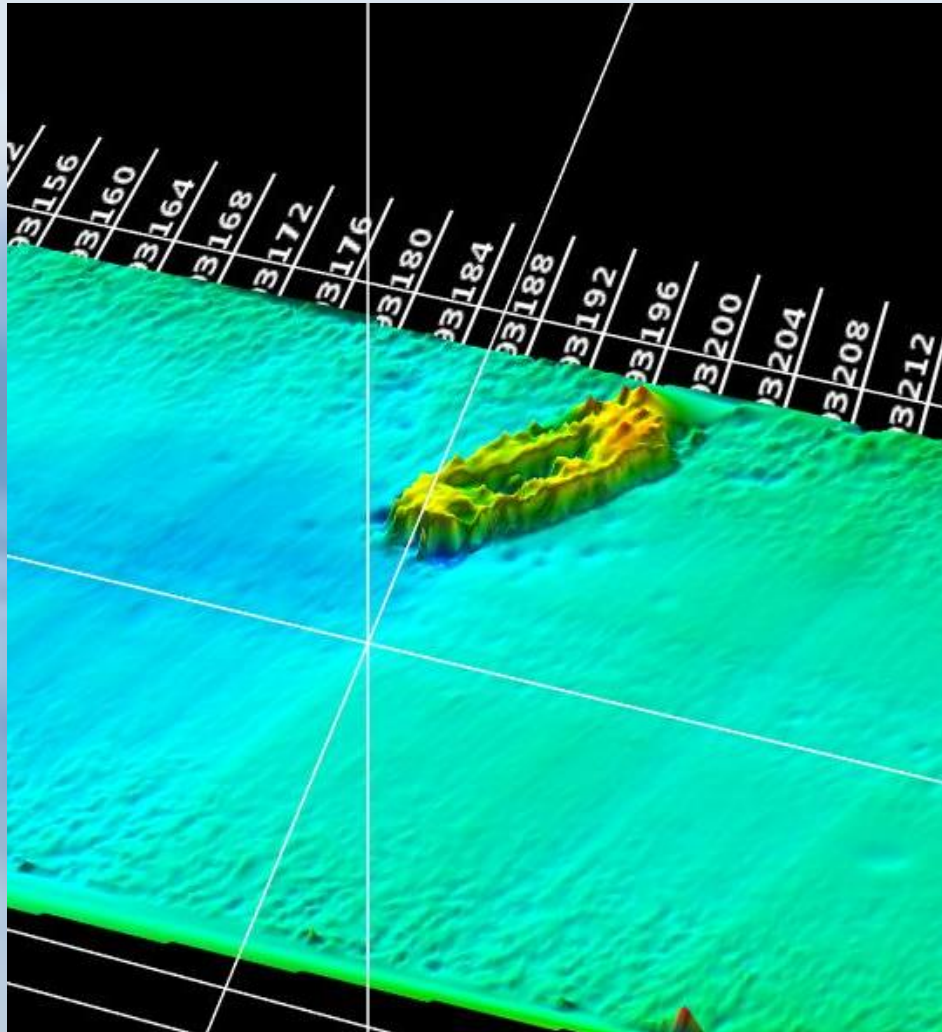
Where do we go from here ?

# Three-Dimensional

- 3-D Bathymetry
- Every point in the cloud –  $(x,y,z)$  coordinates



# Sunk Wood Barge – late 1800's

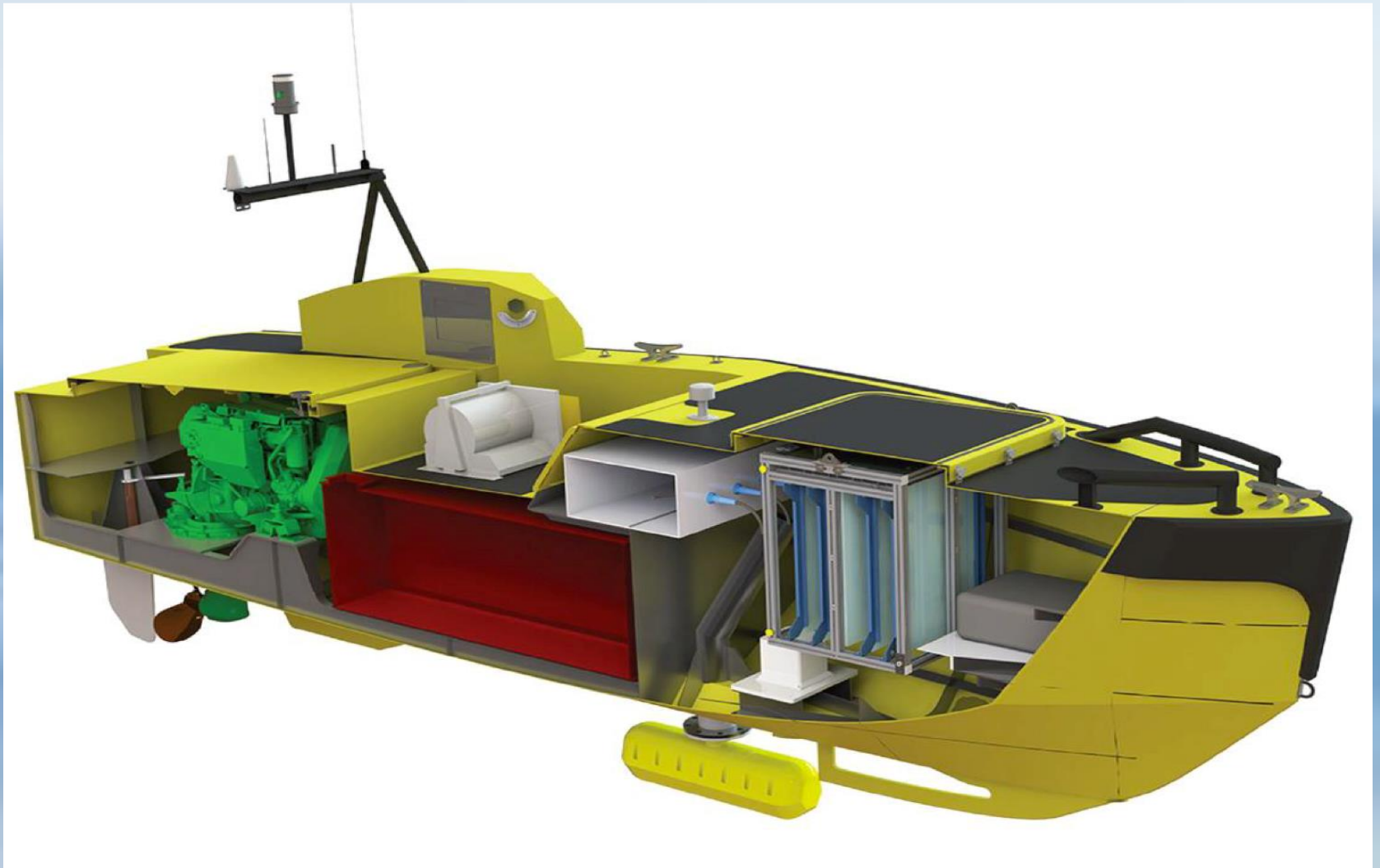


# ASV Global C-Worker 5



- Length X Beam X Draft: (5.5 m X 1.7m X 0.9m)
- Weight = 1900 kg
- Propulsion: Direct Drive Diesel: 57 hp
- Endurance: Up to 5 Days at 7 kts

# C-Worker 5





# Thank You!

## Questions ?



Photo courtesy of FTC&H

