



# Mapping the World's Oceans

(with a focus on the Atlantic Ocean)



With  
(Rear Admiral Retired)  
**Simon Hardern**



# 100 Years Ago This Week





# Make the Sea Measurable and you Make the World Reachable



*'The surveyor's pencil is the navigator's best friend'*

Rear Admiral Francis Beaufort  
Hydrographer of the Royal Navy (1829–1855)  
and Inventor of the Beaufort (Wind/Sea State) Scale





# The Strategic Landscape



# Our Oceans are Big!



About 71% of the world's surface is covered in water; **95% of that is in our oceans**

**Only 28% of the World's oceans are surveyed to modern standards with modern sonar** (or an area about five times the size of South America)

**Only 5% of the seabed has been explored from a topographic perspective**



# Illustration of Resolution



## Earth Surface



Mapped to  
30 cm per pixel



## Moon Surface



Mapped to  
10 m per pixel



## Mars Surface



Mapped to  
20 m per pixel



## Earth Ocean Seabed



Mapped to  
4,000 m per pixel





# Strategically Important ... Above

Global Trade, Population and Prosperity Depend on Maritime Routes



## Humanity is Concentrated

95% on 5% of land, mostly along coasts



## The World Moves by Sea

About 80 % of global trade (by volume) is moved by ship



## A Global Lifeline

70% by value depends on shipping networks

## Oceans Power the Global Economy

 **3 billion**  
livihoods

 **4.3 million**  
port calls / year

 **11 billion**  
tons of cargo / year

About 119,000 ship over 1,000 tonnes, 3,750 cruise/passenger ships, 4.9 million fishing vessels and about 30 million private boats



# Strategically Important ... Above



It is said that half of the world would starve without ships to move our food

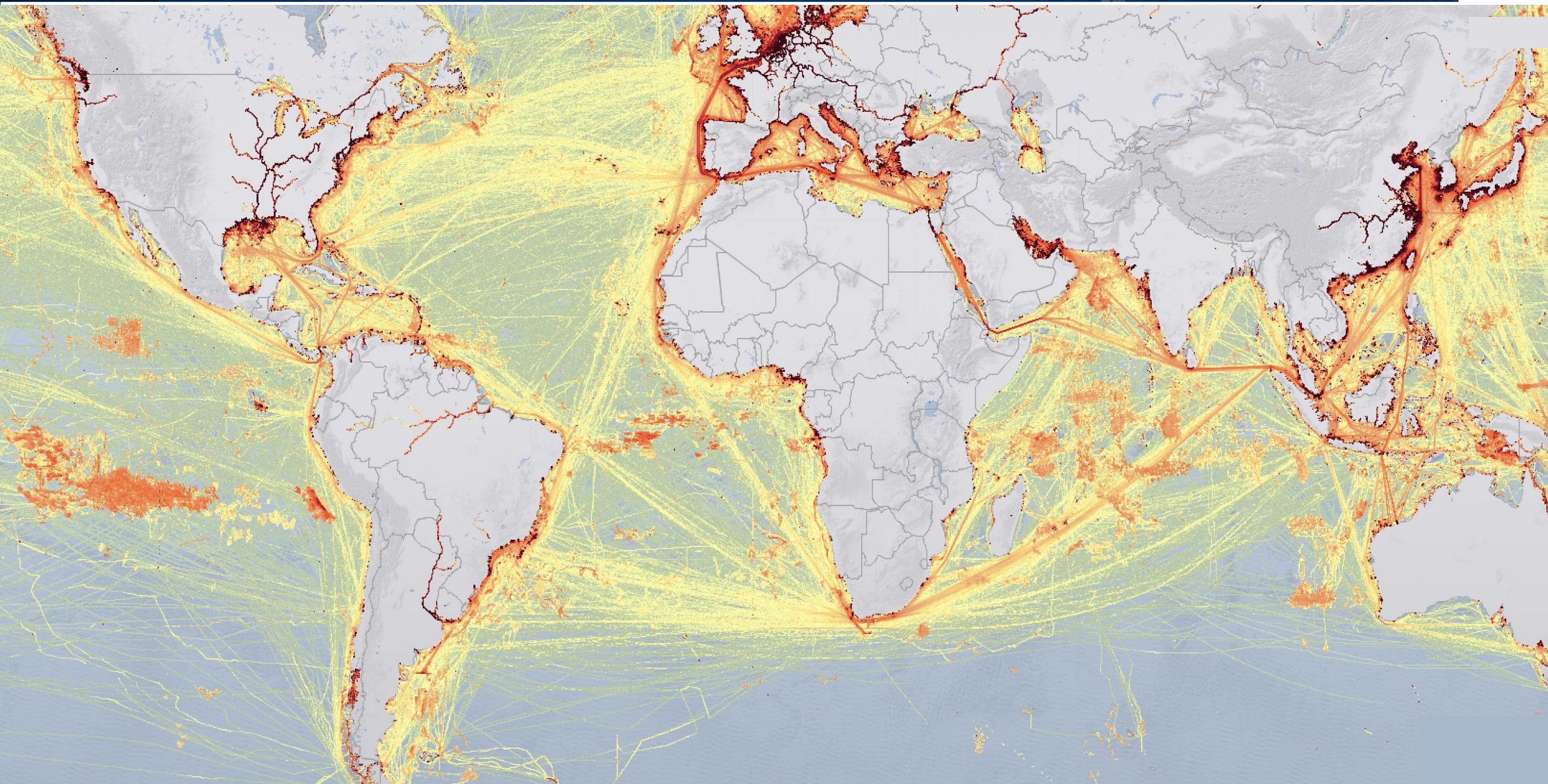
... and that the other half would perish without the oil to heat our homes

For the UK, as an island nation, in the 1960s the 'four weeks to starvation' figure was a genuine Cold War-era vulnerability assessment that circulated in official and public discourse

**Ships don't just carry cargo - they carry stability**  
**Take them away, and the global system starts to come apart surprisingly fast**



# The Oceans Connect Our World Above



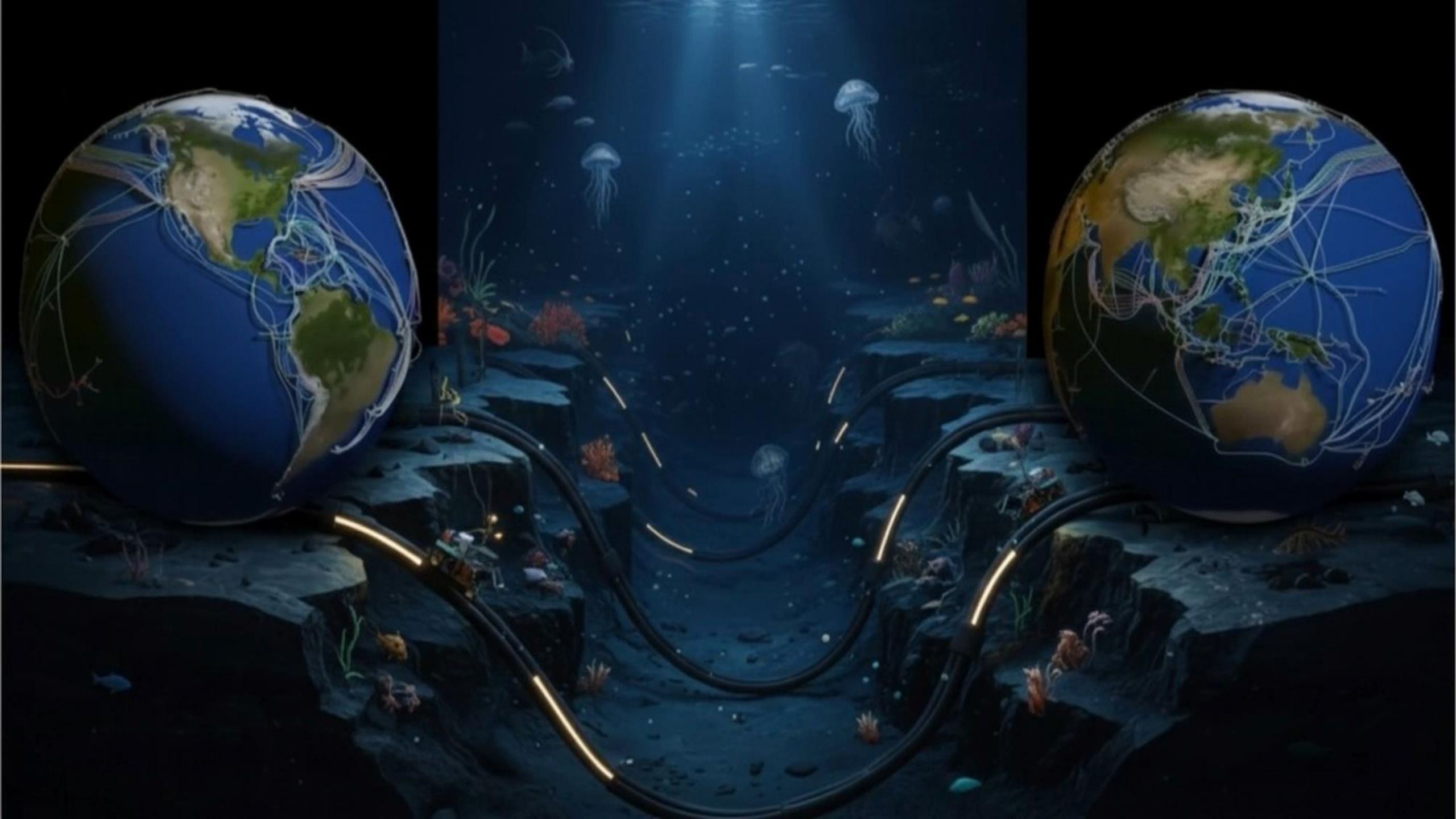




# ... and Below



- **More than 95%** of data is carried around the world in (**nearly a million miles of**) **fibre optic cables**, carrying terabytes per second rather than megabytes per second by satellite at the speed of light ... important given about **1.7 Mb of data is created per person per second**
- For context: 1.6 million km is roughly four times the distance from the Earth to the Moon, or enough to wrap around the equator 37 times; and **90% of all global data has been created in just the last two years**





# And Still So Much We Do Not Know

USS SAN FRANCISCO hit an uncharted seamount in the Western Pacific Ocean in January 2005



USS CONNECTICUT hit an uncharted seamount in the South China Sea in October 2021

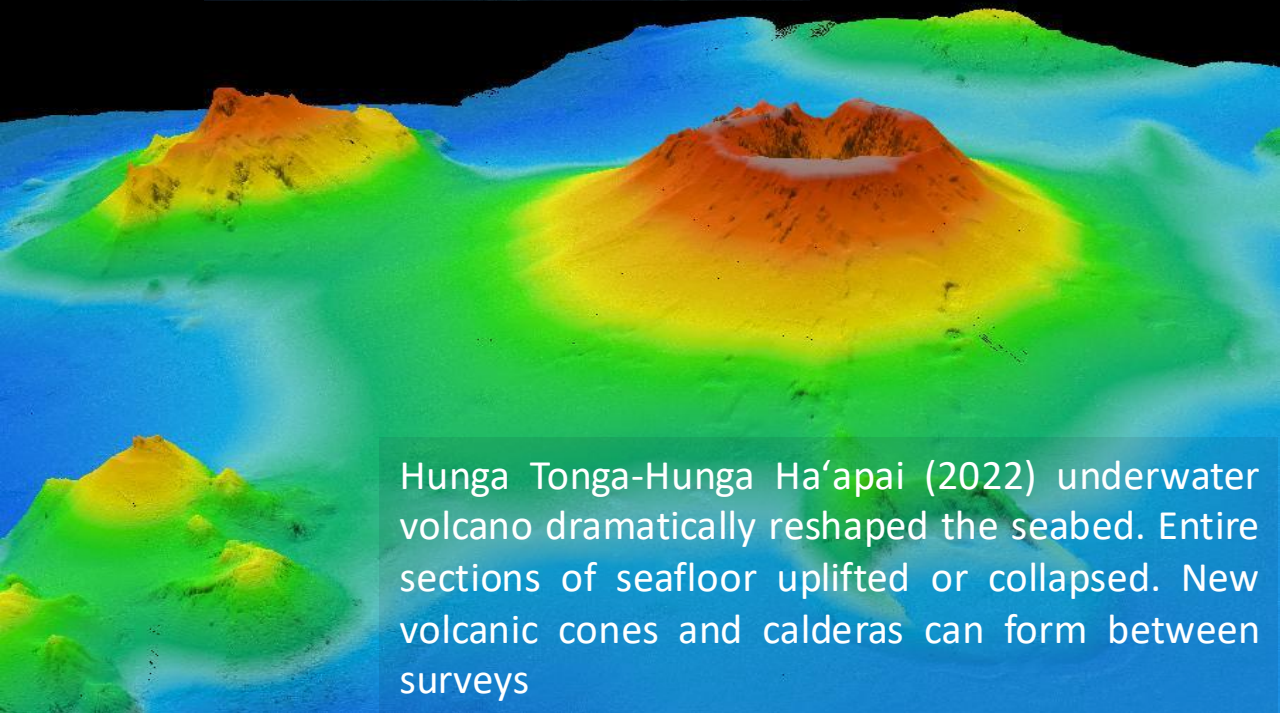
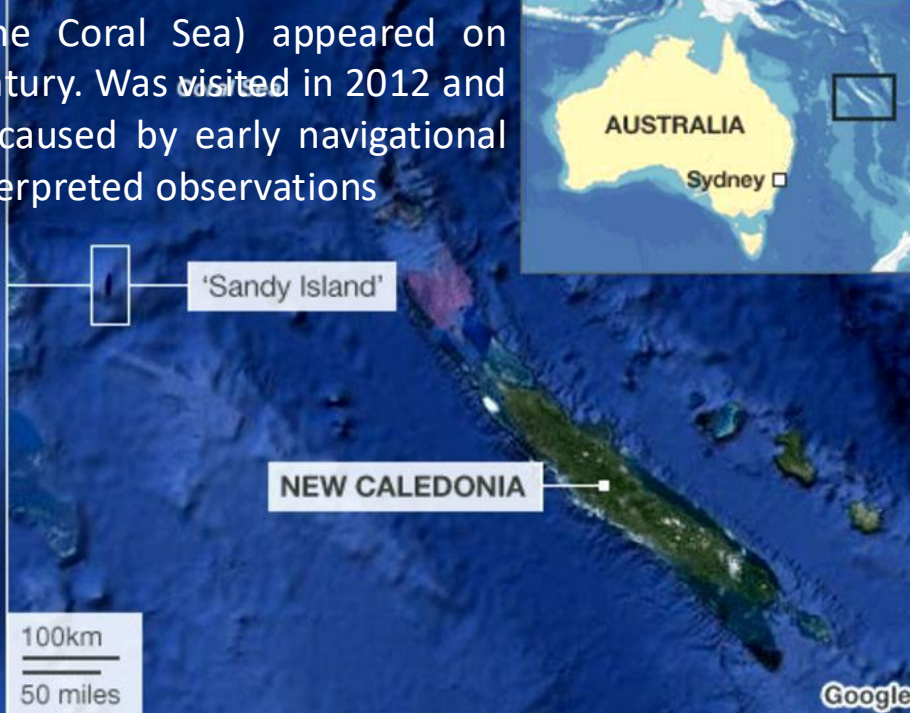


It is estimated that about 100,000 underwater seamounts exist ... but remain uncharted



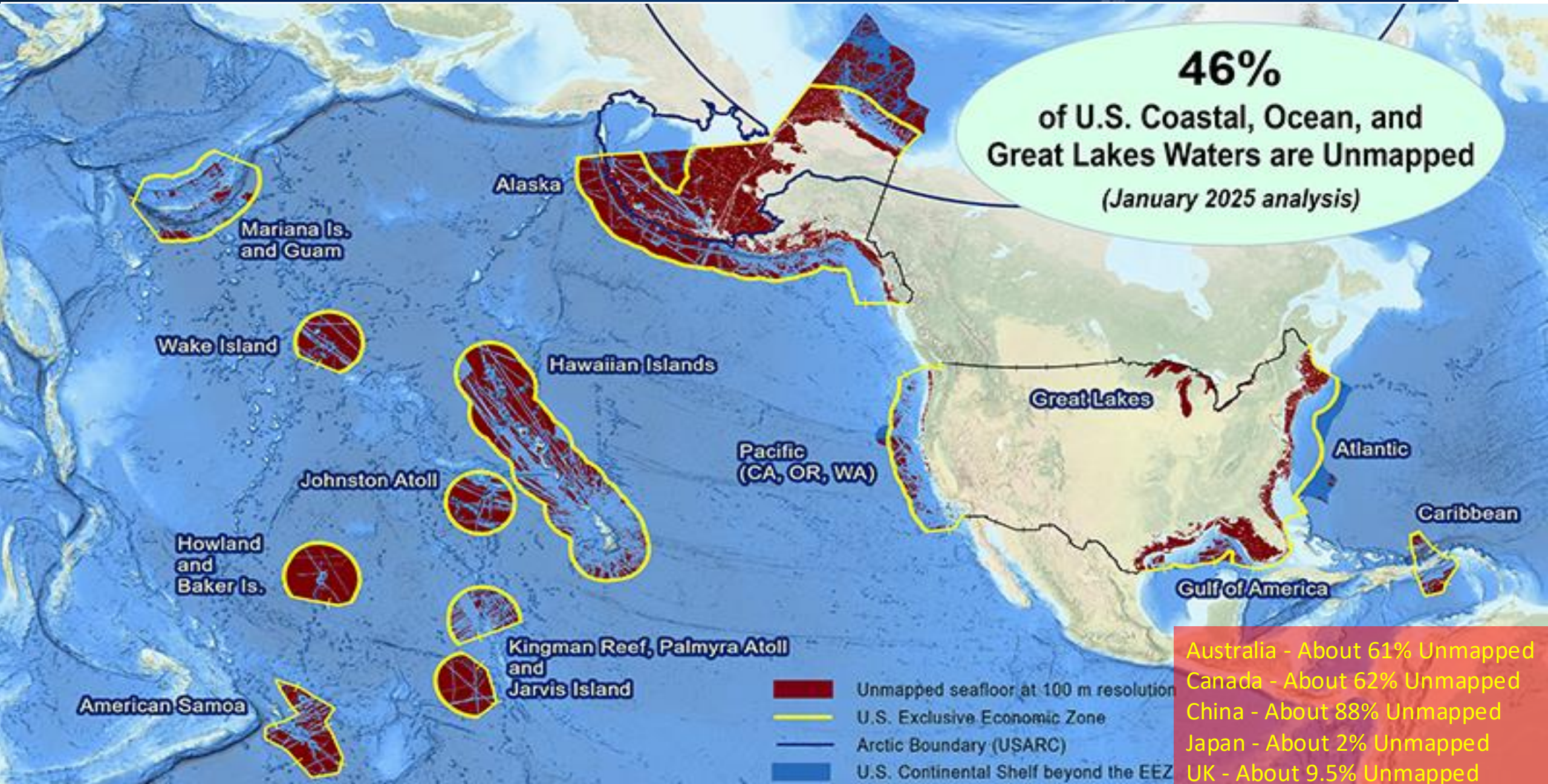
A seamount three times the height of the Burj Khalifa (Dubai) was found off Guatemala in the Pacific in 2023

Sandy Island (in the Coral Sea) appeared on charts for over a century. Was visited in 2012 and didn't exist - likely caused by early navigational errors and/or misinterpreted observations



Hunga Tonga-Hunga Ha'apai (2022) underwater volcano dramatically reshaped the seabed. Entire sections of seafloor uplifted or collapsed. New volcanic cones and calderas can form between surveys

# Modern Survey Analysis of US Waters - January 2025



Australia - About 61% Unmapped  
Canada - About 62% Unmapped  
China - About 88% Unmapped  
Japan - About 2% Unmapped  
UK - About 9.5% Unmapped



# Impact on the Blue Economy



Support Sustainable Development

Drive Maritime Economic Activities



80% of All Animal Life Lives in our Oceans and Seas

# The Caribbean Sea and Atlantic Ocean





# The Caribbean Sea



## Charting Challenges:

- With close to 7,000 islands, accurate charting in the Caribbean isn't just about aesthetics - it's about safety. With coral reefs, unpredictable currents and narrow passages, charts are the difference between smooth sailing and disaster. They also preserve centuries of maritime knowledge, blending history with modern technology
- Mix of volcanic and non-volcanic islands complicates seabed mapping
- The Cayman Trench is one of the deepest parts of the Caribbean
- Seasonal hurricanes frequently disrupt survey and charting operations

## Historical Context:

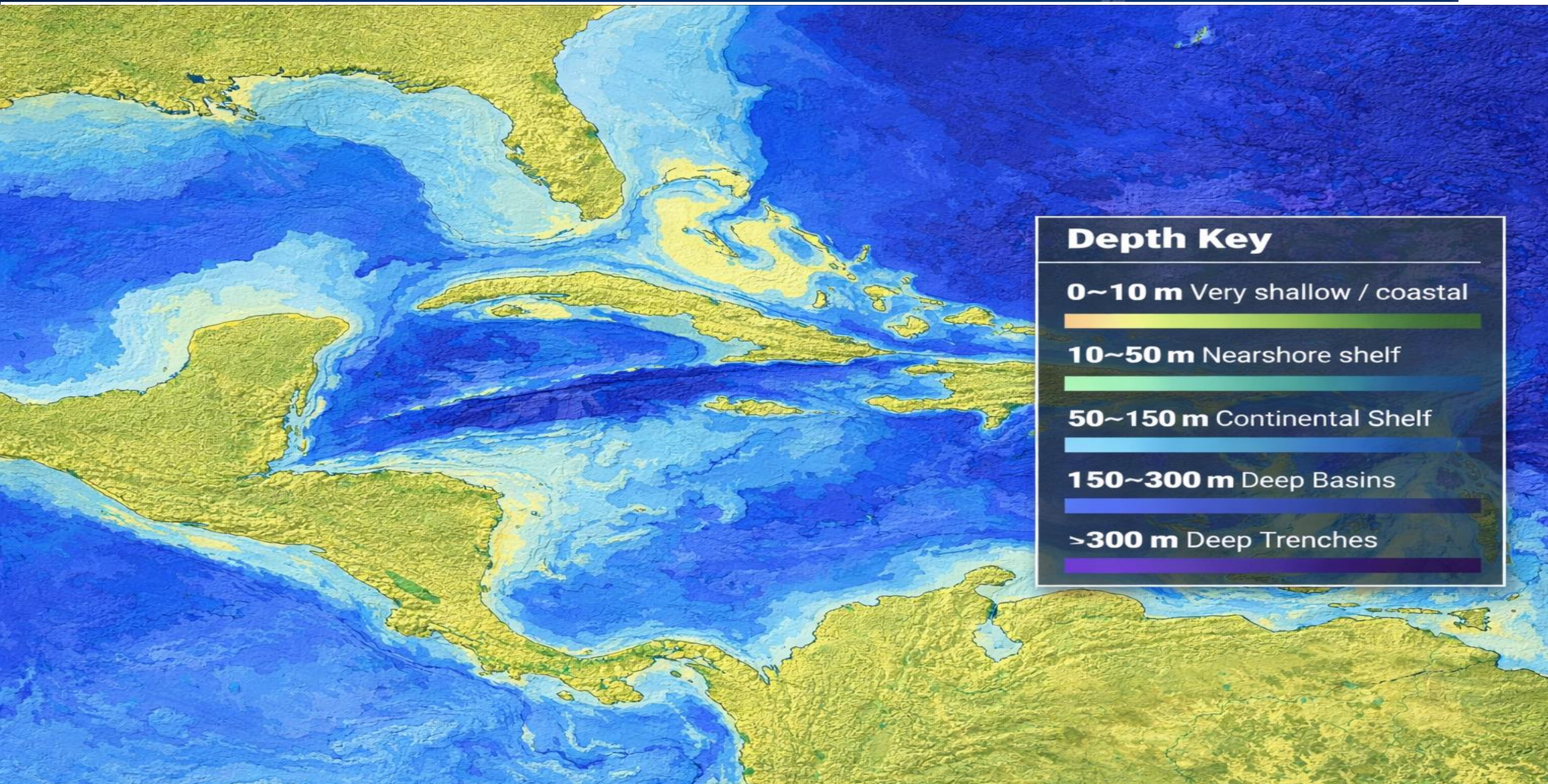
- Early explorers misidentified the region as the 'West Indies'
- The longitude problem made accurate positioning difficult at sea. The Longitude Act of 1714 led to major advances in navigation
- Colonial powers competed to control the region

## Oceanographic Factors:

- The Caribbean Current flows westward and feeds the Gulf Stream, playing a key role in wider Atlantic circulation patterns
- Trade winds drive consistent northeast-to-southwest surface flow
- Warm waters contribute to frequent tropical storm development



# Bathymetric Map of the Caribbean Sea



## Depth Key

**0~10 m** Very shallow / coastal

**10~50 m** Nearshore shelf

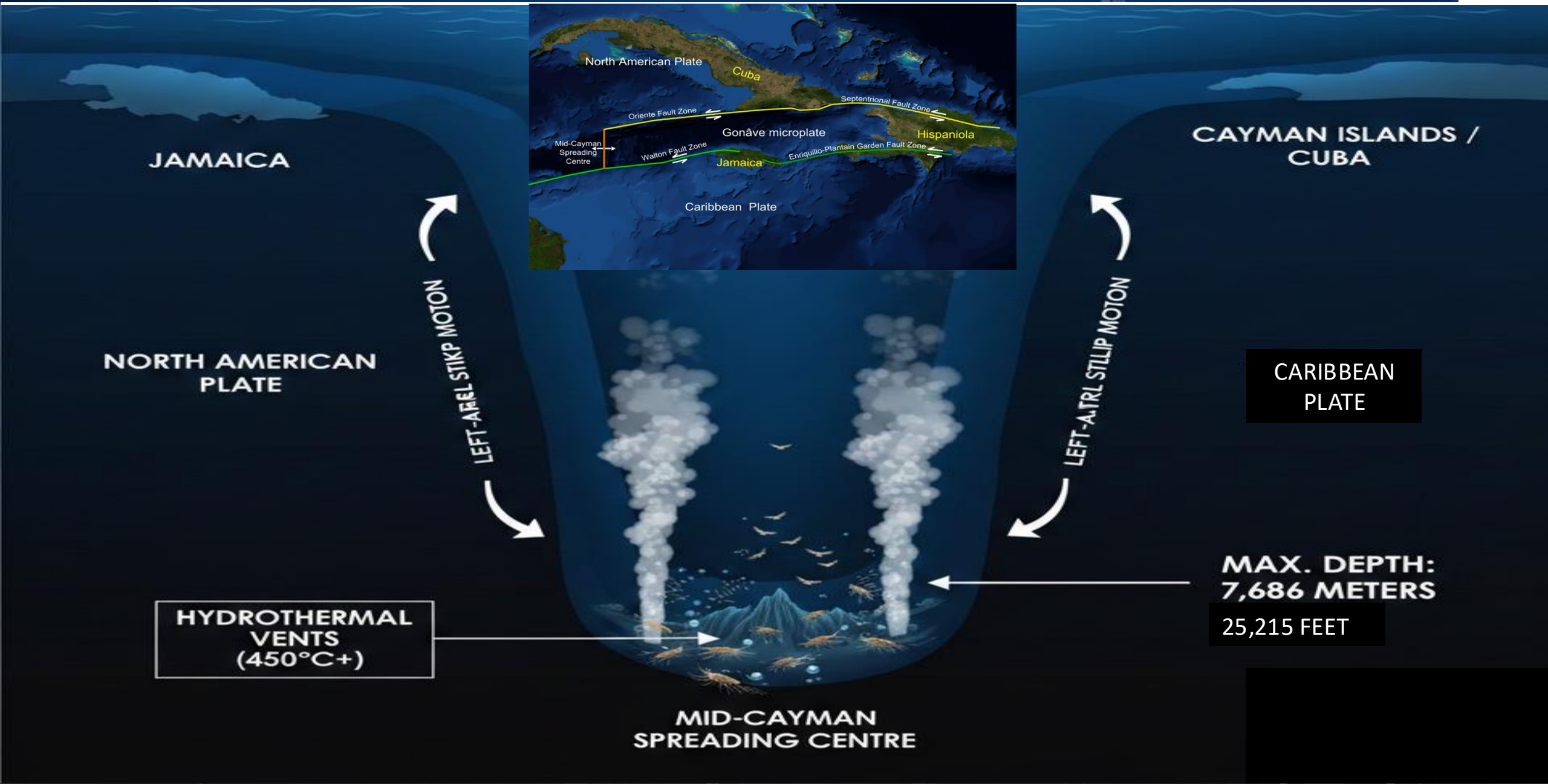
**50~150 m** Continental Shelf

**150~300 m** Deep Basins

**>300 m** Deep Trenches



# Deepest Point (Cayman Trench/Bartlett Deep)





# The Atlantic Ocean - Big Picture

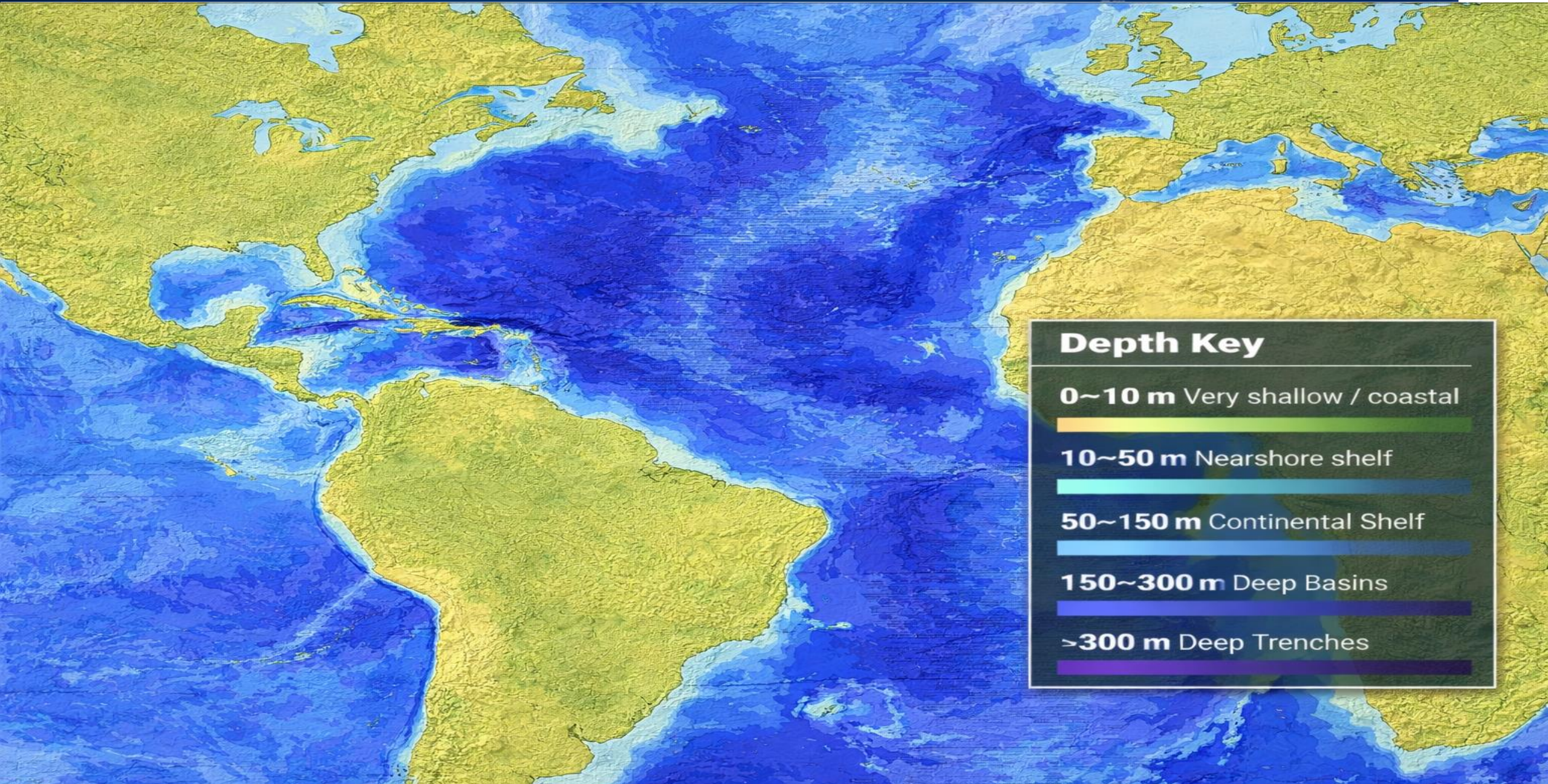


- **The Atlantic** is the **second-largest ocean** (after the Pacific Ocean), covering about **23%** of Earth's surface (the Pacific Ocean covers 46%)
- It acts as the main ocean link between the Americas, Europe and Africa with **some of the World's busiest shipping routes crossing the North Atlantic**
- The ocean is still **widening** as tectonic plates slowly move apart
- The Atlantic has shaped centuries of exploration, trade and global history





# Bathymetric Map of the Atlantic Ocean



## Depth Key

**0~10 m** Very shallow / coastal

**10~50 m** Nearshore shelf

**50~150 m** Continental Shelf

**150~300 m** Deep Basins

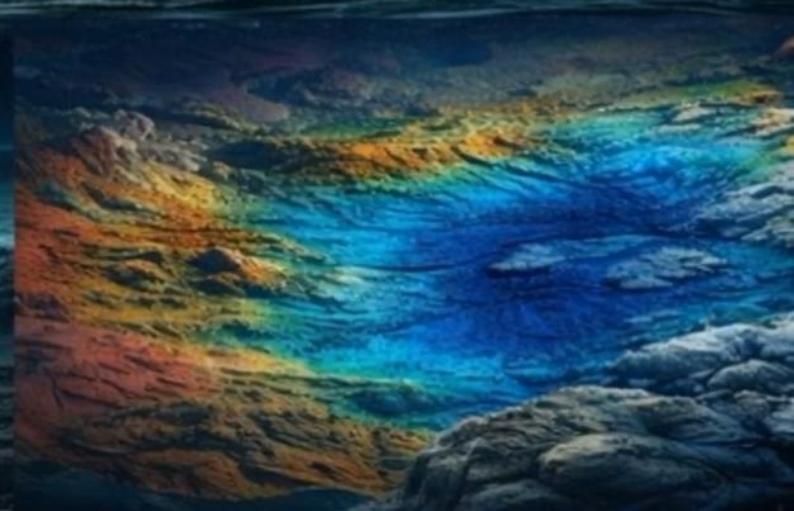
**>300 m** Deep Trenches



# Mapping the Hidden Atlantic

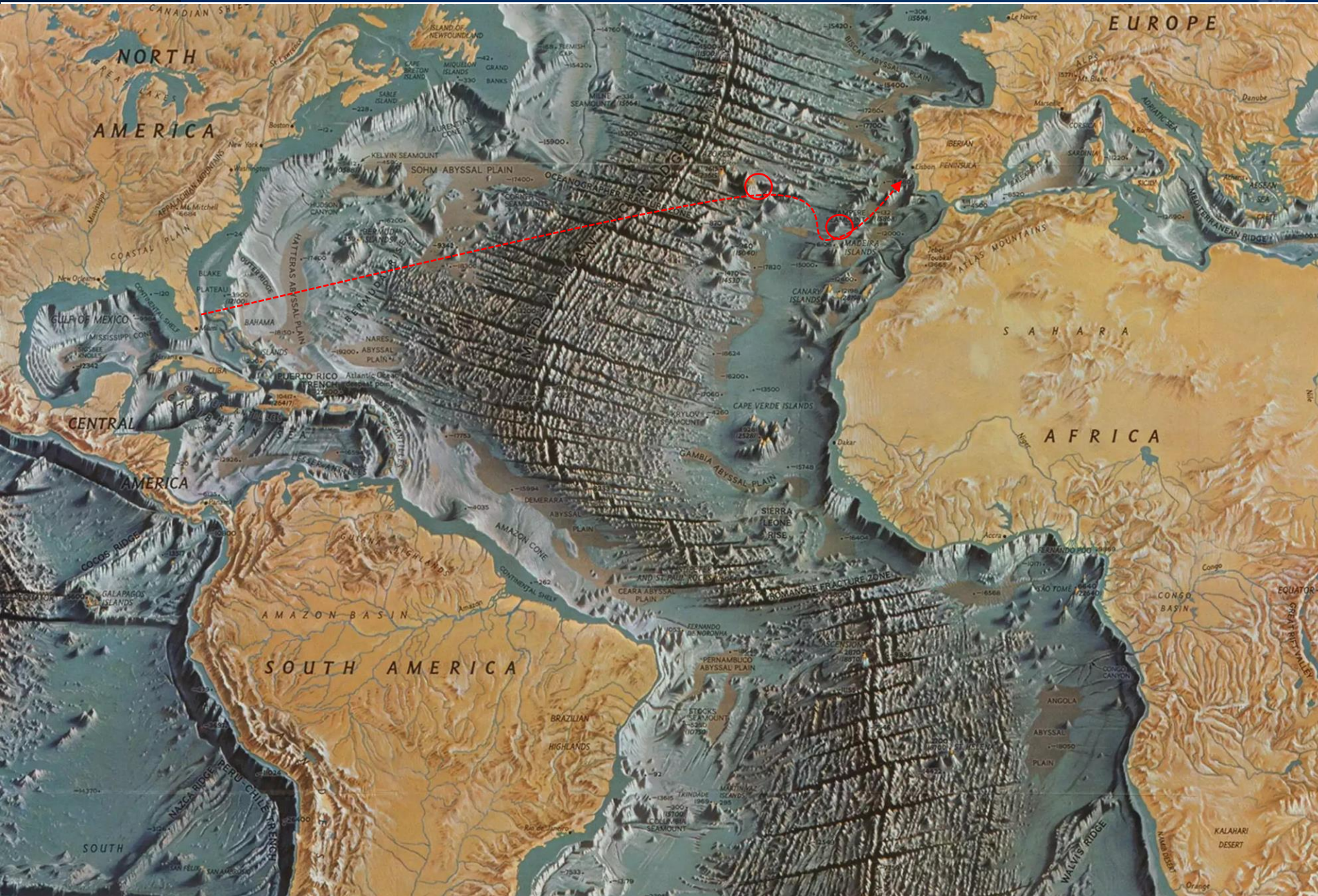


- **The Mid-Atlantic Ridge** is the longest mountain chain on Earth - mostly underwater
- Vast **abyssal plains** make parts of the Atlantic seafloor among the **flattest places** on the planet
- Huge **submarine canyons** carve the continental margins, moving sediment into the deep ocean
- **Modern bathymetric** surveys continue to reveal previously unmapped seafloor features





# The Atlantic Ocean Drained



High Resolution Map  
of The Mid-Atlantic  
Ridge and Atlantic  
Ocean Floor

by Bruce Heezen and  
Marie Tharp



# The Atlantic Abyssal Plain



There is a chain of them - Sohm, Hatteras, Nares, Iberian, Cape Verde, Angola and Argentine abyssal plains - Sohm, the biggest (900,000 km<sup>2</sup>), is what we are passing over now

Total size of the Atlantic abyssal plains is 20.3 million km<sup>2</sup>. For scale, that is about twice the size of Europe, or roughly 80 times the size of the United Kingdom



# The Atlantic is an Oceanographic Powerhouse



- Warm tropical waters make it a major **hurricane development region**
- The **Atlantic** is one of the saltiest major oceans due to strong **evaporation**
- **The Gulf Stream** carries warm water northward, keeping **Western Europe** unusually mild
- It plays a key role in the **global ocean circulation system (the Atlantic Meridional Overturning Circulation or AMOC)**





# The Atlantic Conveyor Belt



**>50%**

collapse probability (up from ~5%)

## Why the ocean beneath this ship may be at a tipping point

### What Is AMOC?

The Atlantic's great heat engine - a vast conveyor belt carrying sun-warmed tropical water north to Europe and the Arctic

There it cools, sinks, and returns south along the ocean floor

It keeps Western Europe far warmer than it would otherwise be - without it, London and Paris would face Scandinavian winters

AMOC is already at its weakest in 1,600 years

### The New Finding

**1,600 Years**

Weakest AMOC has been in recorded history

**42-58%**

Projected slowdown by 2100 in reliable models

Scientists matched dozens of models against real ocean data. The pessimistic models - those showing the greatest slowdown - proved to be the accurate ones

### If It Collapses

#### Western Europe

Severe cold winters and prolonged droughts

#### Africa and Americas

Tropical rainfall belt shifts - threatening food supplies for hundreds of millions

#### Sea Levels

50-100 cm additional rise along Atlantic coastlines

#### Timescale

Tipping point could become irreversible by mid-century



# Surveying and Charting Elements



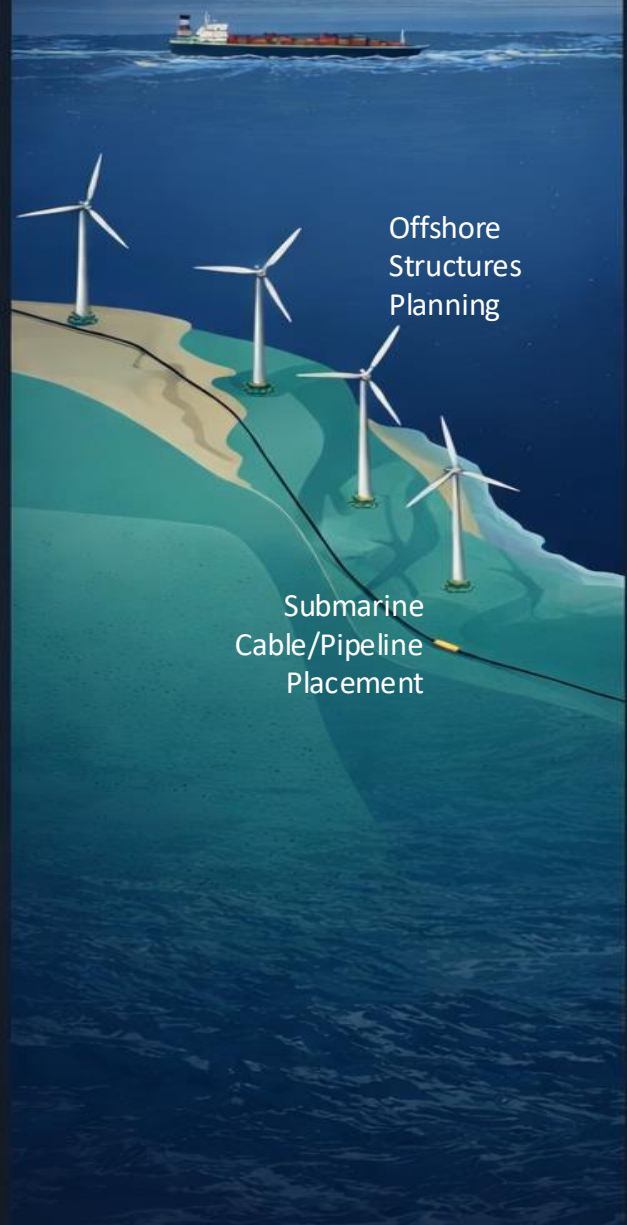
# Why We Need to Survey the Oceans



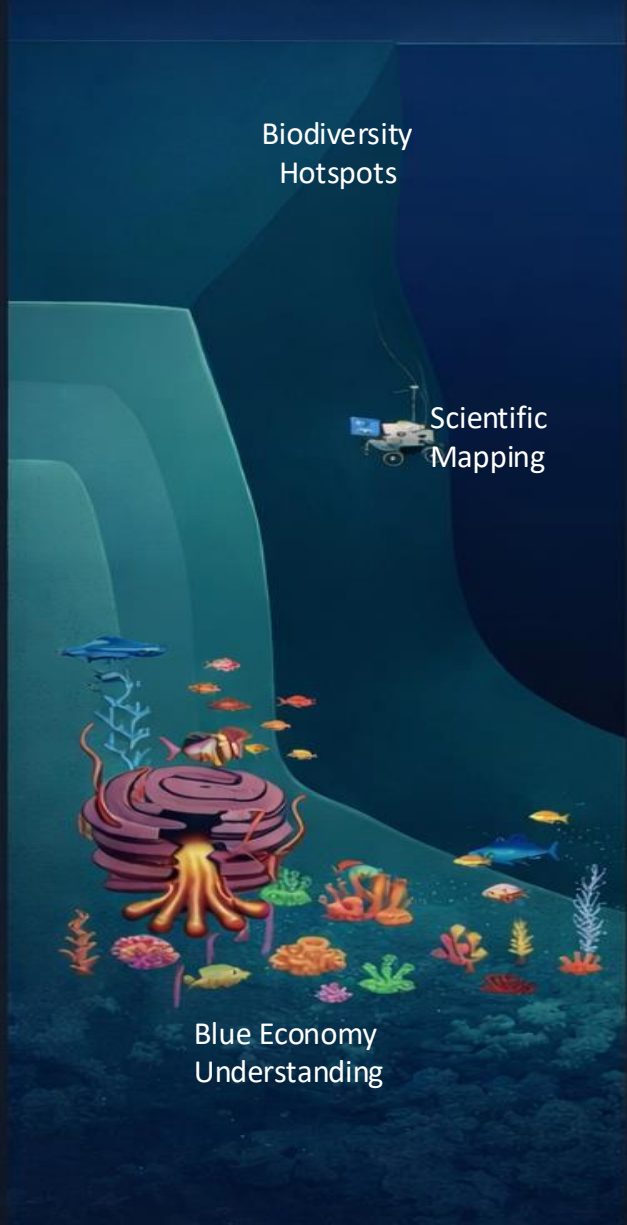
## Safety of Navigation



## Planning and Development



## Environmental Understanding



## Unveiling the Deep



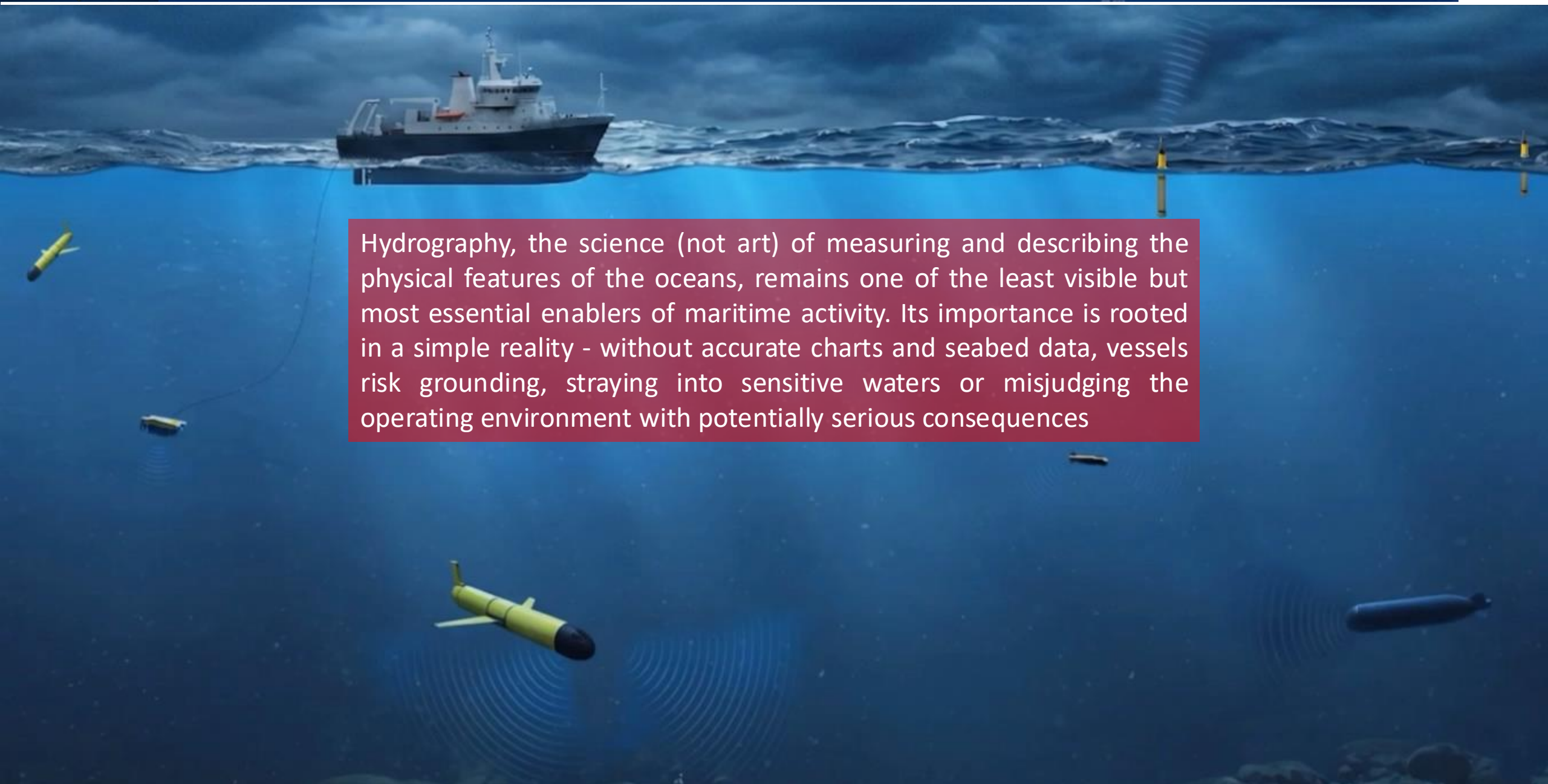


# Safety of Navigation - The Most Crucial Driver





# So ... We Have Hydrography!

A large hydrographic survey vessel is shown on the surface of the ocean. Below the surface, several autonomous underwater vehicles (AUVs) are visible, some emitting sonar waves. The scene is set in a deep blue ocean under a cloudy sky.

Hydrography, the science (not art) of measuring and describing the physical features of the oceans, remains one of the least visible but most essential enablers of maritime activity. Its importance is rooted in a simple reality - without accurate charts and seabed data, vessels risk grounding, straying into sensitive waters or misjudging the operating environment with potentially serious consequences



# The Role of Hydrography and Hydrographers



The Future of Hydrography



# The International Hydrographic Organization



**IHO**

International  
Hydrographic  
Organization

Founded in Monaco in 1921

## Charting The Oceans For Safe Navigation



Global Standards  
For Seabed Mapping  
& Nautical Charts



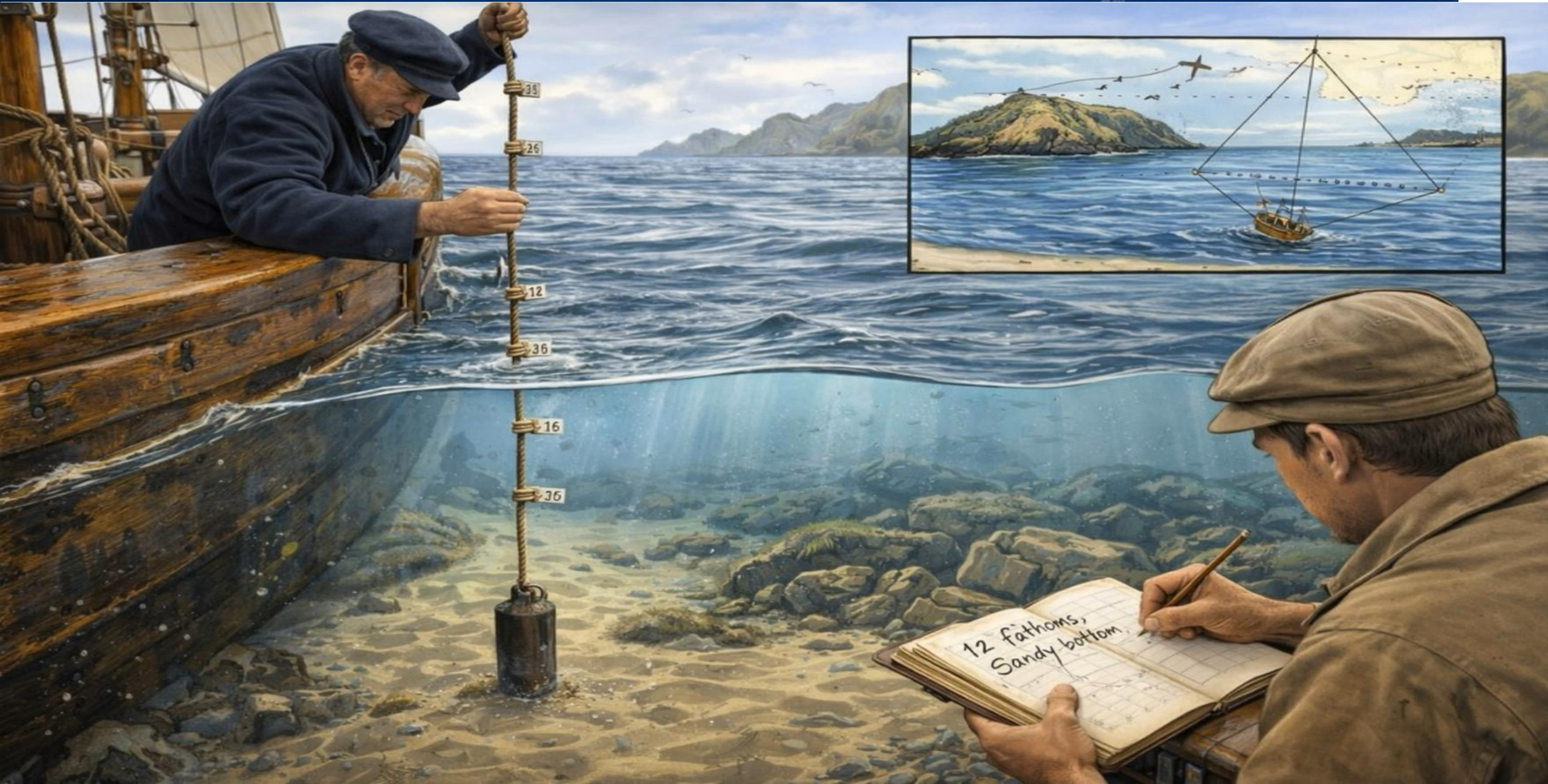
Promotes Int'l  
Cooperation  
& Training



S-100 Universal  
Data Model &  
Digital Navigation

Now has 104 Member States - Helping Protect our Planet's Waters

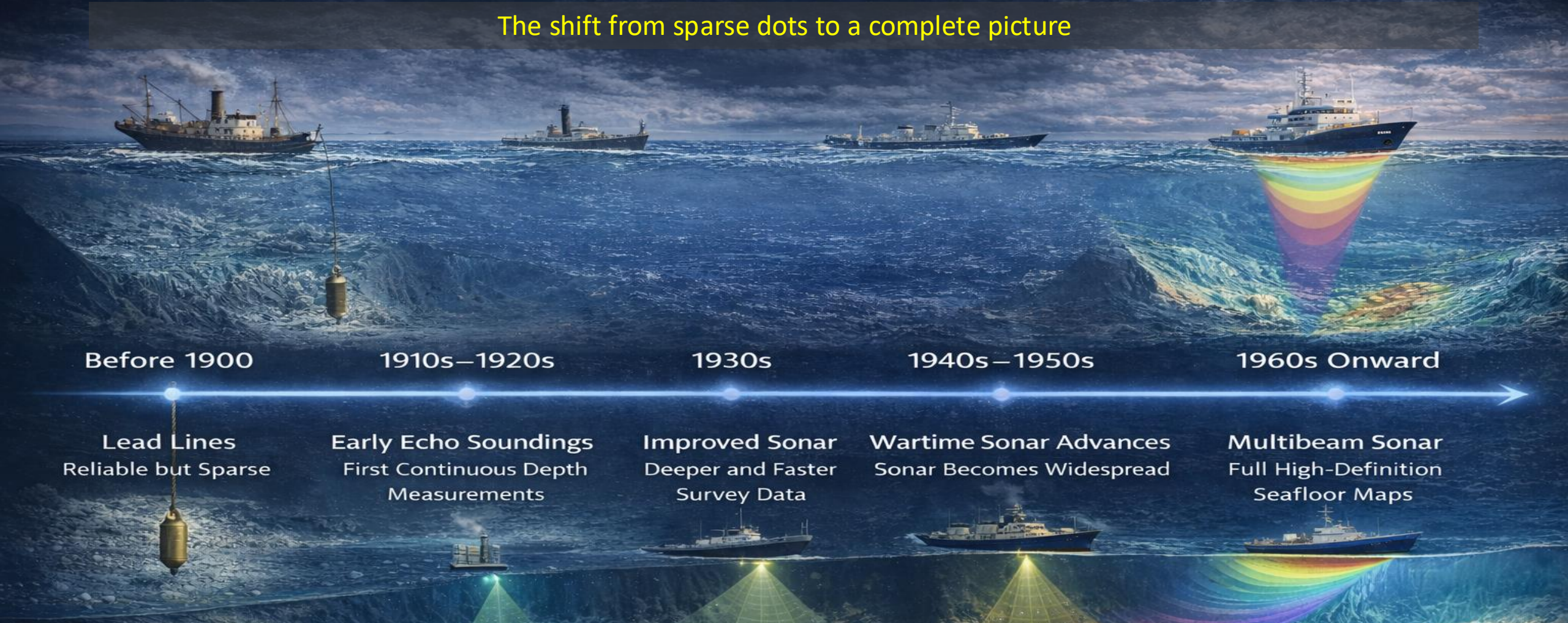
# Hydrographic Surveys - Lead Line - Used Until 1930s!





# From Lead Line to Sonar

The shift from sparse dots to a complete picture



Before 1900

1910s–1920s

1930s

1940s–1950s

1960s Onward

**Lead Lines**  
Reliable but Sparse

**Early Echo Soundings**  
First Continuous Depth Measurements

**Improved Sonar**  
Deeper and Faster Survey Data

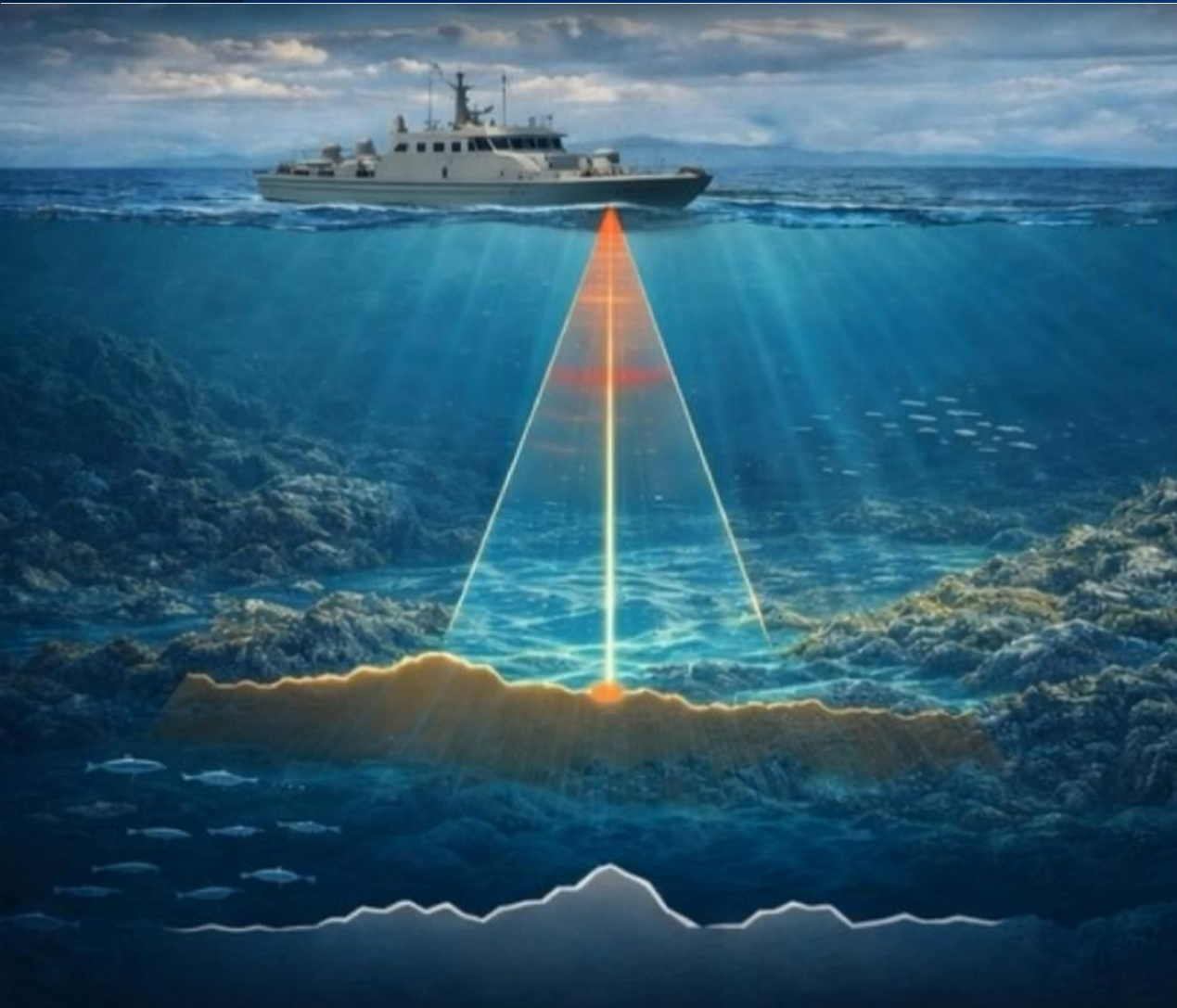
**Wartime Sonar Advances**  
Sonar Becomes Widespread

**Multibeam Sonar**  
Full High-Definition Seafloor Maps

Sonar turned the ocean from a series of guesses into a continuous picture

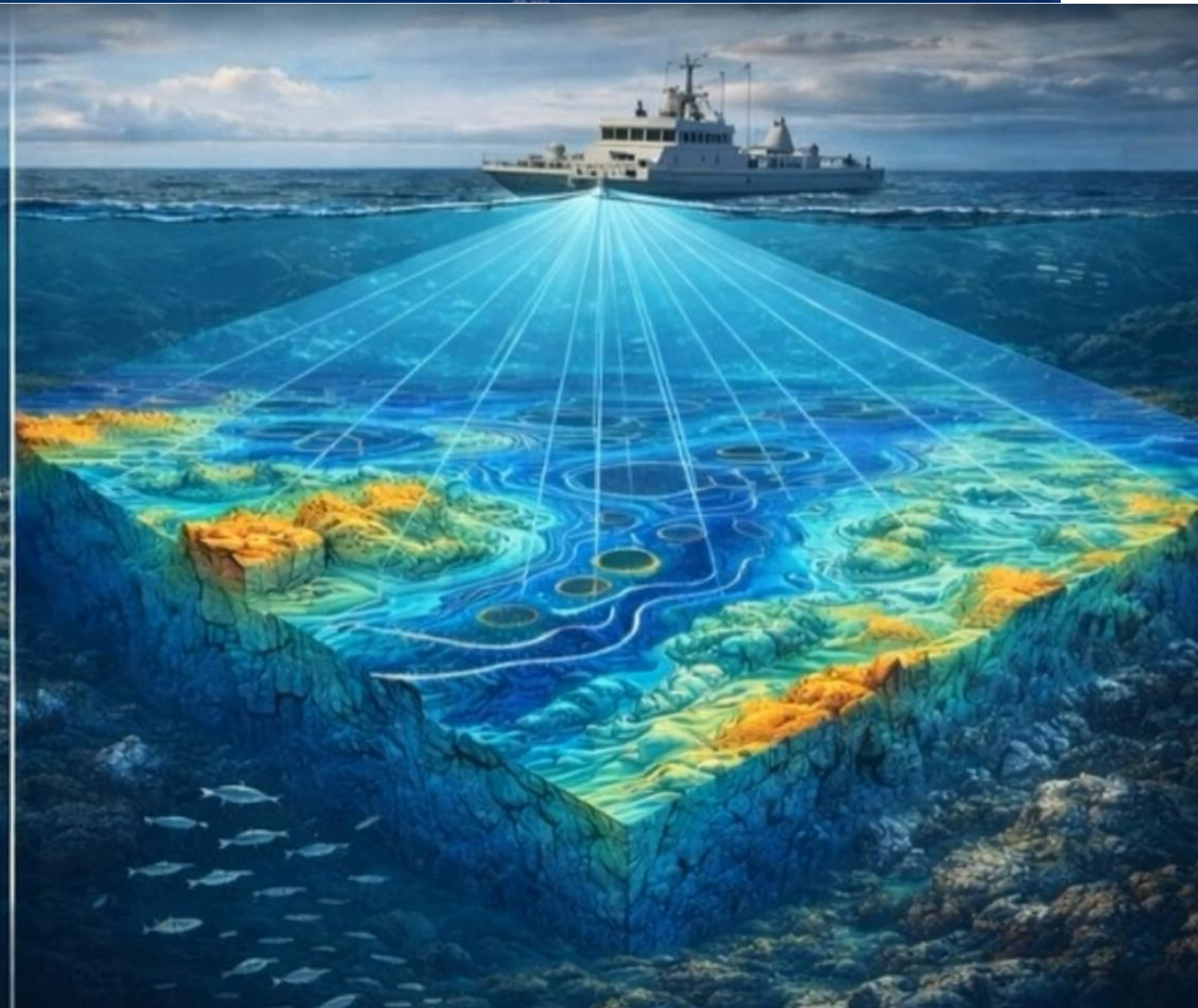


# Hydrographic Surveys - System History



## Single Beam Survey

Limited Coverage & Resolution



## Modern Multi-Beam Survey

Full Seafloor Coverage & Detailed Mapping



# The Future



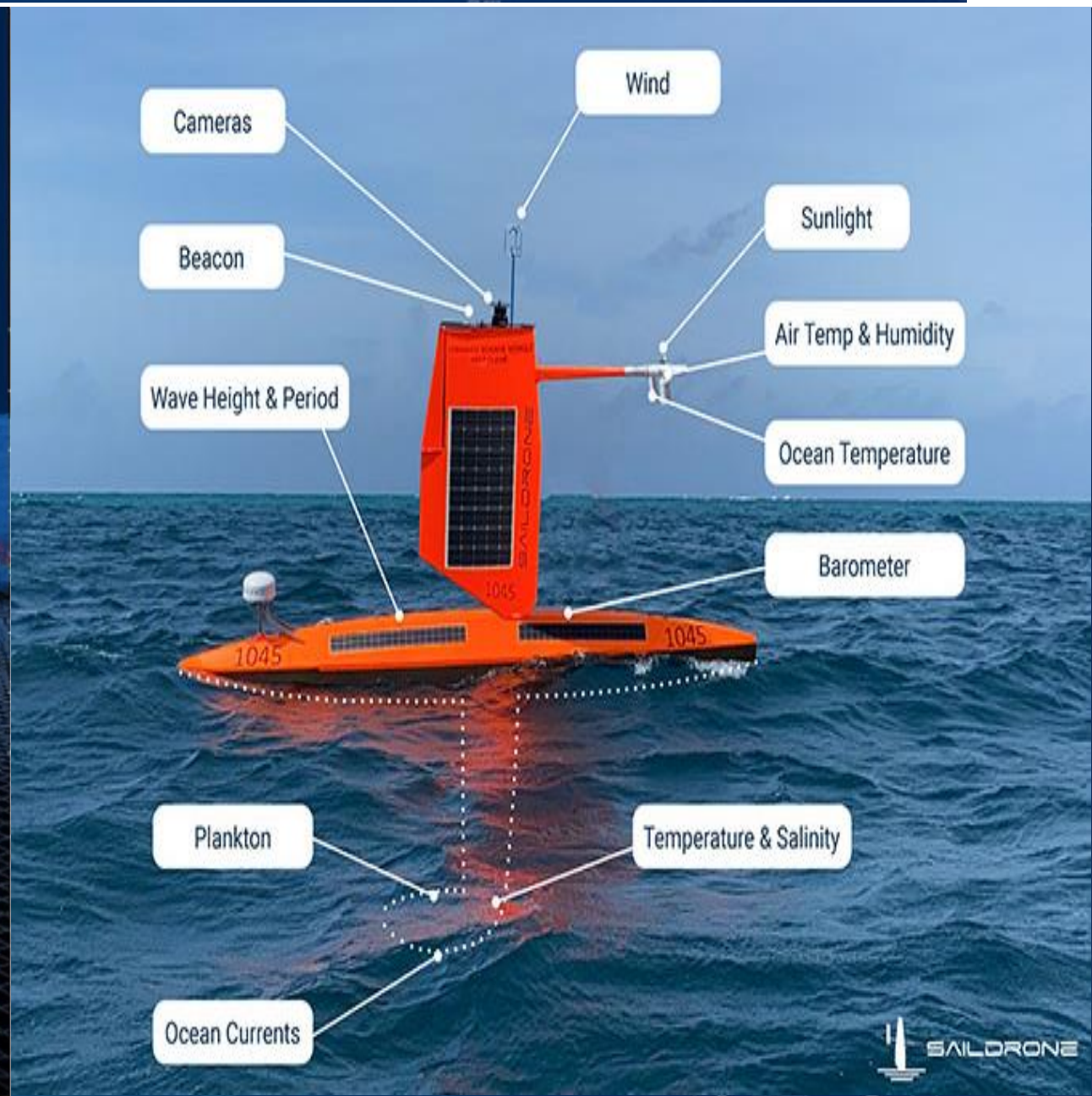
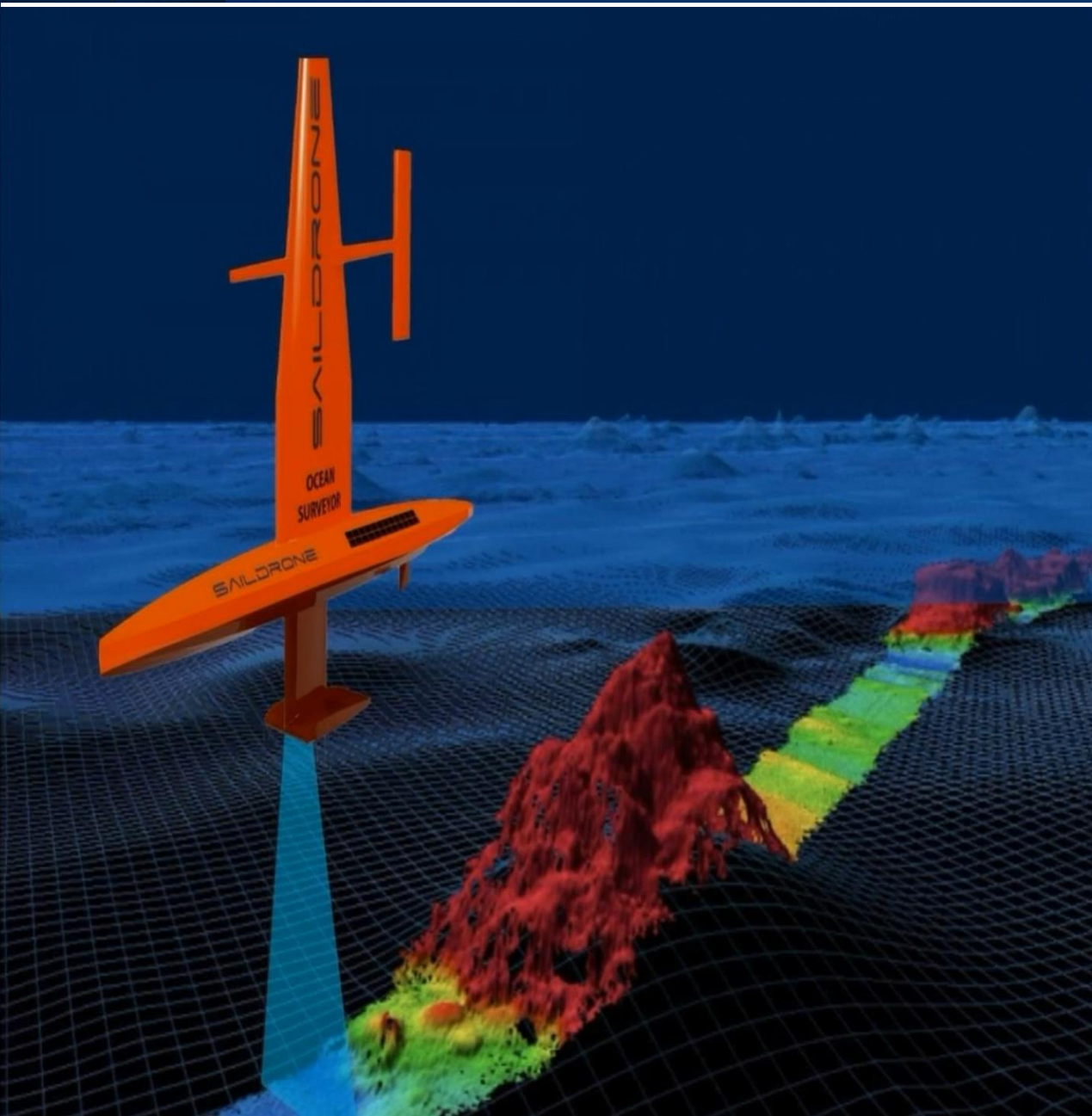


# The Future



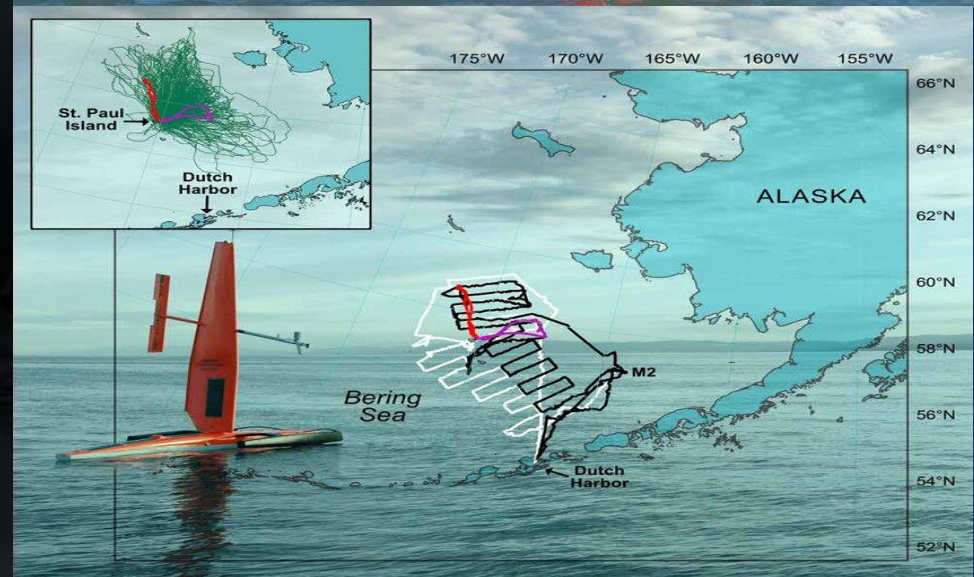


# Autonomous Vessels



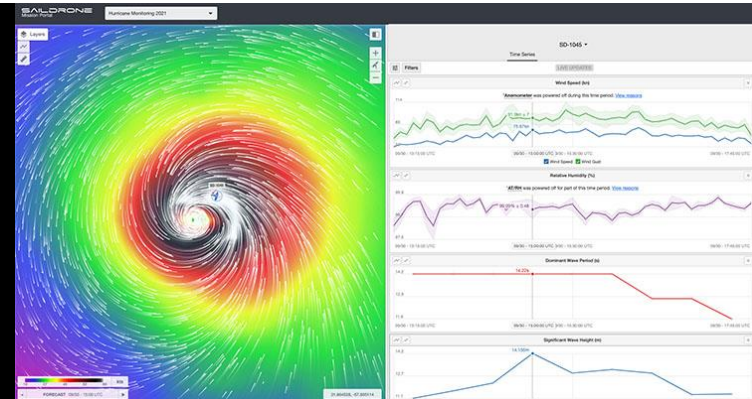


# Autonomous Vessels - Control Centre





# Autonomous Vessels - Into the Hurricane

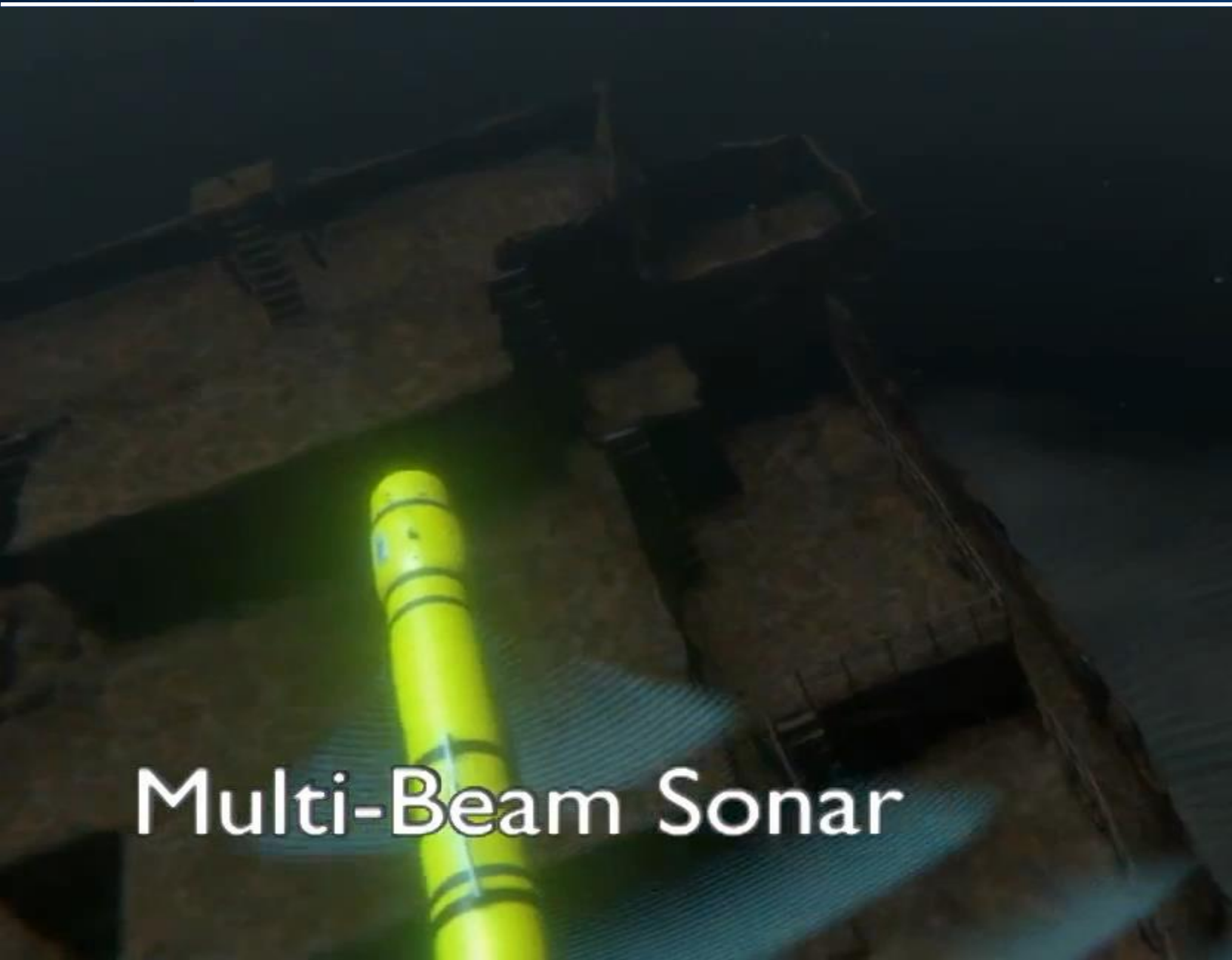




# Deep and Shallow Water Underwater Drones



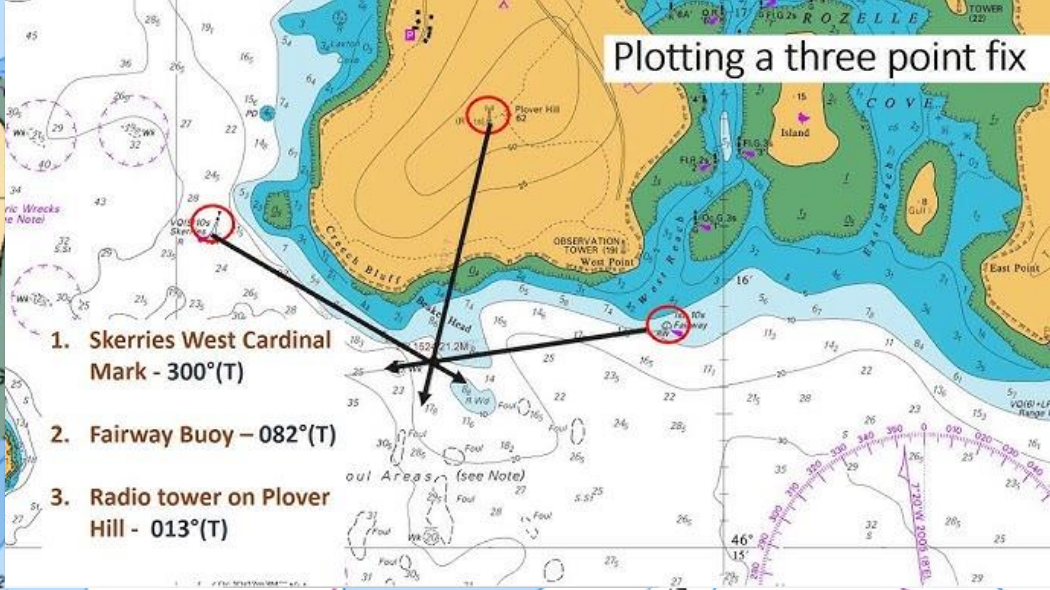
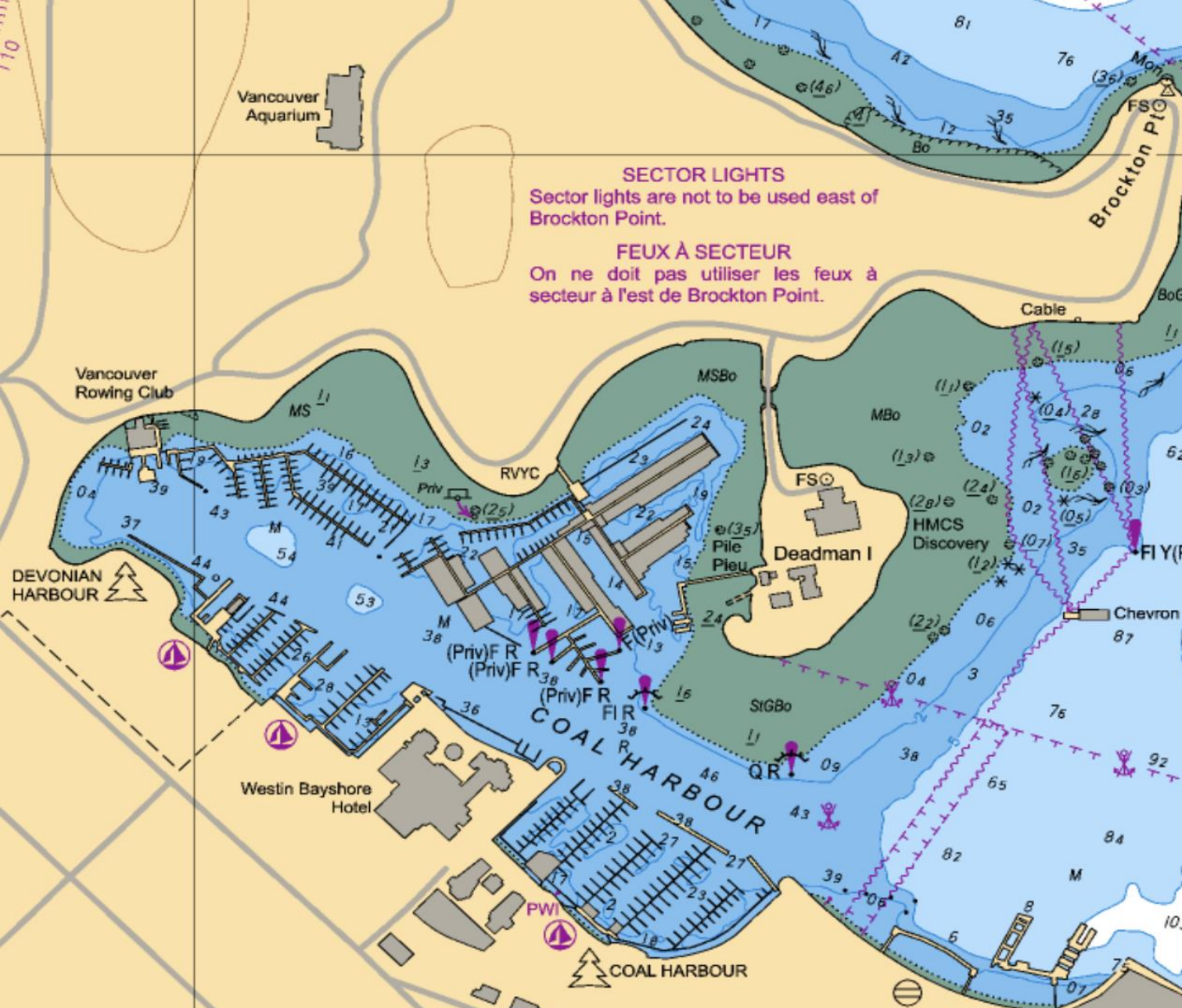
Multi-Beam Sonar





# The Old Paper Chart



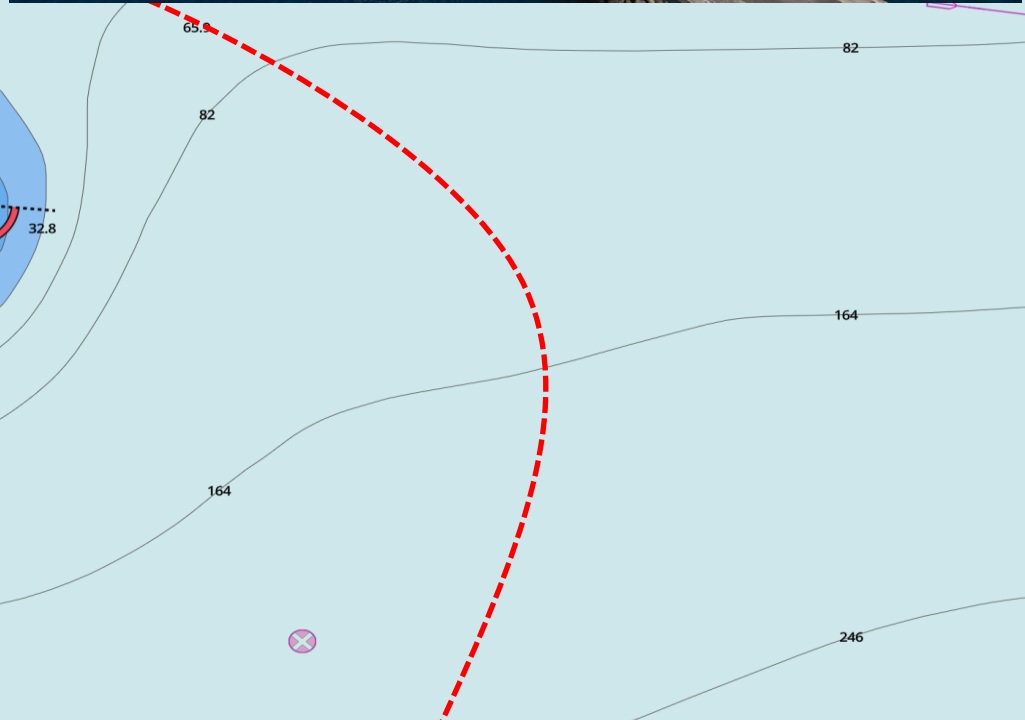
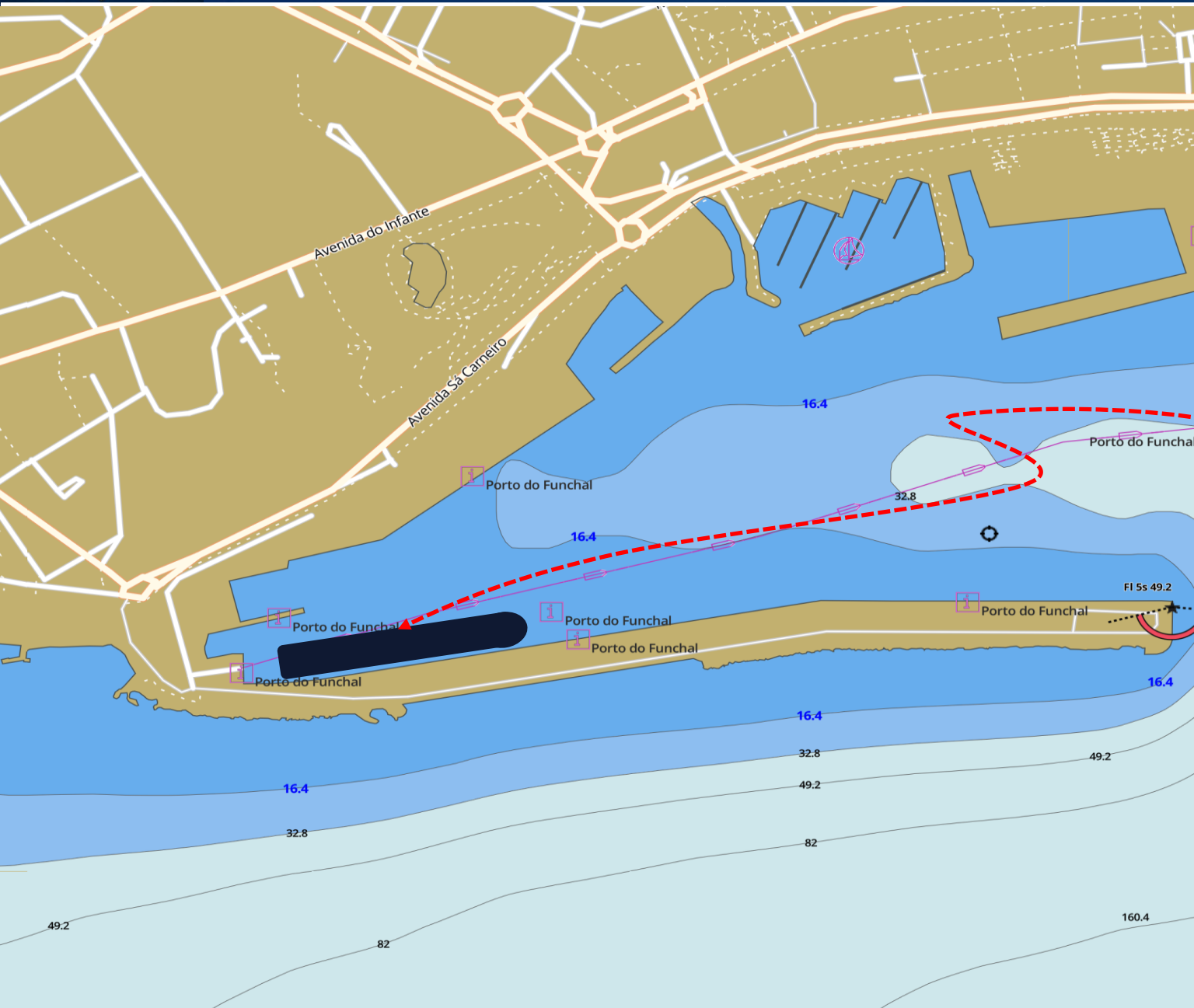


- The US withdrew all its Paper Charts as of December 2025; Australia is doing the same this year
- The UK, the world leader in paper chart production, tried to do the same, announcing a withdrawal in July 2022 to be completed by 2030; it was met with such consternation that it withdrew its plan in February 2023 - now, no end-date
- Most large ships are still mandated to carry some paper charts in the event of failure of electronic means; GPS can also be jammed and we have already had our first GPS assisted groundings

# The Current Paper Chart



# Paper Chart of Funchal

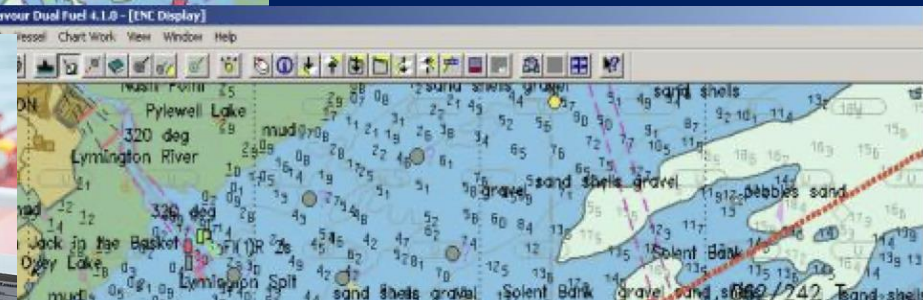
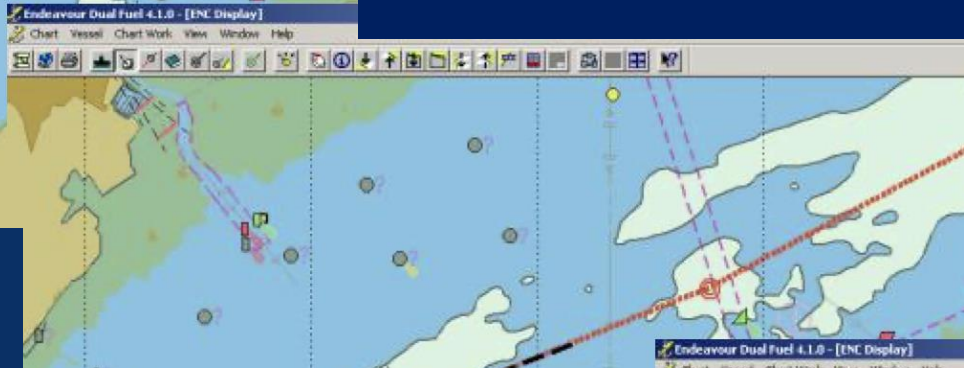




# From Paper To Digital



# The Electronic Navigation Chart







# Types of Electronic Navigational Charts



marine traffic

harbour operations

# The beginning of **S-100**

ocean sciences

**S-102**

Bathymetric  
Surface

**S-101**

ENC

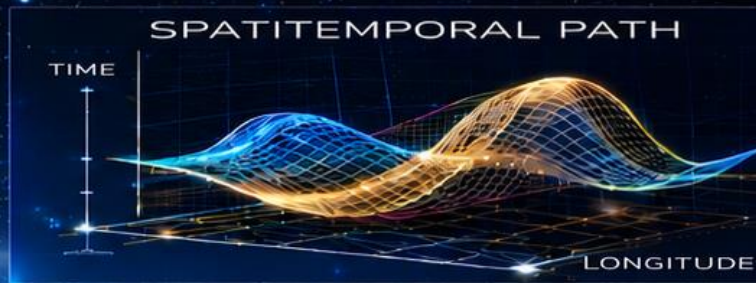
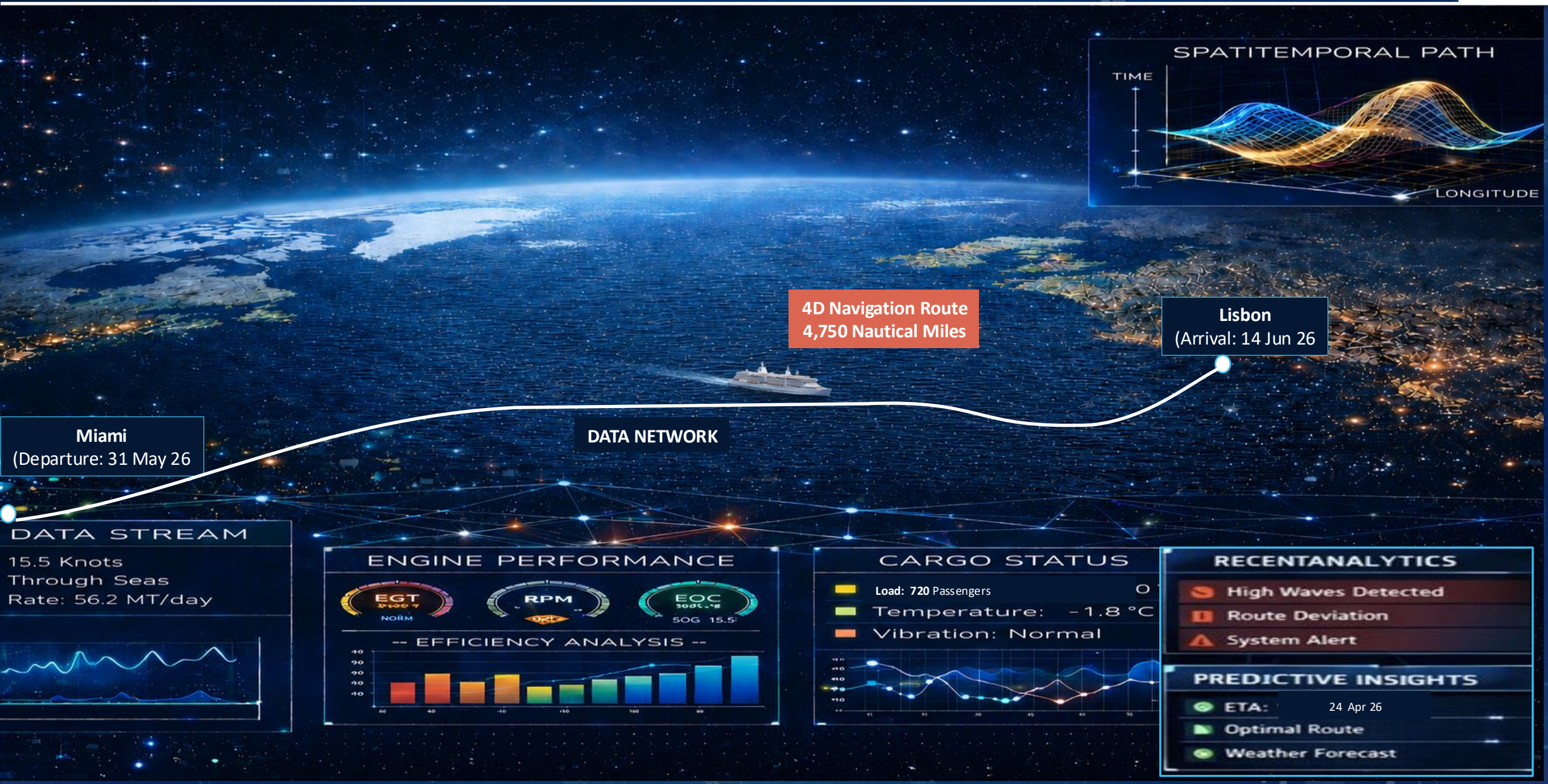
**S-126**

Physical  
Environment

## To This ... The Future



# What Will This Look Like



4D Navigation Route  
4,750 Nautical Miles

Lisbon  
(Arrival: 14 Jun 26)

Miami  
(Departure: 31 May 26)

DATA NETWORK





# What Will This Look Like



- ✓ Port Clearance Approved
- ✓ Berth 12C Allocated
- ✓ Cargo Manifest Verified
- ✓ S-211 Port Call
- ✓ S-421 Route Exchange

Optimised Route

ETA: 17:45 UTC  
Fuel Efficiency  
Emissions: Green  
Compliant

# Digital Twin Ports

Rotterdam, Singapore and Shanghai operate AI digital twin models of their ports, creating virtual environments that optimise operations and enable proactive maintenance and real-time decisions



Rotterdam



Singapore

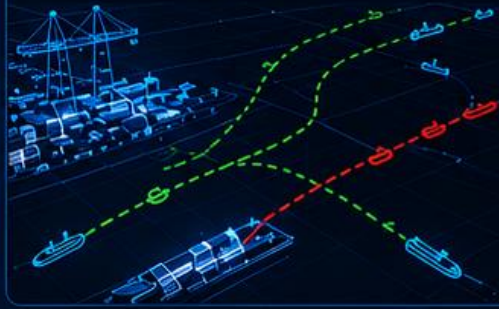


Shanghai



## AI Digital Twin Platform

Vessel Movements



Gate Operations



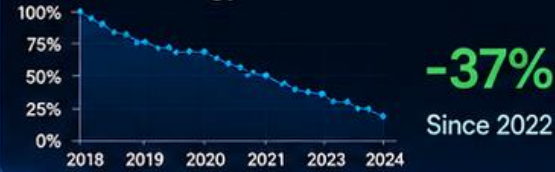
Traffic Flow



Real-time Efficiency



Energy Use Reduction



Operational Performance



Secure Data Hub

Rotterdam

Singapore

Shanghai





# Move Away from Static Charting to Living Navigation

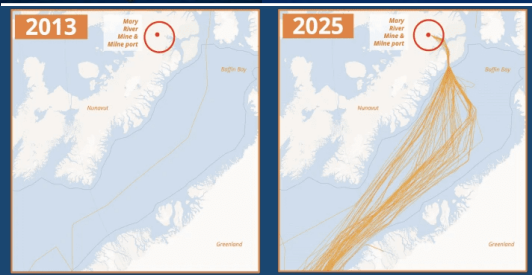




# Other Interesting Surveying and Charting Issues

COG 195.1°  
12.5 kns

# Arctic Shipping - Changes Afoot



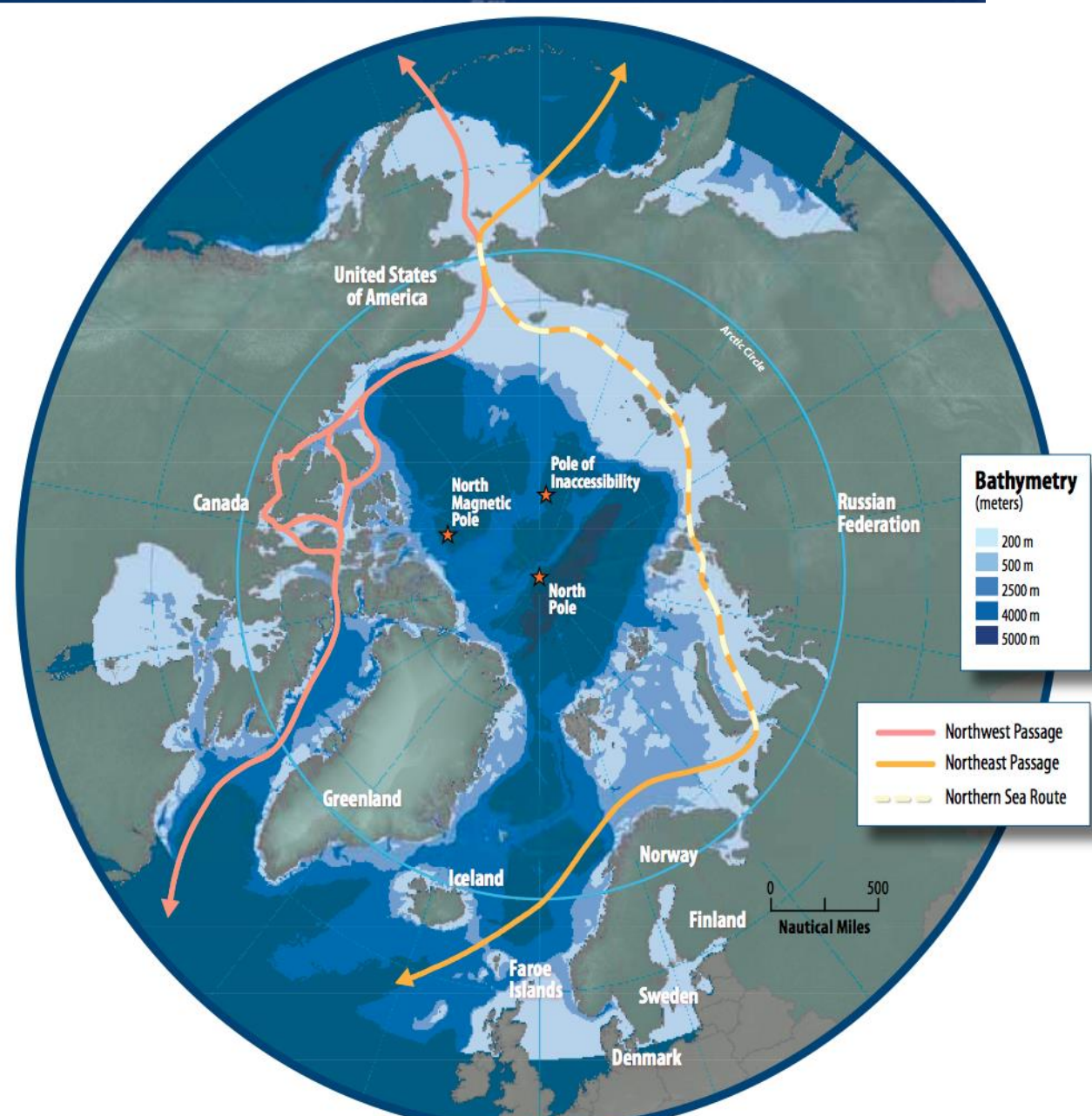
**Record High Activity**

- 1,812 unique vessels in 2025
- ~40% increase since 2013
- Total distance sailed nearly doubled



**Highly Seasonal**

- Traffic peaks August to October
- Follows minimum sea ice extent
- Still not year-round open water



**Who Is Sailing There?**

- Fishing vessels
- General cargo ships
- Rapid growth in oil and LNG carriers



GAS TANKER TRAFFIC TO AND FROM YAMAL



# Arctic - Challenges and Risks



## Harsh Environment

- Severe storms, high waves, shifting sea ice
- Extreme cold, icing, fog limit navigation
- Slow emergency response, evacuation challenges

## Safety and Incident Risks

- Collisions, groundings on uncharted waters
- Oil spills, hazardous cargo accidents
- Deaths and search-and-rescue incidents rising

## Lack of Infrastructure

- Few ports, emergency response bases
- Limited communication networks
- Long distances, minimal SAR capabilities

## Geopolitical Tensions

- Arctic sovereignty disputes
- Military posturing from regional powers

## Insurance and Liability

- High insurance costs, premiums rising
- Incidents raise liability concerns
- Complex legal, insurance claims in remote waters



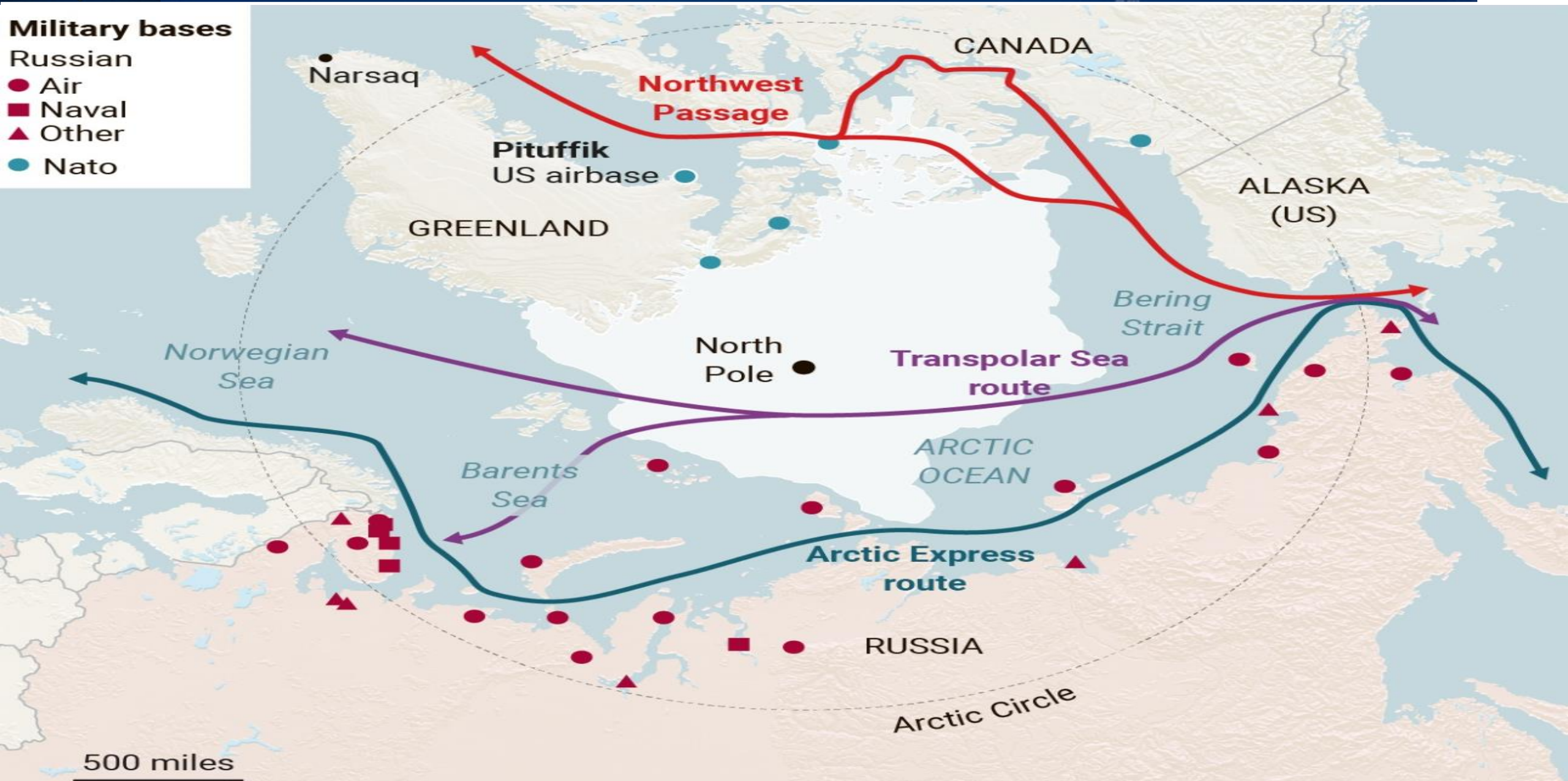


# Arctic - Explaining the Interest in Greenland!



**Military bases**

- Russian
- Air
- Naval
- ▲ Other
- Nato





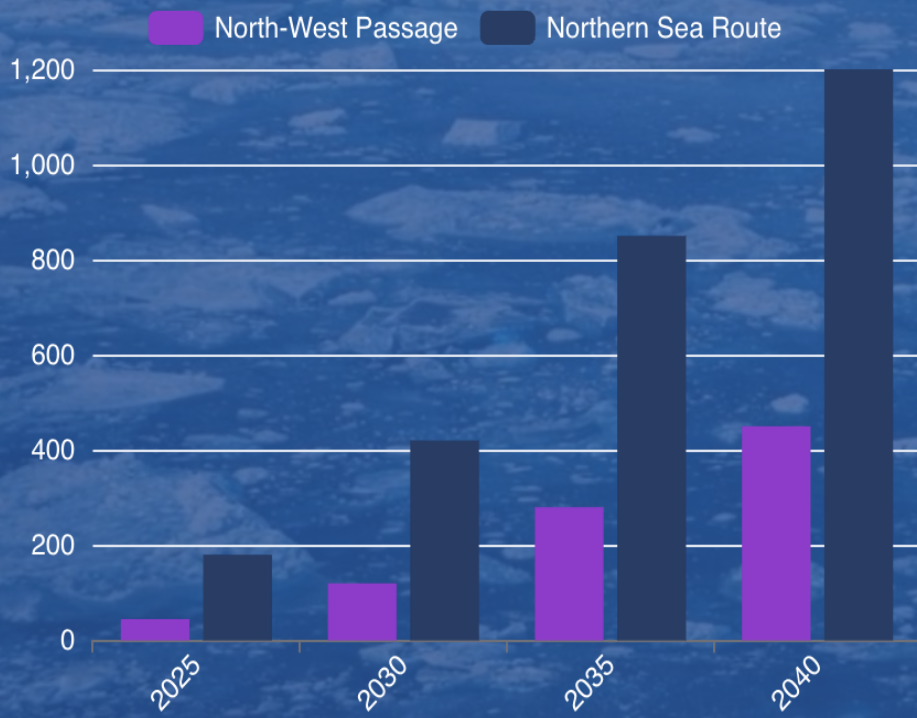
# North-West Passage-Future Gateway



## Economic Impact

Projected \$500B in trade value by 2040, with Canada estimating \$100B+ in Arctic infrastructure investments

## Projected Arctic Shipping Growth



## Time Savings

Reduces Asia-Europe journey by 7-10 days compared to Panama Canal, cutting fuel costs by 20-30%

