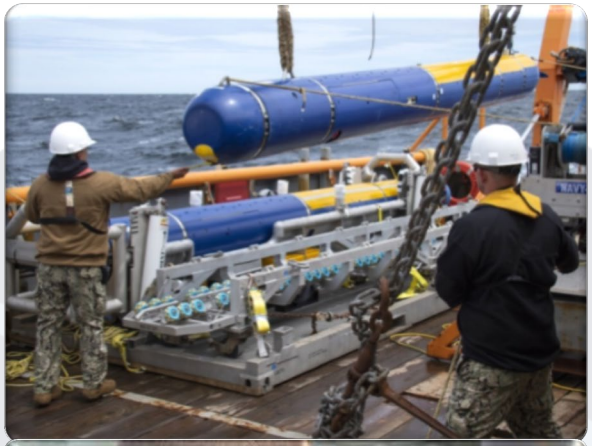
GENERAL DYNAMICS
Mission Systems

Complex Environment Operations
Bluefin Robotics®
Unmanned Underwater Vehicles

Adam Mara
General Dynamics Mission Systems
Undersea Systems

Agenda

- Operational Overview
  - GDMS Marine Operators
  - Unmanned Underwater Vehicle (UUV) Design Considerations
  - Payload Selection
  - Logistics
  - Architecture and Evolution
- Complexities of operating UUVs in varying environments
  - The Solent- United Kingdom
  - The Patuxent River, Chesapeake Bay Maryland
  - The Arctic Circle
  - Australia



General Dynamics Mission Systems

Marine Operations Engineers

- Team of advanced UUV operators
- Test all Bluefin Robotics® UUVs at sea
- Critical to product lifecycle and testing process
- Train Commercial & Government customers

Operations

- Global presence from the Arctic Circle to the Southern Ocean
- At sea, on over 11 vessels of opportunity (VOO) in 2019/20
- Operate over 7 different product platforms

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Bluefin Robotics UUV Product Family

Bluefin™-9 / Two-man Portable Littoral Survey Vehicle

Bluefin™-12 / Lightweight Littoral Survey Vehicle

Bluefin™-21 / Heavyweight Deepwater Survey Vehicle

Class	Diameter	Length	Weight	D Rating	Endurance
Small	9.375” (24 cm)	95” (231 cm)	155 lbs (70kg)	656 ft (200 m)	8 hrs at 3 knots
Medium	12.8” (32 cm)	15.8” (4.8 m)	550 lbs (250 kg)	656 ft (200 m)	24 hrs At 3 knots
Medium	21” (51 cm)	16.2” (4.9 m)	1,650 lbs (750 kg)	1,650 lbs (750 kg)	24 hrs

Knifefish

ANTX

ICEX

Bluefin-12

Bluefin-9

SHARK-DASH

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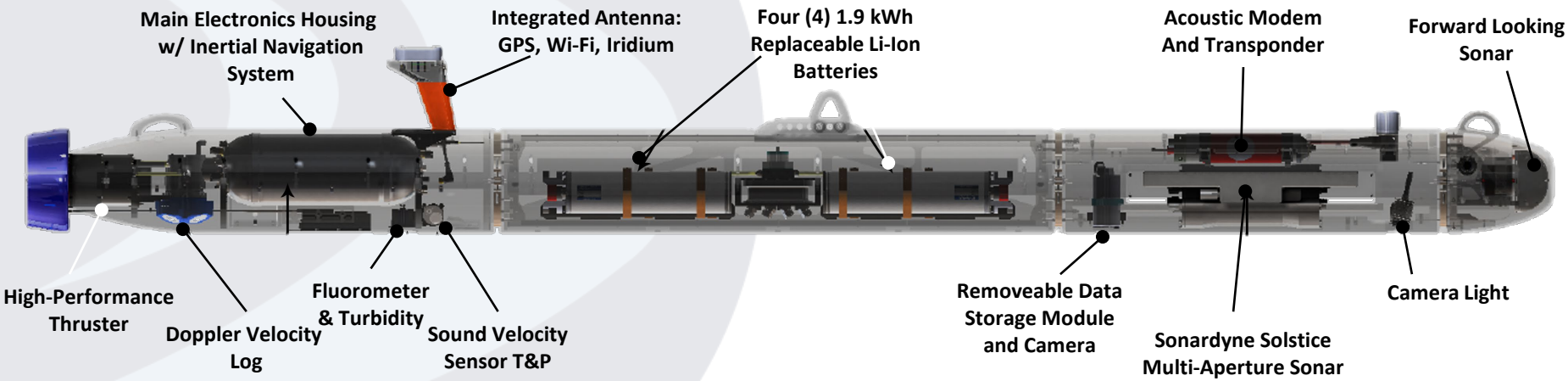
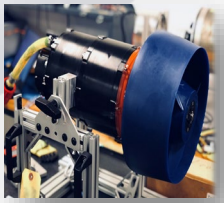
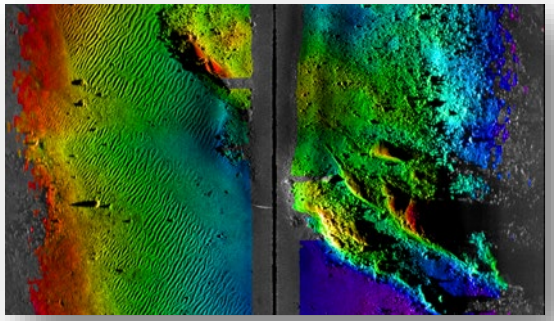
BLUEFIN-12 Architecture







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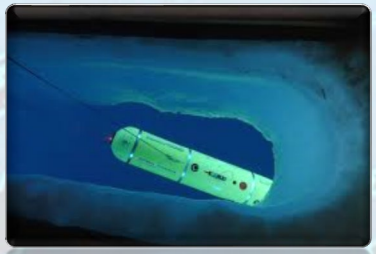
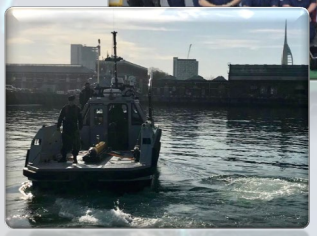
Operational Highlights

THE ARCTIC CIRCLE



HMNB PORTSMOUTH
THE SOLENT



THE PATUXENT
RIVER
CHESAPEAKE BAY

ROYAL AUSTRALIAN
NAVY SEA 1778

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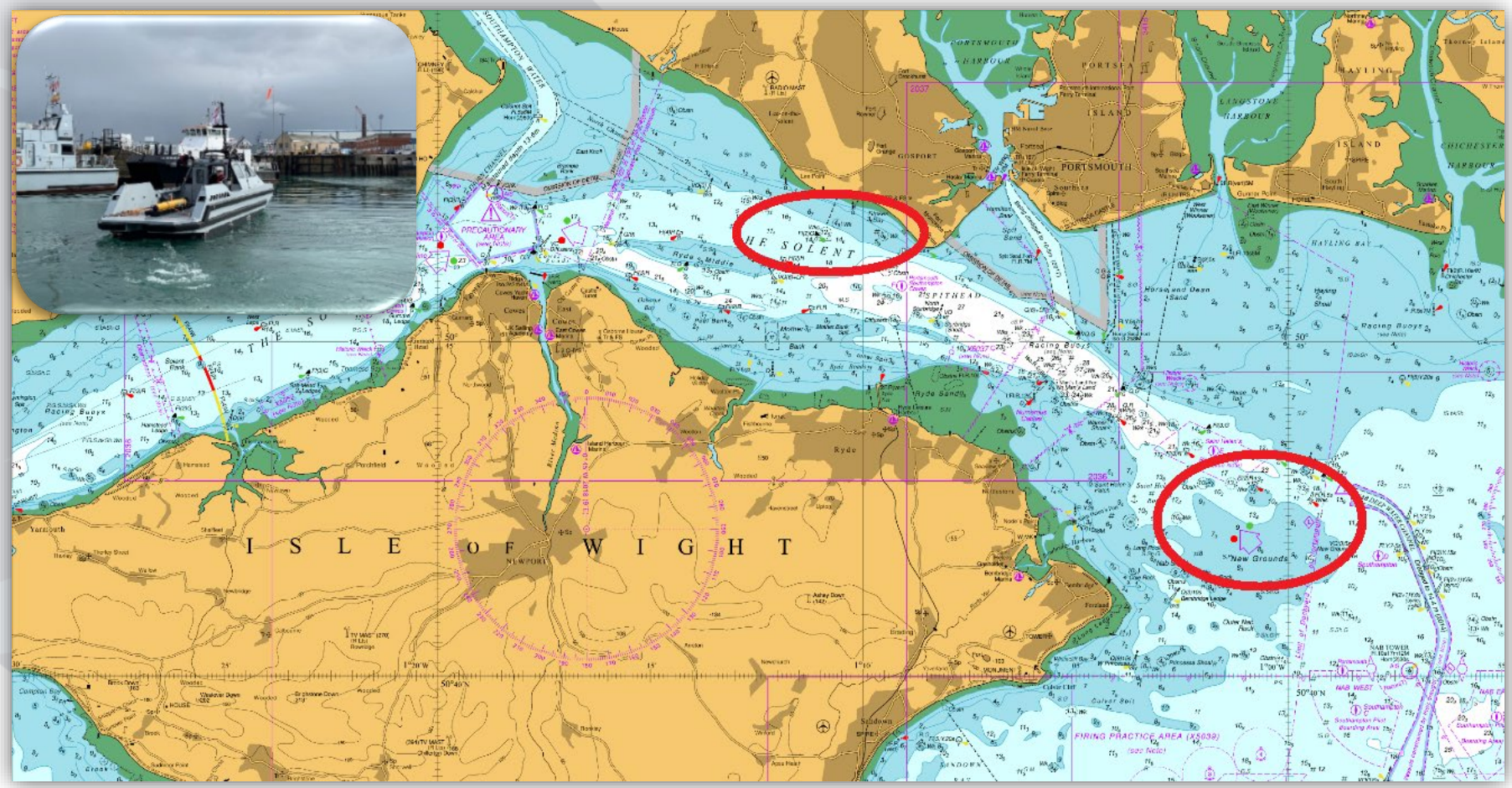
Environmental Challenges- The Solent

UUV Operations in High Water Currents



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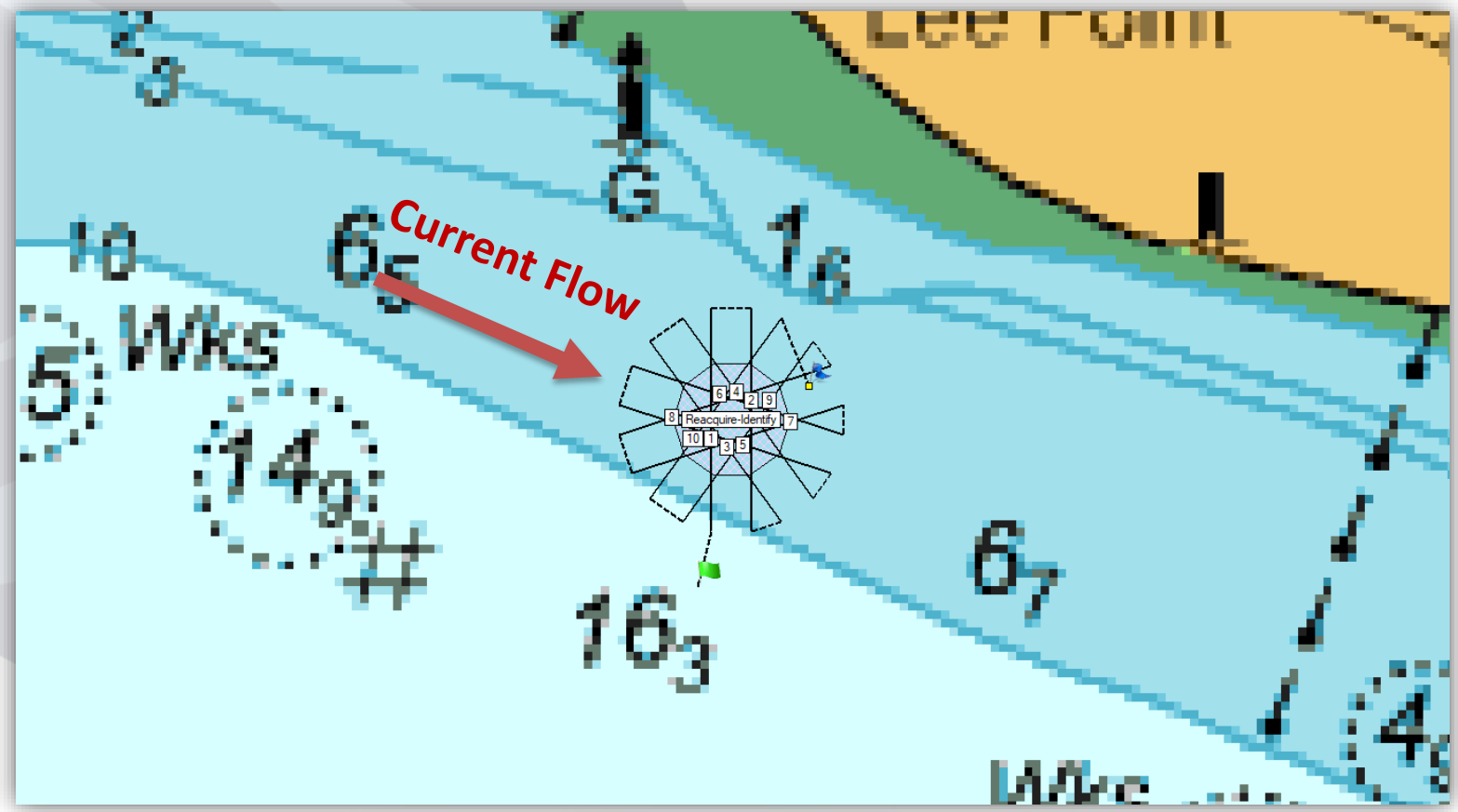
The Challenge

- The team was tasked with surveying in high currents at multiple angles of incident
- Our approach was to use speed over bottom mode and reduce crab angles by running at higher speeds.



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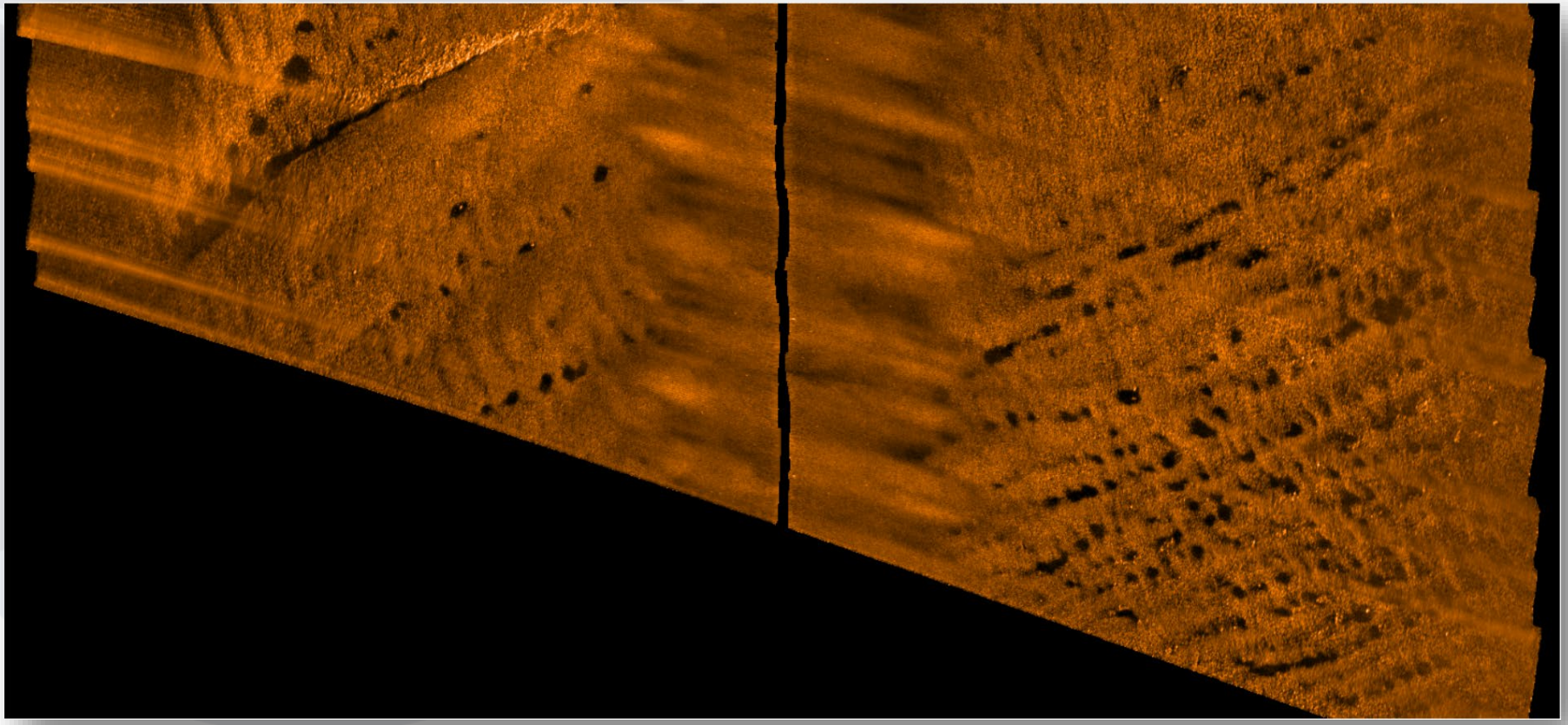
Lessons Learned

- Challenge:
  - How to configure the UUV to use Speed Over Bottom Mode in high velocity and turbulent waters for data collection
    - Vehicle thruster varying RPM to maintain Speed Over Bottom
    - Smaller crabbing angles
    - Decreased roll stability
- Solution:
  - By configuring the UUV in Constant RPM Mode instead and decreasing speed, data was collected in a challenging, varied water condition
    - Maintained consistent thrust
    - Higher crab angles
    - Increased vehicle stability
- Multi-Aperture Sonar showed little degradation in data quality at high crab angles
  - The overall swath range slightly reduced
  - No skew in contacts represented in the data (as shown in the following slides)

High Crab Angle Sonar

- 20° Crab Angle
- Range reduced by only 4 – 5 meters



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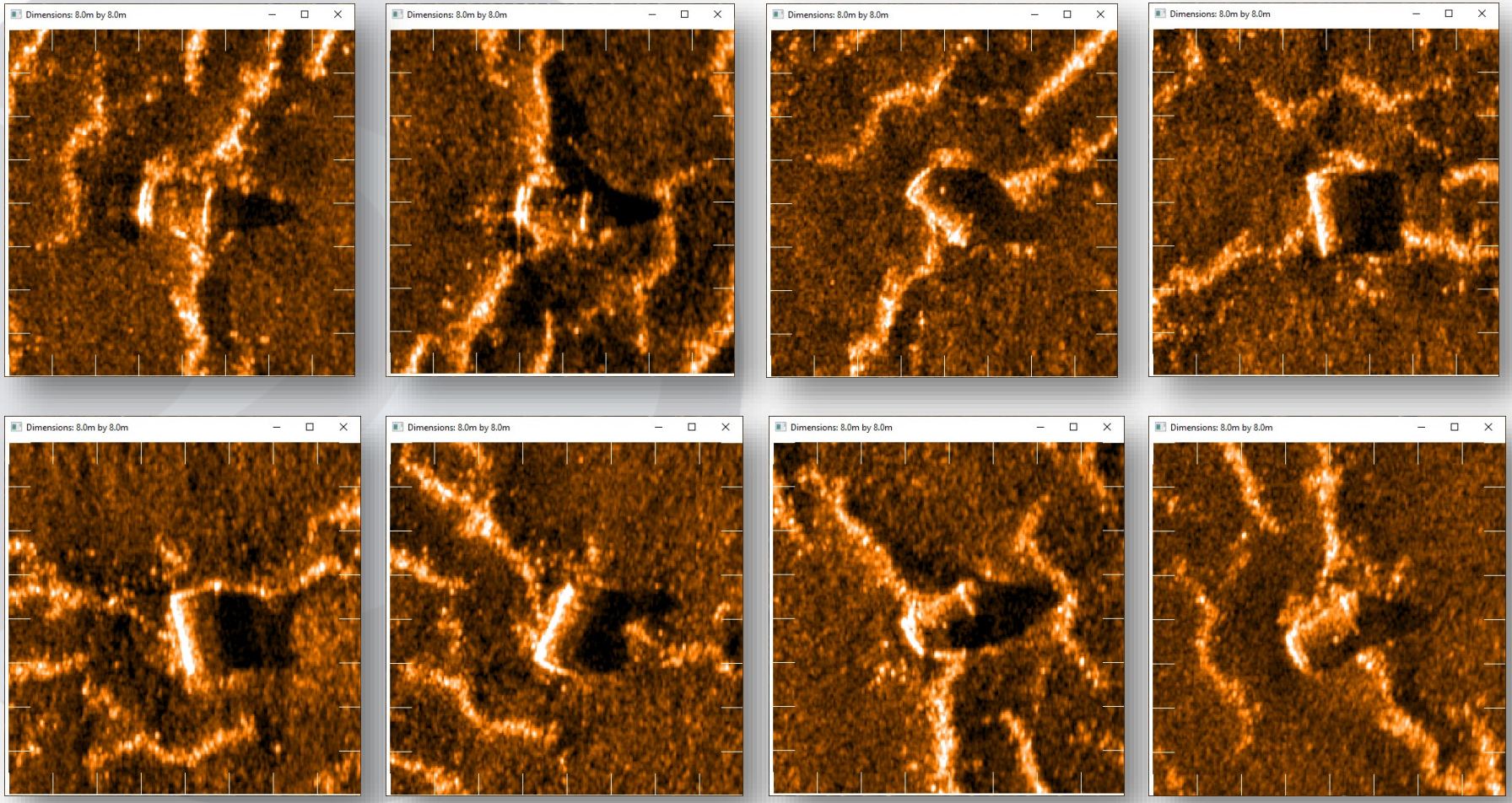
2m Cylinder Target – Imaged by Bluefin-9 UUV



8m x 8m Squares

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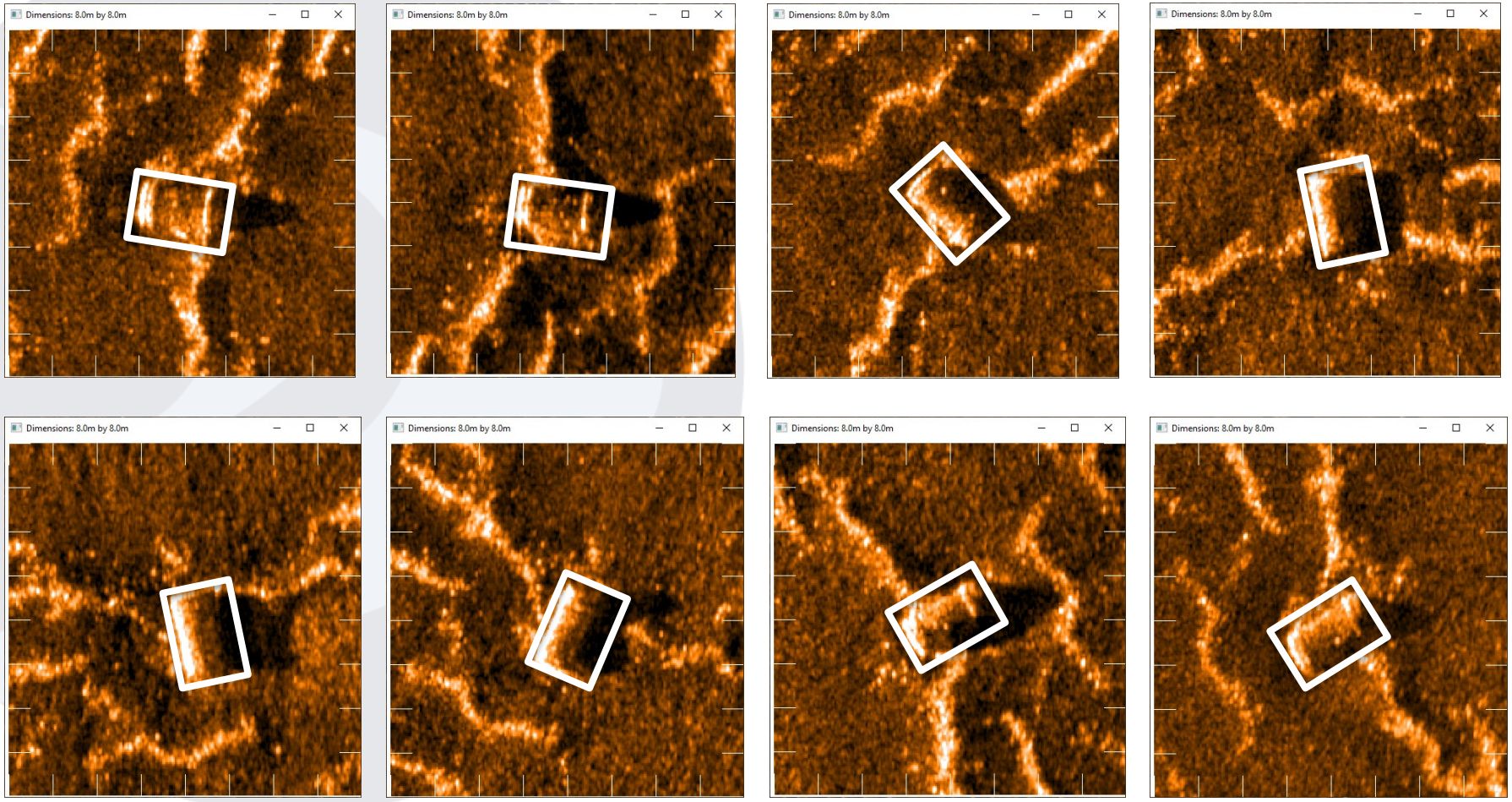
2m Cylinder Target – Imaged by Bluefin-9 UUV



8m x 8m Squares

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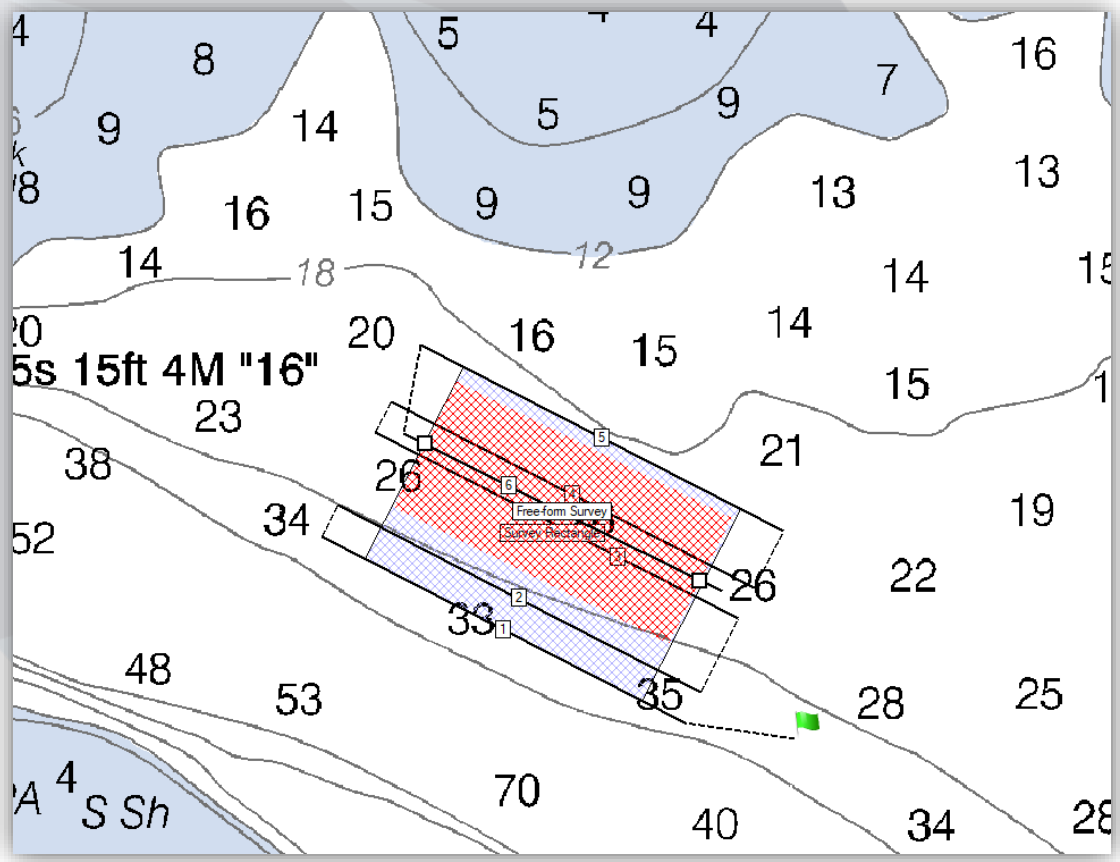
Environmental Challenges- The Patuxent River, Chesapeake Bay

UUV Operations in Shallow Waters with Varying Salinity



- The UUV had to operate just under surface in turbid water due to depth
- The optimum sonar altitude 7.5m off of the bottom
- Shallow water forced a 5m altitude configuration
- The mission was configured for a planned survey to test the best approach
- The Sonadyne Solstice sonar can collect data at 100m range in high current

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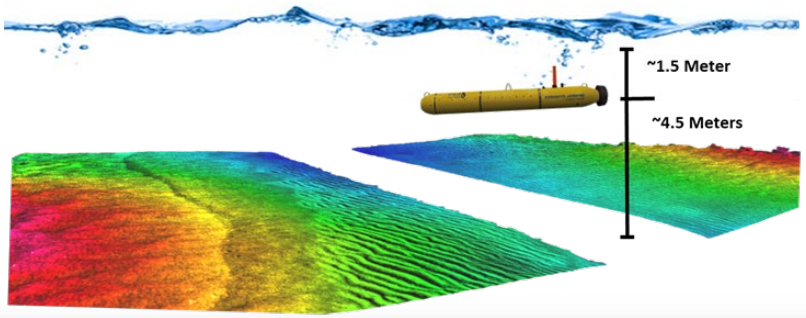
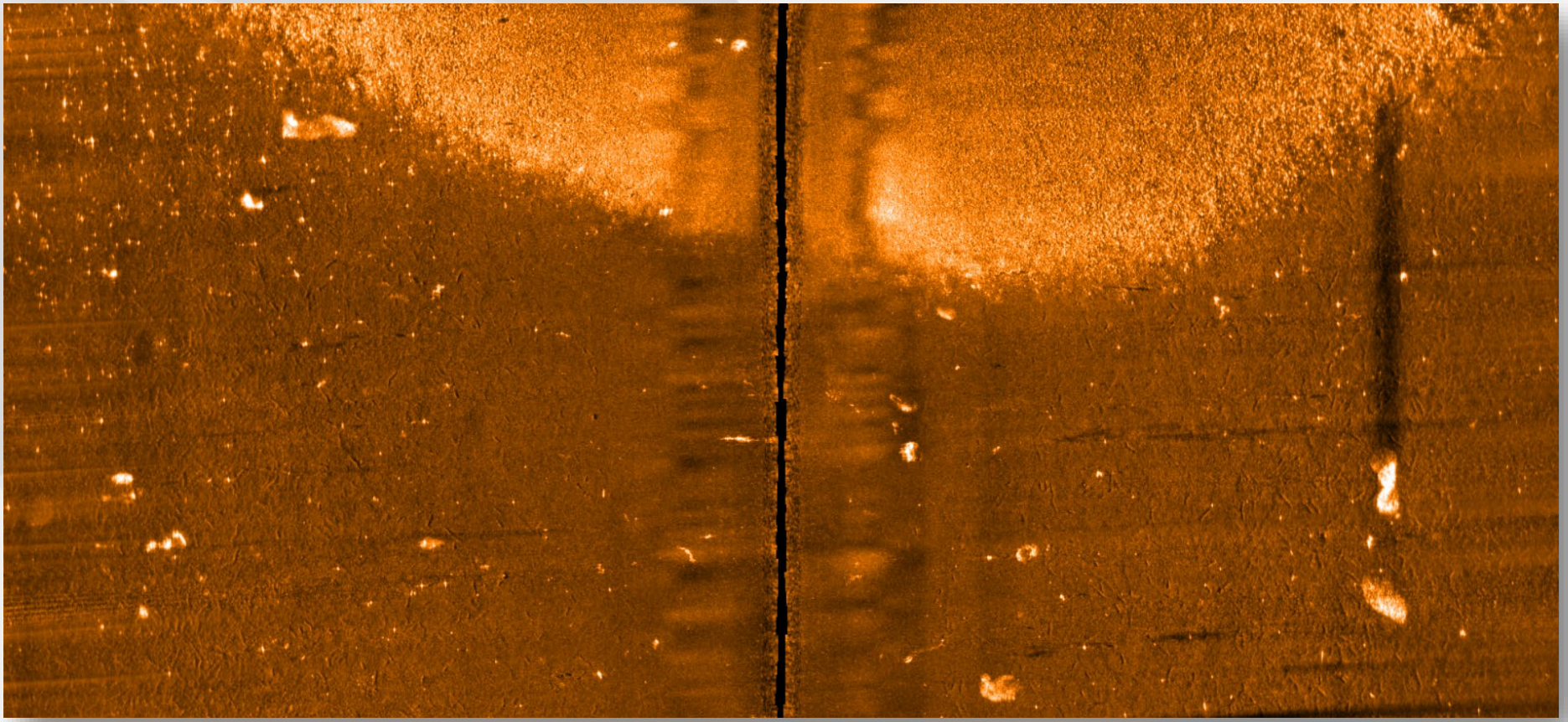
Environmental Challenges

UUV Operations in Shallow waters

Data Captured at 5m altitude, 1.5m depth





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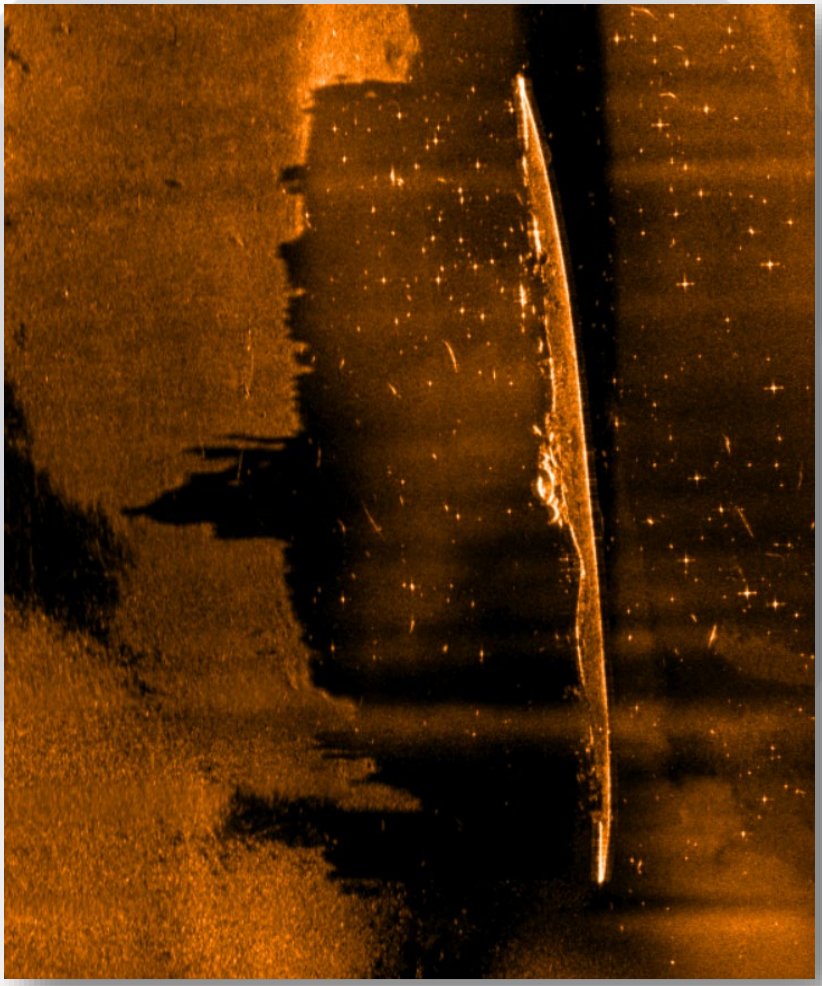
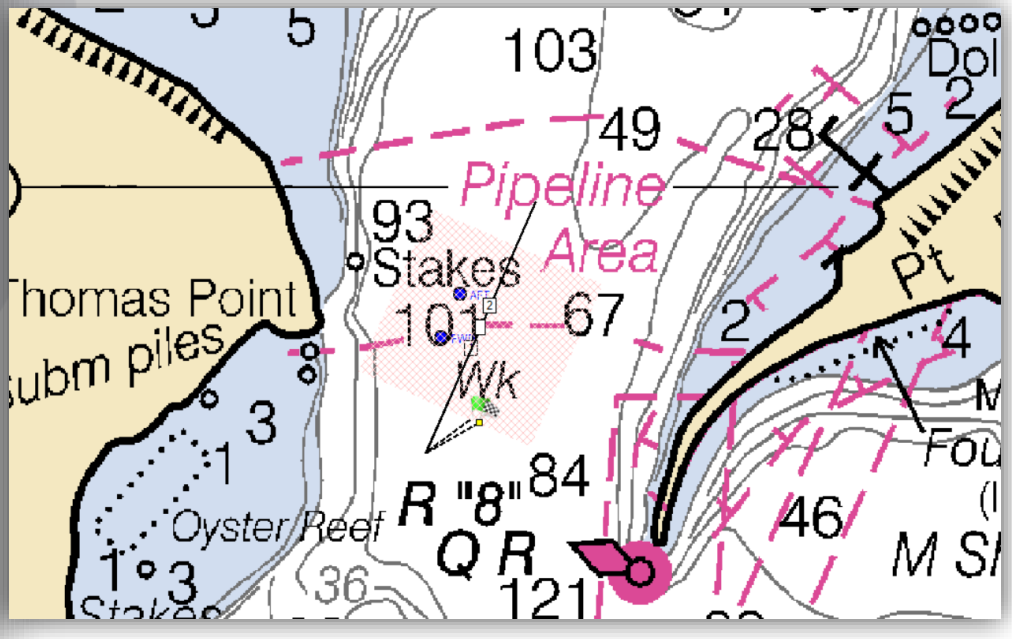
USS S-49

Bluefin-9 UUV Survey of Point Patience, Patuxent River





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Lessons Learned

- Challenge:

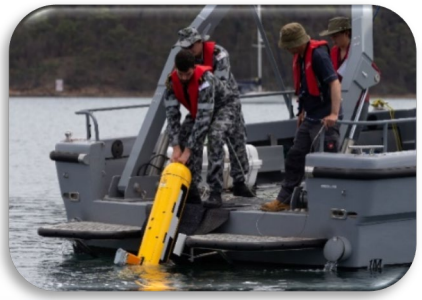
  Perform a side scan survey in very shallow, turbid water with varying salinities and freshets

- Solution:
  - Shallow water use of multi-aperture sonar produced usable data
    - < 5M altitude generated usable data (even with surface effect)
  - UUV training
    - Older platform experience translates to new products
  - Free flooded architecture is an advantage in varying salinities
  - In-field maintenance saves operational time

Additional Operational Highlights

UUV Operations

- ICEX 2020
  - Autonomous under-ice navigation
- Knifefish UUV
  - USN Operational Assessment
    - Low-Rate Initial Production/Milestone C
- SEA 1778 Australia
  - Training and testing of the Bluefin-9, Bluefin-12 platforms
  - GDMS to deliver Four (4) Bluefin-9s and three (3) Bluefin-12s to the Royal Australian Navy under Project 1778



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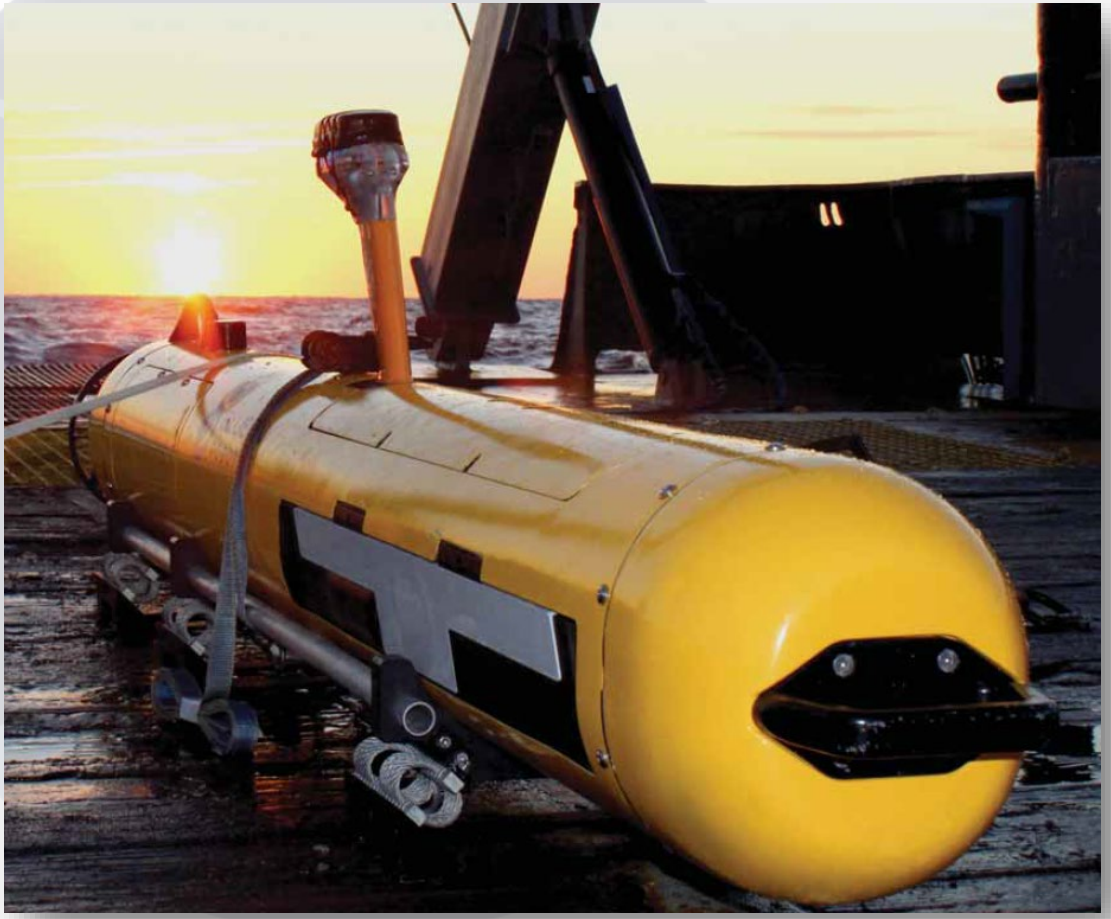
Video..

- https://www.youtube.com/watch?v=HyyLSTj6eBM

Thank you!

General Dynamics Mission Systems- Bluefin Robotics UUVs



If you have any questions, please do not hesitate to contact us at +1.617.715.7000 or Bluefin_sales@gd-ms.com

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