National Oceanography Centre

OVER THE HORIZON AND UNDER ICE ADVANCES IN MARINE ROBOTICS FROM NOC

26-SEP-2024

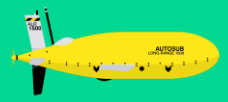
MATT TIAHLO

NMF MARINE ROBOTICS AND AUTONOMOUS SYSTEMS (MARS) TEAMS

National Oceanography Centre

Long Range Fleet

Operational



ALR 1500 x 3

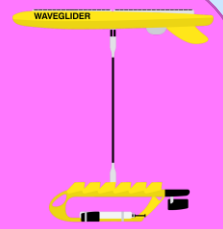
ALR 6000 x 3

X 6

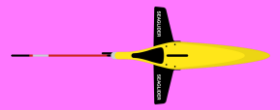
AUV Team

Slocum G2 1000 x 12
Slocum G3 1000 x 2

Slocum G2 200 x 10
Slocum G3 200 x 1



Waveglider x 2



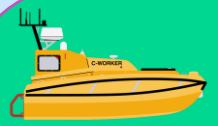
Seaglider x 9

X 11

Glider Team

Short Range Fleet

Operational

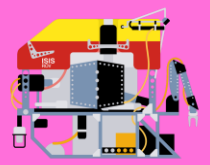


C-Worker 4 x 2

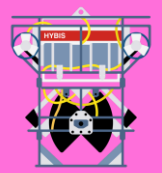
Autosub5

X 6

AUV Team



ISIS ROV



Hybis

X 7

ROV Team

Under Development

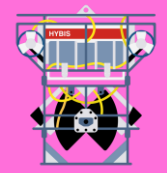
Development Group

X 25

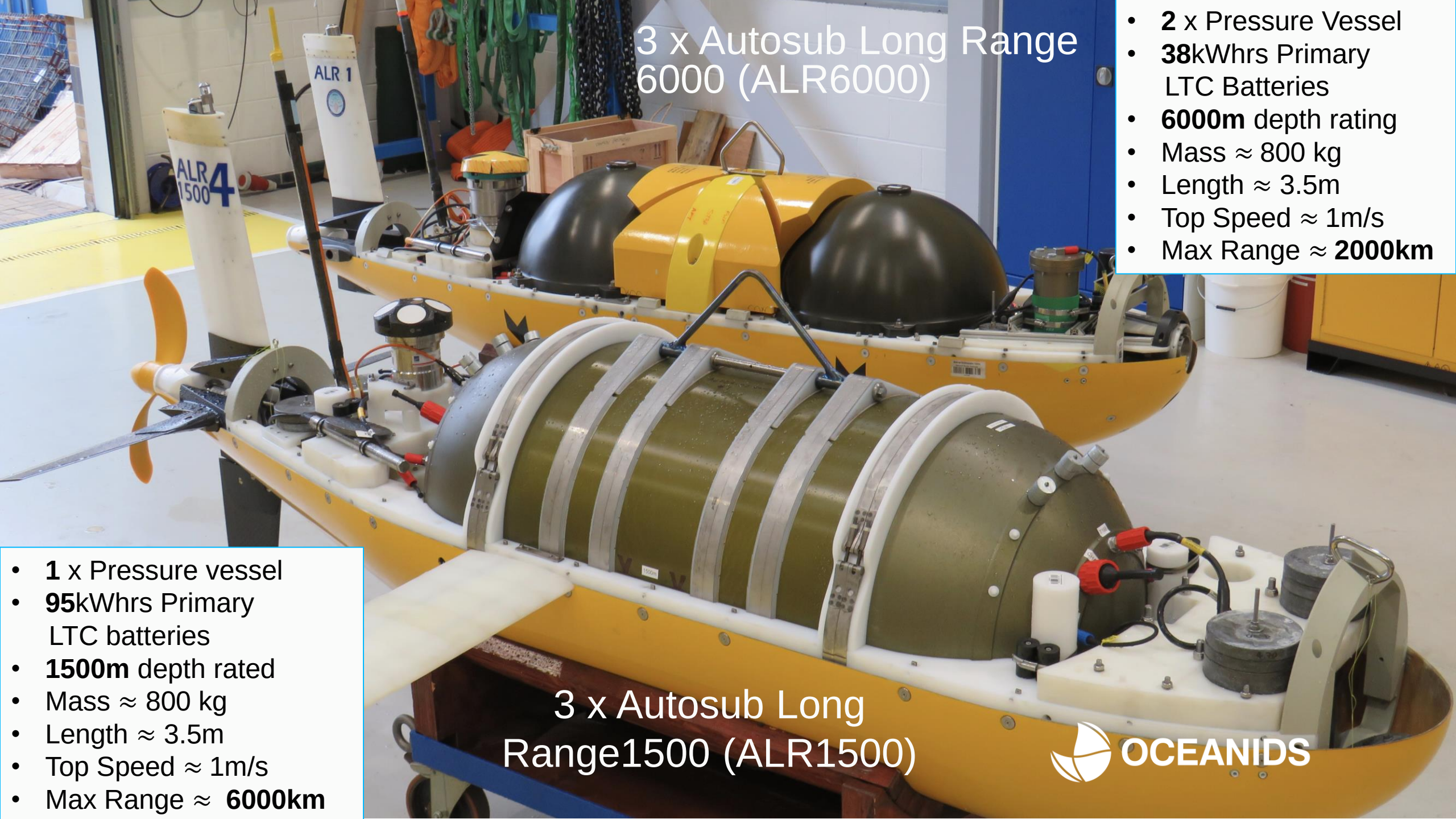
Autosub Hover 1

Sparus

ecoSUBm



MPUS



3 x Autosub Long Range 6000 (ALR6000)

- **2** x Pressure Vessel
- **38**kWhrs Primary LTC Batteries
- **6000m** depth rating
- Mass ≈ 800 kg
- Length ≈ 3.5m
- Top Speed ≈ 1m/s
- Max Range ≈ **2000km**

3 x Autosub Long Range1500 (ALR1500)

- **1** x Pressure vessel
- **95**kWhrs Primary LTC batteries
- **1500m** depth rated
- Mass ≈ 800 kg
- Length ≈ 3.5m
- Top Speed ≈ 1m/s
- Max Range ≈ **6000km**

OCEANIDS

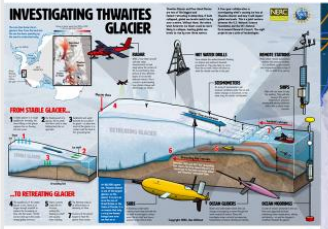
RECENT ALR MISSIONS

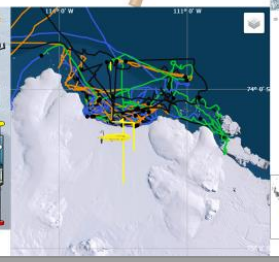
TARSAN – Q1 '22

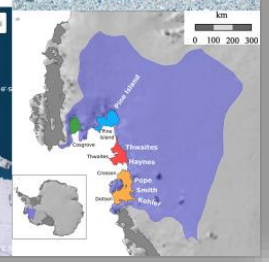
University of East Anglia · Thwaites Glacier · Natural Environment Research Council · National Oceanography Centre

Multi-day deployment of ALR1 from the Nathanial B Palmer under Dotson Glacier as part of TARSAN International Thwaites Glacier Collaboration

Longest track was 40km in under the ice flying at circa 100m altitude





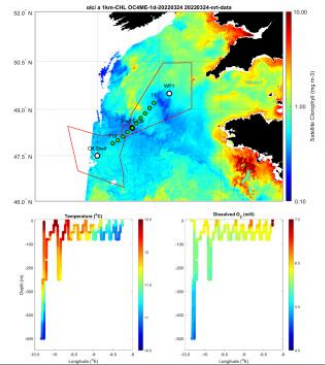


https://thwaitesglacier.org/projects/tarsan

BIOGEOCHEMISTRY (DY149) – Q1 '22

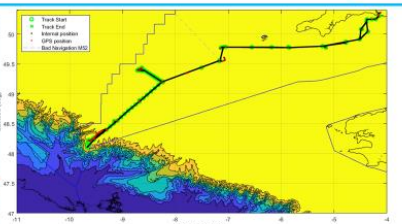
Chelsea Technologies · University of Southampton · OCEANIDS · National Oceanography Centre

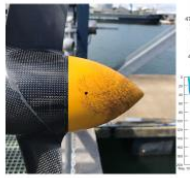
AUV	ALR2
Depth Rating	6000 m (Nominal) Currently de-rated to 600 m for sensor payload
Energy	Lithium Thionyl Chloride (~10 Days)
System sensors	• 300 kHz RDI ADCP • PNI Magnetic Heading Sensor • CTD SBE 52
Science sensors	• CTD SBE 52 MP + DO • ADCPs as per system ADCPs • DO SBE 43F • AutoNuts – Nutrients ○ LOC Nitrate ○ LOC Silicate ○ LOC Iron (Chemiluminescent) ○ LOC Iron ○ LOC Nitrite ○ LOC Phosphate • Carcass – Carbonate ○ LOC pH ○ LOC TA ○ LOC DIC ○ ANB pH ○ Stafes-App – Primary Productivity

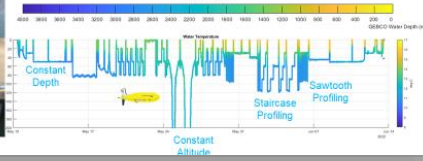


LONG DISTANCE PROVING TRIAL (LDPT) APRIL 22

Natural Environment Research Council · OCEANIDS · National Oceanography Centre

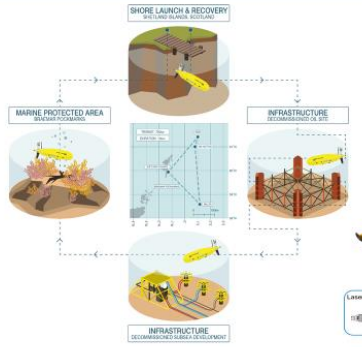




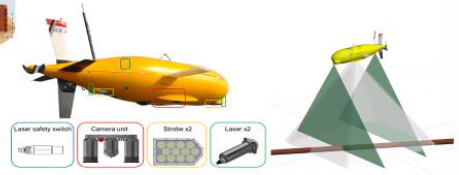


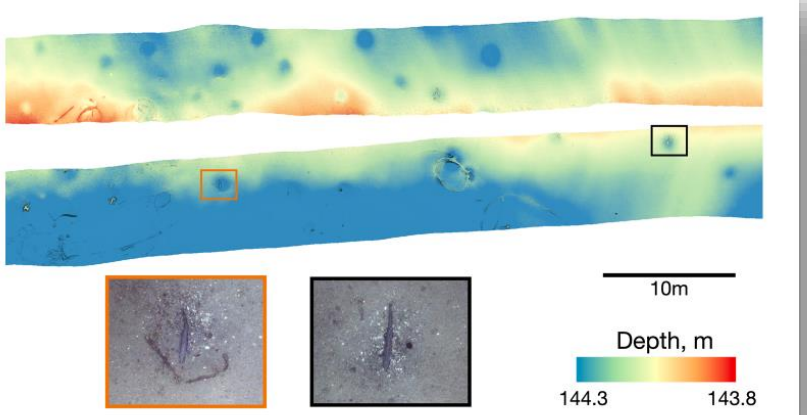
INSITE ATSEA (SEPT/OCT 2022)

University of Southampton · National Oceanography Centre



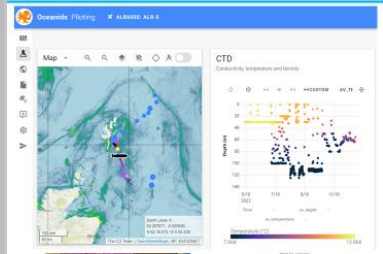
- INSITE is an independent science programme examining the effects of man-made structures in the North Sea
- The Autonomous Techniques for anthropogenic Structure Ecological Assessment ATSEA project is aiming to assess the feasibility and efficacy of fully autonomous monitoring of multiple decommissioning-related sites without the aid of a support vessel by demonstrating the use of an existing shore-launched, long-range, fully autonomous underwater vehicle for marine environmental survey.

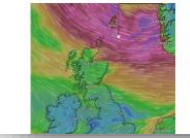


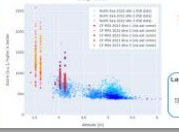


OCTOBER 2023 CENTRAL FLADDON MPA SURVEY

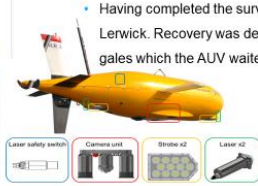
Department for Environment Food & Rural Affairs · University of Southampton · National Oceanography Centre



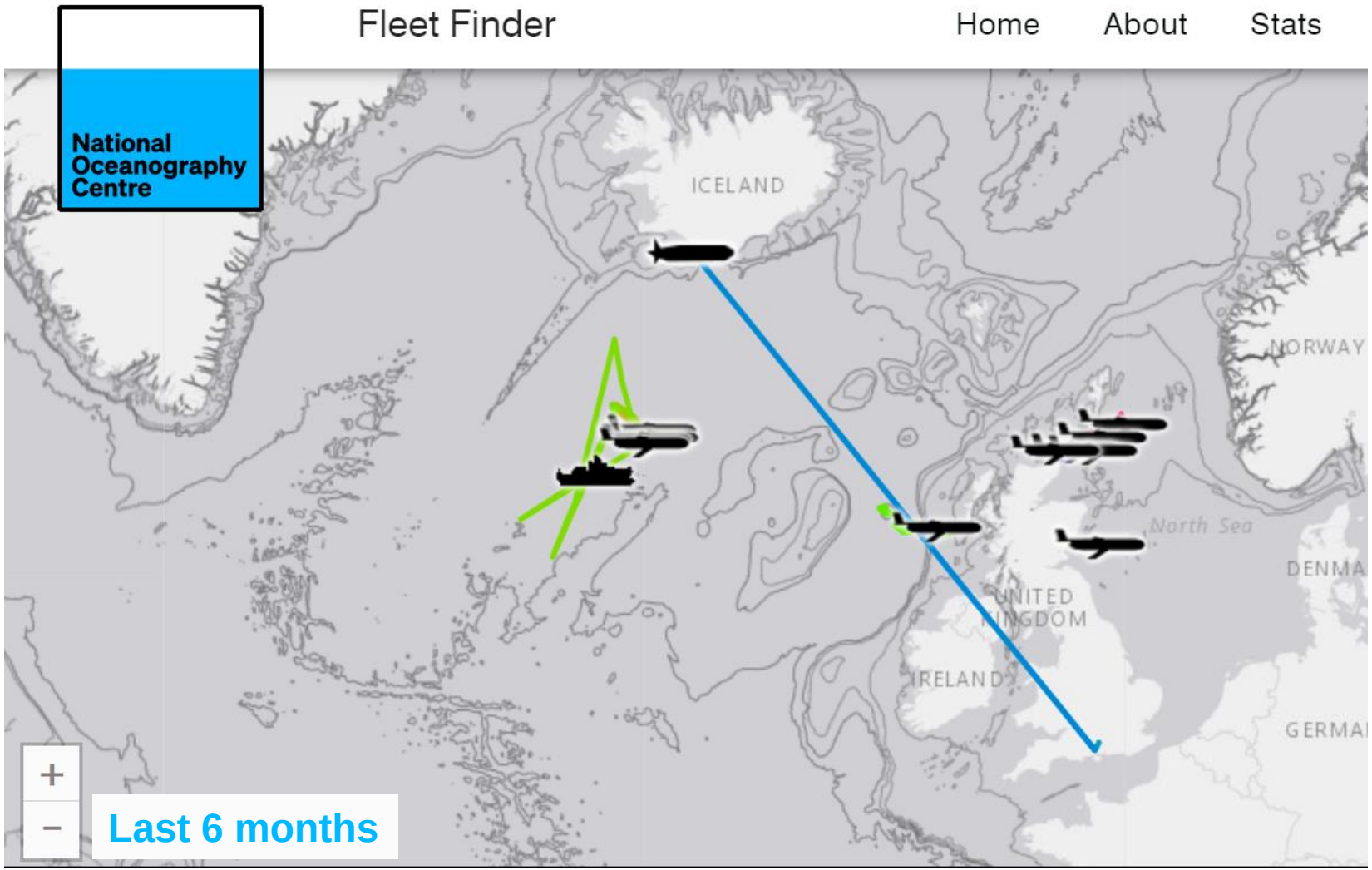




- ALR4 was deployed from Lerwick on the 4th October, following a short tow the AUV traversed 110 km to the Central Fladdon MPA.
- Within the MPA the system took ~1M images with the BioCAM imaging system flying between 3.5m and 4.5m altitude from the seabed.
- Having completed the survey the AUV transited back to Lerwick. Recovery was delayed by strong Autumn gales which the AUV waited out loitering subsea.



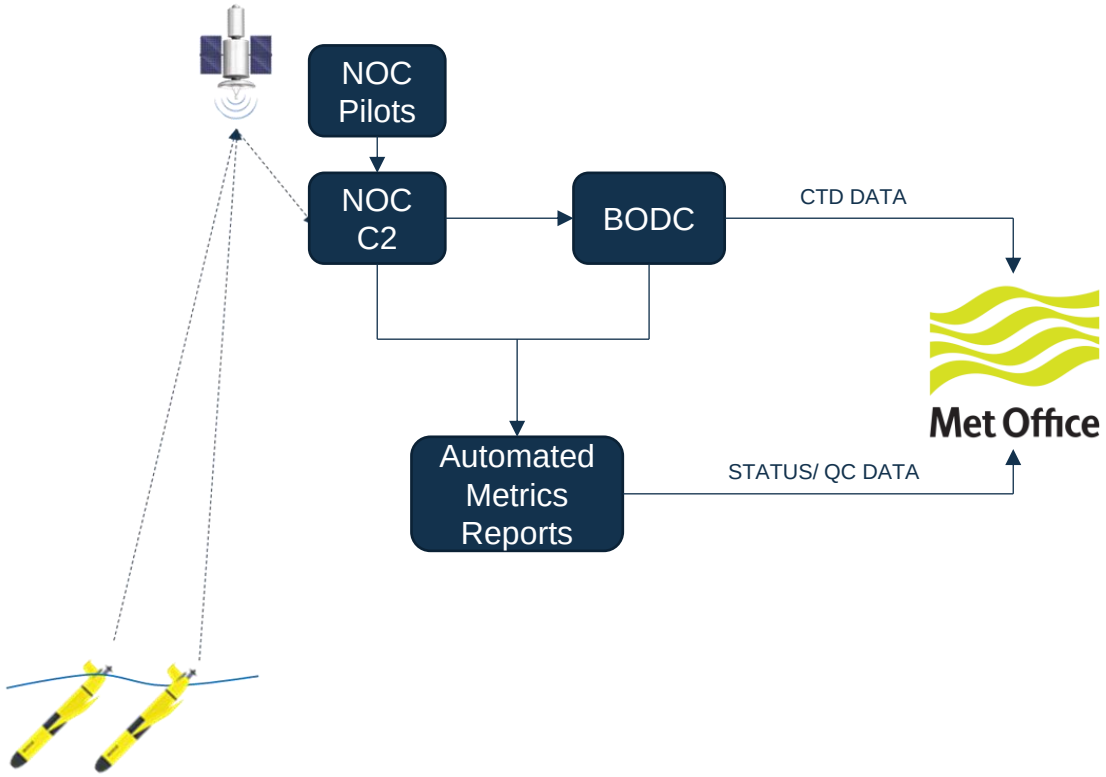
WHAT IS HAPPENING NOW (ISH)

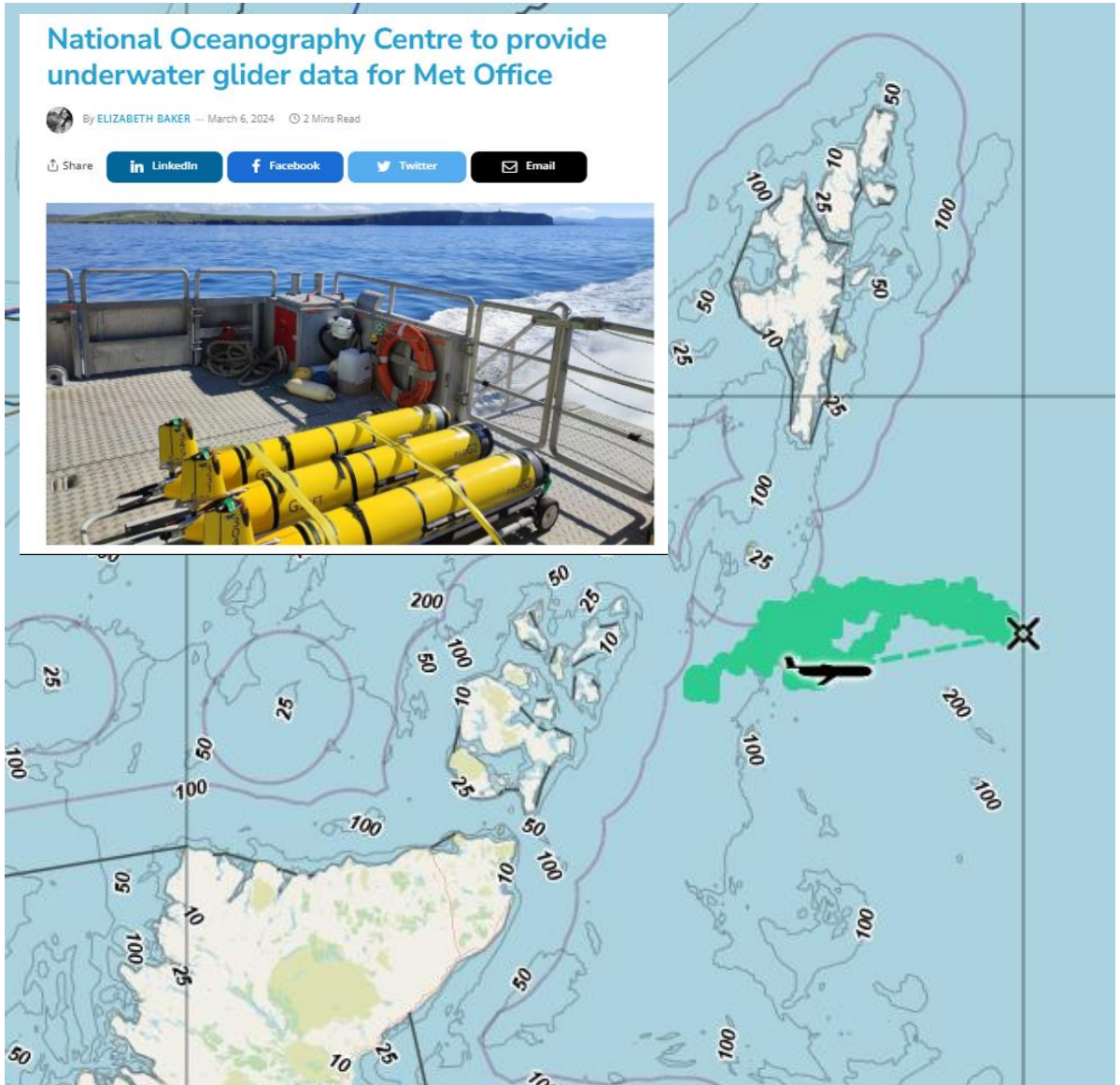


www.mars.noc.ac.uk

MOGLI - UK MET OFFICE GLIDER PROJECT
CONTINUOUS PRESENCE ON THE JONSIS LINE

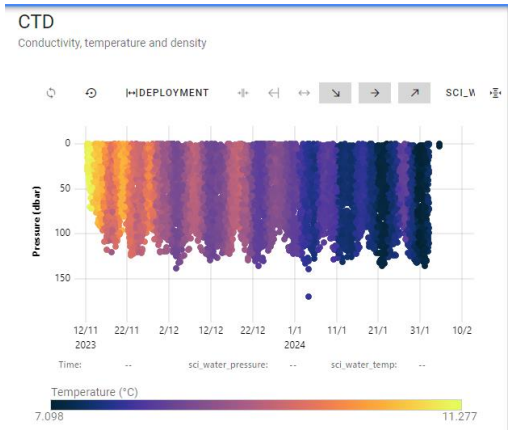
- Patrolling Western end of the JONSIS Line for last 21 months
- Providing Near Real Time Conductivity, Temperature, & Depth (CTD) Data that is fed into the AMM 15 ocean model.

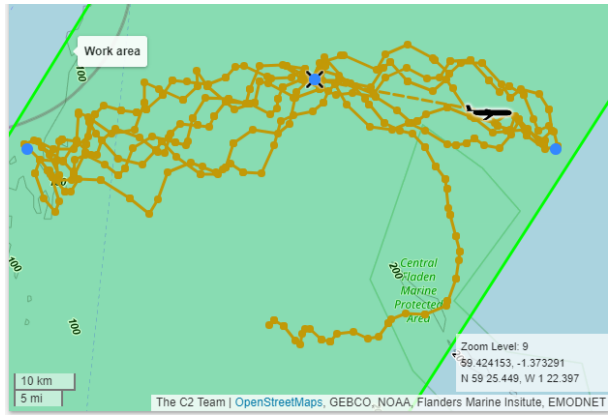


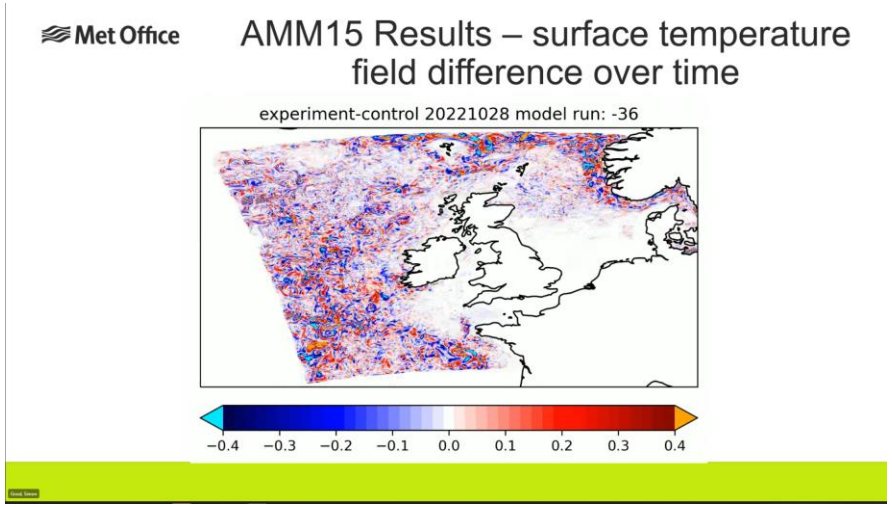


MOGLI – THE GOOD AND THE BAD

The Good – positive impact on model performance





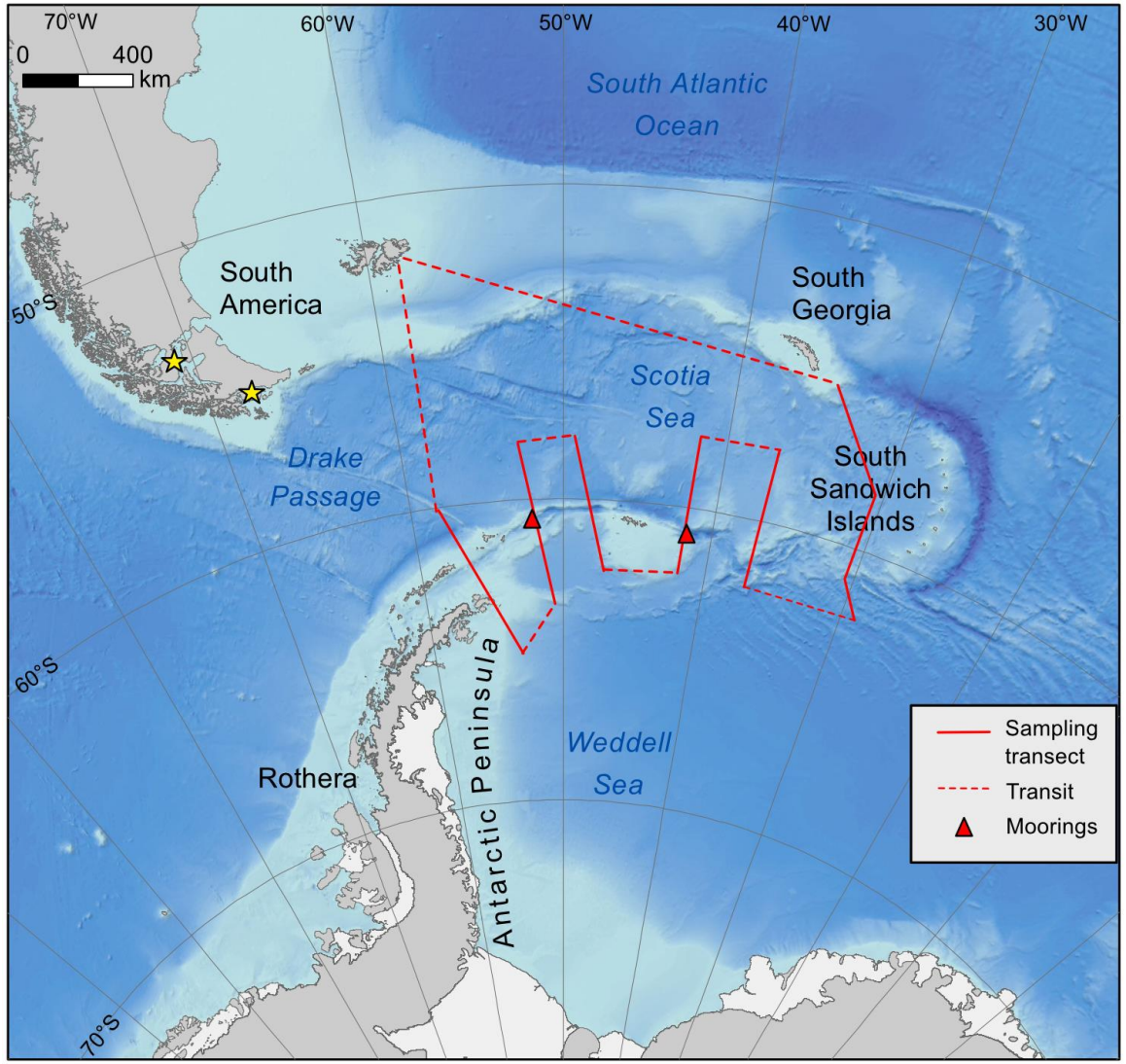


The Bad – We lost a glider

We had factored a loss into the project

BIOPOLE (DEC 23-FEB 24)

- BIOPOLE is an interdisciplinary NERC programme examining biogeochemical processes and ecosystem function in polar ecosystems.
- An Observational campaign in the Weddell sea using of ships, moorings and gliders
- Gliders made short duration missions under retreating sea ice using a Backseat Driver and upwards altimeter to enable this capability.

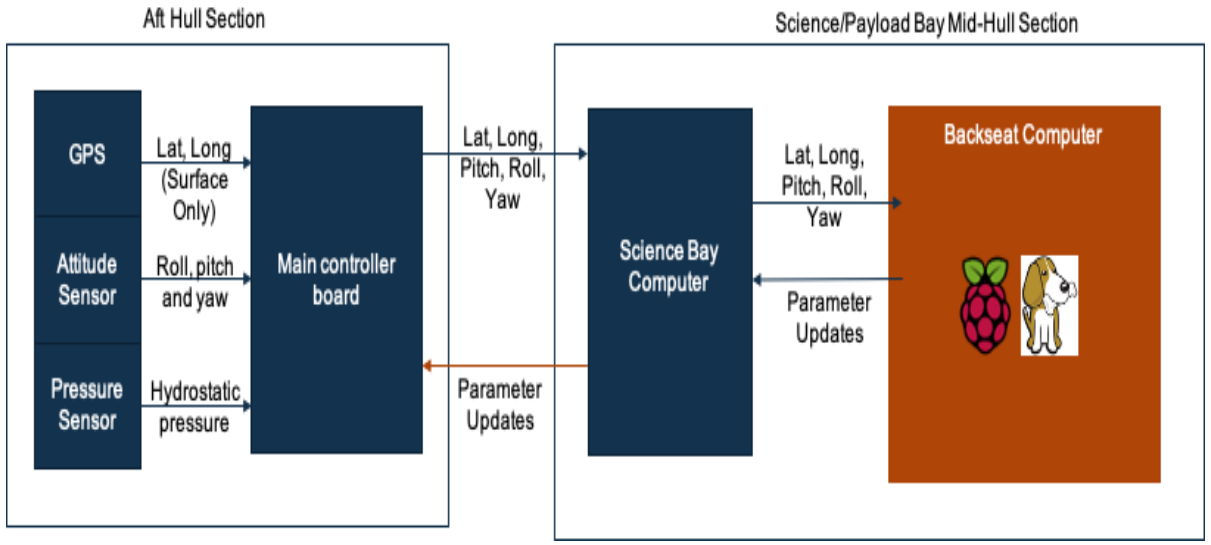


BIOPOLE – GLIDER BACK SEAT DRIVER

National Oceanography Centre

Goal

Develop ice coping strategies and add to a “backseat driver” to control the gliders under ice



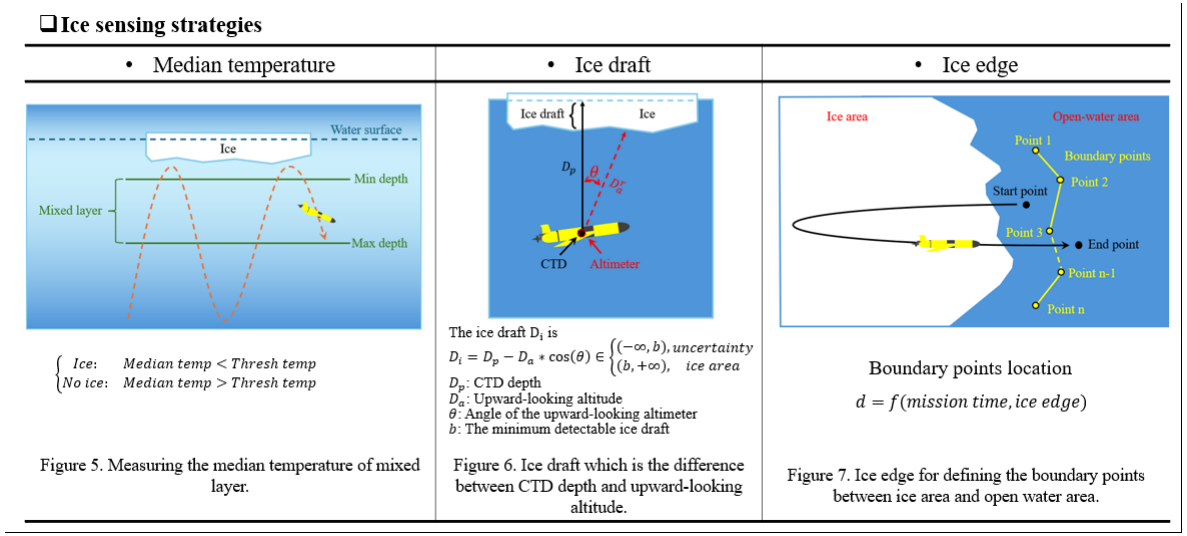


Figure 5. Measuring the median temperature of mixed layer.

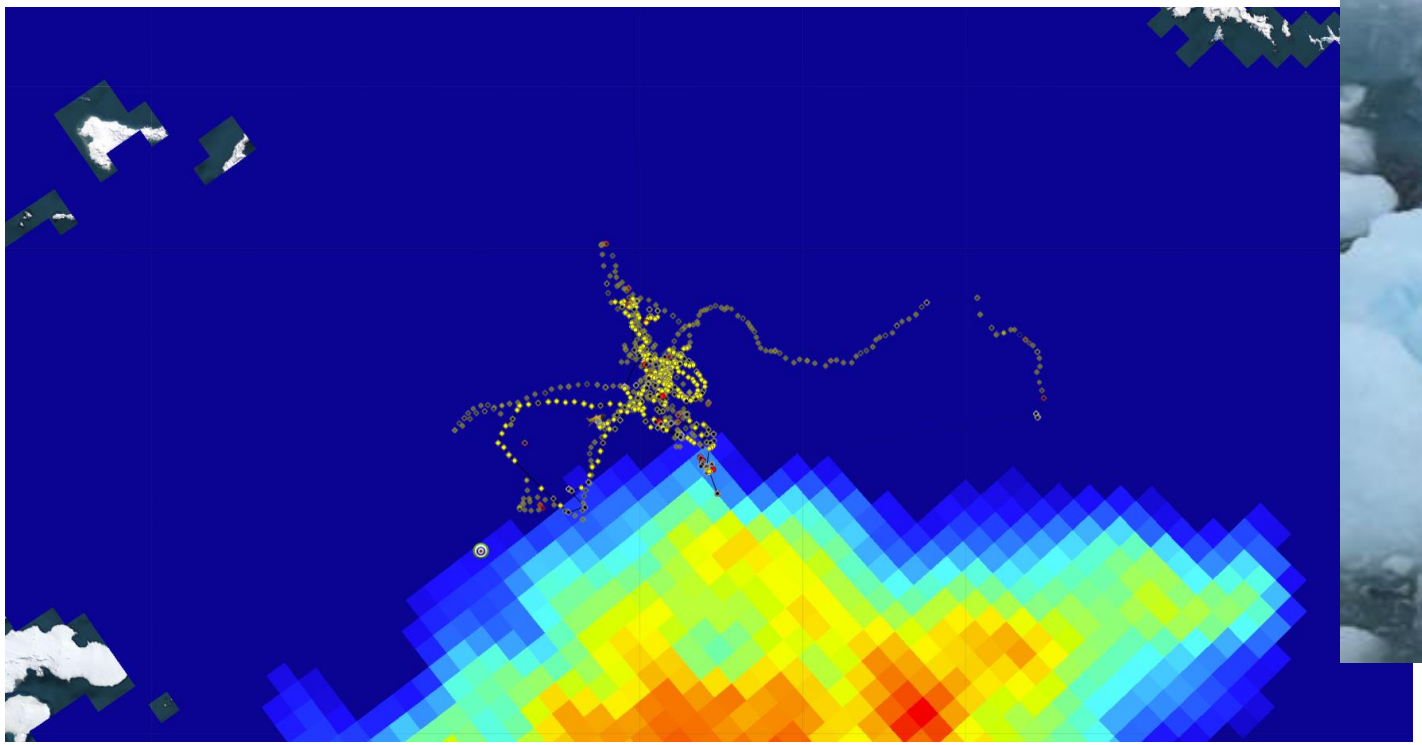
Figure 6. Ice draft which is the difference between CTD depth and upward-looking altitude.

Figure 7. Ice edge for defining the boundary points between ice area and open water area.

Courtesy of Yaomei Wang

GLIDER OPERATIONS – IT WAS VERY DIFFICULT

Piloting using satellite data to get into and out of the marginal ice zone



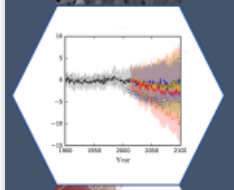
Gliders just before being “munched” by the ice

Lots of lessons to learn about the environment and best approach to it

THE BIOCARBON PROGRAMME

The major science questions

How does marine life affect the ability of seawater to absorb carbon dioxide, and how will this change?



How will the rate at which marine life consumes carbon dioxide change?

How long can marine life store carbon in the ocean and how will climate change affect this?

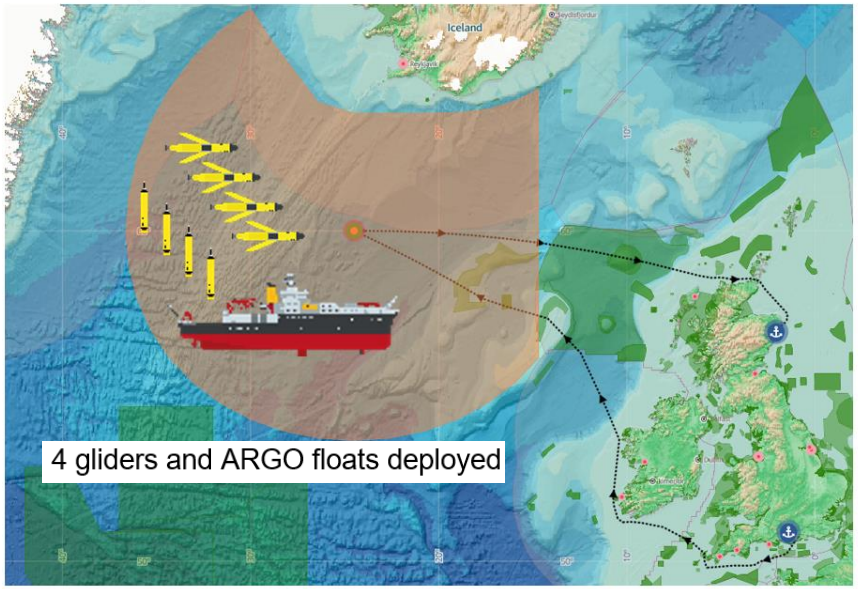
BIO-Carbon programme

- Focussed on understanding role of marine life in ocean carbon storage and how this will alter under climate change
- Baseline information necessary for many mCDR discussions
- Strategic Programme, £10.3M, spanning ~6 years, started 2022
- Nine projects already funded, including a gap analysis (BRICS)
- Three fieldwork projects - 6 months of activity just begun
- Final stage will be aimed at modelling and synthesis

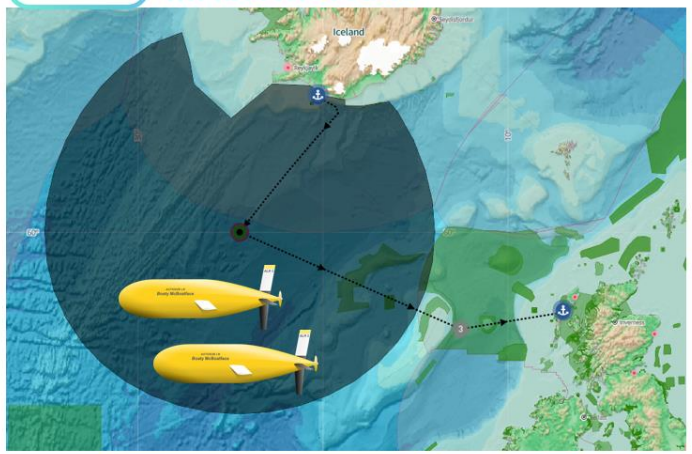
THE BIOCARBON PROGRAMME

Fieldwork

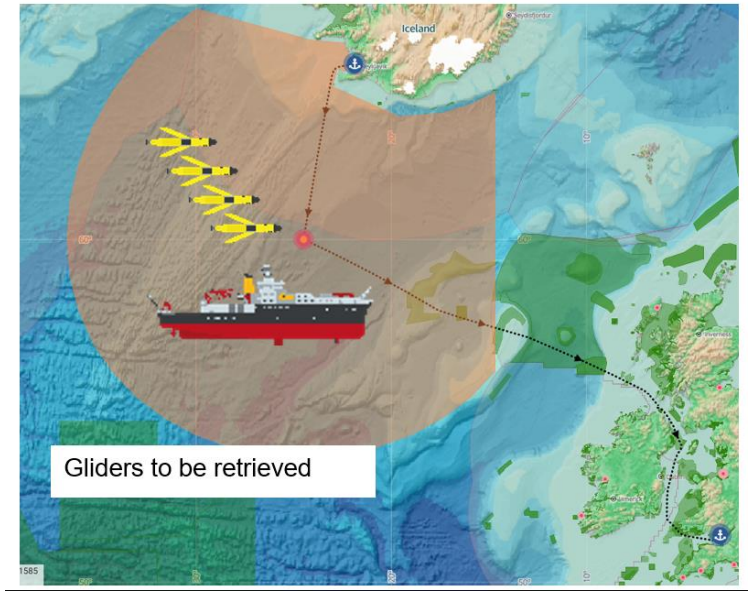
Spring cruise – DY180
21 May – 27 June



BIO-Carbon-FMRI ALR mission
June - August



Autumn cruise – JC269
6 September – 13 October



BIOCARBON ALR4

MiXed Layer ALR (ALR4) BIOCARBON Natural Environment Research Council FUTURE MARINE RESEARCH INFRASTRUCTURE National Oceanography Centre

TRIOS RAMSES hyperspectral radiometer: ACC-VIS (320-950nm)

LoC:
2 x OTE LoC
- TA
- DIC

4 x OTE LoC
- pH
- Nitrate
- Phosphate
- Silicate

All Via OTE Hub

eco-triplet: BBFLCD (chlorophyll, backscatter 700nm, fdom)
https://seacatalog.com/product/wet-labs-eco-flrtd-fluorometer/

Nortek 500 DVL/ADCP: down current measurement
https://www.nortekgroup.com/products/dvl500-6000-m/pdf

CTD+DO: SBE 52MP CTD and 43F dissolved oxygen sensor.
https://www.seabird.com/sbe-52-mp-moored-profiler-ctd-and-optional-do-sensor/product?id=60762467706

AquapHOx-LX (standalone)

UVP6: The Underwater Vision Profiler or UVP (CNRS patent) is designed to study large (>100 µm) particles and zooplankton simultaneously and to quantify them in a known volume of water. The UVP system makes use of computerised optical technology with custom lighting to acquire digital images of zooplankton IN SITU down to depths of 6000m.
http://www.hydroptic.com/index.php/public/Page/product_item/UVP6-LP

BIOCARBON ALR-4 OVERVIEW

Shore Launched
09.06.2024
Vestmannaeyjar, Heimaey, Iceland

First Trans-Basin Autosub Deployment

>56 days on Mission 64% increase on previously demonstrated Endurance
>25 days energy remaining

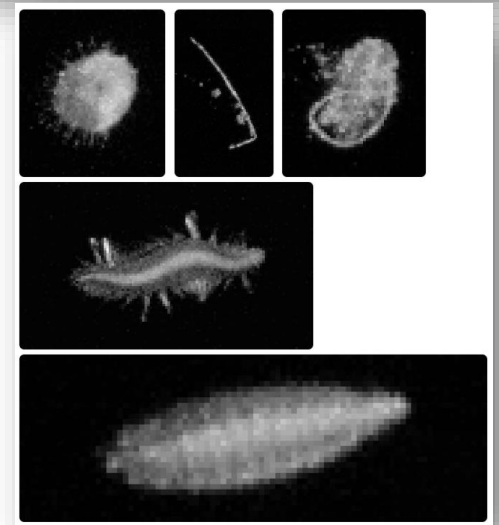
>2500km / 1350 Nautical Miles Travelled - 25% increase on previous best

>250 Dives

59 Over-the-Horizon Missions Commanded and Controlled via Satellite

Shore Recovered
05.08.2024
Leverburgh, Harris, United Kingdom

Payload:
CTD, Conductivity*, Temperature* and Pressure*, + Dissolved Oxygen*
6x in-situ Miniaturised Chemical Analysers; DIC*, TA*, pH*, SiO_4*, PO_4*, & NO_3*
Laser Zooplankton Imaging system UVP6
Hyperspectral Radiometer
Up & Down ADCP, Acoustic Doppler Current Profilers
*Near Real Time data telemetered via satellite.

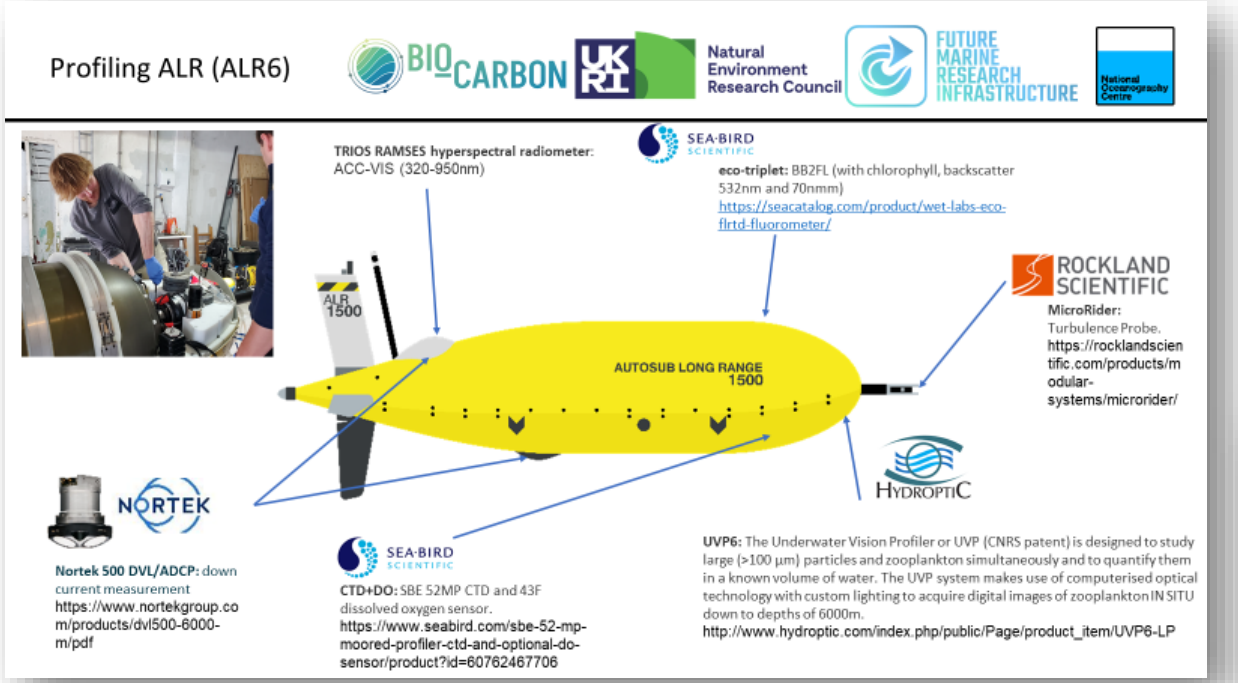


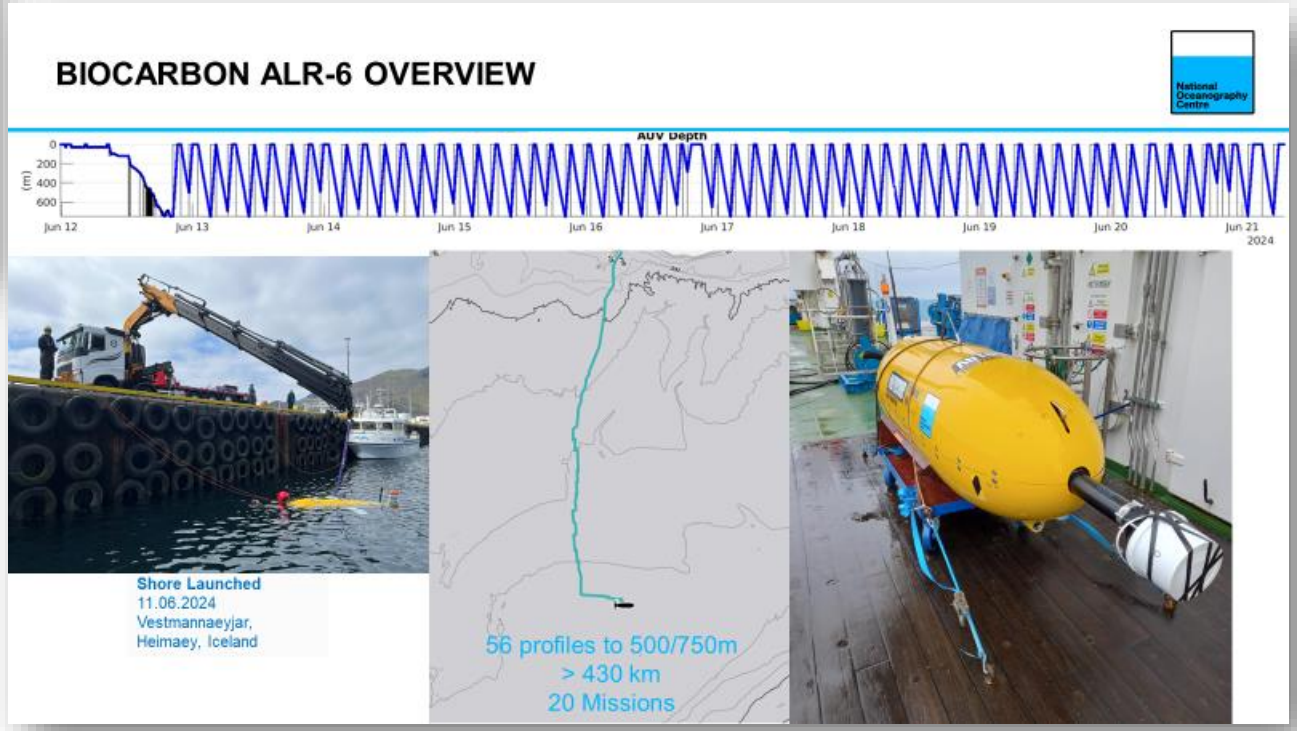
BBC NEWS

Down into the ocean's 'twilight zone' with Boaty McBoatface

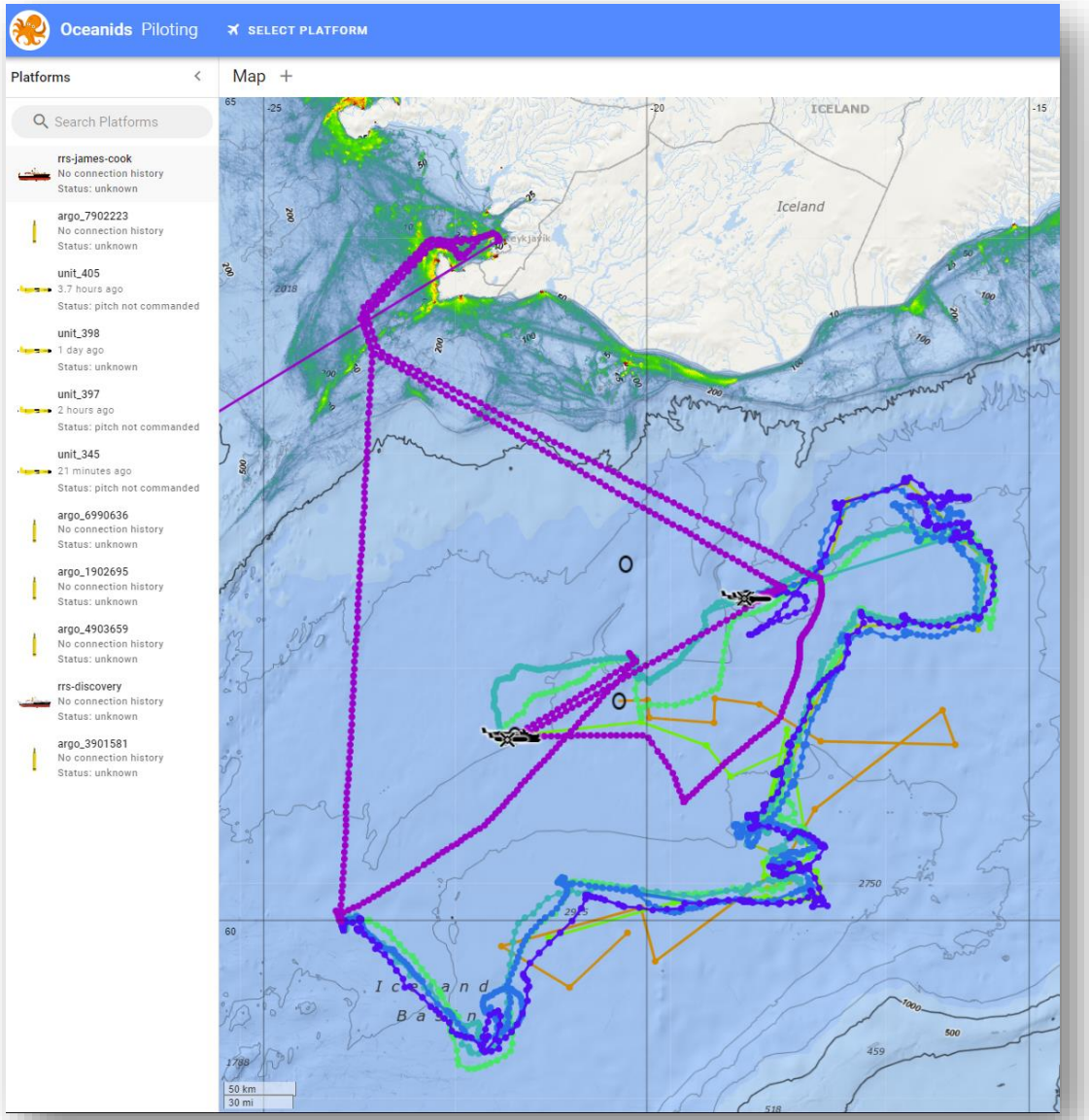
Boaty McBoatface spent 55 days at sea before coming ashore in Scotland

BIOCARBON ALR 6

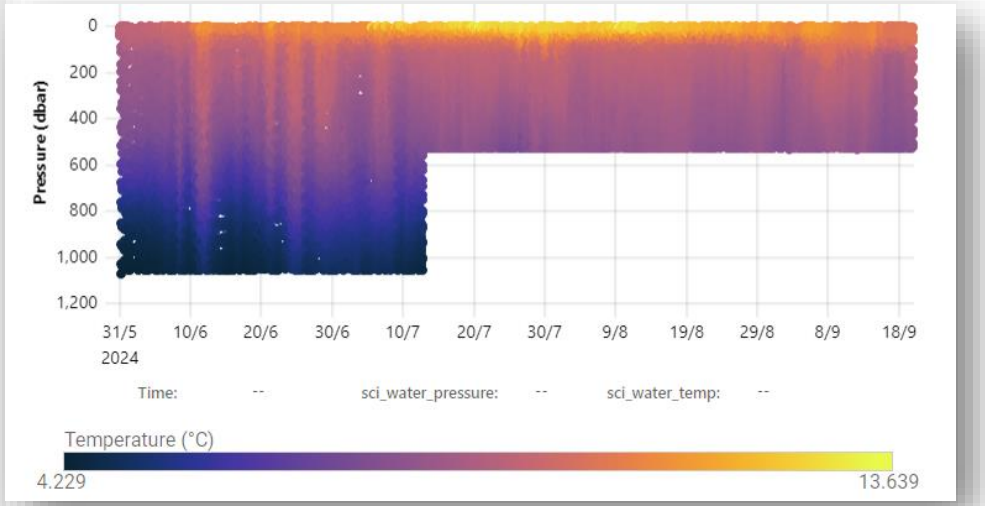


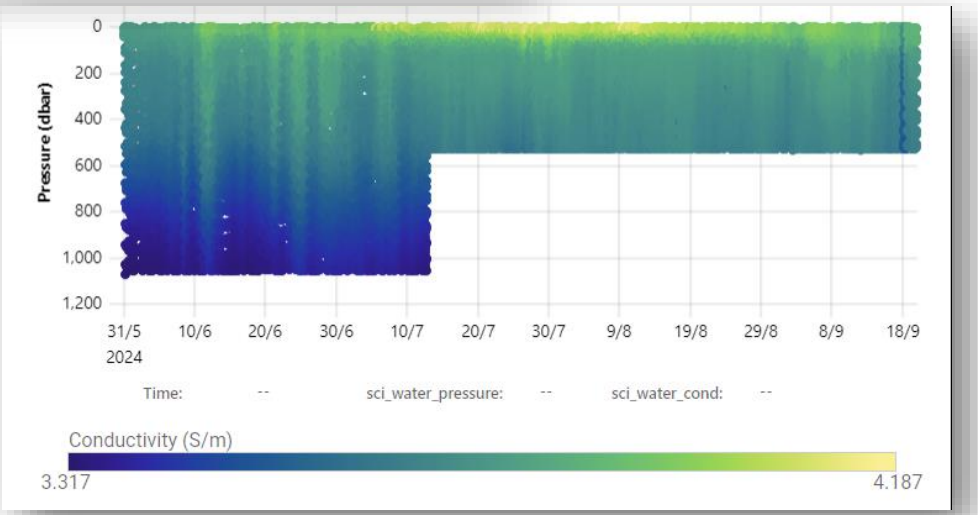


WHAT'S HAPPENING NOW?



Slocum Unit 397 (Nelson) Temperature and Conductivity





Follow progress on:
https://bio-carbon.ac.uk
https://mars.noc.ac.uk/

FINAL THOUGHTS – AND LESSONS LEARNED

- Marine Robotics are just other tools in the toolbox they don’t replace ships but augment them
- You will lose them at some points
- To get the best out of marine robotics you need to have:
  - Staff with a deep understanding of the tech
  - Detailed knowledge of the environment you are operating in
  - Good processes and tools to support the staff
  - Luck is also always useful
- Combined ship operations and autonomy provide interesting opportunities