NOC MARINE AUTONOMY & TECHNOLOGY SHOWCASE

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

noc.ac.uk/matshowcase

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Prof Russ Wynn

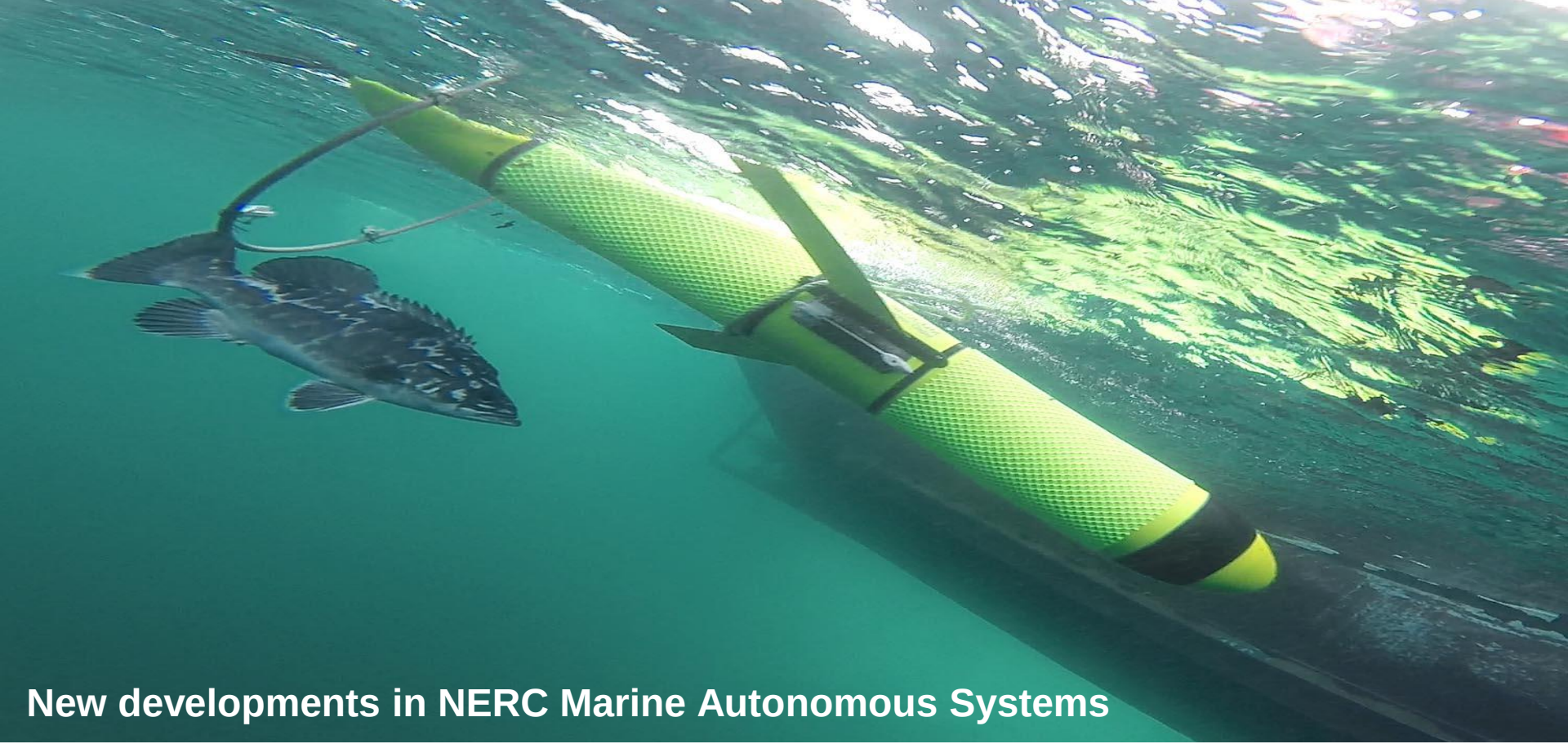
Chief Scientist Marine Autonomous and Robotic Systems MARS NOC

Session Chair Marine Autonomous Systems (MAS) Update

NERC Marine Autonomous Systems and NEXUSS showcase

0900-0930: Arrival and registration
0930:1000: New developments in NERC Marine Autonomous and Robotic Systems (Russell Wynn, NOC)
1000-1020: Shallow-water seabed mapping using an AUV (John Howe, SAMS)
1020-1040: Novel glider deployments in submarine canyons (Rob Hall, UEA)
1040-1100: The utilisation of Unmanned Aerial Vehicles in Antarctica (Carl Robinson, BAS)
1100-1130: Coffee
1130-1150: The NERC Deep Links project: MAS-based survey of UK seamount habitats (Nils Piechaud, Plymouth Uni)
1150-1210: Novel ROV-based imaging of deep-sea canyon habitats (Katleen Robert, NOC)
1210-1230: Unmanned Aerial Vehicles for coupled oceanographic and atmospheric studies (Phil Anderson, SAMS)
1230-1250: Recent developments in MAS-based polar research and the Southern Ocean Glider Base (Alex Brearley, BAS)
1250-1345: Lunch
1345-1400: NERC-EPSRC NEXUSS Centre for Doctoral Training (Alberto Naveiro-Garabato, Uni Southampton)
1400-1500: NEXUSS student/partner presentations
1500-1530: Coffee
1530-1540: Introduction to the NERC sensors capital programme (Matt Mowlem, NOC)
1540-1600: Science enabled by gliders and highlights from the EGO conference (David Smeed, NOC)
1600-1610: Accessing the MARS fleet (Maaten Furlong, NOC)
1610-1630: NERC MAS capital programme: introduction and opportunities (Maaten Furlong, NOC)
1630: Close

1700: Evening drinks (Dancing Man)



New developments in NERC Marine Autonomous Systems

Prof Russell B Wynn (Chief Scientist, MARS)

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noc.ac.uk

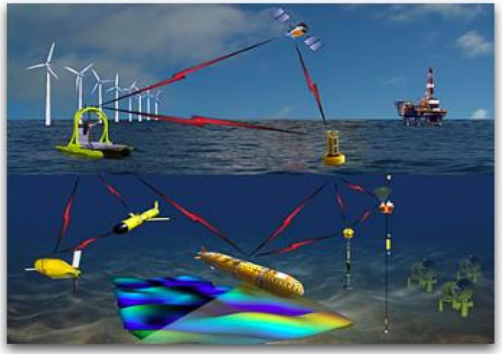
NERC SCIENCE OF THE ENVIRONMENT

NERC puts £15m into creating new marine robots and sensors

27 April 2016

NERC will invest £15m in Marine Autonomous Systems (MAS) and sensors over a five-year development programme.

A £10m investment will be made through the NERC National Oceanography Centre (NOC) to ensure the UK remains at the forefront of global marine science and technology innovation by developing a new 1500m depth-rated Autosub Long Range (ALR1500) and a new 6000m depth-rated autonomous underwater vehicle (Autosub6000 Mk2). This will support future under-ice and deep-ocean science, including a number of upcoming major marine research programmes such as the Changing Arctic Ocean programme. There will also be investment in command-and-control systems for efficient fleet management, and new equipment to support the NERC-EPSRC Centre for Doctoral Training in 'Smart and Autonomous Observing Systems', called NEXUSS - 'NEXt generation Unmanned System Science'.



In this section

2016 news announcements
└ **NERC puts £15m into creating new marine robots and sensors**

Related links

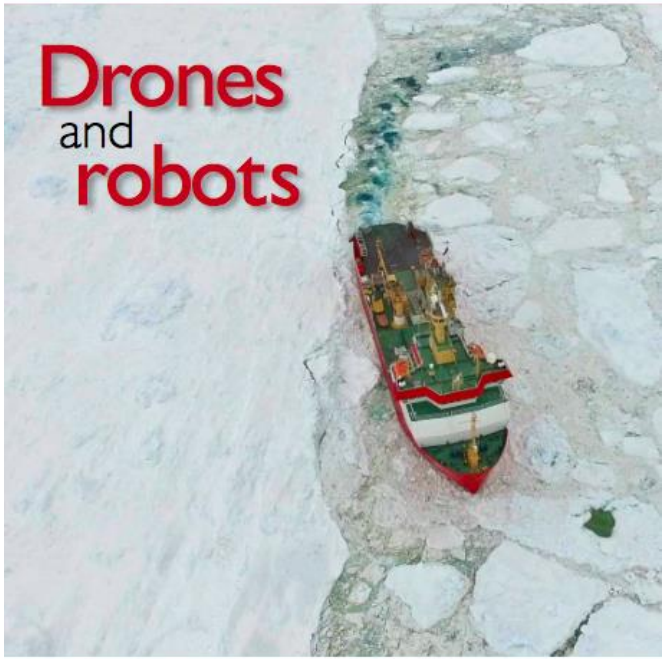
- Capital funding
- Changing Arctic Ocean: Implications for marine biology & biogeochemistry
- NERC and EPSRC announce new Centre for Doctoral Training in smart observation

>endurance/flexibility/inter-operability/AI, <size/speed/cost

NERC SCIENCE OF THE ENVIRONMENT

Summer 2016

Planet Earth

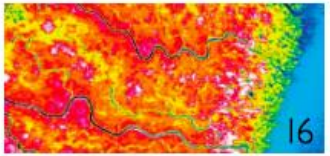


Drones and robots

Mapping our landscape from the air | Hitching a lift on the Global Hawk | Autosubs are go!

In this issue

Summer 2016



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Science & Environment

Arctic crossing planned for 'Boaty' sub

By Jonathan Amos
BBC Science Correspondent

24 minutes ago | Science & Environment

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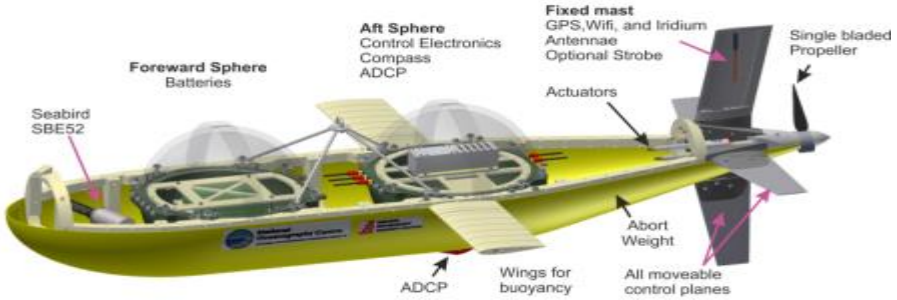
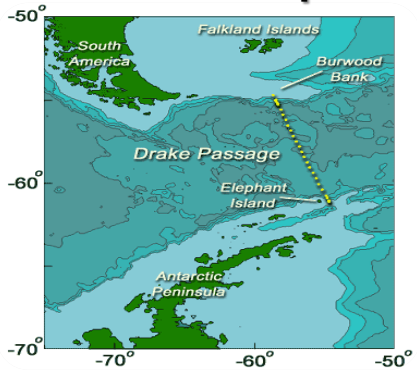
The UK's favourite new yellow submarine, Boaty McBoatface, is in training for a grand challenge.

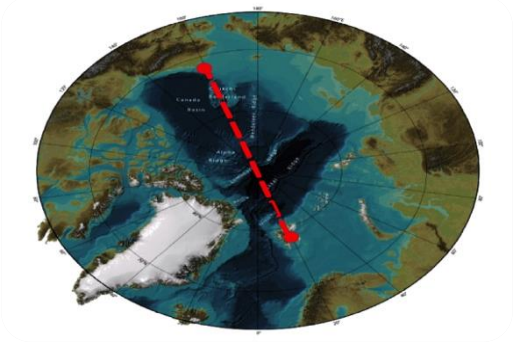
MARS Autosub Long Range (ALR)



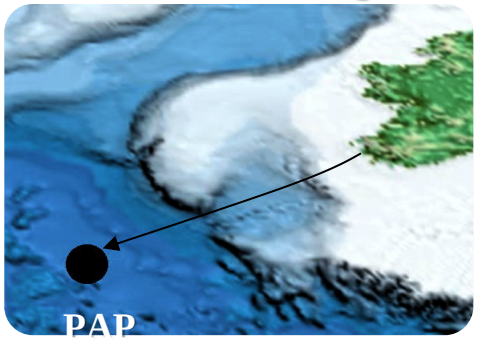
Long-term observation of ocean choke points



Crossing the North Pole



Self deploying long-term moorings



ALR applications in long-term CCS monitoring

energy technologies institute

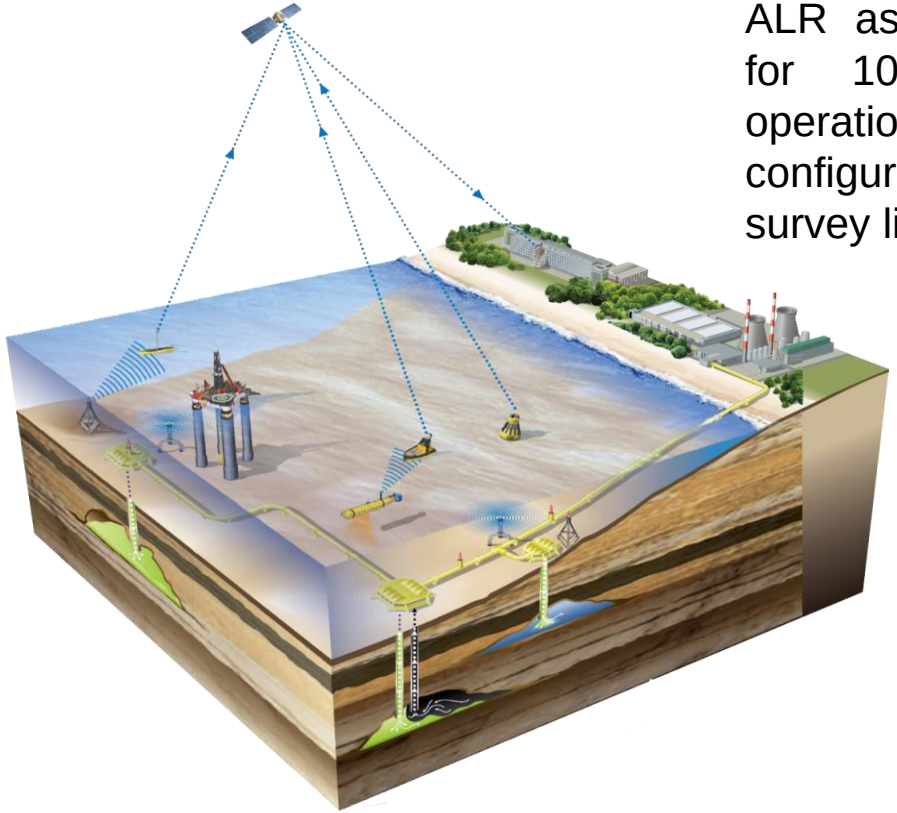
Sonardyne SOUND IN DEPTH

FUGRO

PML | Plymouth Marine Laboratory

UNIVERSITY OF Southampton

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL



ALR as shore-launched vehicle for 10-14 day North Sea operations, depending on sensor configuration, running 5 km survey lines

MARINE ROBOTICS INNOVATION CENTRE

Celebrating our first year

INVESTMENT

£15m investment from NERC for autonomy, sensors and commercial projects

£8m collaborative research and development project impact underway

x6 new NOC employees working in Marine Autonomous Robotics Systems (MARS)

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SBRI: Long Endurance Marine Unmanned Surface Vehicles (LEMUSV)

MOST AV ‘AutoNaut’

ASV ‘C-Enduro’

AutoNaut secures investment as Seiche takes majority stake

2nd August 2016

AutoNaut has secured investment from the Seiche Group to advance R&D aims, assure long-term growth and develop business across UK and international markets.

In September 2015, Seiche agreed its first investment in AutoNaut and this new deal sees them take a majority stake in the company. AutoNaut Ltd is the new name for the company previously trading as MOST (Autonomous Vessels).

Directors David Maclean and Mike Poole will continue to run the company from their Chichester base, concentrating on Technical and Marketing/Sales activity respectively. The investment from Seiche will provide additional resources for R&D and manufacturing as well as administrative support. Seiche will also help to expand all sales and marketing activity. As one of the fastest growing companies in the marine technology sector, Seiche will provide a springboard for AutoNaut into a number of commercial markets.

Roy Wyatt, MD of Seiche, comments: "AutoNaut is set to be the go-to marine data collection hub of the future. AutoNaut can independently operate offshore for months fitted with a suite of cutting edge sensor technologies. AutoNaut complements and completes Seiche's portfolio of monitoring, mitigation and measurement products and services."

SBRI: Adaptive Autonomous Ocean Sampling Networks (AAOSN)

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FROM COAST TO DEEP OCEAN – MAKING SENSE OF CHANGING SEAS

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NOC Events

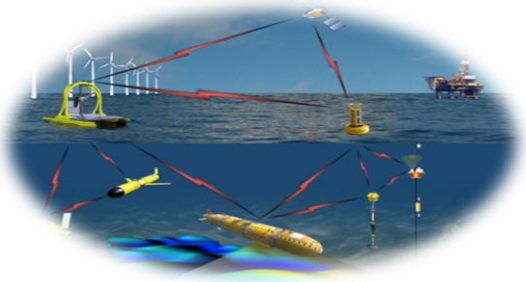
Marine Autonomy and Technoloy Showcase 2016
November 14, 2016 - November 18, 2016
Marine Autonomy & Technology Showcase

Home ▸

Finalists announced in £1.5 million competition to develop advanced autonomous systems

July 21, 2015

The final phase of a competition to develop novel Adaptive Autonomous Ocean Sampling Network (AAOSN) management systems for the National Oceanography Centre (NOC) is now underway. Two UK consortia will move forward to develop systems capable of coordinating a suite of marine autonomous vehicles gathering data from the ocean over periods of months, and tracking and sampling dynamic features.



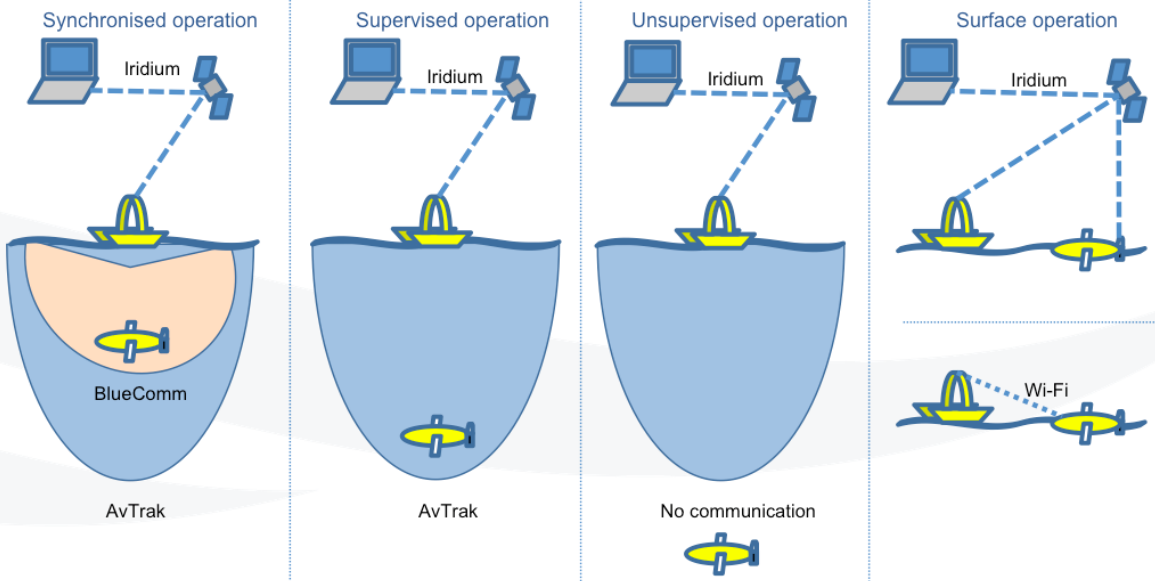
The two-phase competition was launched last September by the Natural Environment Research Council (NERC) in partnership with the Defence Science and Technology Laboratory (DSTL) and Innovate UK, with £1.5 million being made available for the project. Phase one saw nine consortia submit feasibility studies, five of which were funded. After a review of the outcomes of the phase one studies, two consortia were invited to apply for phase two for the development of prototypes, which would be capable of undertaking demonstration missions at sea.

The two consortia moving forward to the final stage are led by SeeByte Ltd in partnership with ASV and the Marine Biological Association (MBA) and University of Exeter in partnership with Marine South East Ltd and the Met Office. Each will now spend the next 12 months developing their products, with the first test mission expected to take place in February 2016.

NERC SCIENCE OF THE ENVIRONMENT [dstl] SBRI Government challenges Ideas from business. Innovative solutions.

ASSS: Autonomous Surface Sub-surface Survey System

ASSS Operating modes



ASV unmanned marine systems

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Innovate UK - Project

Launch & Recovery of Multiple AUVs from an ASV

Planet Ocean Ltd

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ASV unmanned marine systems

UNIVERSITY OF Southampton

NERC and EPSRC announce new Centre for Doctoral Training in smart observation

6 October 2015

NERC and the Engineering & Physical Sciences Research Council (EPSRC) are launching a new £2·5m Centre for Doctoral Training (CDT) in the use of smart and autonomous observation systems (SAOS) for the environmental sciences.

Known as NEXUSS - 'NEXt generation Unmanned System Science' - the CDT will provide specialised training in this increasingly vital area, creating a community of highly skilled people whose expertise will contribute both to scientific breakthroughs and to economic growth.

The consortium behind NEXUSS is led by the University of Southampton, in partnership with the British Antarctic Survey, Heriot-Watt University, the National Oceanography Centre, the Scottish Association for Marine Science and the University of East Anglia. It will fund training for three annual intakes of ten PhD students each, starting in 2016.

Professor Duncan Wingham, NERC chief executive, said:

RSS *Discovery* with its fleet of autonomous vehicles.

University of East Anglia

COAS
Centre for Ocean and Atmospheric Sciences

NERC
ADVANCED TRAINING

Ocean Gliders: Autonomous Monitoring of the Marine Environment

6-10 February 2017
University of East Anglia, Norwich

Conference Home
Conference Workshops
Programme

7th EGO conference on autonomous ocean gliders and their applications



The 7th EGO Conference

Monday 26th September – Thursday 29th September 2016

National Oceanography Centre, Southampton

MASSMO1 (2014) Combining surface and submarine gliders

MASSMO2 (2015-16) MAS for environmental and defence research

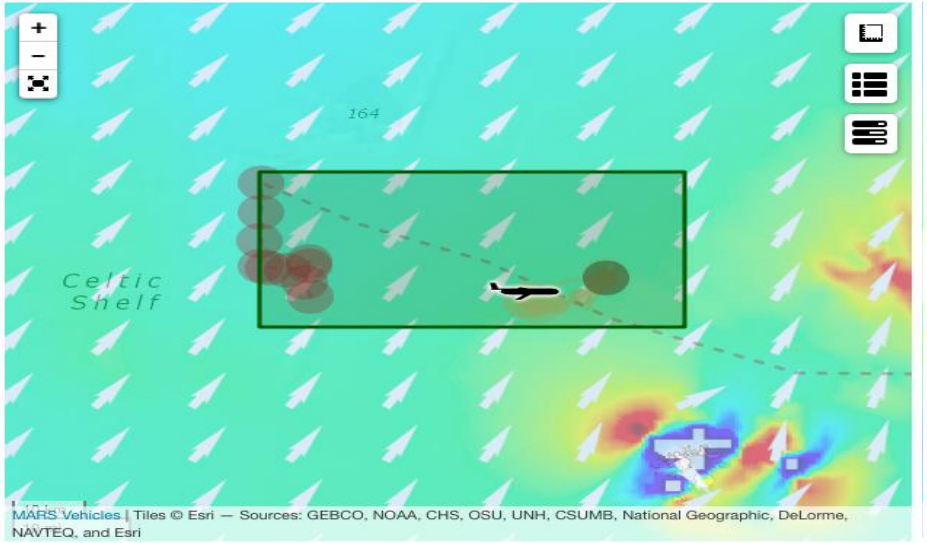
NMF Vehicles | Browse | Help | Login

C-Enduro Thomas on mission MASSMO 2A-2

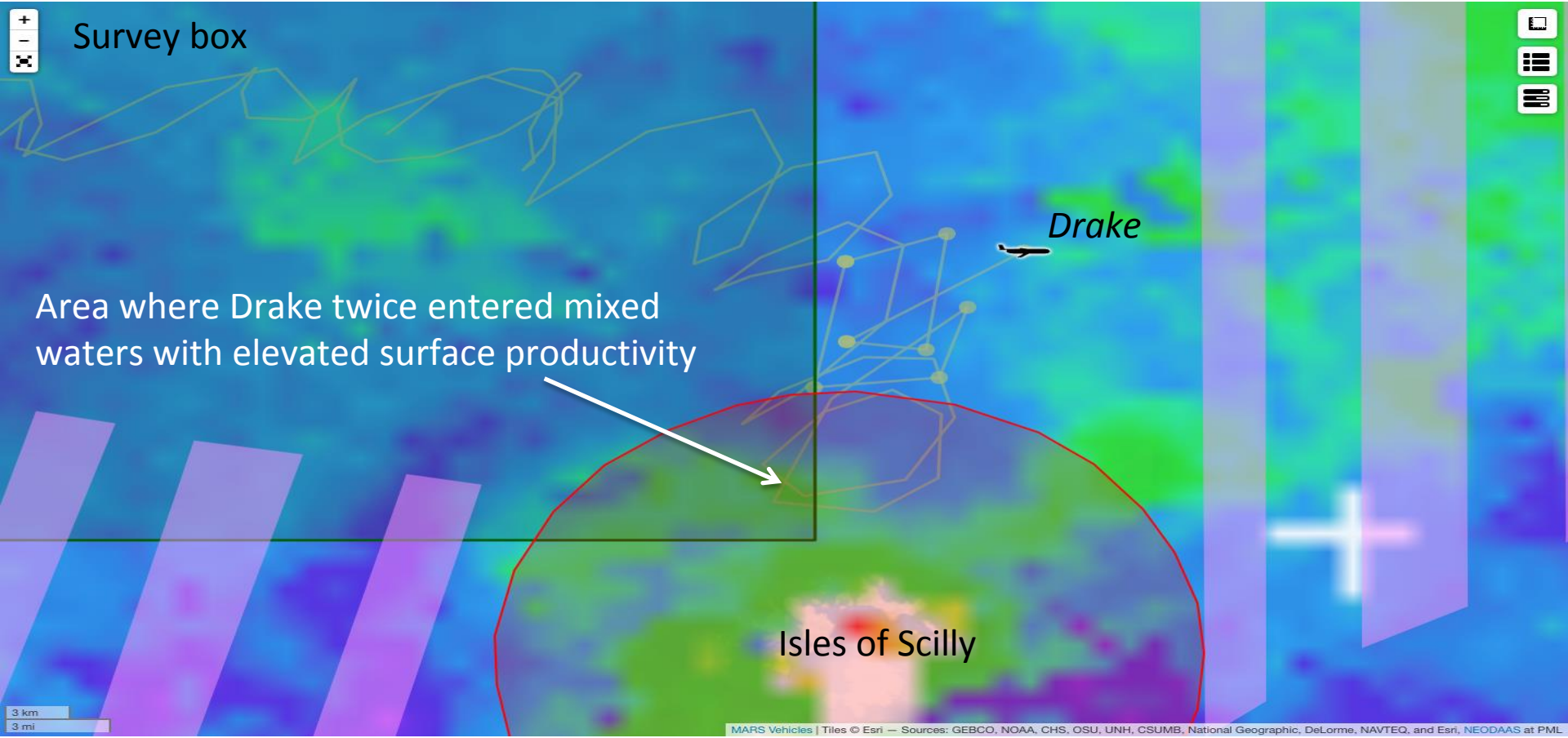
- **Public vehicle**
- Serial Number 996
- Operated by NOC on the MASSMO project
- Current Status: Deployed

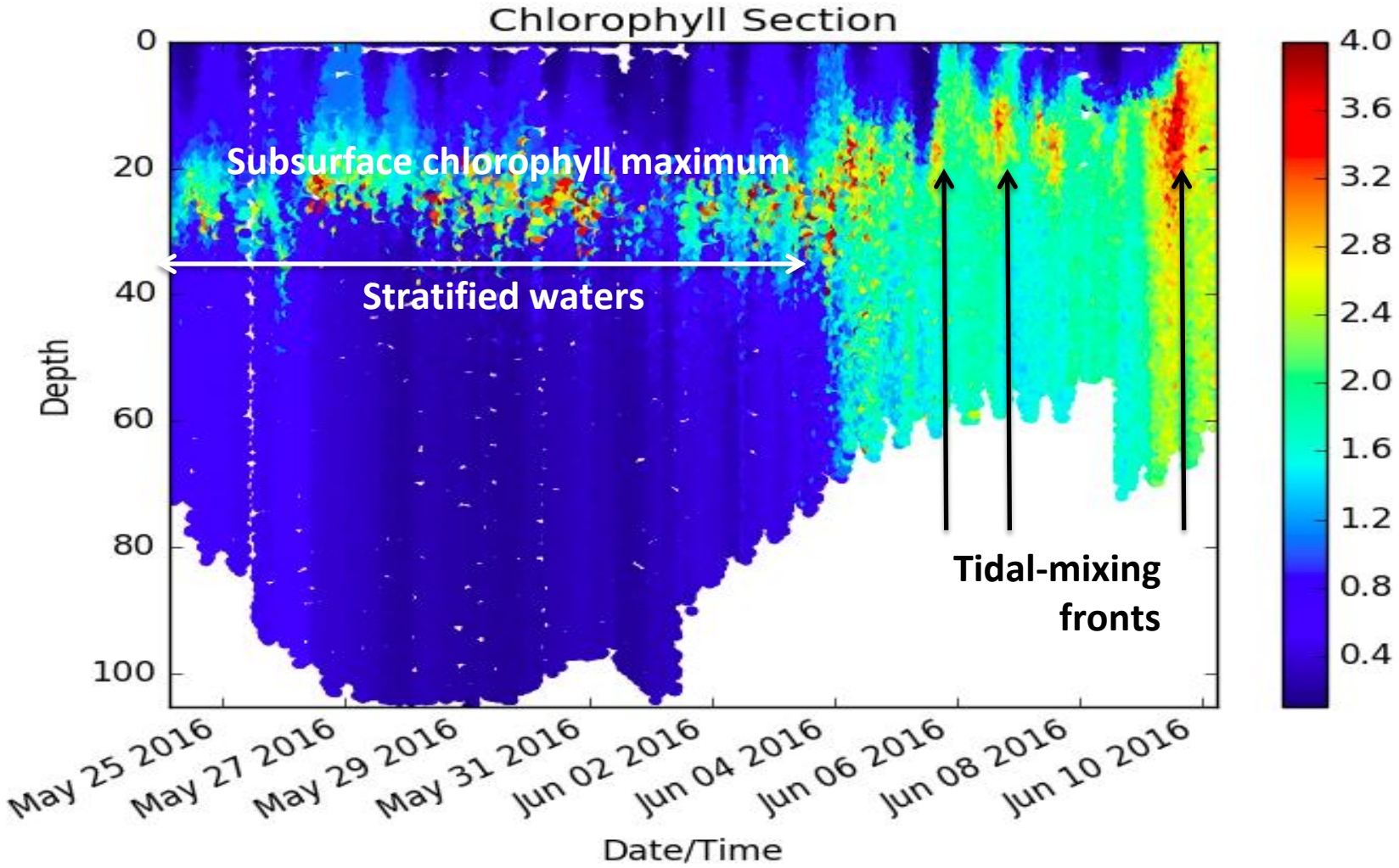
C-Enduro Camera Feed

- **Deployed:** 2016/05/22 00:00:00 UTC (15 days ago) by David White
- **Time at Sea:** 15 days
- **Profiles Performed:** 118



Targeting surface features with a submarine glider using satellite imagery




Chlorophyll Section
Subsurface chlorophyll maximum
Stratified waters
Tidal-mixing fronts
Depth
0
20
40
60
80
100
May 25 2016
May 27 2016
May 29 2016
May 31 2016
Jun 02 2016
Jun 04 2016
Jun 06 2016
Jun 08 2016
Jun 10 2016
Date/Time
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

Project funding

ROYAL NAVY

[dstl]

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Ministry of Defence

QinetiQ

MASSMO3
Autumn 2016

Public engagement

Data management

BODC British Oceanographic Data Centre
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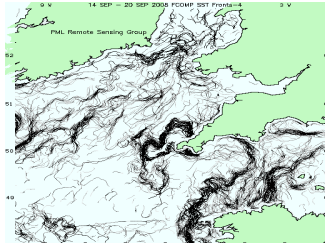
Operational products



PML Plymouth Marine Laboratory

United Kingdom Hydrographic Office

Met Office

esri UK

helyx

seebyte

The MASSMO3 fleet at 0820 hrs on 01 Sept 2016

The largest simultaneous deployment of operational MAS in UK waters to date

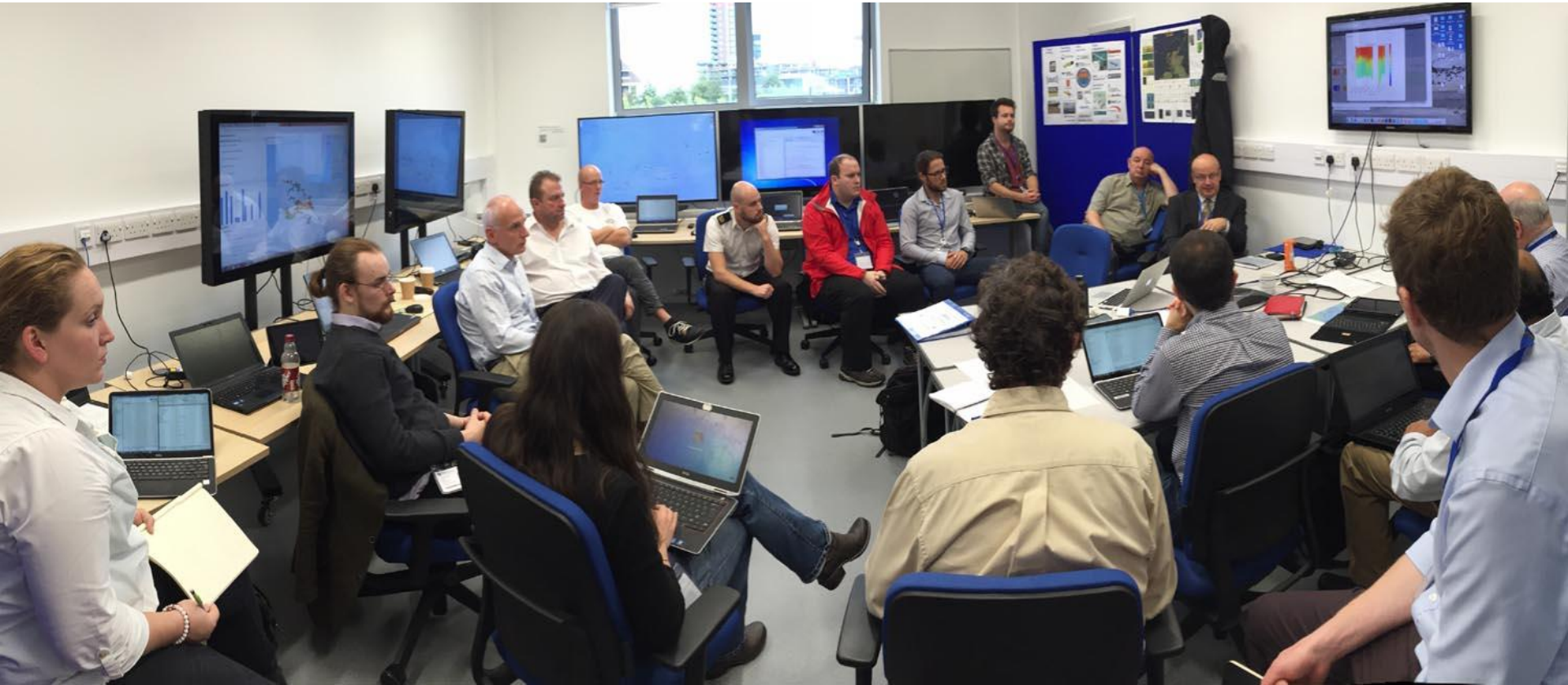
Wave Glider x 3

Stornoway

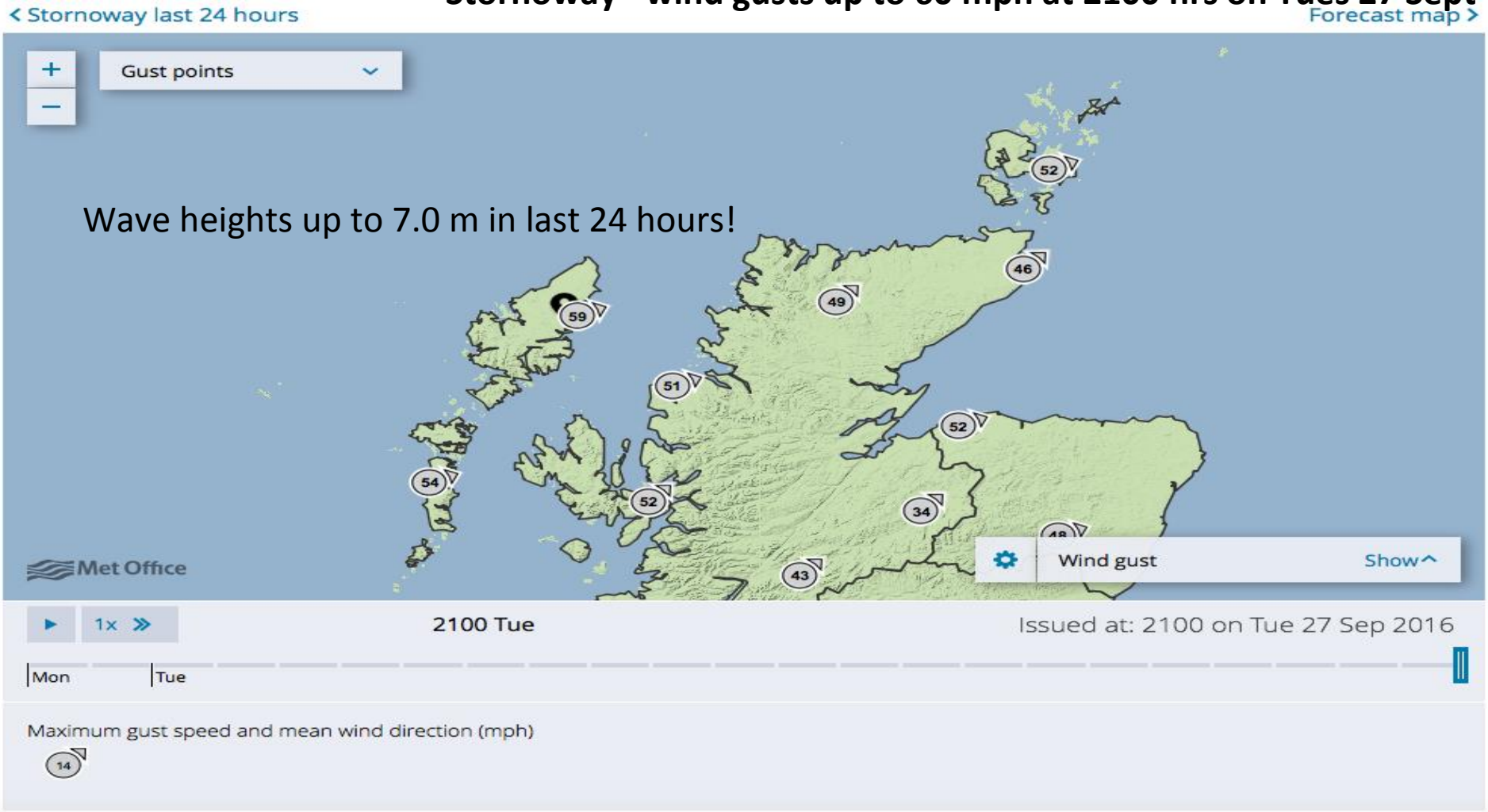
Submarine Glider x 7

Oban

MASSMO3 Operations Room at NOC on 29 Sept 2016



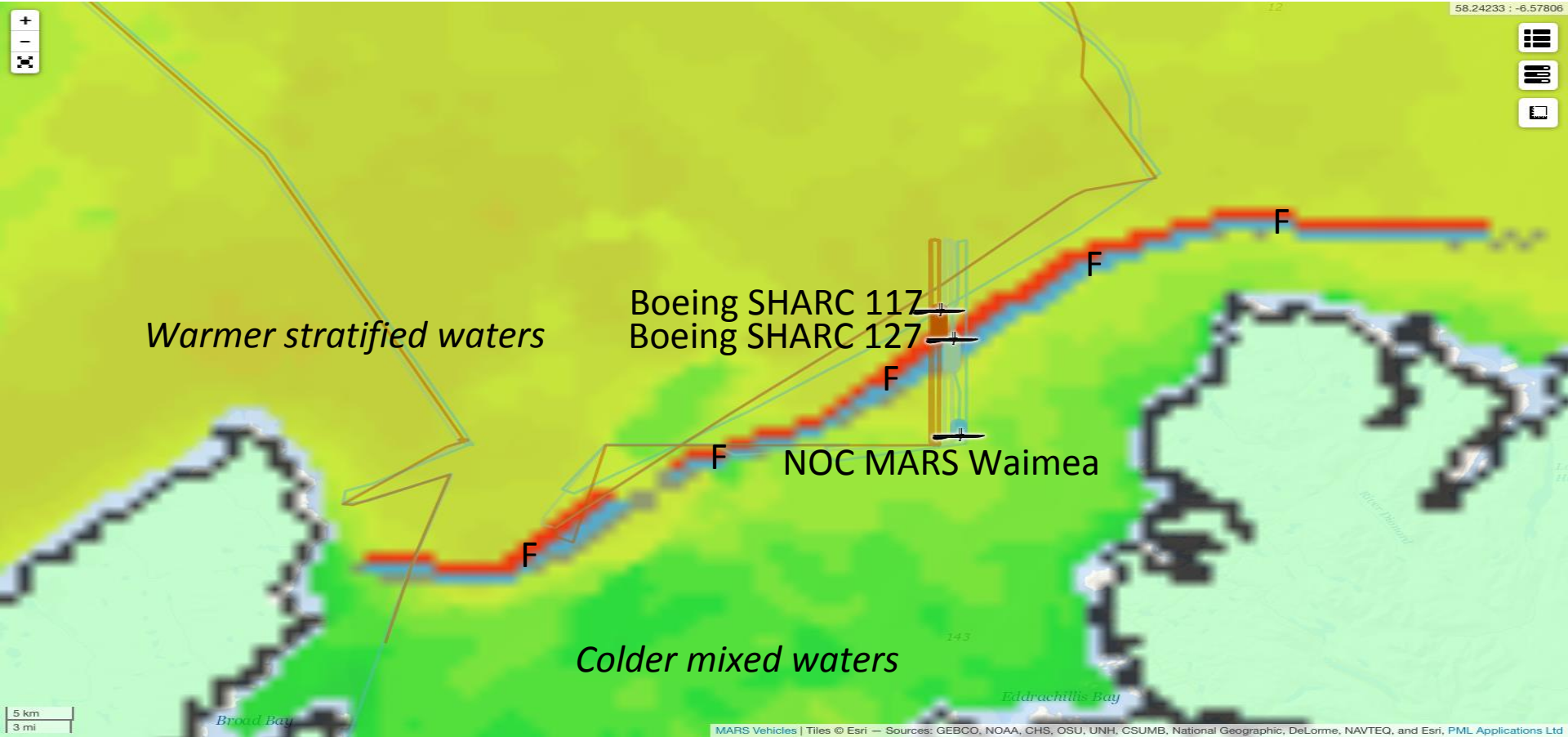
Stornoway - wind gusts up to 60 mph at 2100 hrs on Tues 27 Sept



Wave Glider locations at 0630 hrs on 28 Sept 2016

Wave Gliders are undertaking repeat crossings of the front marked F below

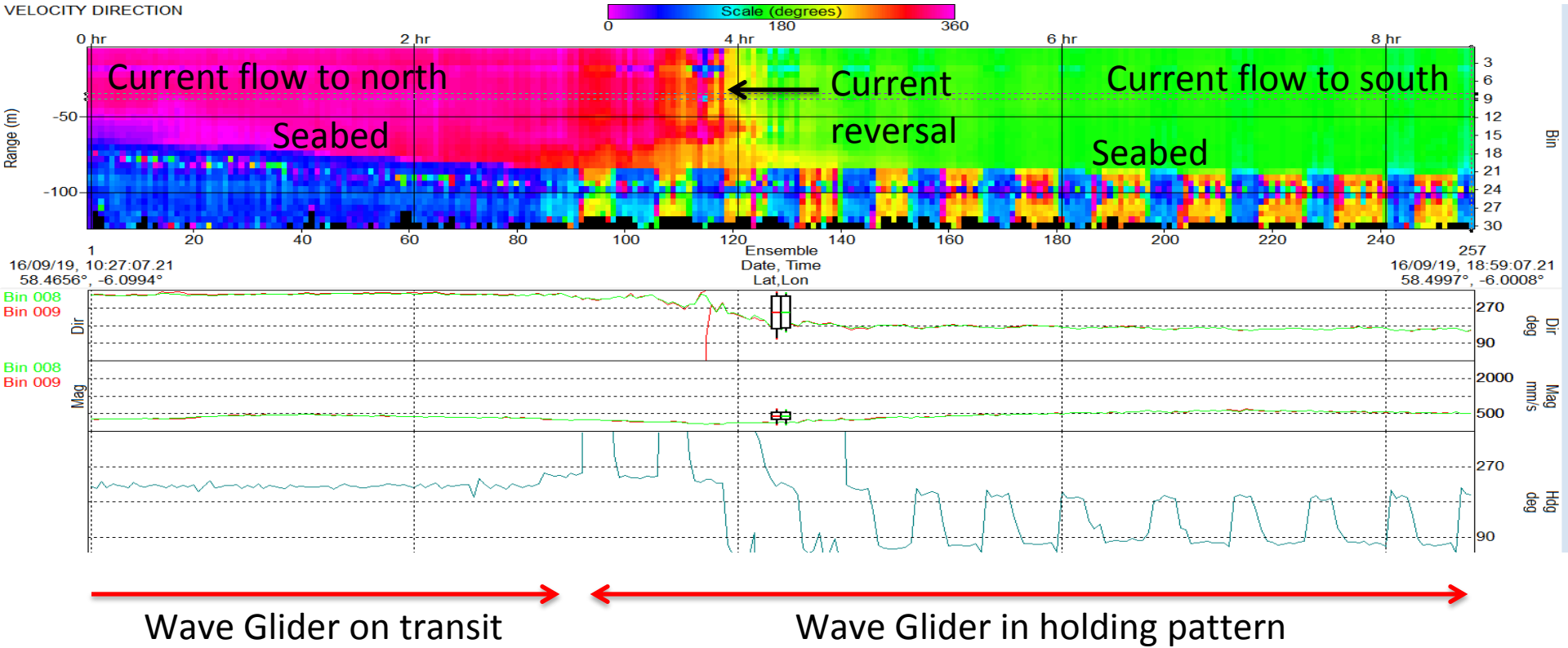
Sea surface temperature map shows colder mixed surface waters south of this front



Wave Glider ADCP data from 19 Sept 2016

Wave Glider was in northern Minch, arriving on station for shakedown period

Data show clear tidal current reversal and seabed at 60-80 m depth



Wave Glider on transit

Wave Glider in holding pattern

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Large-scale deployment of robots in sea off Scotland

1 November 2016 | Highlands & Islands

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The 10 robots were deployed during a two-week research mission in October

The largest simultaneous deployment of marine robots yet attempted in UK waters was achieved last month, scientists have said.

A fleet of 10 marine robots collected information on ocean temperature, tidal currents and wave conditions off Scotland's north west coast.

The work involving Oban's Scottish Association for Marine Science was done during the inaugural **Unmanned Warrior**.

Held by the Royal Navy, Unmanned Warrior tested military robotics.

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UK's Marine Robots Mission Complete

A fleet of ten marine robots has completed two-week mission off northwest Scotland.

The mission comprised the largest simultaneous deployment of marine robots in UK waters, with seven submarine gliders and three surface Wave Gliders operating in waters around the Outer Hebrides, National Oceanography Centre (NOC) explained.

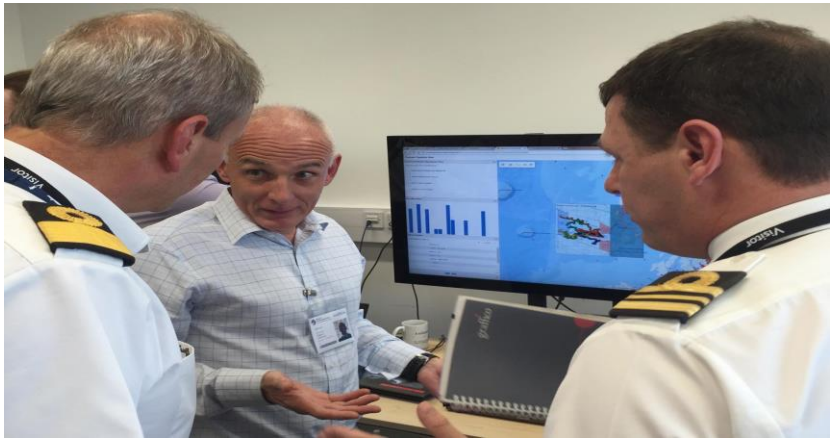
The robot fleet was collecting a variety of marine environmental data including ocean temperature, salinity, oxygen, turbidity, tidal currents, and surface weather and wave conditions.

As NOC explained, the submarine gliders surveyed an area of over 5000 km2 during the two-week deployment, venturing up to 125 km offshore of the island of Barra into waters over 1000 m deep. The Wave Gliders ventured up to 150 km north of the island of Lewis, each covering a distance of more than 300 km.

The mission was co-ordinated by the National Oceanography Centre (NOC) in partnership with the Scottish Association for Marine Science (SAMS), and involved over 20 industry and government partners. The UK Defence Science and Technology Laboratory (Dstl) was the primary sponsor of the mission, which was in support of the Royal Navy's 'Unmanned Warrior' programme, and all of the collected data will be archived at the British Oceanographic Data Centre and made available for future scientific research.

Professor **Russell Wynn** of NOC, who was chief scientist of the mission, said: *"This mission benefited hugely from the local knowledge at SAMS and the offshore expertise provided by the Royal Navy, which enabled us to safely deploy and recover the ten vehicles in difficult conditions; it also highlighted the ability of marine robots to continue collecting high quality data in sea states that would have hampered or even terminated traditional vessel-based observations."*

MASSMO3 - VIP visit day to NOC Operations Room



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SAMS

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Robotic gliders herald sea of change in ocean survey work

News release, July 30

Robotic underwater Seagliders used by the Oban-based Scottish Association for Marine Science have now gathered the equivalent of five years of oceanographic data, most of which was collected in the past 18 months.

This milestone, which was reached today, highlights a major change in how marine scientists collect information such as sea temperature, salinity, pressure and oxygen, as the six-feet-long Seagliders can spend months at sea collecting data that contributes to our understanding of climate change.

To date, the seven SAMS Seagliders have spent the equivalent of five years at sea, travelling more than 33,000 kilometres. One of the Seagliders, Ardbeg, has this week broken a SAMS distance record by completing a return trip of more than 3,400km along the Extended Ellett Line, a route from Scotland to Iceland that has been surveyed by scientists for 40 years.

Dr Stefan Gary, a research associate in physical oceanography at SAMS, said: "Seagliders allow oceanographers to make cost-effective, long-term, and long-distance observations, often in hard-to-access regions that ships

contact us

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Oban, Argyll, PA37 1QA
T: 01631 559000
F: 01631 559001
E: info@sams.ac.uk

Tweets by @ScotMarineInst

SAMS
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Five spaces still available on autonomous underwater vehicle workshop #AUV on 6/7 Dec here in #oban.

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SAMS News - Flying and Diving Robots working together

SAMSmarinescience

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NERC commissions ambitious multi-centre research programmes

22 March 2016

NERC has commissioned five highly ambitious research programmes, worth £34m, that will see its research centres working closely together to tackle major scientific and societal challenges.

This is the first result of a new way of allocating national capability funding designed to enable more ambitious science than any single research organisation could provide.

The new approach to allocating national capability funding does not use new money, but realigns and refocuses the capabilities of the centres to drive more ambitious science through collaboration. It's also intended to maximise the value of these investments by providing the foundation for other NERC-funded activities.

NERC's chief executive, Professor Duncan Wingham, said:

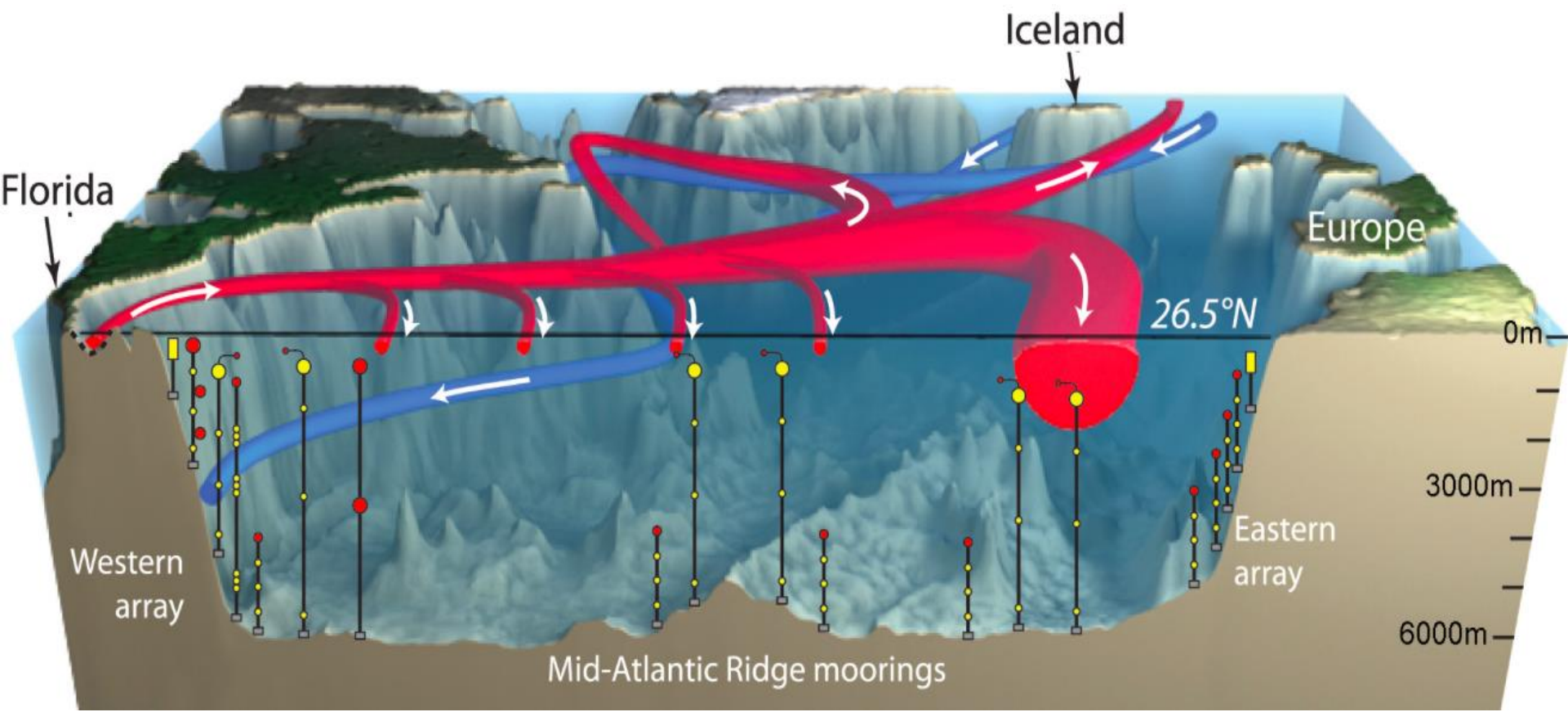
> "I'm pleased that our new way of allocating national capability funding has resulted in ambitious proposals which have the potential to achieve far more scientific impact that any single centre could have alone.

In this section

2016 news announcements
└ **NERC commissions ambitious multi-centre research programmes**

Related links

NERC webinar on national capability research



ACSIS – North Atlantic Climate System Integrated Study

NERC invests £7m in new strategic research programme

In this section

2016 news announcements
└ **NERC invests £7m in new strategic research programme**

1 August 2016

Today, NERC announces it is investing in a new large-scale strategic research programme - the Role of the Southern Ocean in the Earth System (RoSES).

One of the greatest sources of scientific uncertainty in future climate prediction concerns the behaviour of the Southern Ocean carbon sink ie how much carbon dioxide it will absorb from the atmosphere. The Role of the Southern Ocean in the Earth System (RoSES) programme will provide the scientific basis to inform international climate policy on the role of the Southern Ocean carbon system in 21st century global climate change. Research outputs will include:

- measuring and understanding the contemporary state of the Southern Ocean carbon sink
- understanding and modelling how the sink operates
- evaluating the sink's future evolution and impact on 21st century global climate change and
- developing and reporting policy-informing metrics of the sink and its climate impacts.

ODA research and innovation and NERC

12 July 2016

The Chancellor's 2015 Autumn Statement announced that over the next four years there will be progressively more funding allocated to research for international development, termed Official Development Assistance (ODA) research.

Funding for ODA research will be principally through the new cross-research council Global Challenges Research Fund (GCRF), an expanded Newton Fund and the research funds of the Department for International Development (DFID).

The Global Challenges Research Fund provides a powerful and exciting opportunity for the UK research community to address major challenges facing the developing world. The UK environmental science community are well placed to compete successfully for these new international development funds. Only small amounts of the UK's ODA environmental research funding will be identified and

In this section

2016 news announcements
└ **ODA research and innovation and NERC**

Related links

- Global Challenges Research Fund
- Newton Fund
- Department for International Development

University of East Anglia
School of Environmental Sciences

Seaglider Overview for Mission: 31 (BoBBLE)

Home | MATLAB Ice Map View | Earth View (plugin required)

Mission: 31 (BoBBLE)

Deployment of sg613 and sg619 (Microstructure) and sg579, sg620 from UEA, and sg532, sg533 and sg534 from MARS

Mission Number	Mission Name	Start Date	End Date	Notes	
4	Vigo	01/06/2010	21/09/2010	GOPINA - Glider observations of productivity in the North Atlantic (http://www.uea.ac.uk/~e048/projects/GOPINA.shtml)	Select Mission
5	Ross Sea	22/11/2010	19/02/2011	GOVARS - Glider Observations of Variability in the Ross Sea (http://iop.apl.washington.edu/seaglider/dives.php?glider=502)	Select Mission
6	North Sea Test	07/05/2011	13/05/2011	Test mission in preparation for August deployment at the North Dogger site (http://www.uea.ac.uk/~eqq09ruu)	Select Mission
7	North Sea Hypox	19/08/2011	05/09/2011	An investigation into the chemical, biological and physical mechanisms regulating the occurrence of seasonal oxygen depletion north of Dogger Bank (http://www.uea.ac.uk/~eqq09ruu). The UEA Seaglider will be released mid-August from the RV CEFAS Endeavour during the International Bottom Trawl Survey.	Select Mission

BoBBLE – Bay of Bengal Boundary Layer Experiment

LIQUID ROBOTICS.

Wave Glider Swims 2,808 Miles Home After Helping Fight Illegal Fishing in the South Pacific

The Wave Glider® swam 2,808 nautical miles home to the Big Island of Hawaii after successfully completing a 4-month patrol mission of the Pitcairn Island Marine Sanctuary for the UK Foreign & Commonwealth Office (FCO). This achievement represents a fundamental enabling capability.

- Customers can avoid the high cost and risk of deploying manned vessels for research, commerce, or defense
- Customers can deploy sensors in the most remote locations without sending a large ship for recovery
- Surveillance and patrol are now possible in large expanses of oceans previously inaccessible

The Journey Home

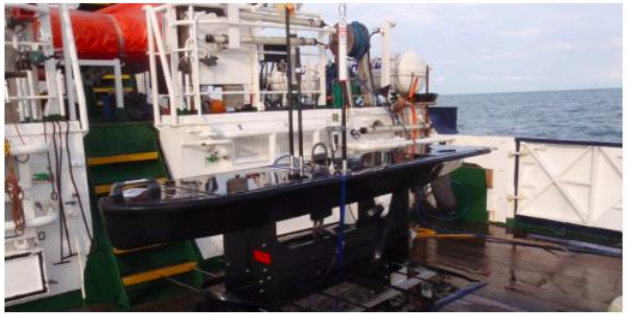
After successfully completing its mission, the Wave Glider was remotely piloted more than 2,800 nautical miles home. During the journey home it:

- Swam through strong equatorial currents, doldrums, and challenging sea states
- Collected 9,516 measurements of meteorological, oceanographic, and marine biodiversity data

Altogether, the Wave Glider was continuously at sea, untouched, for 213 days while traveling a total of 7,205 nautical miles at an average speed of 1.73 knots.

Read more about the journey home here.

Cefas



Cefas Scientists complete world's first "on-demand" autonomous marine water sampling

26 September 2016

In what is believed to be a world's first in the scientific community, **Cefas** (Centre for Environment, Fisheries and Aquaculture Science, UK) and **Liquid Robotics®**, USA have successfully deployed, tested and recovered a remotely piloted **Wave Glider®** which allowed scientists to measure water characteristics and selectively collect samples in near real-time.

The Wave Glider called "Lyra" was deployed in the southern North Sea about 60km off Lincolnshire, UK coastline by *RV Cefas Endeavour* and spent 48 days at sea before being recovered successfully by Trinity House's vessel *Alert*, 20 miles off Lowestoft. Whilst deployed, the Wave Glider was remotely piloted 24/7 by the Liquid Robotics Operations Team from their California headquarters almost 9000 km away and covered over 2700km at sea.

Email: rbw1@noc.ac.uk

John Howe

SAMS

Shallow-water seabed mapping using an AUV

Shallow water autonomous underwater vehicle (AUV) surveys

John A. Howe

Scottish Association for Marine Science, Scottish Marine Institute

MAREMAP Marine Environmental Mapping Programme

Scot-MRF The Scottish Marine Robotics Facility

SAGES Scottish Alliance for Geoscience, Environment and Society

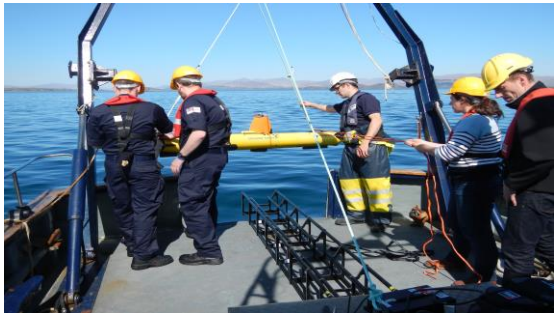
NERC SCIENCE OF THE ENVIRONMENT

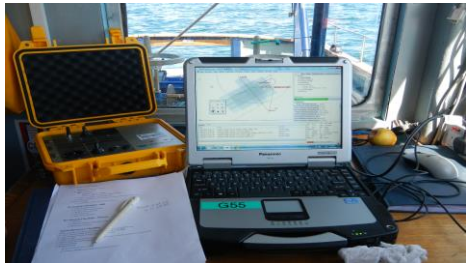
Scottish Association for Marine Science
Scottish Marine Institute

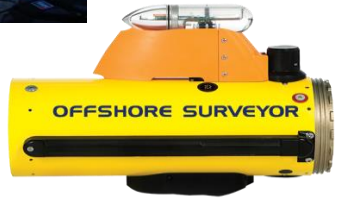
NERC delivery partner
Partner of University of the Highlands and Islands
SAMS Research Services Ltd
Diverse activities; education, research & commercial

Gavia AUV “Freya“

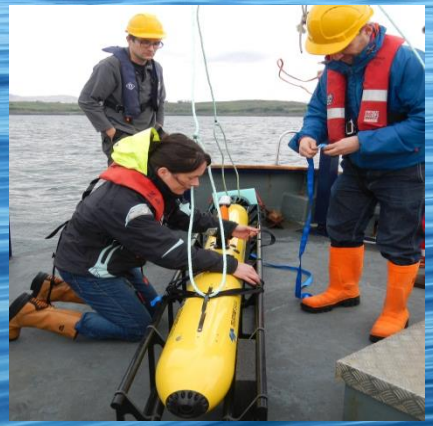
<u>Freya is a low-logistics AUV</u>. She has field-changeable modules that can be replaced in minutes, allowing rapid sensor reconfiguration and battery







Scot - MRF
The Scottish Marine Robotics Facility



AUV Freya configuration

- Offshore Surveyor base vehicle (500 m depth rating)
- High-precision DVL aided Inertial Navigation System
- Swath Bathymetry & side-scan Kongsberg 500kHz GeoSwath+
- Colour Camera & strobe
- Sound Velocity Meter , Obstacle Avoidance Sonar,

MAREMAP
Marine Environmental Mapping Programme

AUV Freya

100 kg

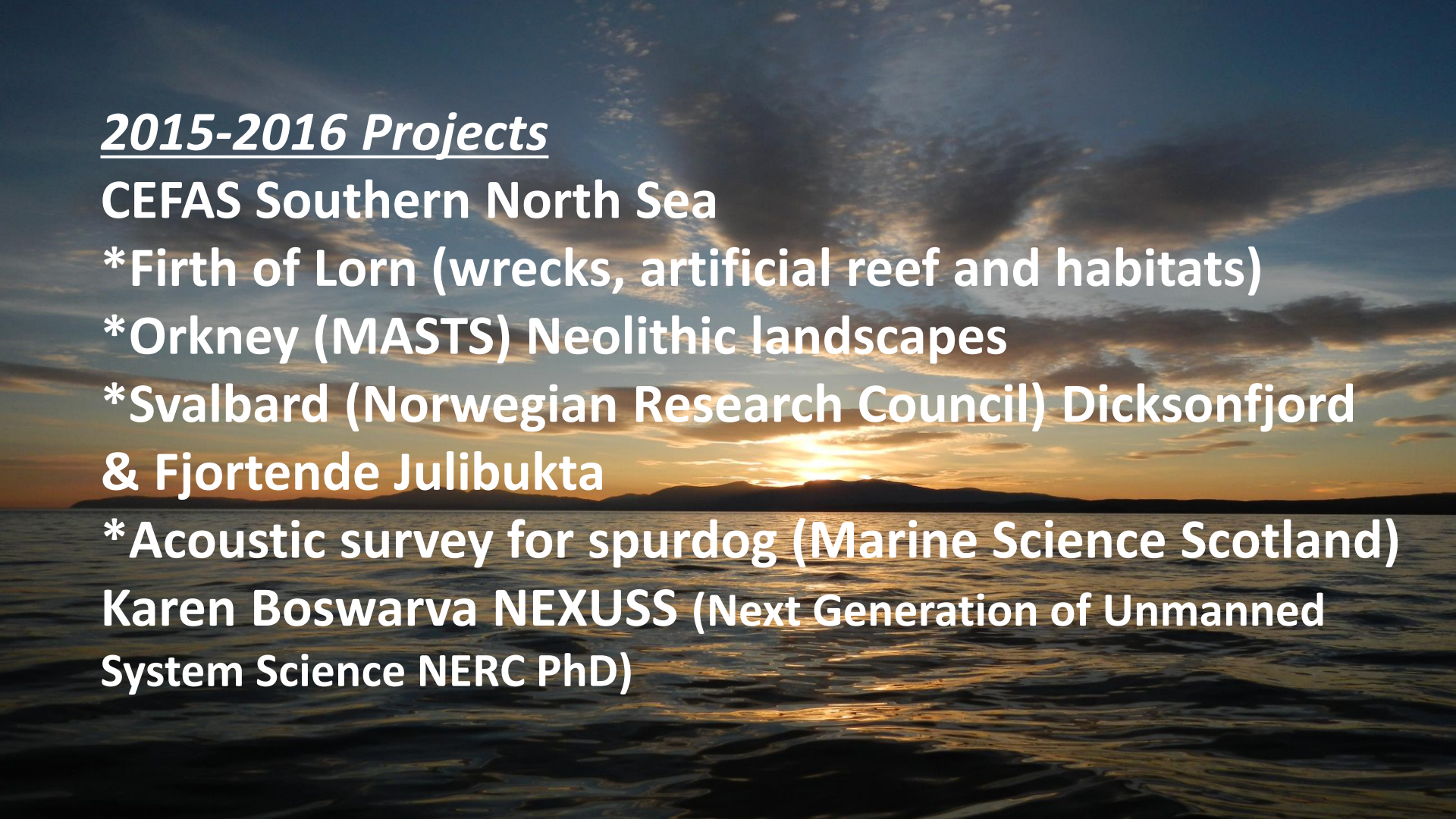
2.7 m long

9 boxes for transport

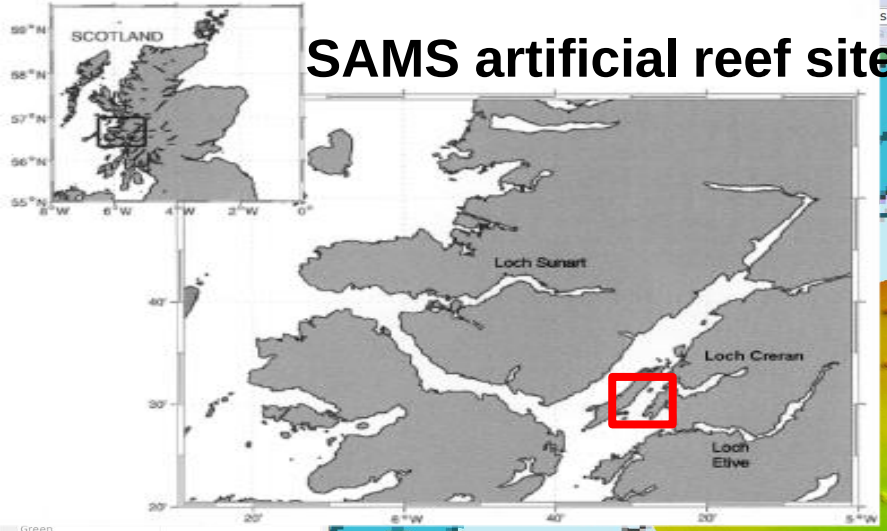
4 hour endurance

~1 km^2 area per mission

Scot - MRF
The Scottish Marine Robotics Facility


2015-2016 Projects
CEFAS Southern North Sea
*Firth of Lorn (wrecks, artificial reef and habitats)
*Orkney (MASTS) Neolithic landscapes
*Svalbard (Norwegian Research Council) Dicksonfjord & Fjortende Julibukta
*Acoustic survey for spurdog (Marine Science Scotland)
Karen Boswarva NEXUSS (Next Generation of Unmanned System Science NERC PhD)

SAMS artificial reef site

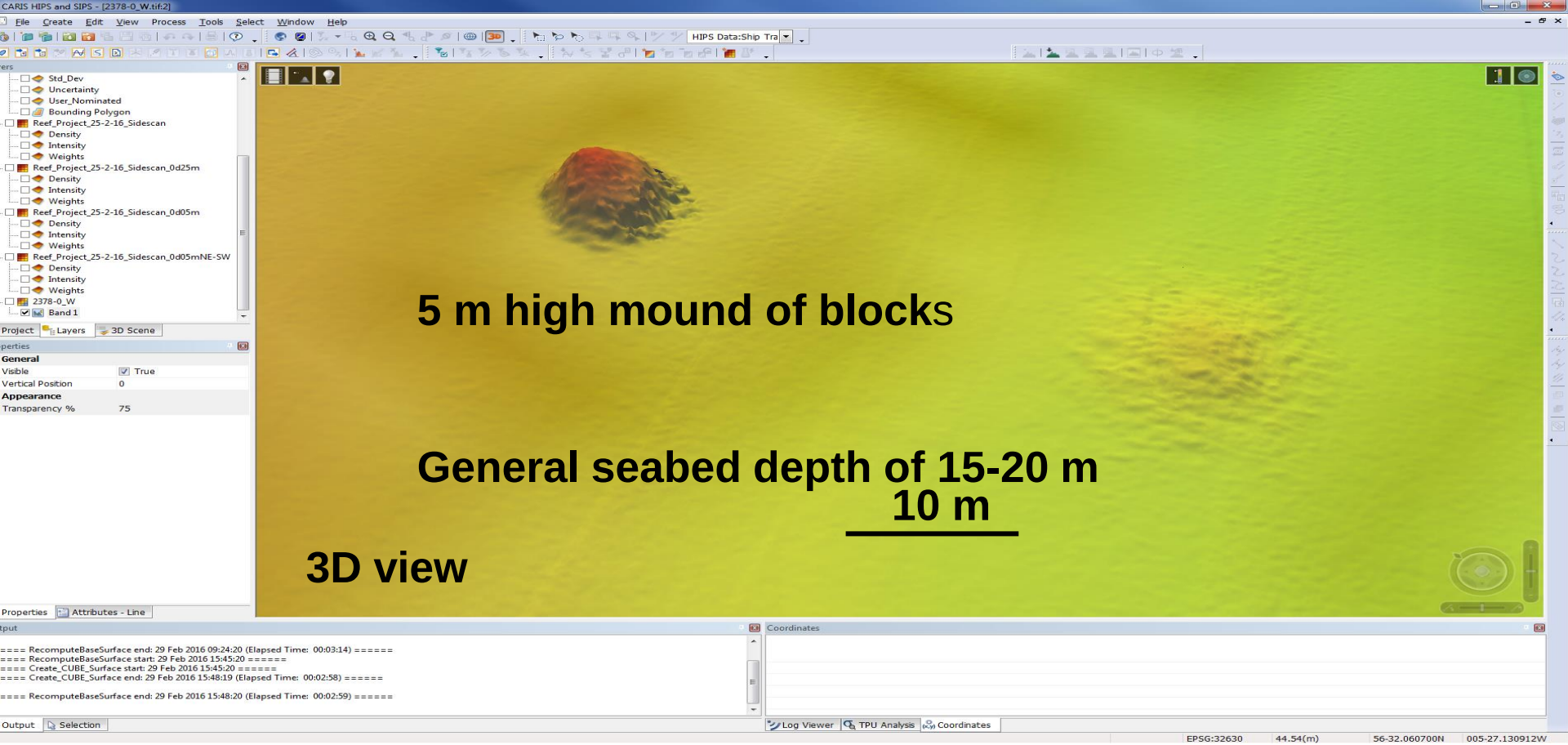


5 m high mound of rock waste blocks

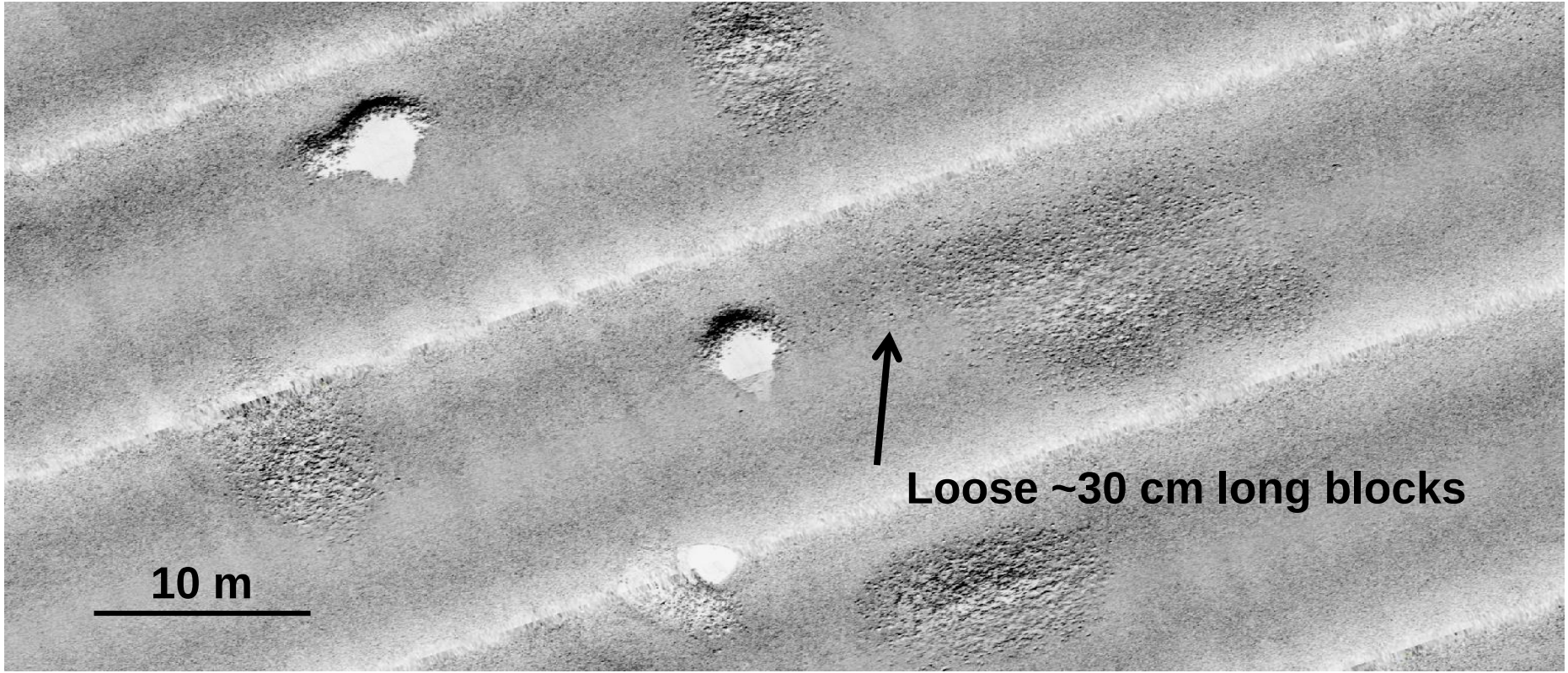
100 m

Dispersed mound

Scot - MRF
The Scottish Marine Robotics Facility



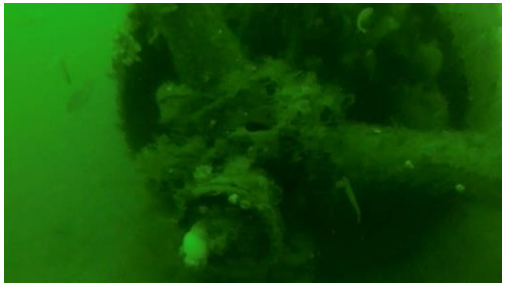
Scot - MRF
The Scottish Marine Robotics Facility



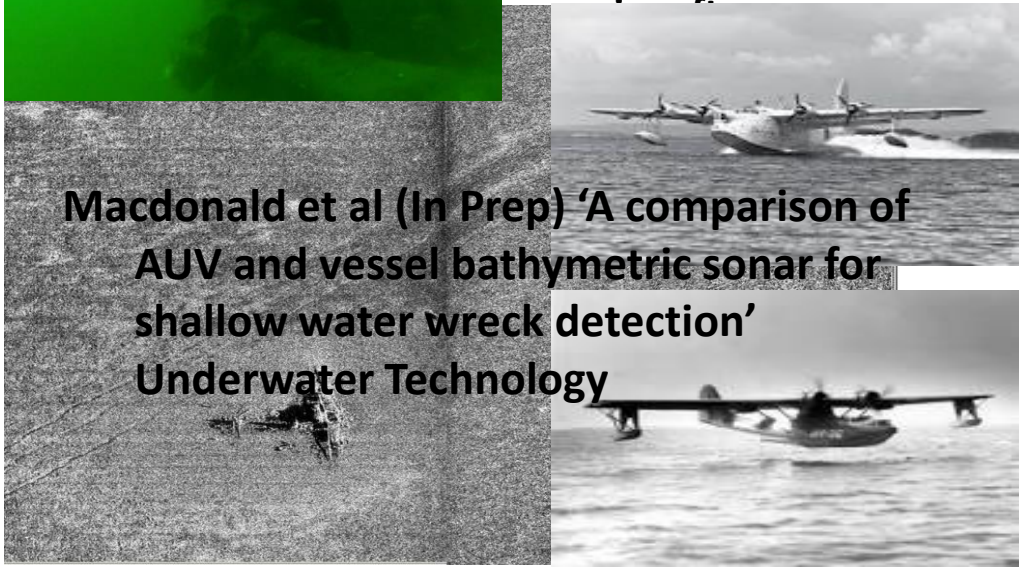
10 cm resolution side-scan sonar data showing individual reef blocks

Scot - MRF
The Scottish Marine Robotics Facility


Photographs of dispersed reef mound from underway AUV,
2 m bottom track above seabed, & using a speed of ~1.5 knots

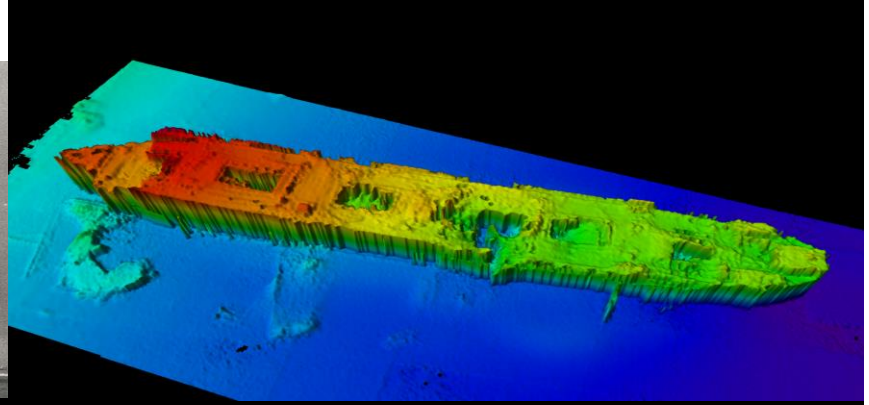


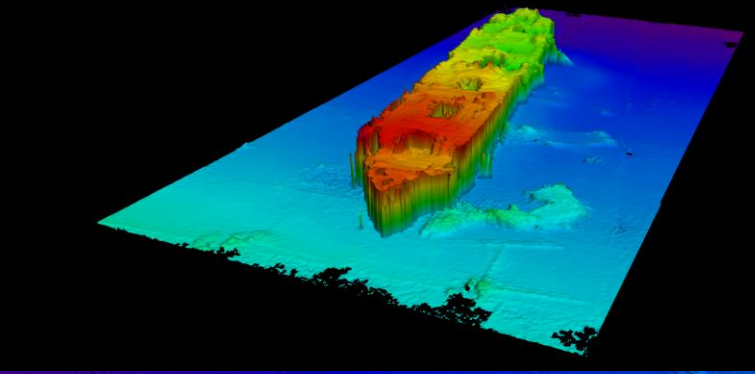
Firth of Lorn a rich maritime Heritage; WW2 flying boat

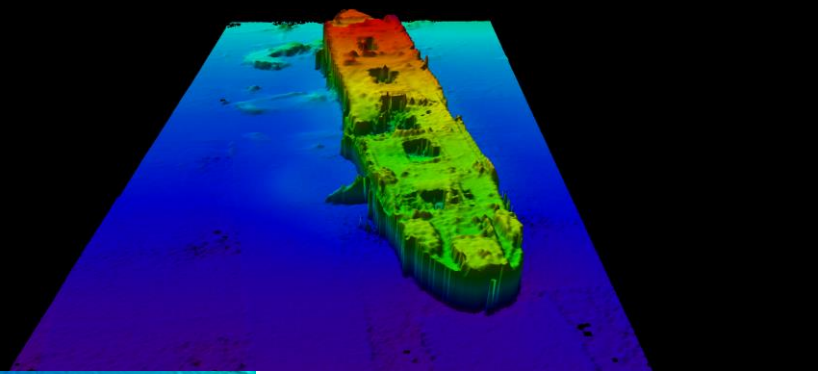


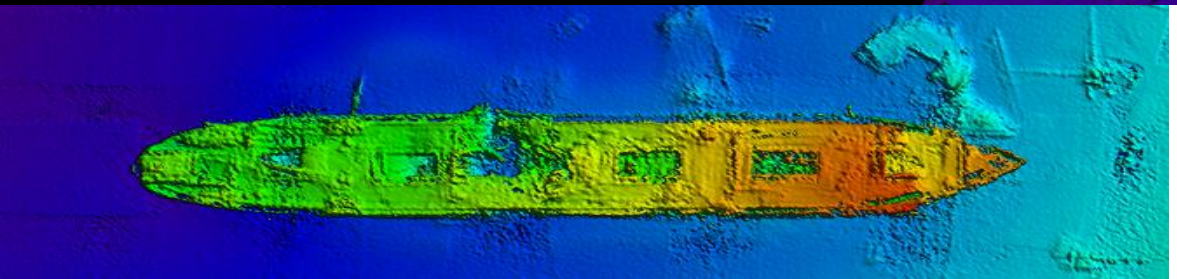
Macdonald et al (In Prep) 'A comparison of AUV and vessel bathymetric sonar for shallow water wreck detection' Underwater Technology

Wrecks located using vessel-based multibeam and AUV dives, surveyed using amateur diving club and Wessex Archaeology









SS Breda. Sunk in 1940. 130 m long

17 m wide and sits 10 m high on a muddy seabed at 30 m. An ideal AUV playground?

Teledyne Gavia promotion material

MASTS-funded

University of St Andrews

(Richard Bates)

Caroline Wickham-Jones

(University of Aberdeen

Google Earth

Orkney – Bay of Firth and Loch of Stenness surveys – understanding landscape and sea level over the last 7 ky

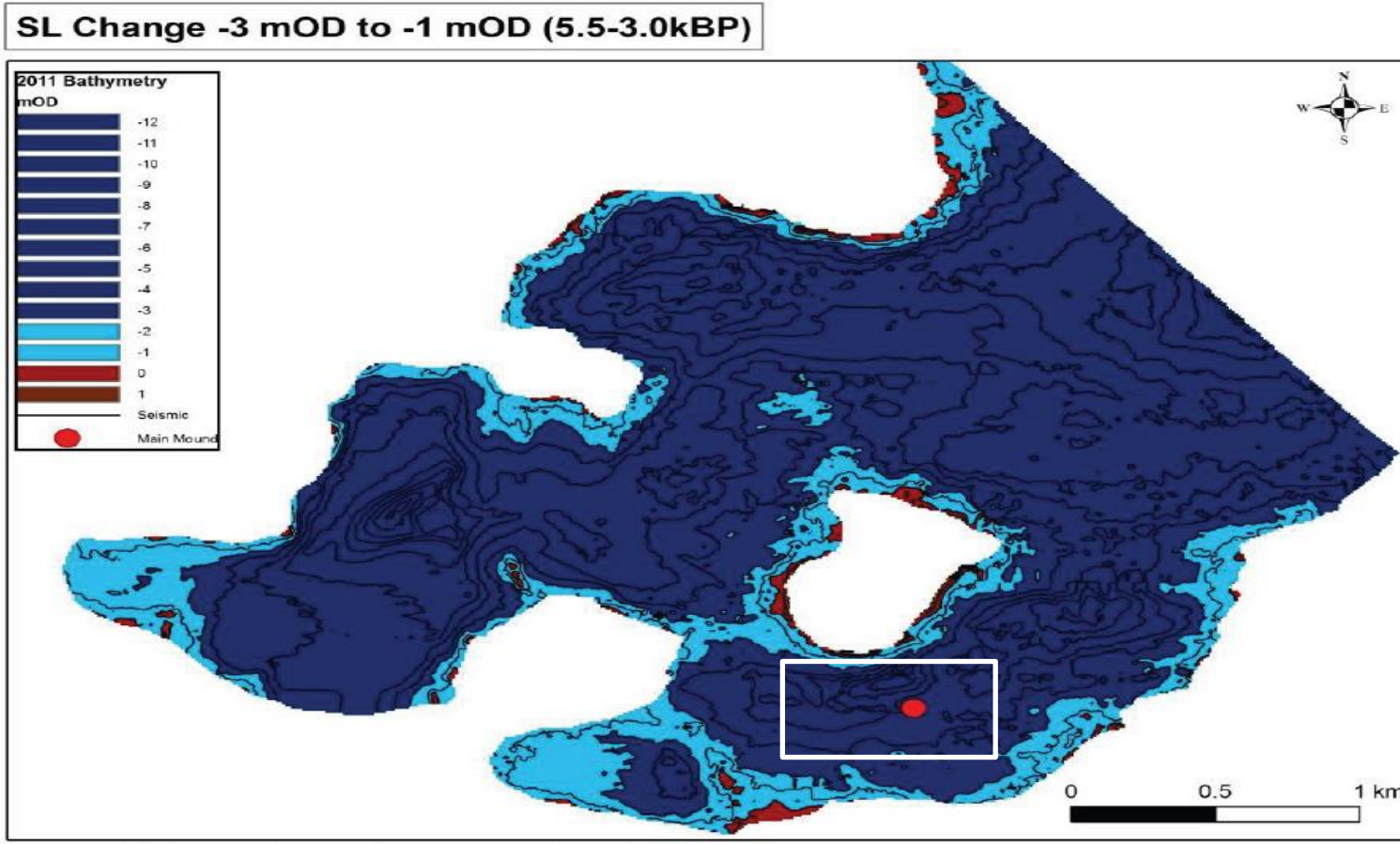
Skara Brae Neolithic village, 5,000 years old

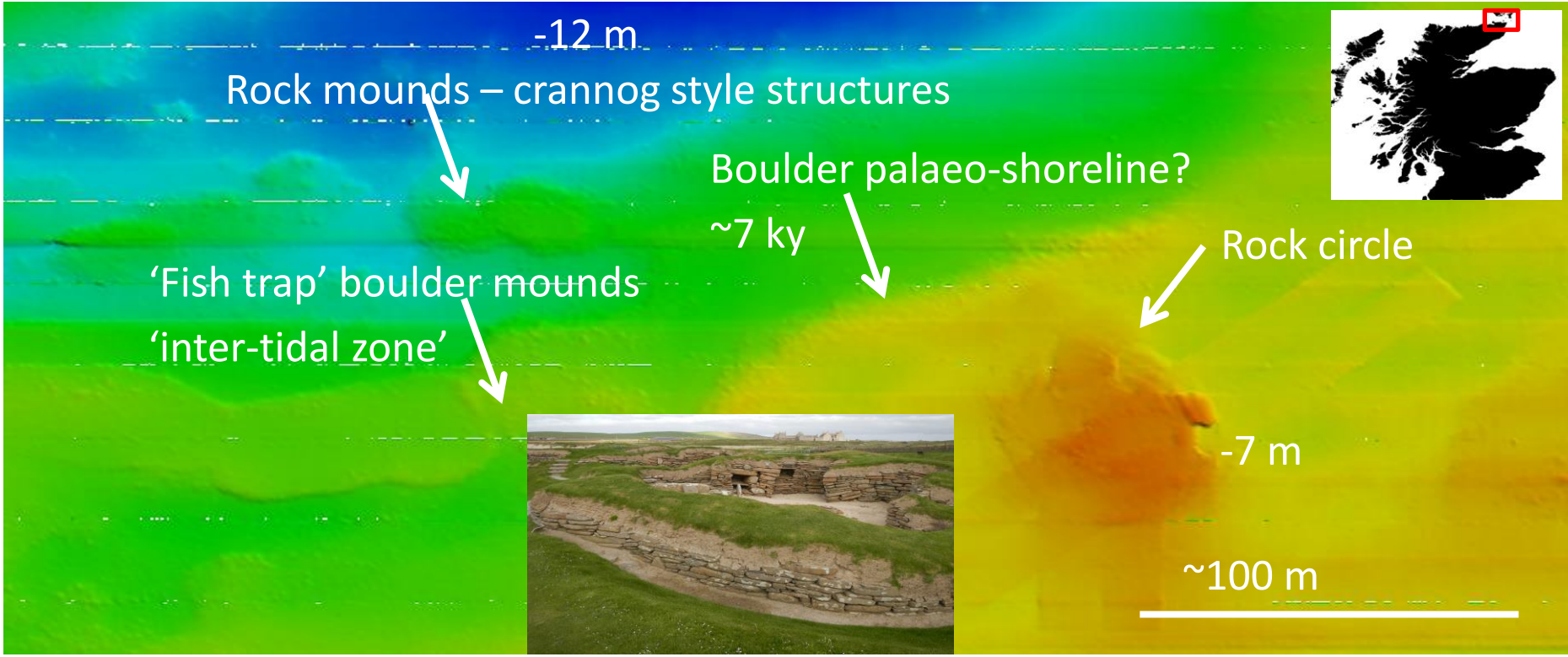
Neolithic – Bronze Age 3,500 – 1,000 BC

Marine

Intertidal Zone

Land





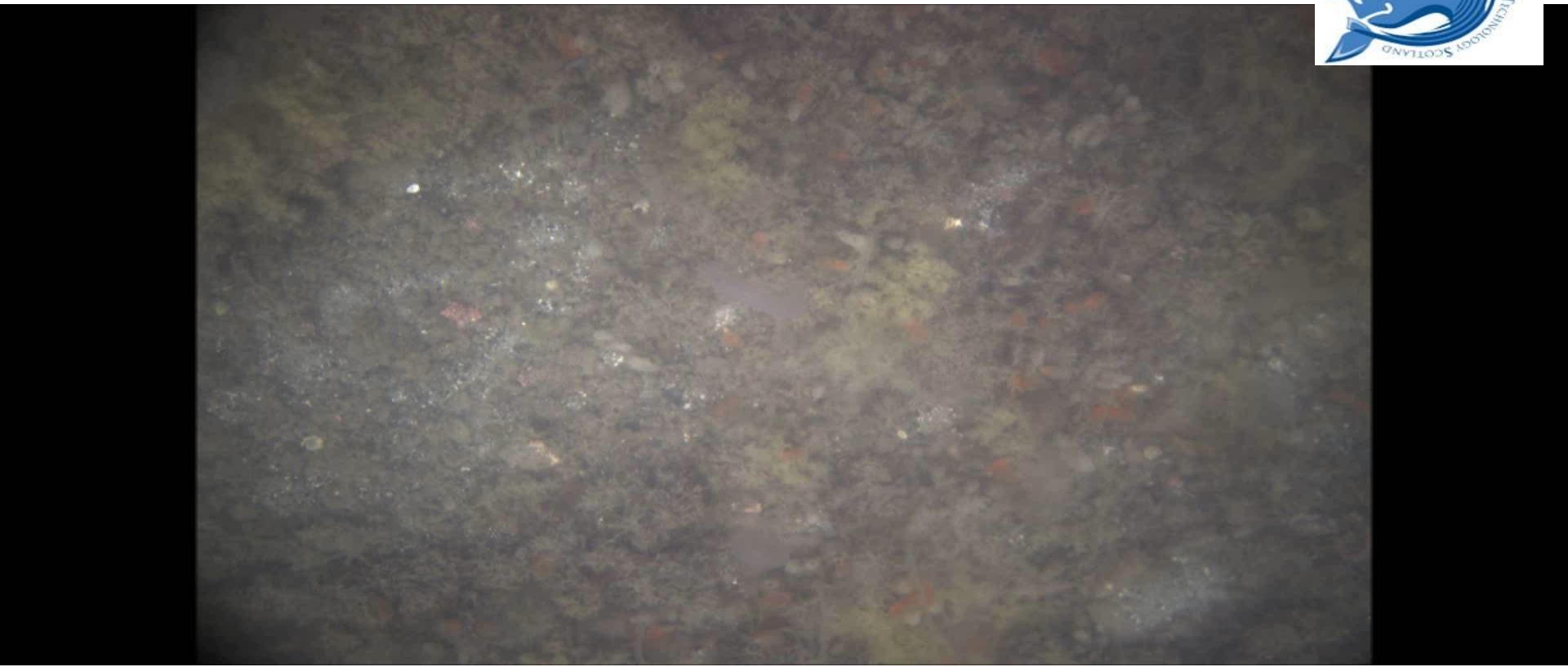
AUV bathymetry of the Bay of Firth, Orkney. Evidence for Mesolithic (7 ky?) settlements during a time of lower sea levels.

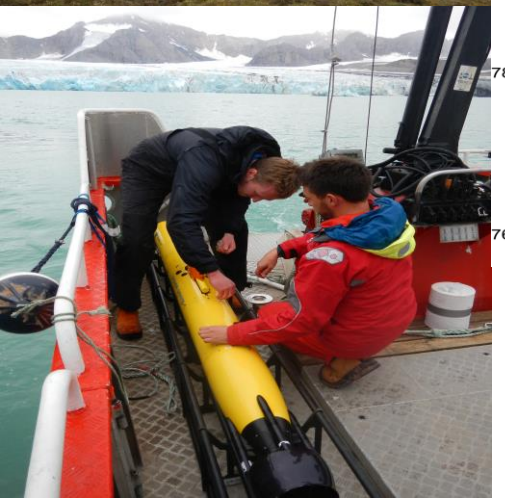
20m

Rock mounds

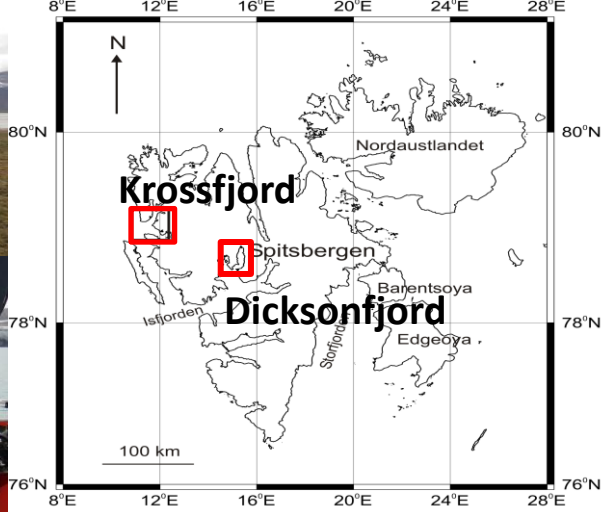
‘Fish trap’ boulder mounds & lines

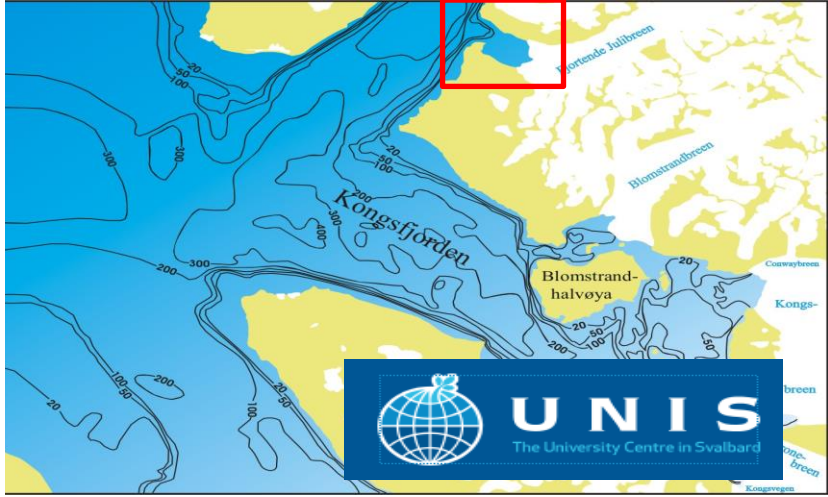
Side scan (500kHz) of rock mounds west of main circle,
Bay of Firth.
Filming for BBC



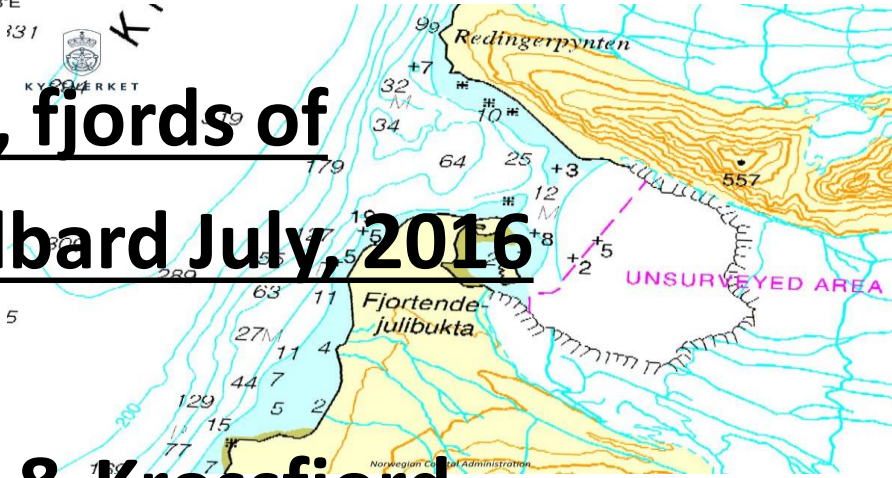


Preparing AUV in Fjortende Julibukta





AUV surveys, fjords of Western Svalbard July, 2016



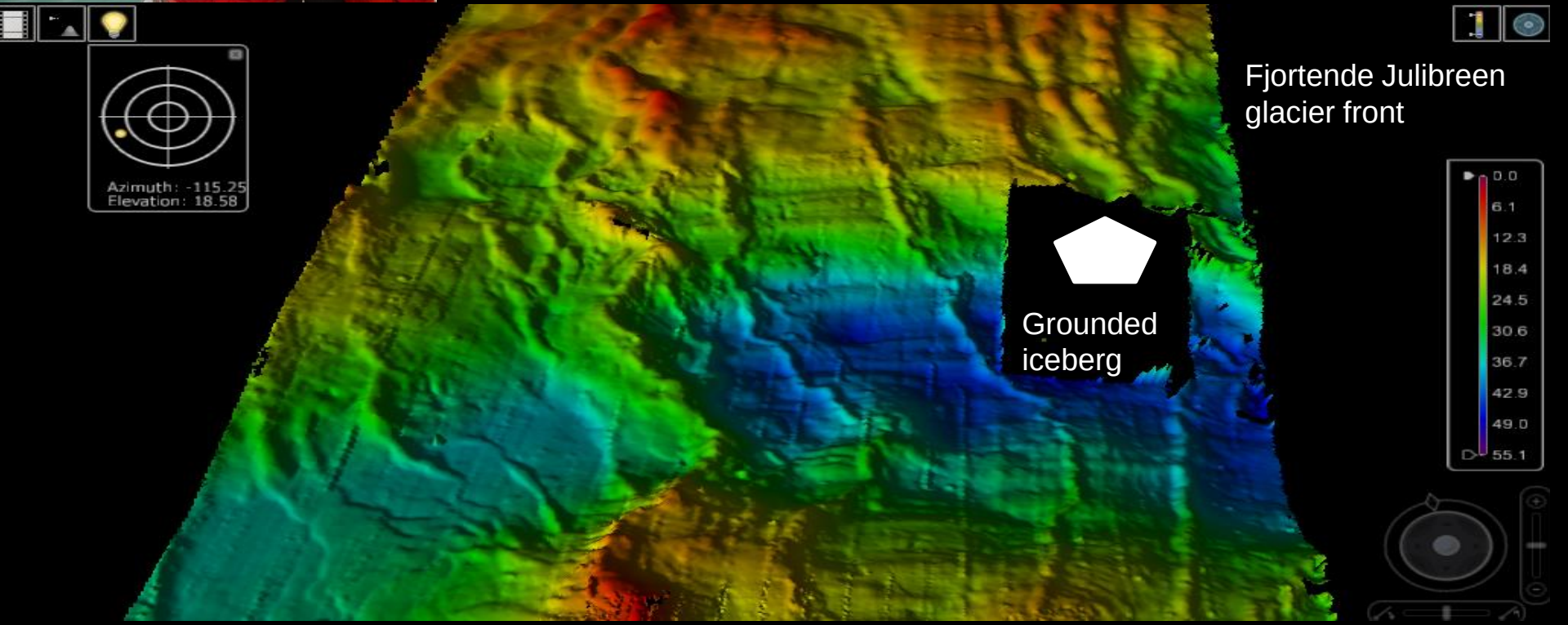
Dicksonfjord & Krossfjord

The research objective is to understand of the role of the coastal zone in Spitsbergen fjords for sediment transfer to fjord basins, as well as the impact of changing sediment supply on biology. Two “end member settings”: 1) a glaciated fjord receiving sediments directly from tidewater glaciers (Kongsfjorden) and 2) a non-glaciated fjord receiving sediments from glacifluvial rivers (Dicksonfjorden)

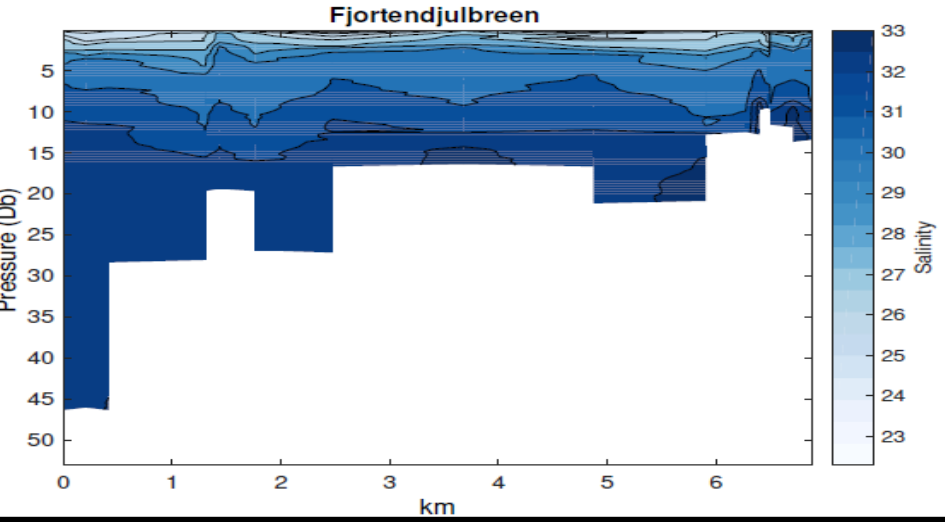
NORSK·POLARINSTITUTT

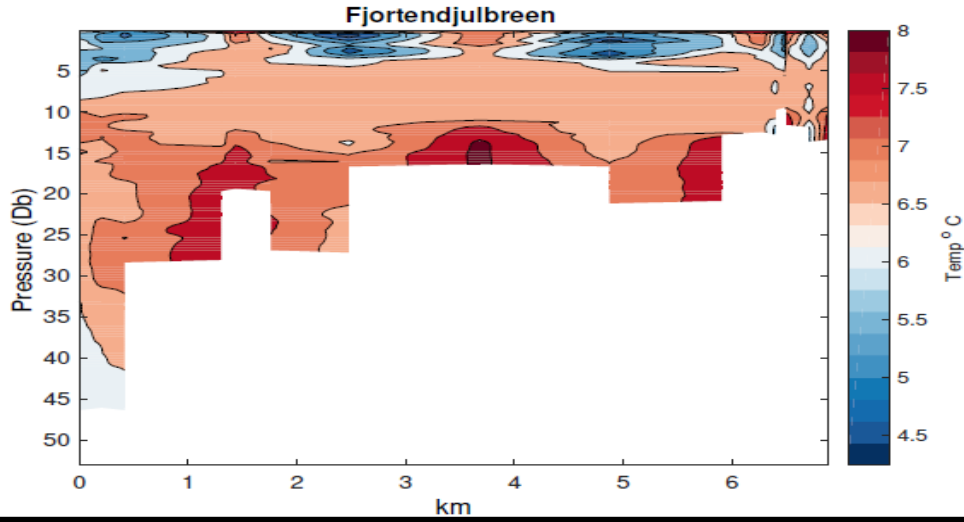
UNIS
The University Centre in Svalbard

AUV survey; bathymetric data from Fjortende Julibreen glacier front



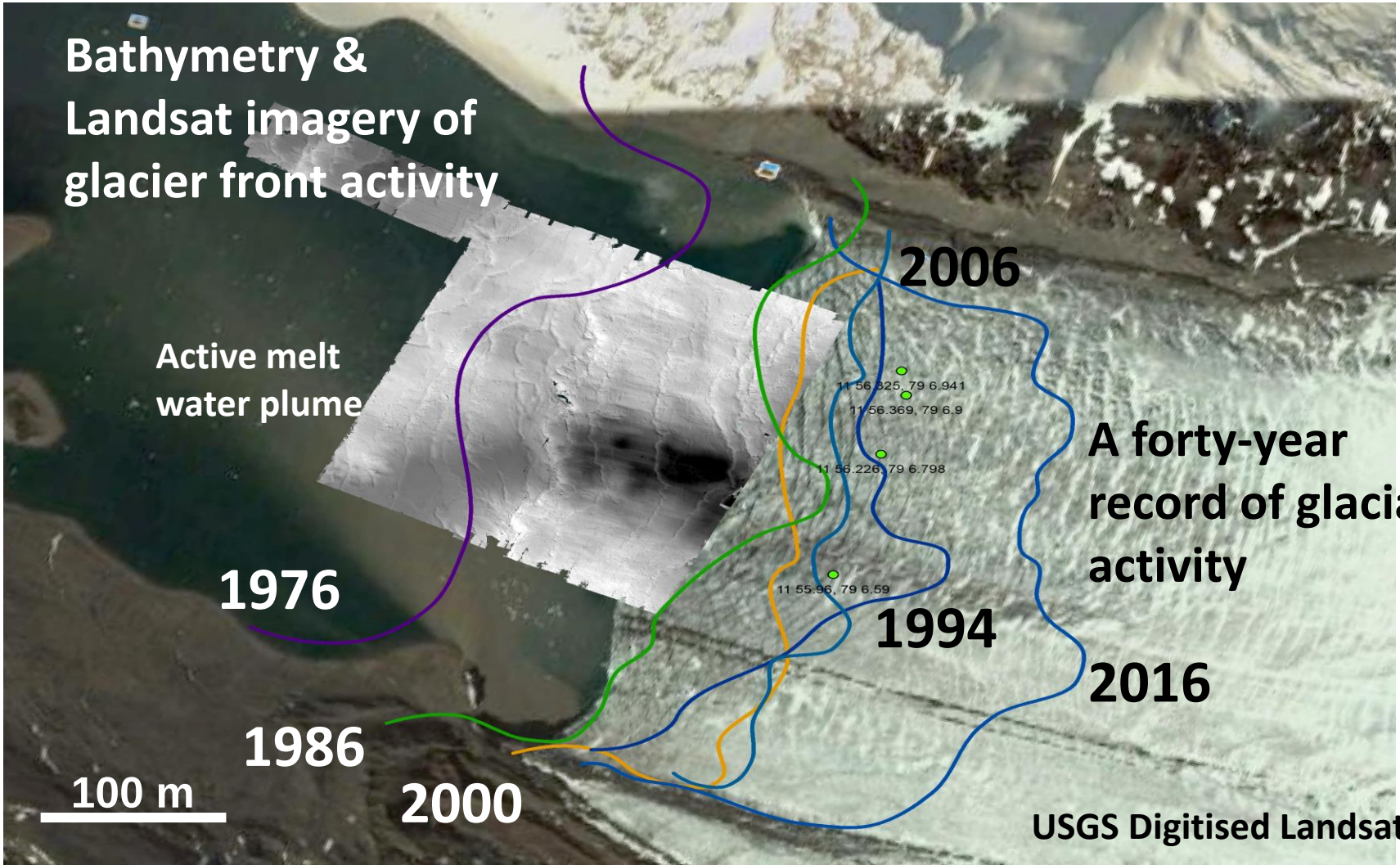
Thank you to everyone at Ny Alesund for your hospitality and

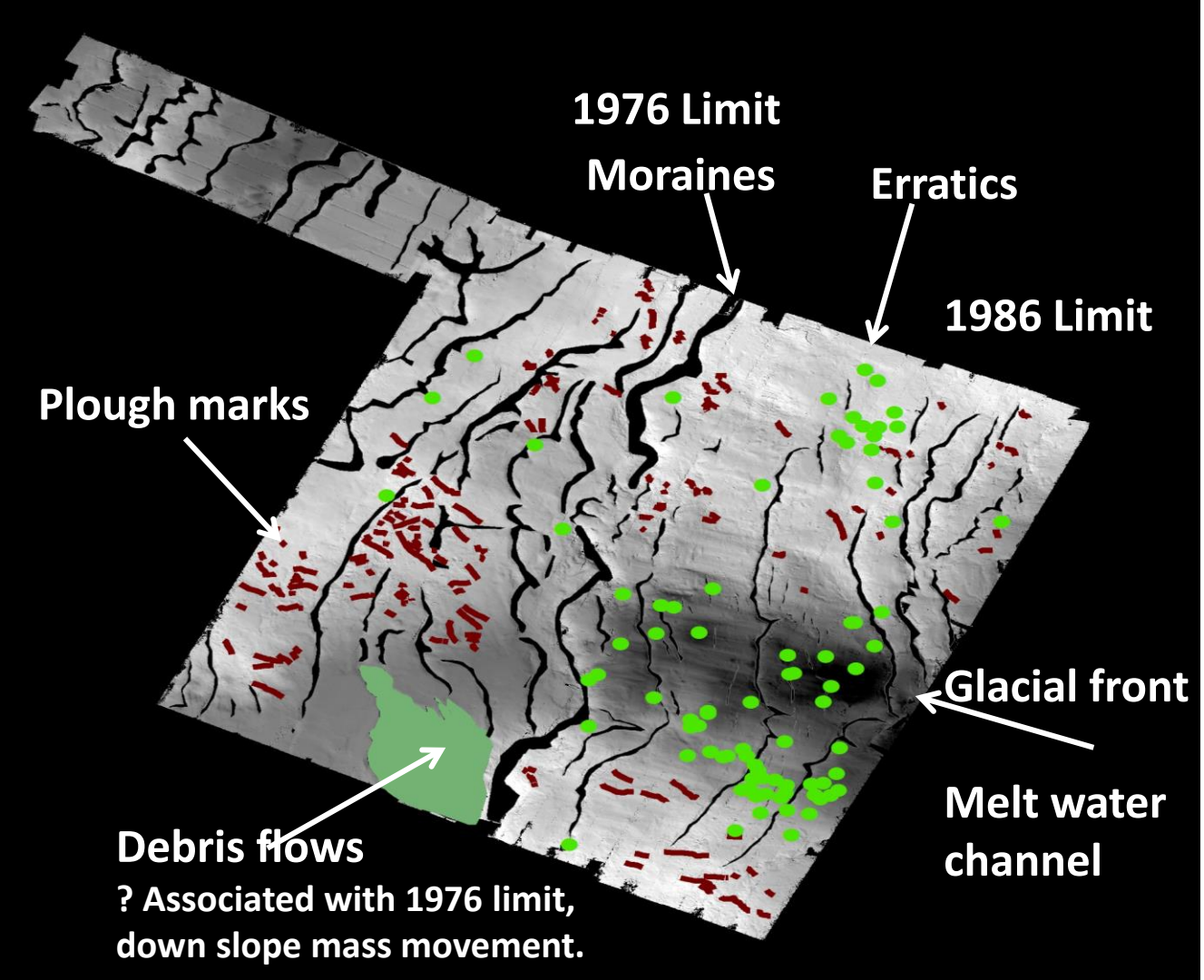




2008 glacial limit.

Conductivity, temperature & depth (CTD) casts 2016 revealing structure and origin of water. Reveal the role of sub glacial melt water.


Bathymetry &
Landsat imagery of
glacier front activity
Active melt
water plume
1976
1986
2000
2006
1994
2016
A forty-year
record of glacial
activity
100 m
USGS Digitised Landsat



Geomorphological Classification of Seabed features

Debris flows
Erratics
Plough marks
Recessional moraines

Defining processes,
Retreat patterns,
effects and colonisation

Marine Science Scotland

Autonomous underwater vehicle (AUV) range-testing of a passive acoustic telemetry array: a proof-of-concept

Lea-Ann Henry (Edinburgh) & James Thorburn (MSS)

AUV equipped with tags acting as a 'shark' to validate Acoustic moorings.

Proposed MPA in Loch Etive

AUV offer a step-change in the continuity and performance of range-testing acoustic monitoring. AUV also offers the potential for fully variable 3D range-testing.

Next steps

Designing AUV for improved stills and video

Bid for additional battery & physics package – wider use of vehicle beyond mapping projects.

New Norwegian proposal for further AUV Arctic work 2017-2019

Feb-March 2017 – Chile Patagonia fjords FONDECYT

July 2017 Svalbard NERC Arctic consortia PRIZE

Thank you

john.howe@sams.ac.uk

Scot - MRF
The Scottish Marine Robotics Facility

Rob Hall

University of East Anglia

Novel Glider Deployments in Submarine Canyons

COAS
Centre for Ocean and Atmospheric Sciences

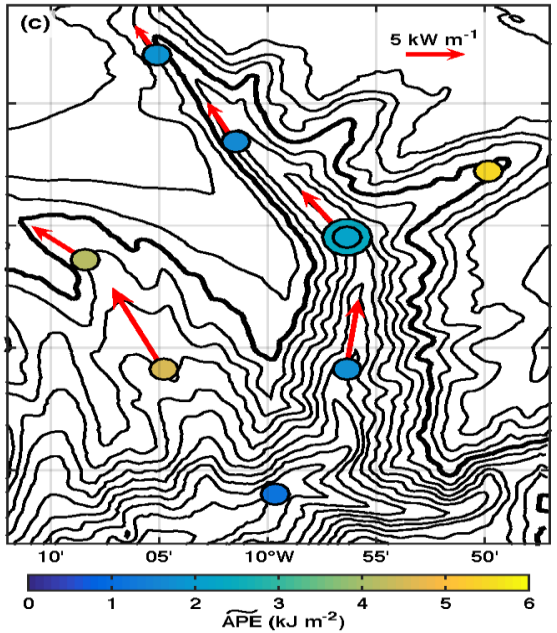
University of East Anglia

Observations of internal tides in Whittard Submarine Canyon using an ocean glider

Rob Hall (UEA)
Tahmeena Aslam (UEA/Cefas)
Veerle Huvenne (NOC)

CODE MAP

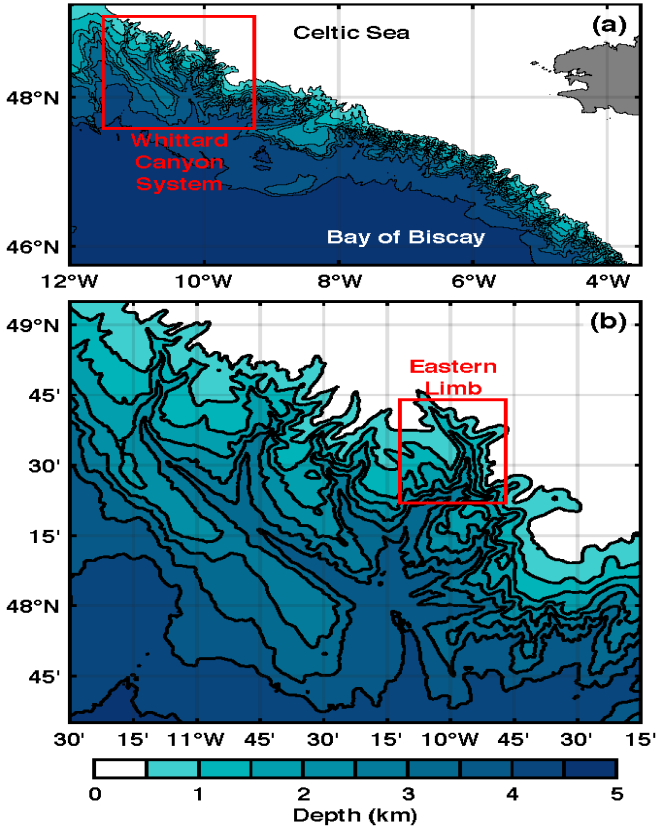
erc



Seaglider deployment as part of CODEMAP (JC125) – August 2015

University of East Anglia

- **Location:** Whittard Canyon (Celtic Sea shelf edge)
- **Duration:** 21 days (eight 36-hour ‘virtual mooring’ stations + two repeat stations)
- **Sampling:** tide resolving 3-hour 1000 m dives (less over shelf)
- **Measured and inferred variables:**
  - θ, S, P, ρ
  - Dissolved oxygen concentration (Aanderaa 4330F)
  - Chlorophyll fluorescence (WETLabs Eco Puck)
  - Optical scatter at 470 nm and 700 nm (WETLabs)
  - Dive-averaged and surface current velocity



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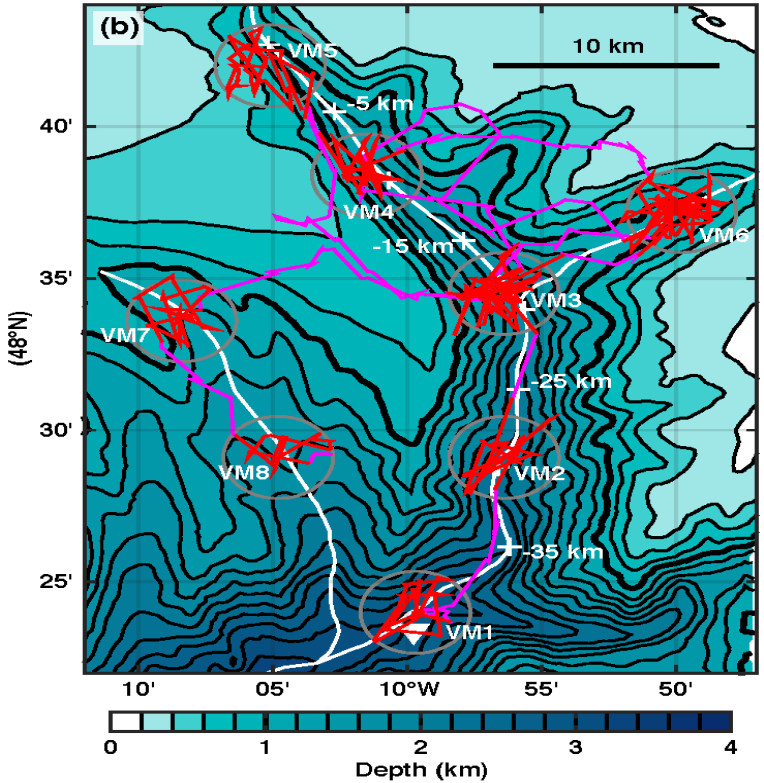

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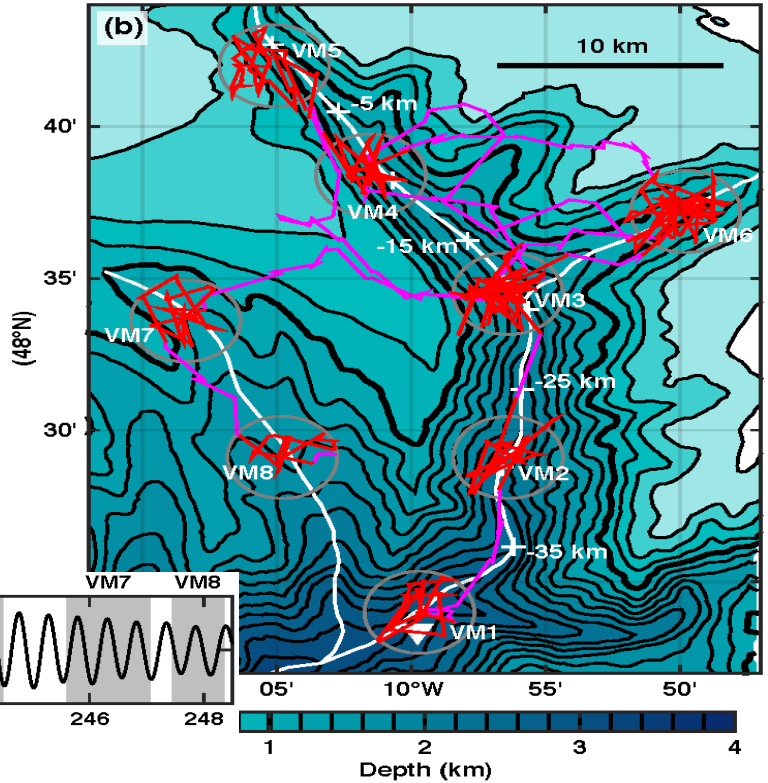
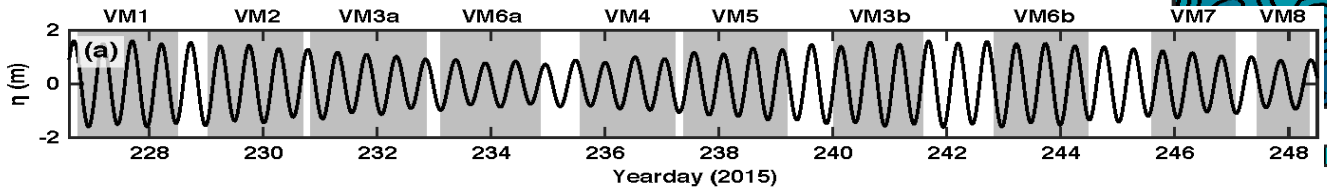
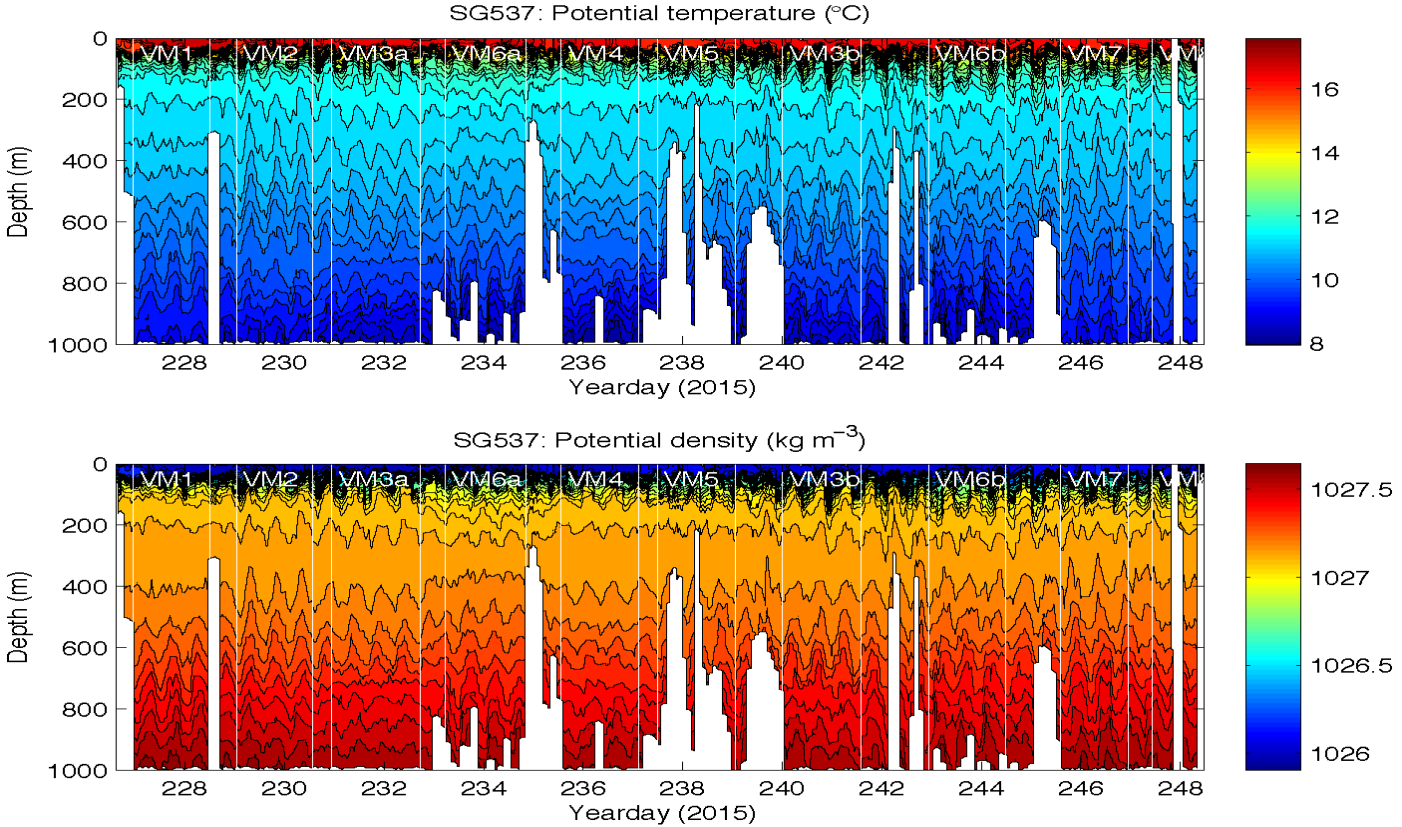
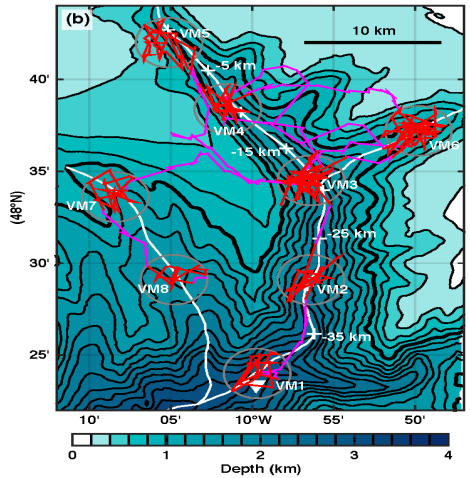


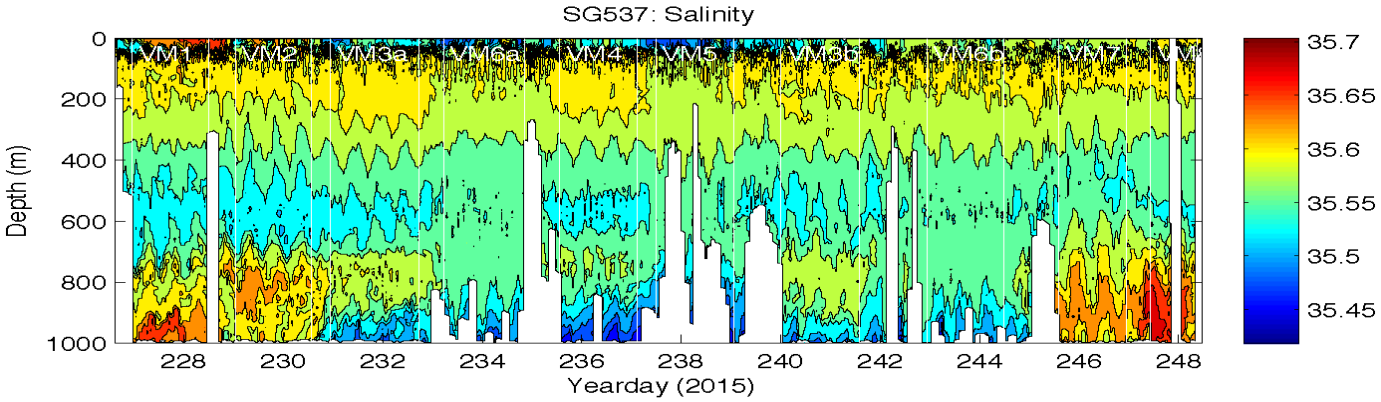


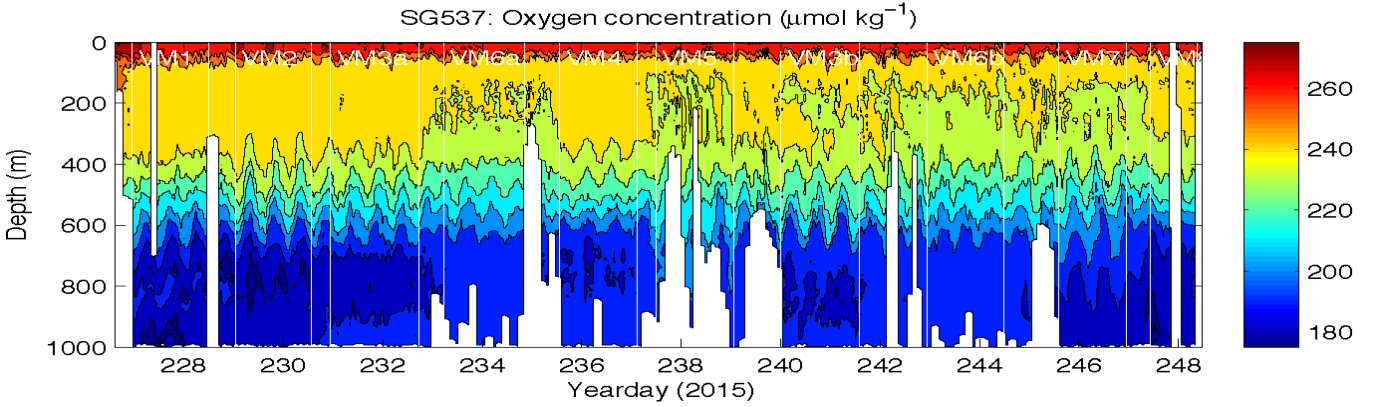
Basic data: temperature and density

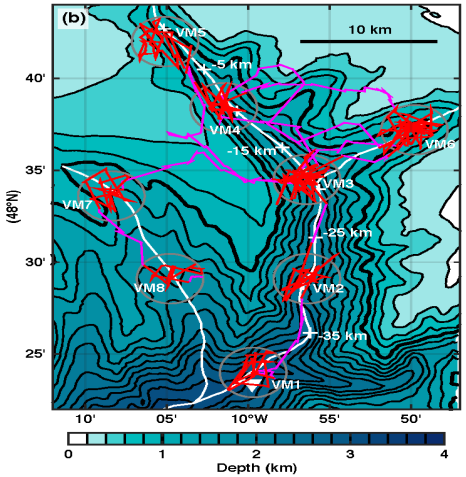




Basic data: salinity and oxygen

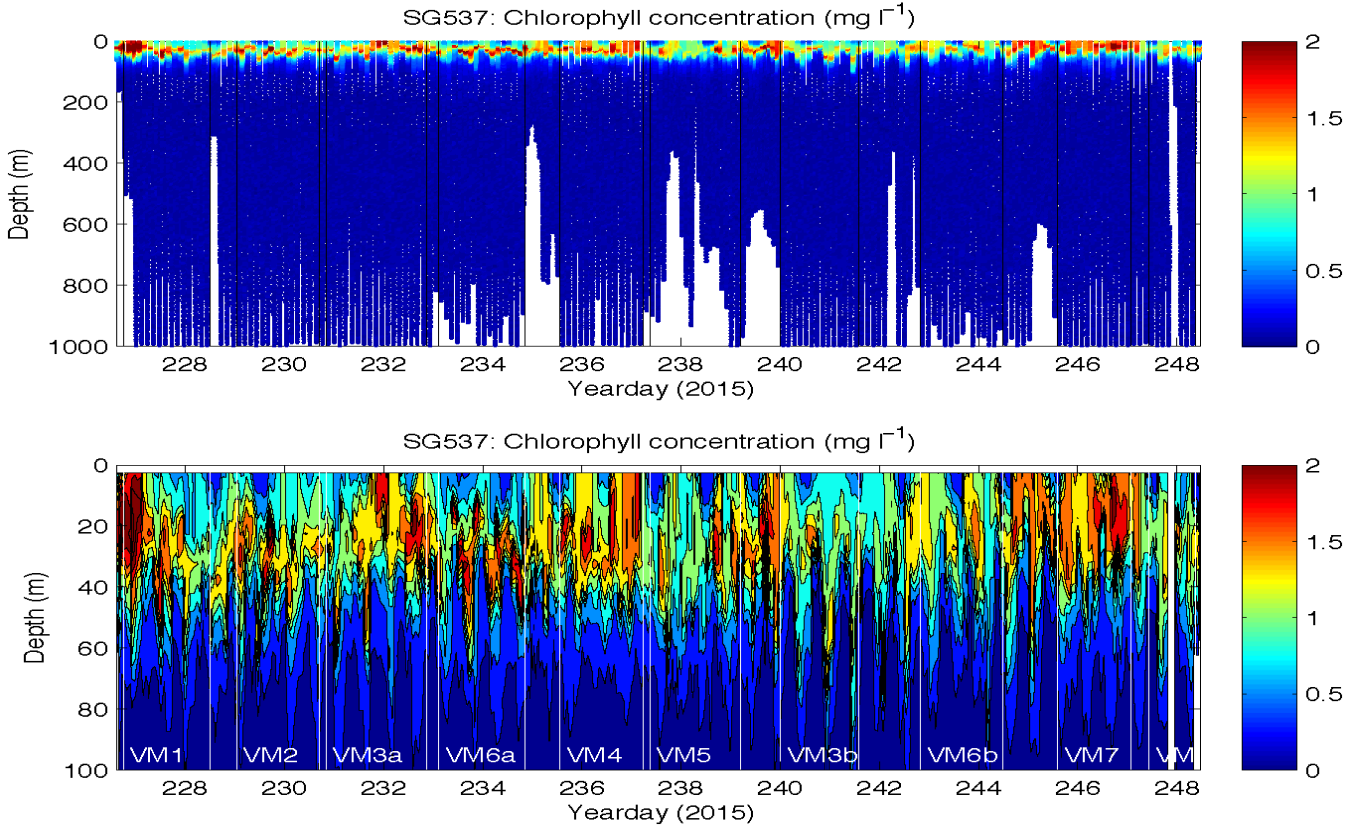


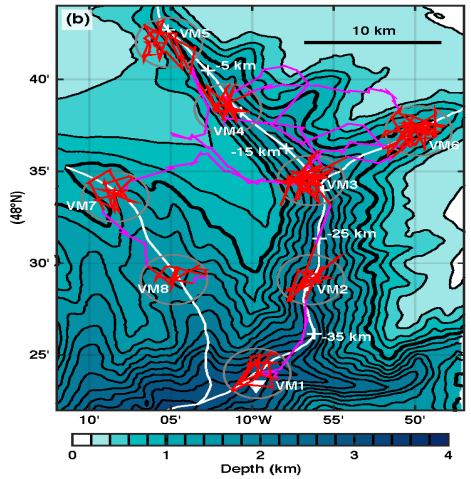




Basic data: chlorophyll

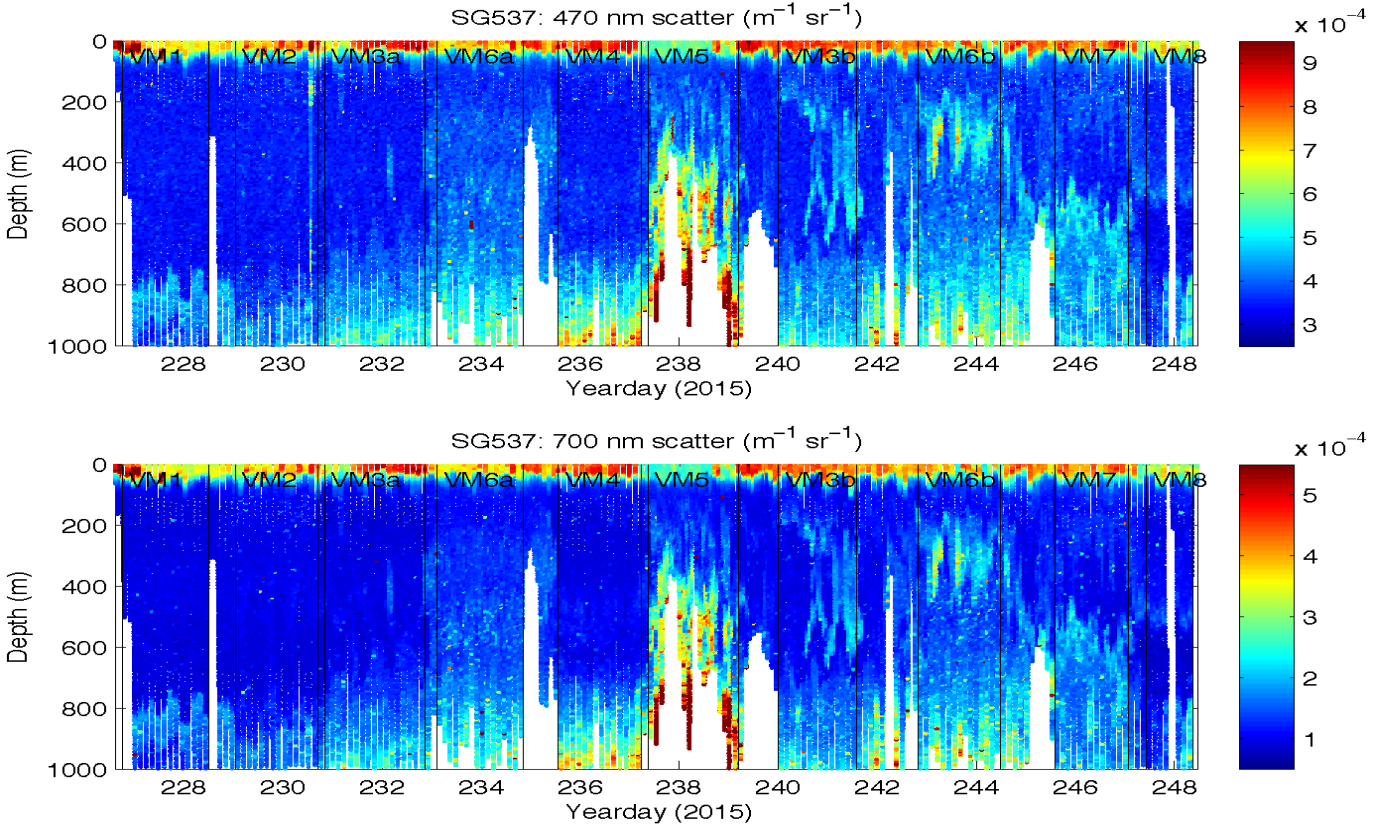
University of East Anglia

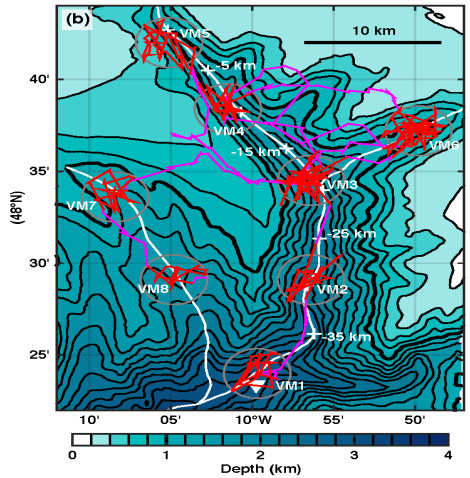




Basic data: optical scatter

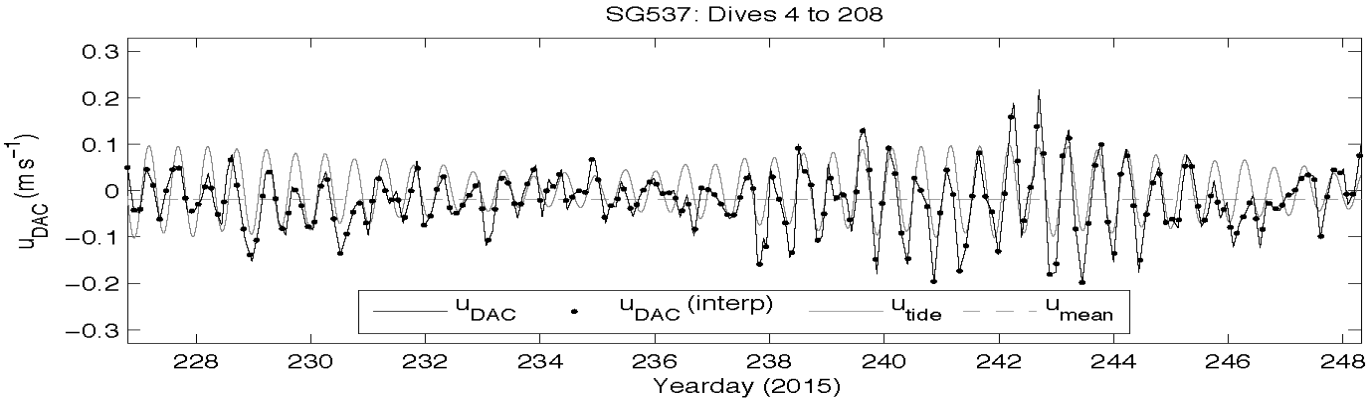
University of East Anglia

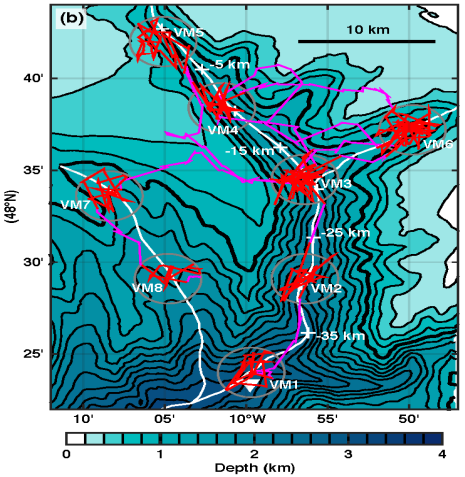


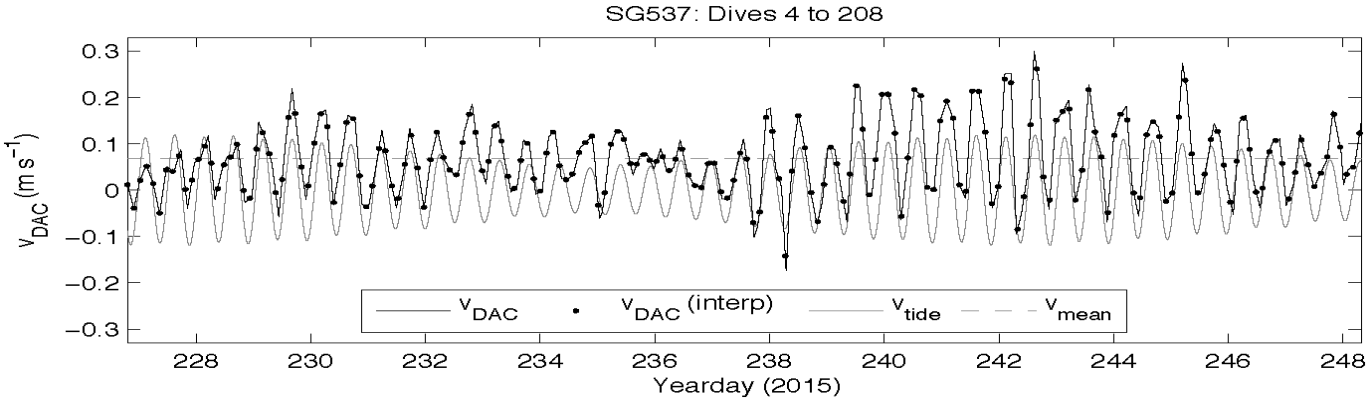


Basic data: dive-averaged current

University of East Anglia

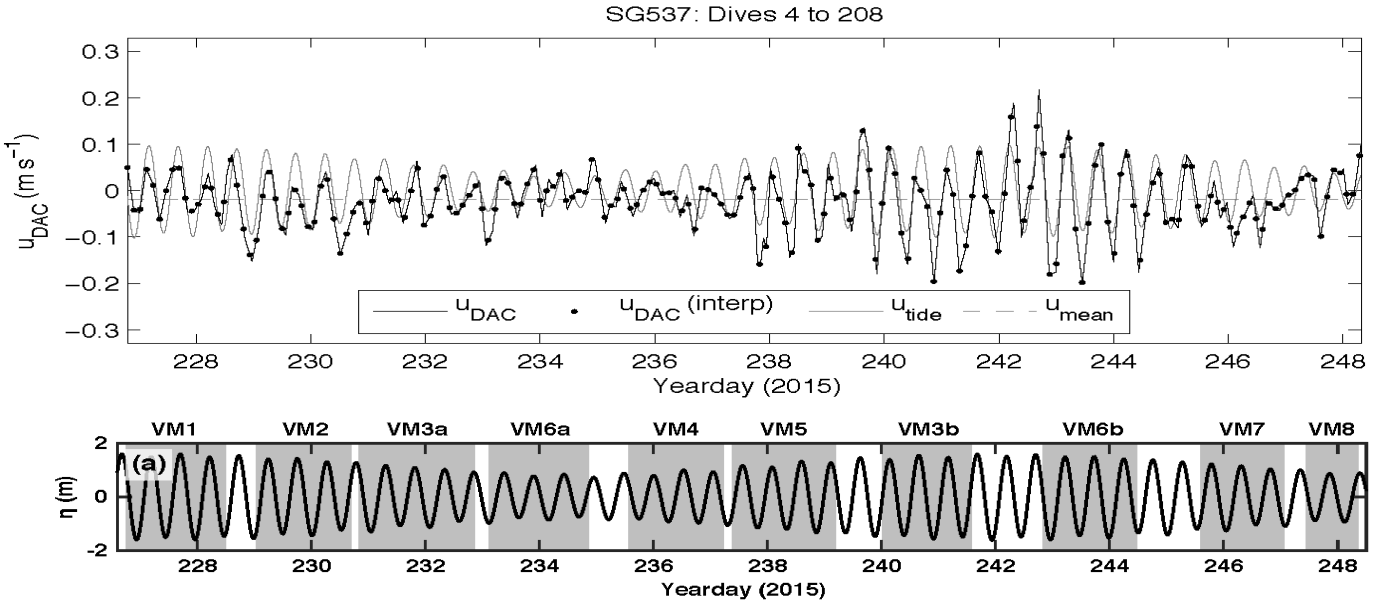


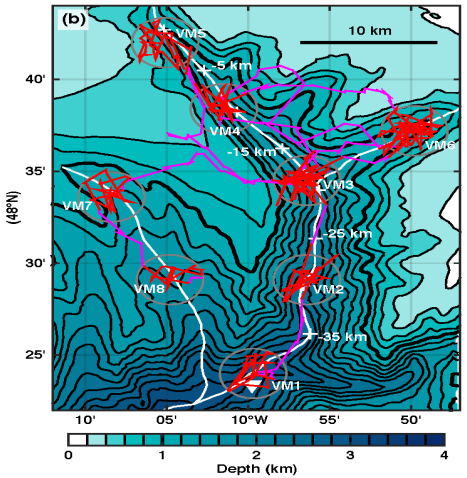




Basic data: dive-averaged current

University of East Anglia





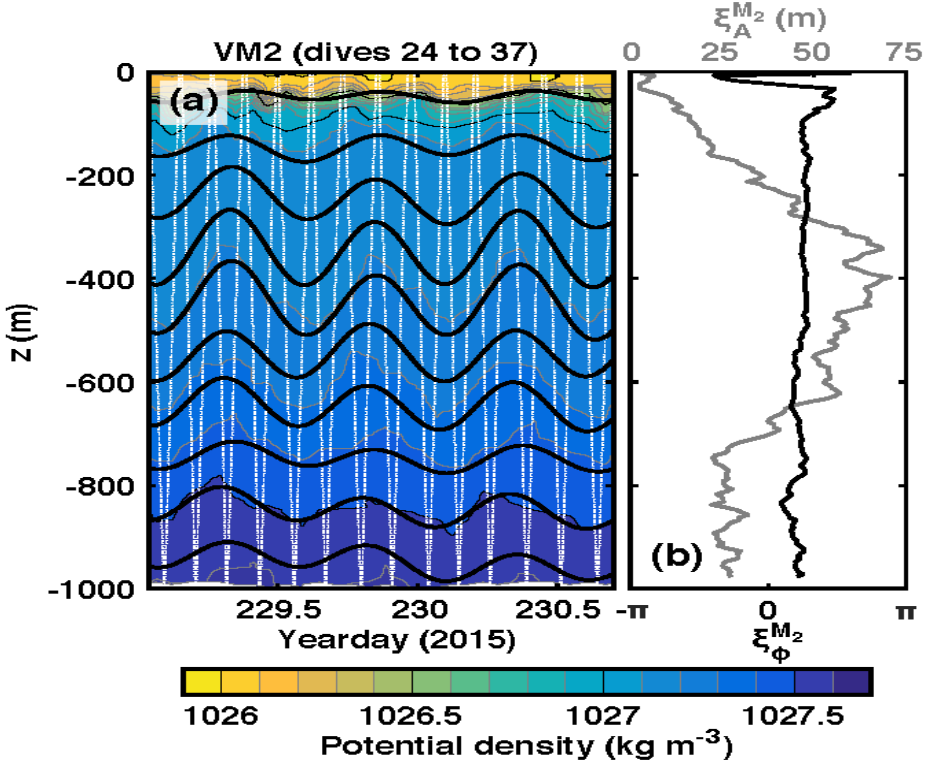
Internal tide diagnostics

University of East Anglia

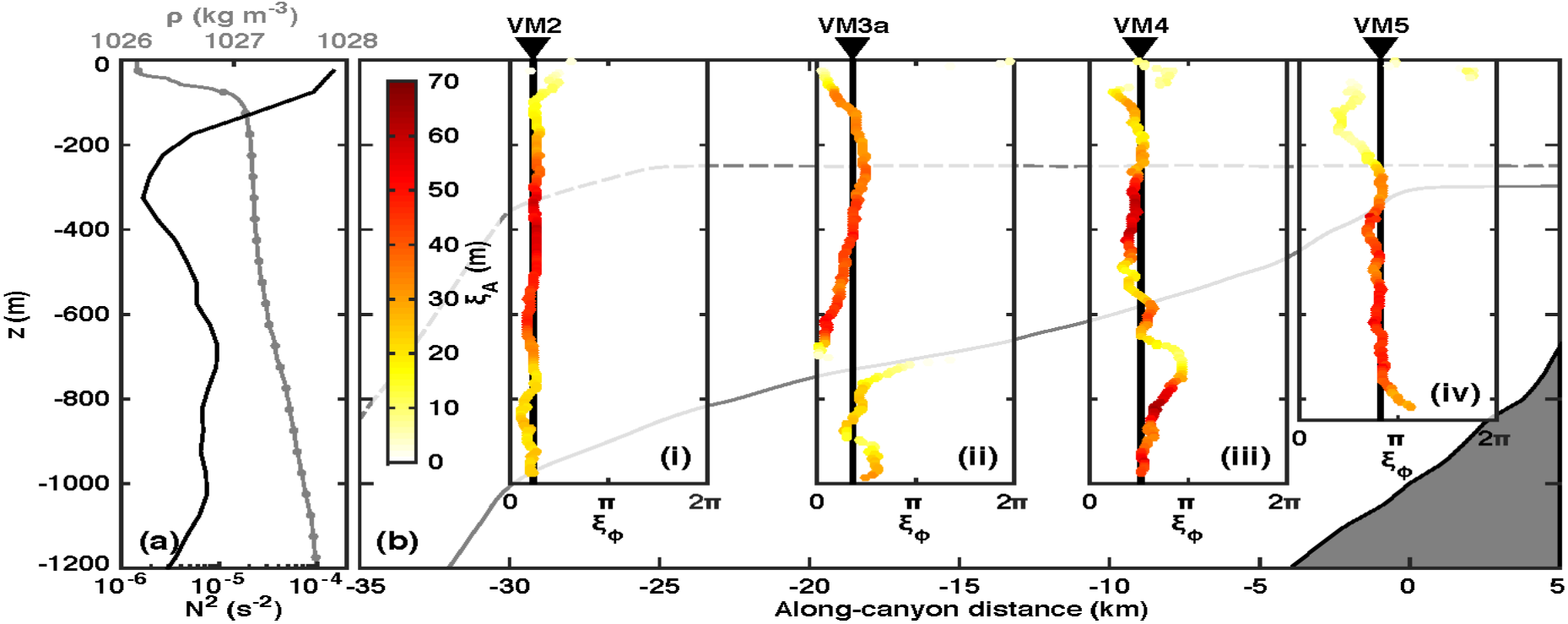
✦ Profiles of semidiurnal (M_2) vertical isopycnal displacement amplitude and phase for each station occupation

✦ Spring-neap cycle not resolved at individual stations but influence of S_2 internal tide removed using TPXO surface tide model and assuming:

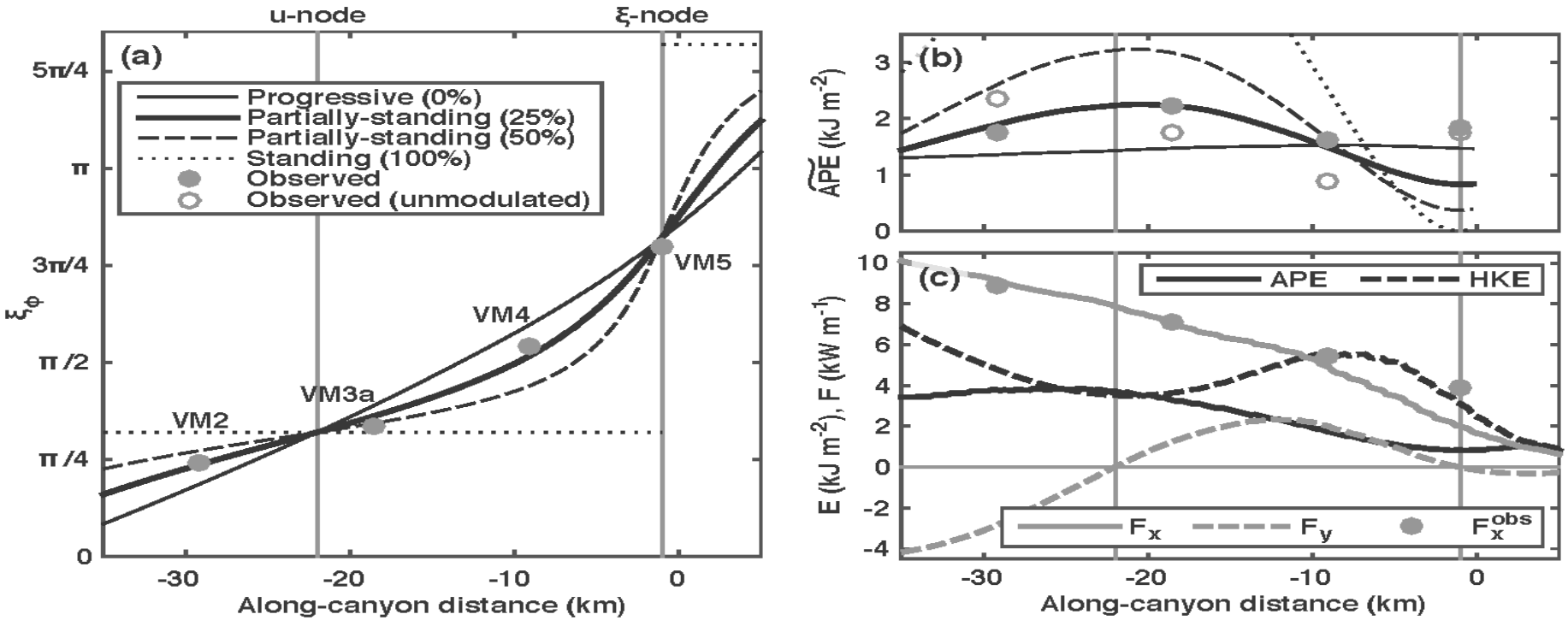
- Local internal tide generation
- Surface and internal and spring-neap cycles have the same amplitude and are in phase



Internal tide progression

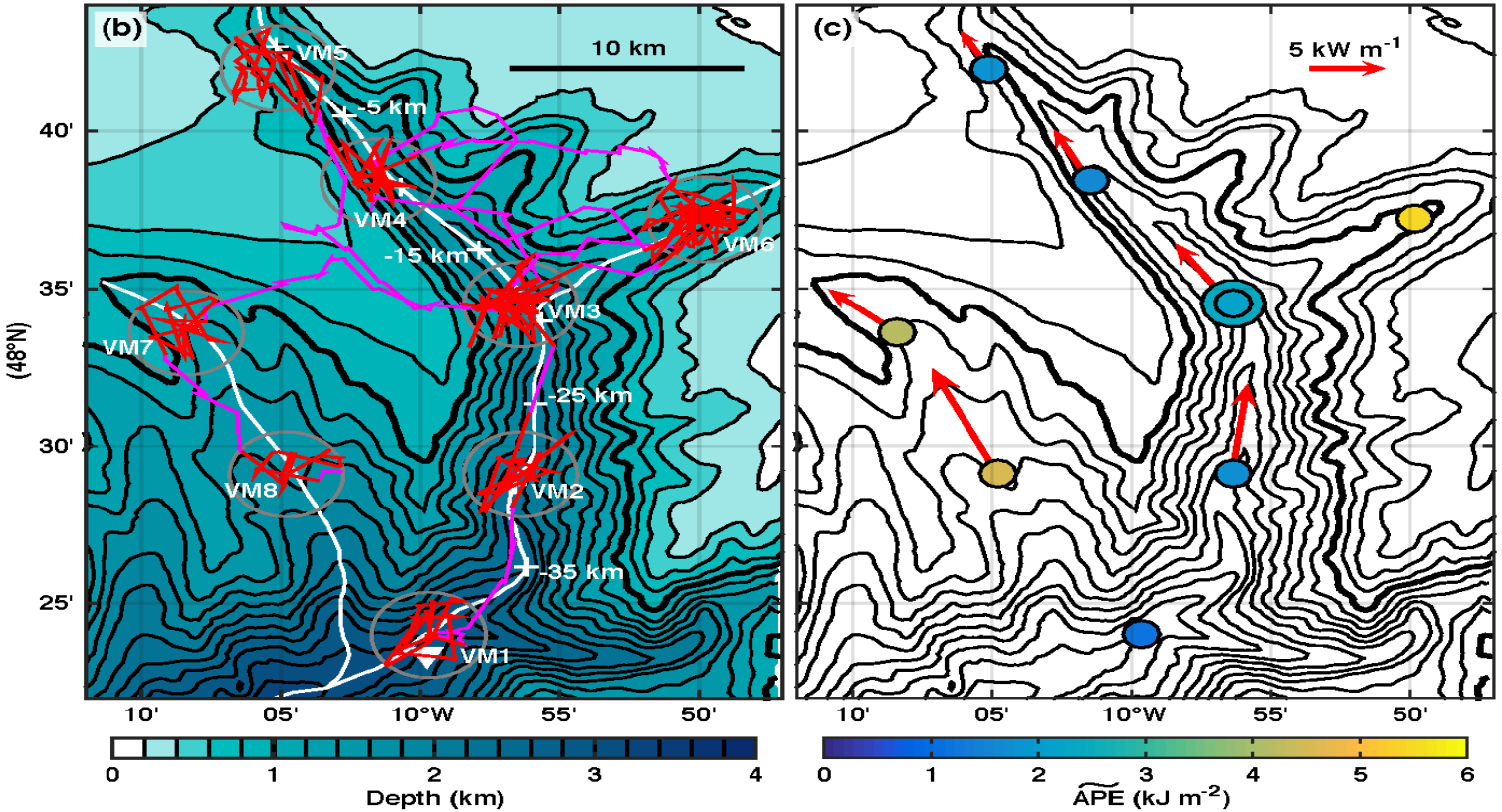


Partly standing internal tide

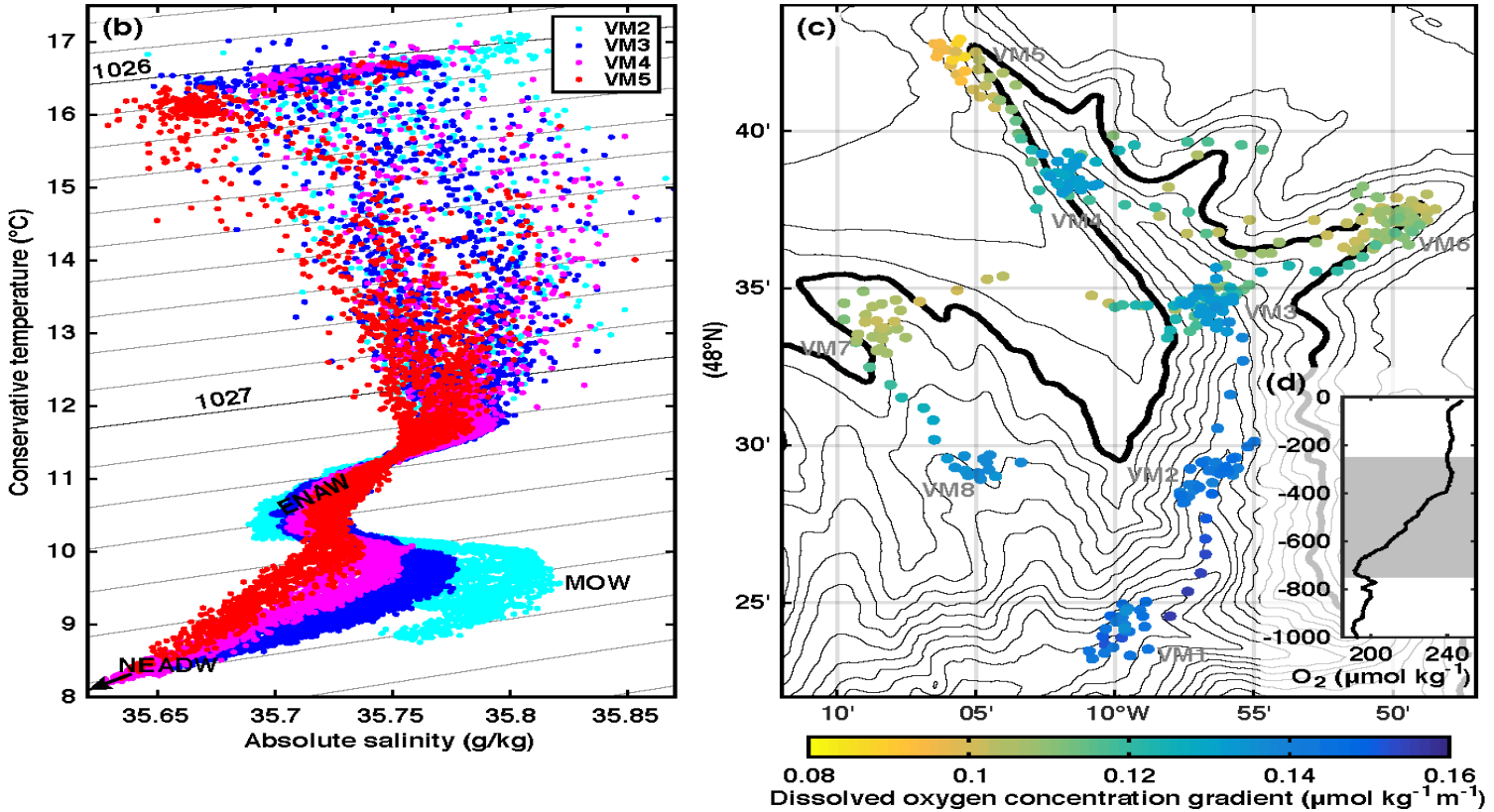


APE and energy flux

University of East Anglia

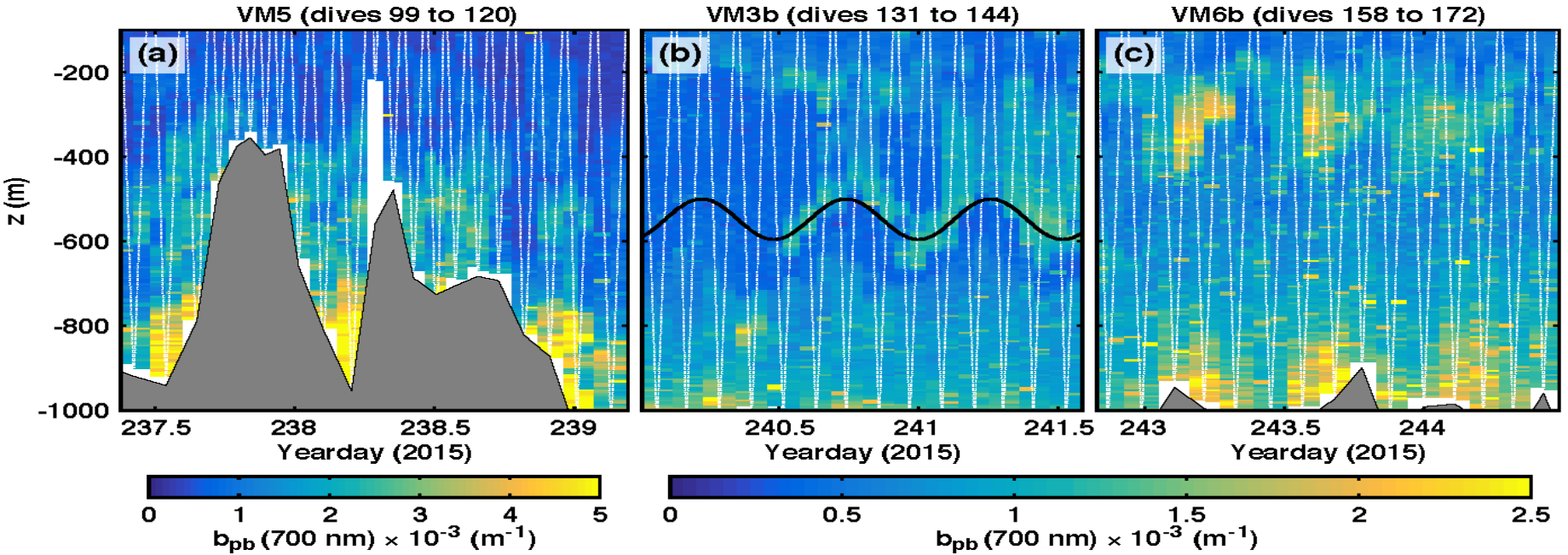


Mixing proxies



Nepheloid layers

University of East Anglia



Conclusions

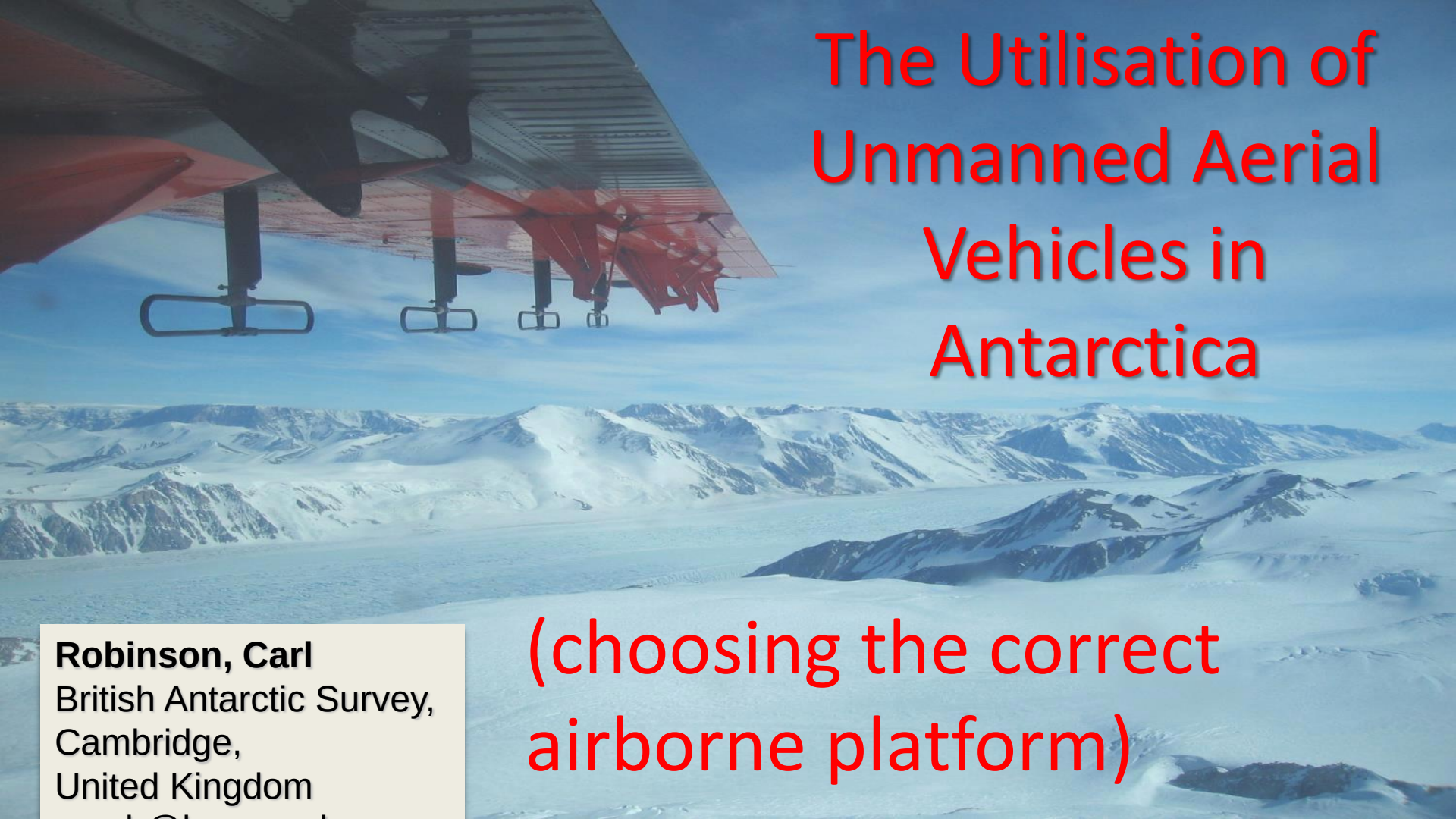
University of East Anglia

- Autonomous ocean glider used to measure the internal tide within Whittard Canyon
- Semidiurnal displacement amplitudes up to 80 m (111 m after spring-neap correction)
- Along-canyon displacement phase suggests internal tide is partly standing (25%)
- Up-canyon energy flux decreases from 9.2 to 2.0 kW m^{-1}
- Implied dissipation rate: 1-2.5 × 10^{-7} W kg^{-1}
- High suspended particulate matter in benthic and intermediate nepheloid layers

Carl Robinson

British Antarctic Survey

Utilisation of Unmanned Aerial Vehicles in Antartctica

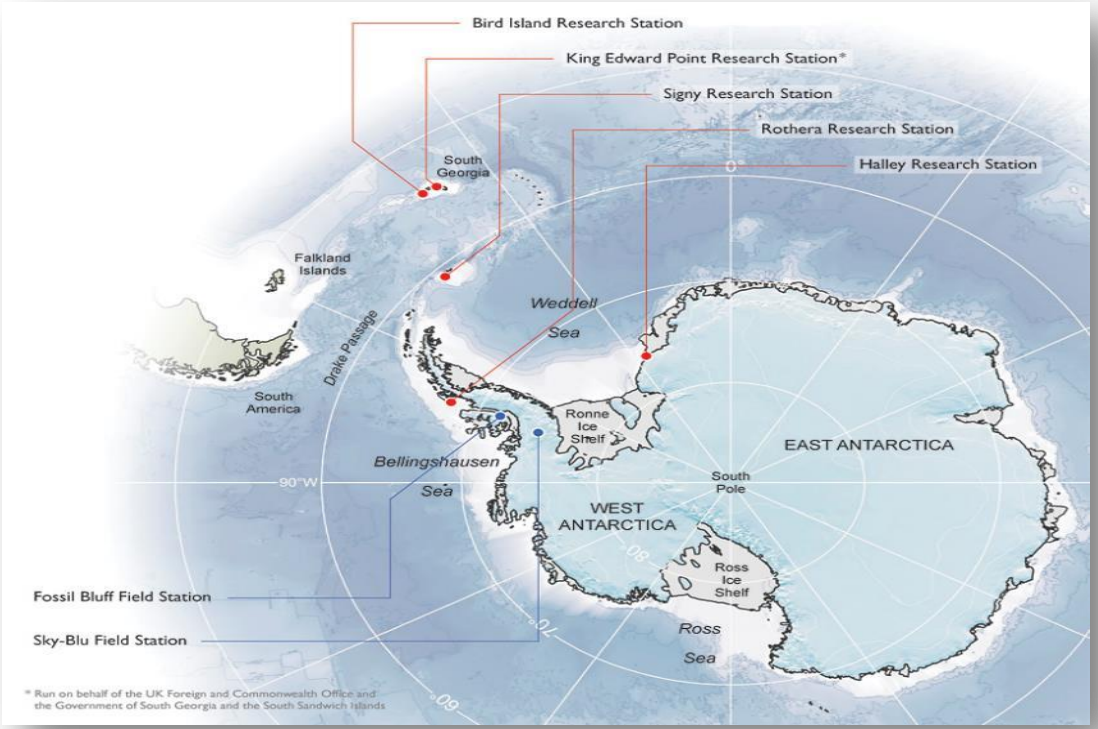


The Utilisation of Unmanned Aerial Vehicles in Antarctica

(choosing the correct airborne platform)

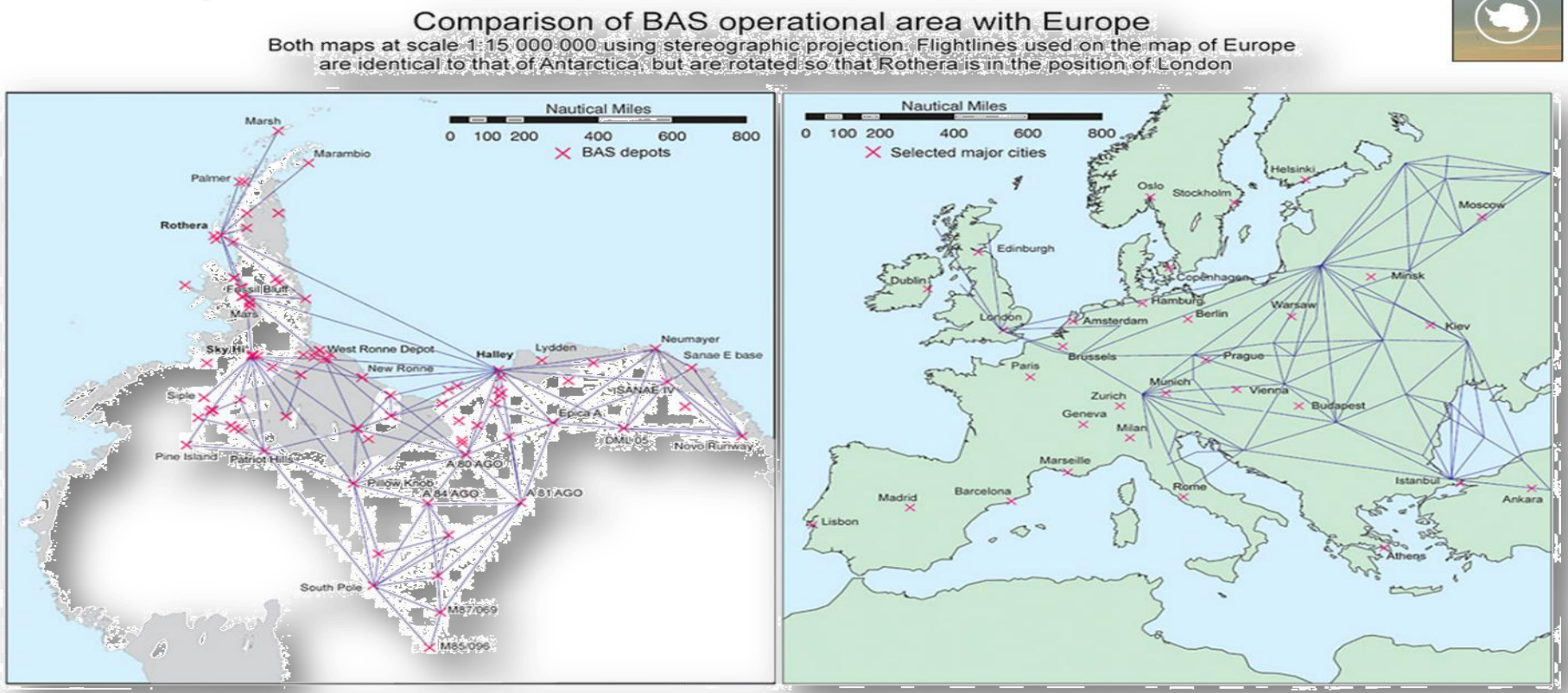
Robinson, Carl
British Antarctic Survey,
Cambridge,
United Kingdom

Capabilities - Location



- Antarctica is a place of extremes. It is the coldest, highest, driest and windiest continent on Earth
- Vast – 13,829,430km^2 (Inc. ice shelf & islands)

Capabilities - Distances



Aircraft Fleet – Right platform for the job

(UAV may not be the right choice)

Mission	UAV	Twin Otter / Dash 7
Location	Geology restricted?	Runway, near base or depot?
Access	By sea, overland, Twin Otter?	Runway or ski-way?
Accessibility	Time of season? Other users?	Time of season? Logistics use?
Fuel	Little fuel available?	Large depot / base fuel?
Mission decisions	Pre-planed?	Pilot / scientist decisions based on observations and data collected?
Size	Fit in Twin Otter/Piston Bulley/Vessel/tent?	Large cabin space required?
Range	Distance to target/time at location?	Distance to target/time at location? Refuel?
Speed	Optimum speed for sensor? Loiter?	Optimum speed for sensor?
AGL	Optimum flying height? Ground clearance?	Optimum flying height? Ground clearance?
Noise	Quieter?	Quiet enough?
Sensor accuracy/resolution	Smaller sensor less resolution and accuracy?	Full format sensor?
Pay load	Small 100s grams to kilo grams?	10s to 100s kg?

Capabilities - Weather

- Wind
  - *katabatics*, formed by cold, dense air flowing out from the polar plateau
  - max wind 199 mph Dumont d'Urville
  - sub 15 knot winds are typical
- Snow and rain
  - Antarctica is classed as a desert
  - Snow and rain in coastal areas a plenty
- Temperature
  - Coldest recorded -89.2°C (Vostok)
  - Warmest recorded +17.5°C (Esperanza Base on the Peninsular tip)
  - Rothera temperatures during summer between +5°C and 0°C , winter -5°C and -20°C

Capabilities – Sun (dark)

- Summer season with aircraft on Continent October to March
- Summer season 24 hours daylight
- UV damage from sun
- Absorb or reflect suns energy?

Capabilities - Fuel

- 448 drums airdropped (FBL 286 drums)
- Average survey groundspeed = 120 kt
- Average fuel burn 538 lb/ hr = 1.49 drums/ hr
- Which equates to 4.48 lb/nm = 80.58 nm / drum

Data provided by D Cochrane British Antarctic Survey

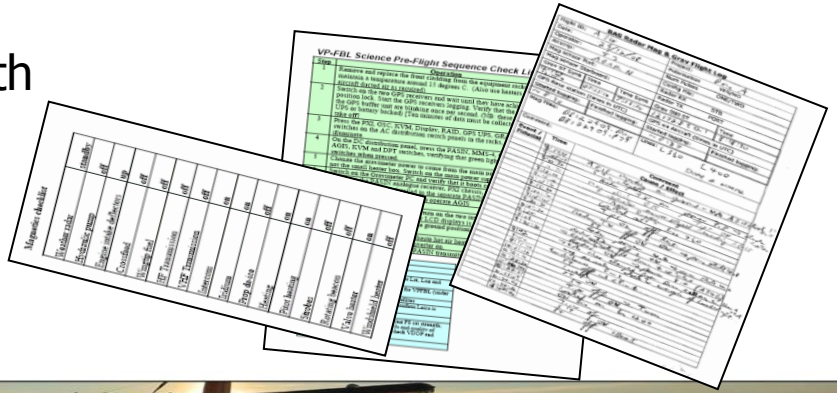
Capabilities - Size

- Physical size –
  - can I carry what I need?
  - Is it over kill?
- Small enough to put away when not in use?
- Light enough to carry?
- Small enough to fit in a Twin Otter?

Capabilities - People

- People + tiredness = mistakes
- People forget?
- Need to be consistent
- Environment makes it hard!

- Staff rotation two operators paired with pilots
- (Cheat sheets, check lists, logsheets)



Aircraft Fleet – DH-Twin Otter Platform

Equipment Payload	
Area Available in Camera Bay [Aperture] Two further apertures in tail	0.5m-long x 0.5m-wide plus cabin space, rear baggage apertures and hard points
Weight	~500 KG (1000 km survey) [540 nm] Less KG (1722 km survey) [930 nm]
Power	28V 250A (from enhanced generators)

Aircraft Operations	
Range	>771 nm, can be increased by long range tank
Airspeed	Cruise 65m/s. Data collection 60m/s
Complement	Pilot + maximum 4 mission operators/scientists (1 is standard)
Altitudes	<30m to 5,000m. Unpressurised but with oxygen fit for pilots and operators

Aircraft Fleet – DH-Dash 7 Platform

Equipment Payload	
Area Available	1.55m-long x 0.62m-wide x 1.2m-high bay plus cabin space and hard points
Weight	Up to 400kg (with out impact on range)
Power	DC 28v, 300A

Aircraft Operations	
Range	>2000nm* (fuel capacity allows 10 hours endurance at 200 knots)
Airspeed	Cruise 120m/s. Data collection 110m/s
Complement	2 pilots + aircraft engineer + max 4 mission operators / scientists
Altitudes	21,000ft operational altitude

*provides at least two hours of survey time at 800 nm return to origin

Aircraft Fleet – UAVE PRION3 Platform

- Two airframes owned
- One ground station
- One catapult
- Gimbaled PhaseOne 50M pixel camera been integrated (in service 2017)
- Instrument area engineered for easy install of further sensors
- Four BAS staff completed one month flight training in Wales

Equipment Payload	
Area Available	Nose and hard points
Weight	Up to 15kg (depending on fuel) 10kg optimal
Power	24Vdc, 12Vdc and 5Vdc

Aircraft Operations	
Range	14 hours, 1000km+
Airspeed	80km/hr data collection
Complement	1 pilot and 1 ground controller
Altitudes	Up to 3,000m AGL plus

Aircraft Fleet – Multi-Rotors

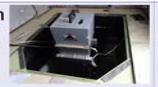
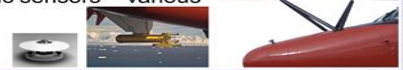
Consumer

Aircraft Operations	
Range	2-3km
Flight time	25+ minutes
Airspeed	Up to 79km/hr
Complement	Pilot + observer
Altitudes	Restricted to 400ft but programmable to greater if required
Equipment Payload	
Sensor	Camera
Weight	Few 100 grams
Power	Self powered or integrated

Professional

Aircraft Operations	
Range	2-3km in general but extendable to 5km
Flight time	50 minutes
Airspeed	Up to 90km/hr
Complement	Pilot + observer
Altitudes	Restricted to 400ft but programmable to greater if required
Equipment Payload	
Sensor	15M camera / IR Camera, Custom
Weight	Few 100 grams to kilo gram
Power	Self powered or integrated

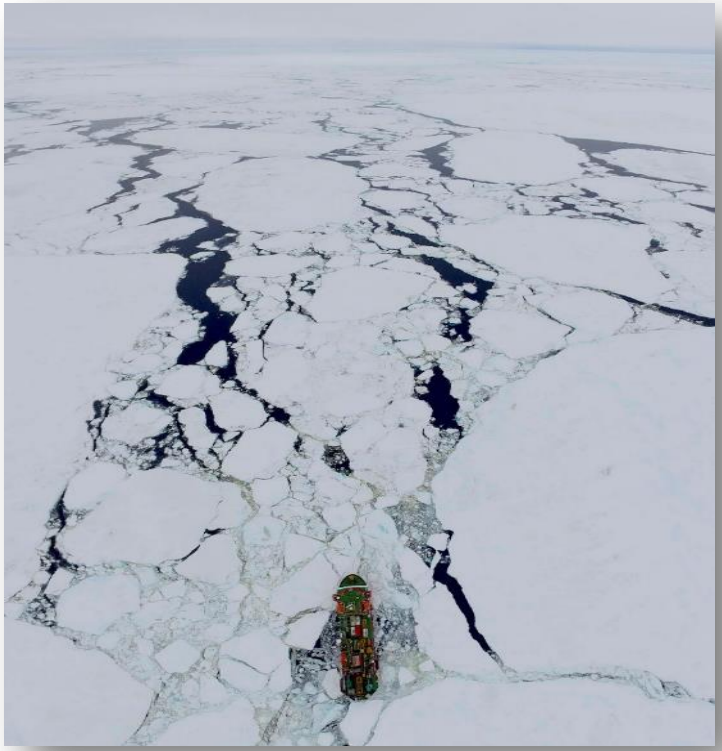
Sensors (UAVs are sensor platforms)

CS3 magnetometer 	Potassium magnetometer? - TBD
Gravimeter L&R modified ZLS Gravimeter 	IMAR FSAS IMU 
Lidar – Various Riegl, Leica, Optech 	TBD – Riegl, Yellow Scan, others? (Tender once project/grant known)
Hyperspectral – Various ITRES TASI, CASI, SASI; Specim Fenix, Owl 	Lower resolution – TBD (Tender once project/grant known)
High resolution camera – Intergraph ZI DMC 	PhaseOne iXU150 
Atmospheric sensors – various 	Some direct install from Twin Otter others TBD (Tender once project/grant known)
Radar – various bespoke radars, BAS PASIN, ESA ASIRAS, BAS SnowRadar 	Custom antenna and system once project/grant known

Case studies – Building inspection

- Pre-work survey
- Inspection
- Site survey

Case studies – Vessel Sea Ice Navigation



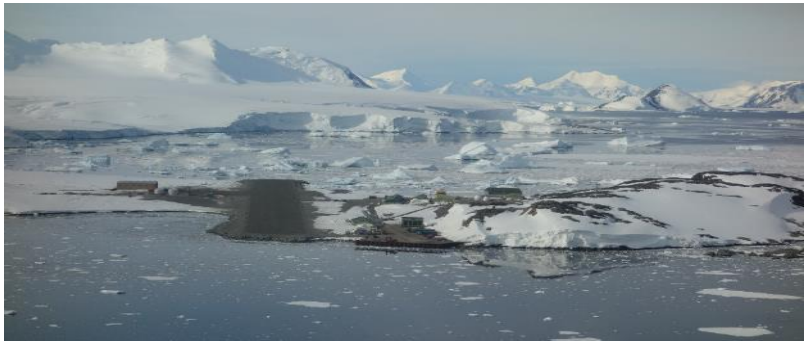
- Previously satellite image and Twin Otter recon flight
- Now satellite image and vessels UAV

Case studies – Situational awareness

- RRS Ernest Shackleton Halley resupply
- Ship mooring
- Cargo off loading

Case studies – Runway inspection

- Survey of run way for first planes in
- Survey for medivac aircraft 2016



In season

Out of season UAV survey

Case studies – Halley 6 Chasm

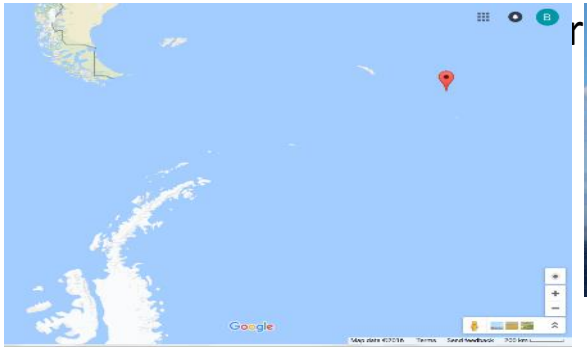
- Survey of chasm (crevasse) and surrounding area

Case studies – Wildlife survey

- Wildlife surveys
- Less intrusive
- No walking through colonies

Case studies – Wildlife Zavodovski

- One of the largest penguin colonies on Earth
- Zavodovski eruption spewing ash since March 2016
- Penguins fate unknown could be fine?
- SkyRanger to be flown off JCR in December to assess how the



Case studies – Air space integration

- Aberporth Wales – Tower Comms
- Pilot and operator ground training at UAVE
- Antarctic flight test program
  - Basic platform proving
  - Taxi, take off and landings
  - Circuits

Case studies – Antarctic Regulation

- Permits
- Minimum requirements Pilot/UAV
- Regulations
- NOTAMS
- Reporting
- Other related rules and regulations

Q&A?

Mid Morning Refreshments

30 Minute Break

Nils Piechaud

Plymouth University

The NERC Deep Links project: ROV and AUV-based survey of UK seamount habitats

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Kathleen Robert

NOC

Novel ROV-based imaging of deep-sea canyon habitats

Phil Anderson

SAMS

Unmanned Aerial Vehicles for coupled oceanographic and atmospheric studies

Alex Brearley

British Antarctic Survey

Recent developments in MAS-based polar research and the Southern Ocean Glider Base

Lunch

55 Minute Break