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 MASSMO 2 and 3: highs, lows and lessons learned

Marine Autonomous Systems in Support of Marine Observations

Prof Russell B Wynn (Chief Scientist, MARS)

MASSMO 2A.2 (May-June 2016)


TELEDYNE
WEBB RESEARCH
Everywhereyoulook
Chelonia Limited
Cetacean Monitoring Systems
SA
instrumentation
SLOCUM
Electric Glider
Damien Guihen
British Antarctic Survey


SAILOR


SAILOR
ASV
WWF
WWF
WWF
WWF

Pre-launch media event on 20 May resulted in regional/national coverage

BBC Sign in | News | Sport | Weather | iPlayer | TV | Radio | M

NEWS

Home | UK | World | Business | Politics | Tech | Science | Health | Education | Entert

Wales | Wales Politics | North West | North East | Mid | South West | South East | Cym

Pembrokeshire robot submarine finds shark 'larder'

By Steffan Messenger
BBC Wales Environment Correspondent

20 May 2016 | South West Wales

Here is footage of the robot when it was launched - and what it hoped to find

A "hidden larder" for sharks and whales has been discovered off the west coast of Wales by a pioneering marine robot.

31

DAILY NEWS 20 May 2016

Thomas the marine engine set to explore UK ocean fronts

Roboboat ready for action
Cerith Jones/WWF

By Laura Hampton

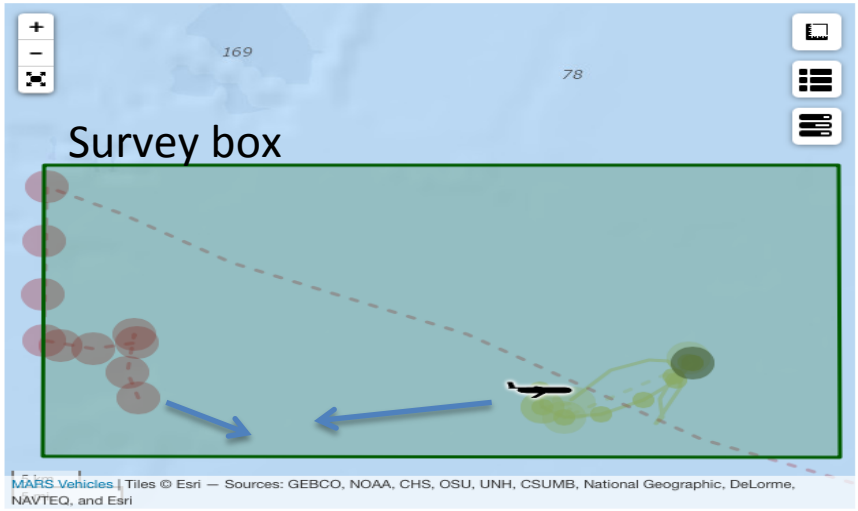
Some secrets are buried too deep to get at. Ocean fronts deep below the surface, where distinct masses of water come together, are hard to study. But a marine robot and its submarine buddy might be about to change that.

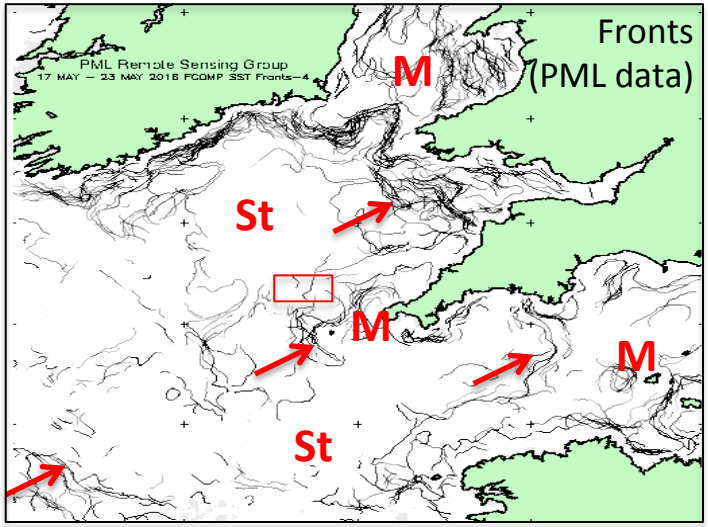
Thomas, an uncrewed boat designed and built near Portsmouth, UK, is embarking on a two-week mission to record data from such hard-to-reach waters.

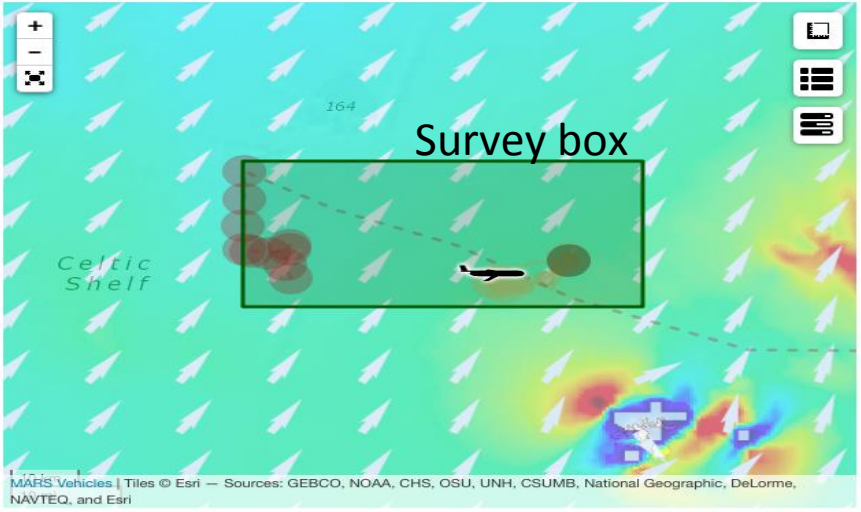
The main goal is to study oceanographic fronts, boundaries between two distinct water masses, which are common in the seas around the UK. The large aggregations of plankton, which thrive in the steep gradients in temperature found in such places, mean they also teem with larger life.

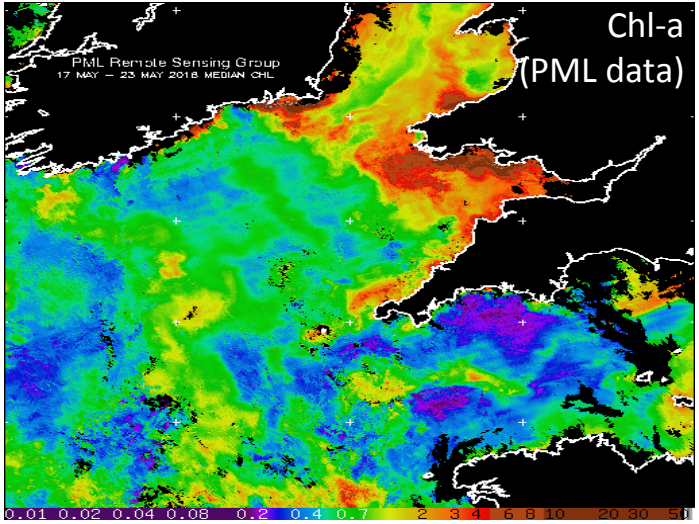
"Fronts are of interest to conservationists because they are biodiversity hotspots," says Russell Wynn of the National


Thomas covered 175 km in two 48-hour missions


Survey box
MARS Vehicles | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri


PML Remote Sensing Group
17 MAY – 23 MAY 2018 FCOMP SST Fronts-4
Fronts
(PML data)
M
St
M
M
St


Survey box
Celtic Shelf
MARS Vehicles | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri


PML Remote Sensing Group
17 MAY – 23 MAY 2018 MEDIAN CHL
Chl-a
(PML data)
0.01 0.02 0.04 0.08 0.2 0.4 0.7 2 3 4 6 8 10 20 30 50

Several thousand still images and several hours of video (including some underwater)

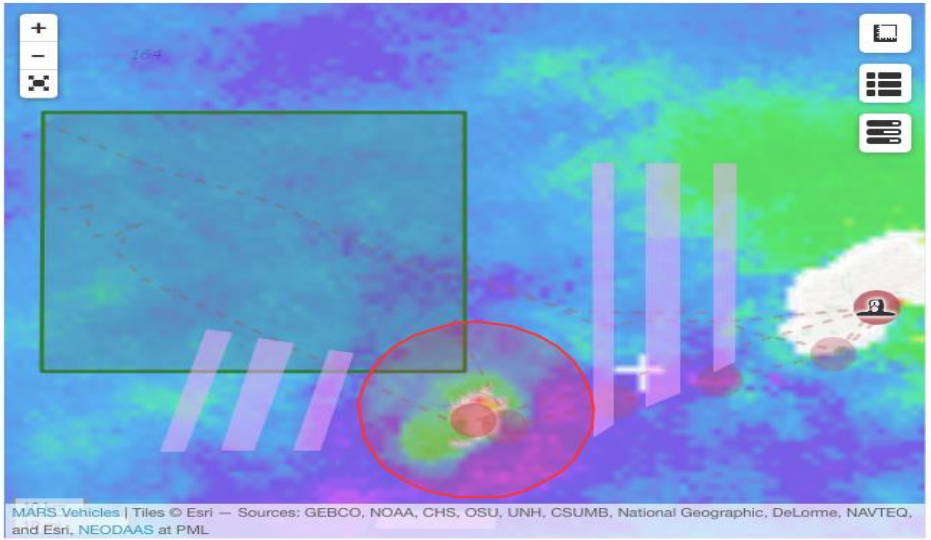
NMF Vehicles | Browse | Help | Login

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



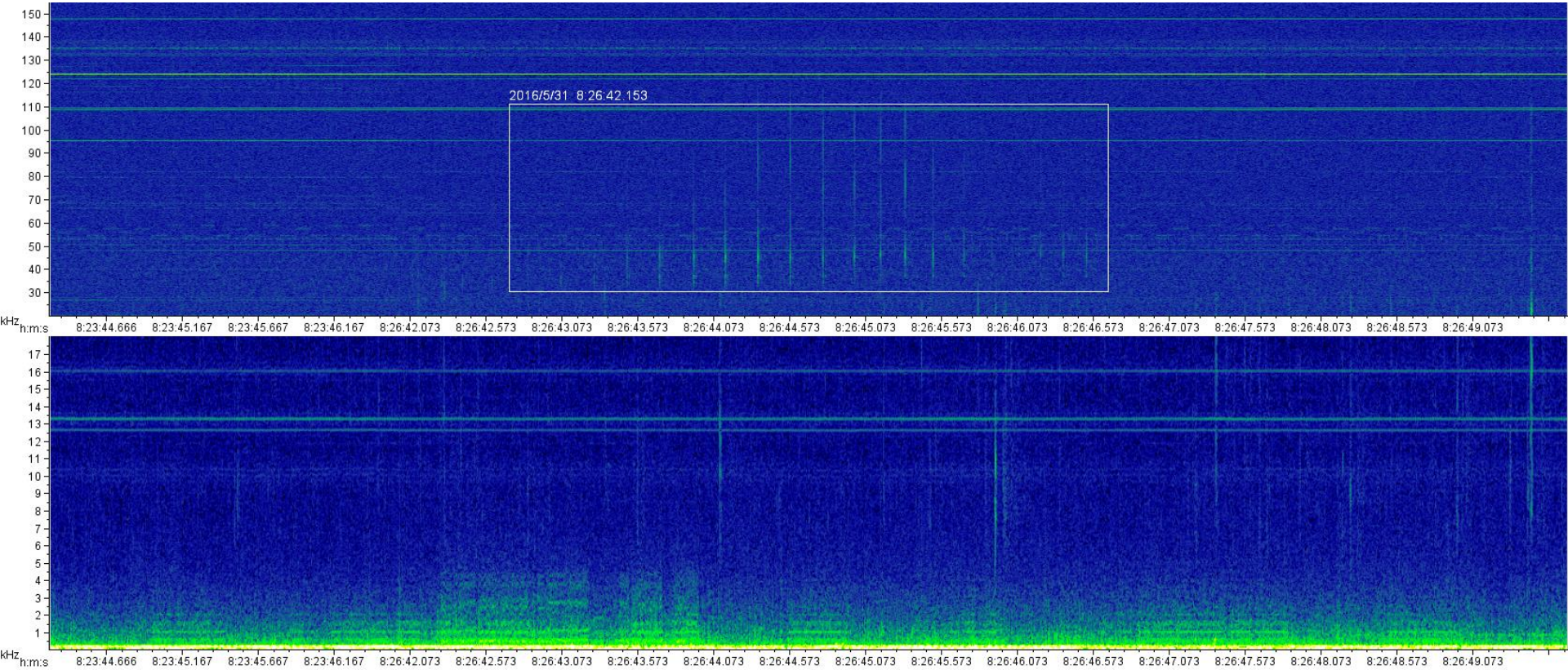
Scillonian ferry

Tanker on horizon

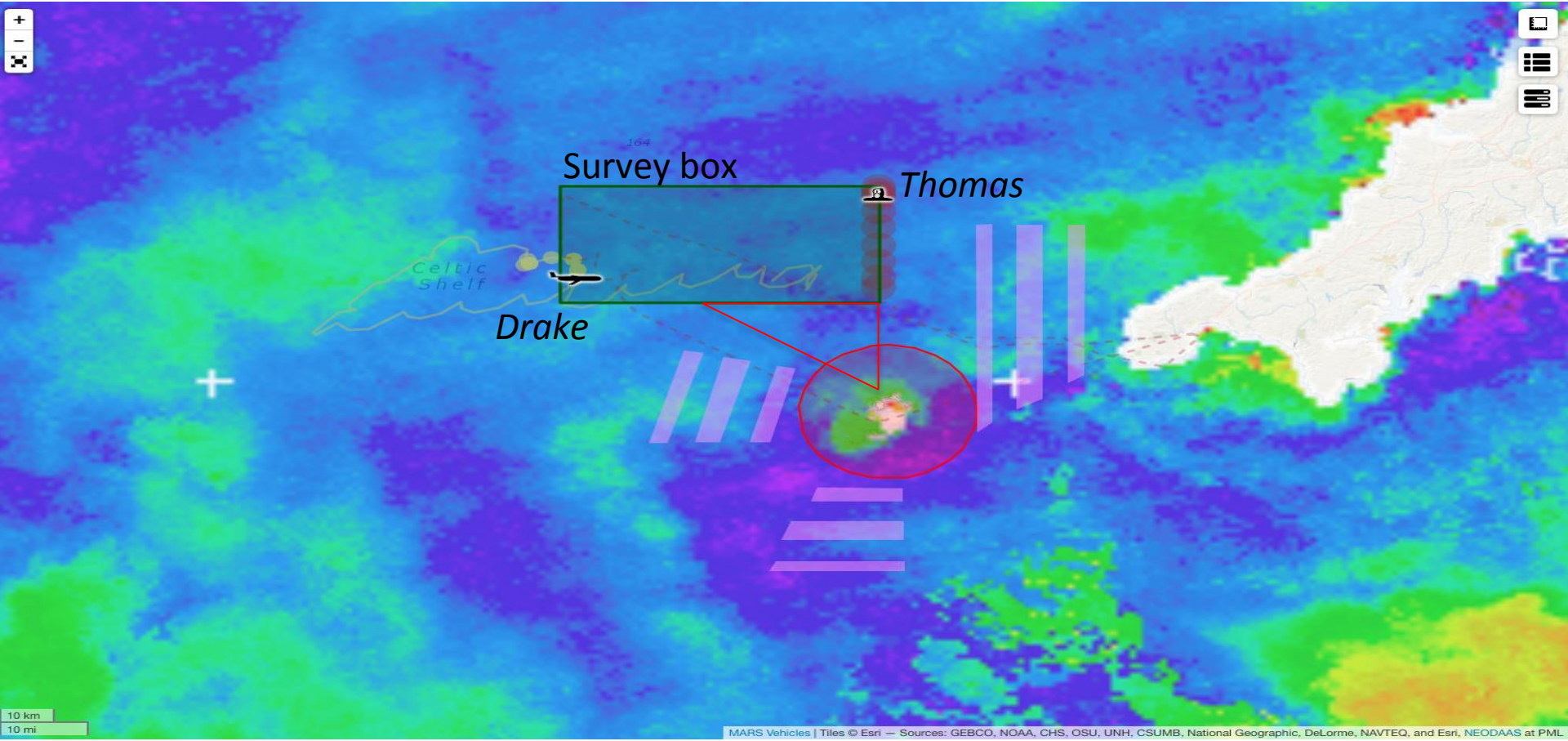
Northern Fulmar

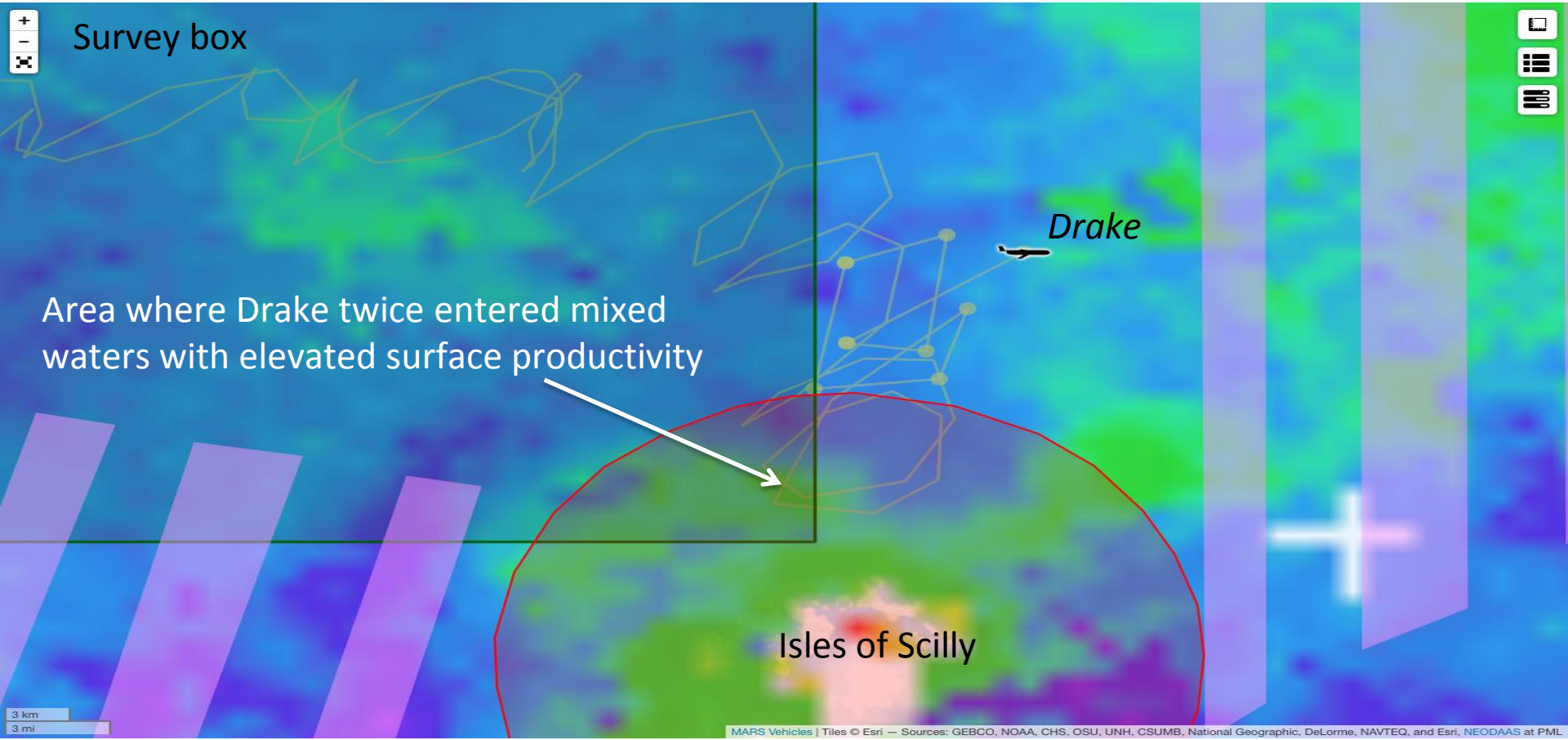
Sunset

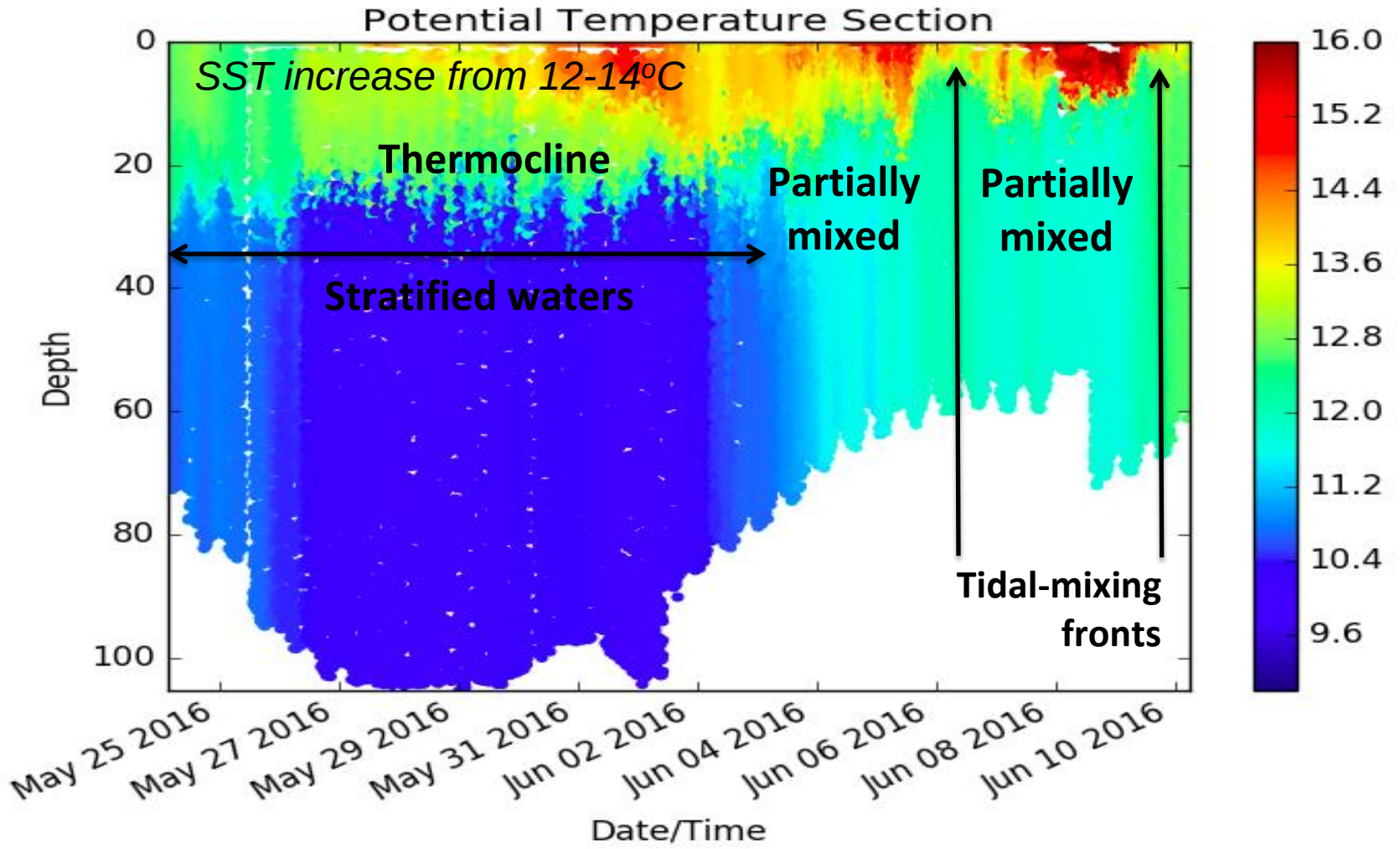
Possible dolphin echo-location trace detected using Seiche towed array

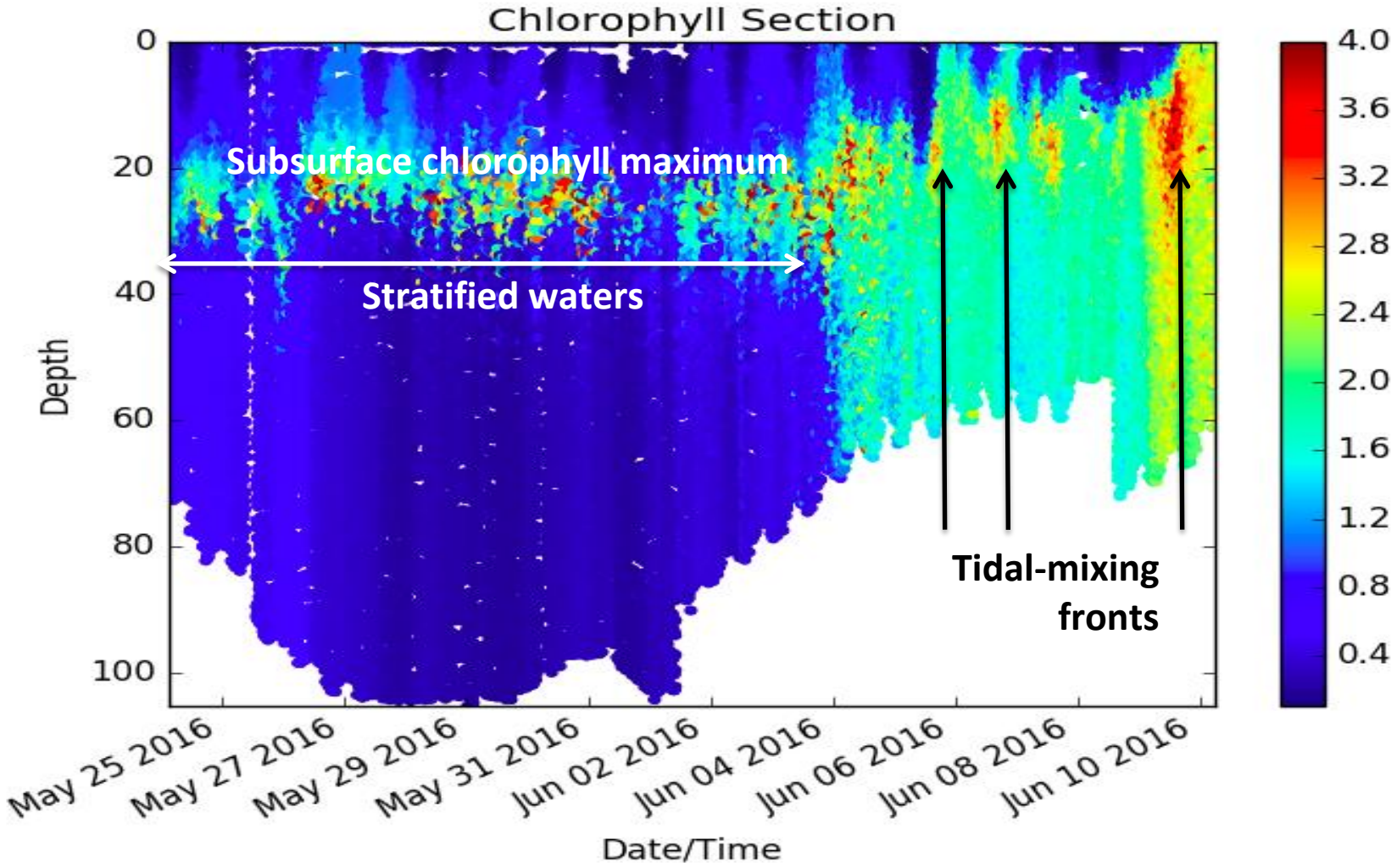


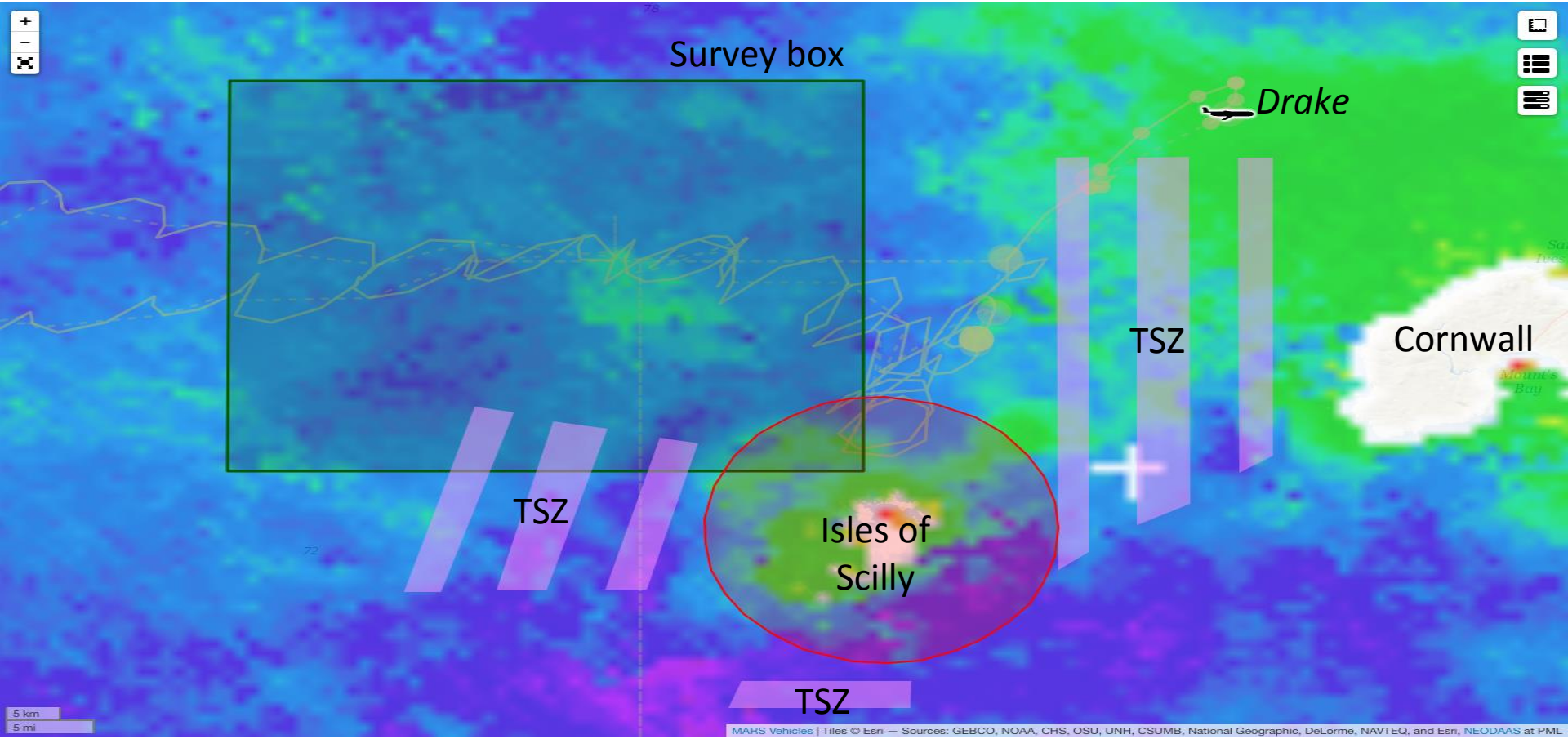
Drake covered >320 km in a three-week mission (>1500 vertical profiles)




Survey box
Drake
Area where Drake twice entered mixed waters with elevated surface productivity
Isles of Scilly
3 km
3 mi
MARS Vehicles | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri, NEODAAS at PML


Potential Temperature Section
SST increase from 12-14ºC
Thermocline
Stratified waters
Partially mixed
Partially mixed
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
16.0
15.2
14.4
13.6
12.8
12.0
11.2
10.4
9.6


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


Survey box
Drake
TSZ
Cornwall
TSZ
Isles of
Scilly
TSZ
5 km
5 mi
MARS Vehicles | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri, NEODAAS at PML

News
News List
Events News
Seminars
Marine Life Talks
News Archive
News Image Gallery
Videos
Media enquiries

Article Links

NOC Events

Everyone's Gliding Observatories (EGO) Conference
September 26, 2016 - September 27, 2016
RRS Discovery in Liverpool
October 4, 2016 - October 7, 2016

UK's largest marine robot mission is underway off northwest Scotland

September 22, 2016

An ambitious two-week mission involving ten marine robots has commenced off northwest Scotland. The third in a series of demonstrator missions, this latest phase sees the largest fleet of marine robotic vehicles simultaneously deployed in UK waters. The mission comprises seven submarine gliders and three surface Wave Gliders that are working together in fleets to collect a range of environmental data.

Gliders on the launch vessel at SAMS prior to deployment on 'Exploring Ocean Fronts'

The National Oceanography Centre (NOC) started the 'Exploring Ocean Fronts' programme in 2014, working with partners across science, government and industry to field-test novel marine autonomous systems for long-endurance ocean monitoring.

Phase one saw a fleet of seven marine robots deployed from the Isles of Scilly, armed with sensors capable of monitoring marine life including plankton, fish, marine mammals and seabirds. The robots travelled up to 150 km offshore, with one of the surface vehicles covering 450 km in 12 days. Three of the surface vehicles were then redeployed in Marine Protected Areas offshore of Plymouth, where they successfully tracked tagged fish using novel acoustic receivers.

Phase two comprised two successive missions off southwest UK in 2015 and 2016, undertaken in partnership with World Wildlife Fund UK (WWF-UK) and Defence Science and Technology Laboratory (Dstl); these missions were used to further test how submarine gliders and unmanned surface vehicles can work together to observe relationships between ocean fronts and marine life.

This third phase is being run in partnership with the Scottish Association for Marine Science (SAMS) and is providing environmental data from an area off northwest Scotland to the Royal Navy's 'Unmanned Warrior' marine robot demonstration. Real-time data are visible via the

Project funding

ROYAL NAVY

[dstl]

NERC SCIENCE OF THE ENVIRONMENT

Promoting innovation

BlueOcean MONITORING

TELEDYNE WEBB RESEARCH Everywhereyoulook™

KONGSBERG

LIQUID ROBOTICS

RS AQUA

BOEING

Joint operations

SAMS

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

UNMANNED 2016 WARRIOR

ROYAL NAVY

[dstl]

Ministry of Defence

QinetiQ

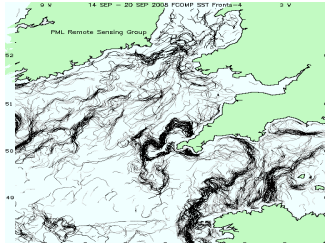
MASSMO3
Autumn 2016

Public engagement

Data management

BODC British Oceanographic Data Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Operational products



United Kingdom Hydrographic Office

Met Office

esri UK

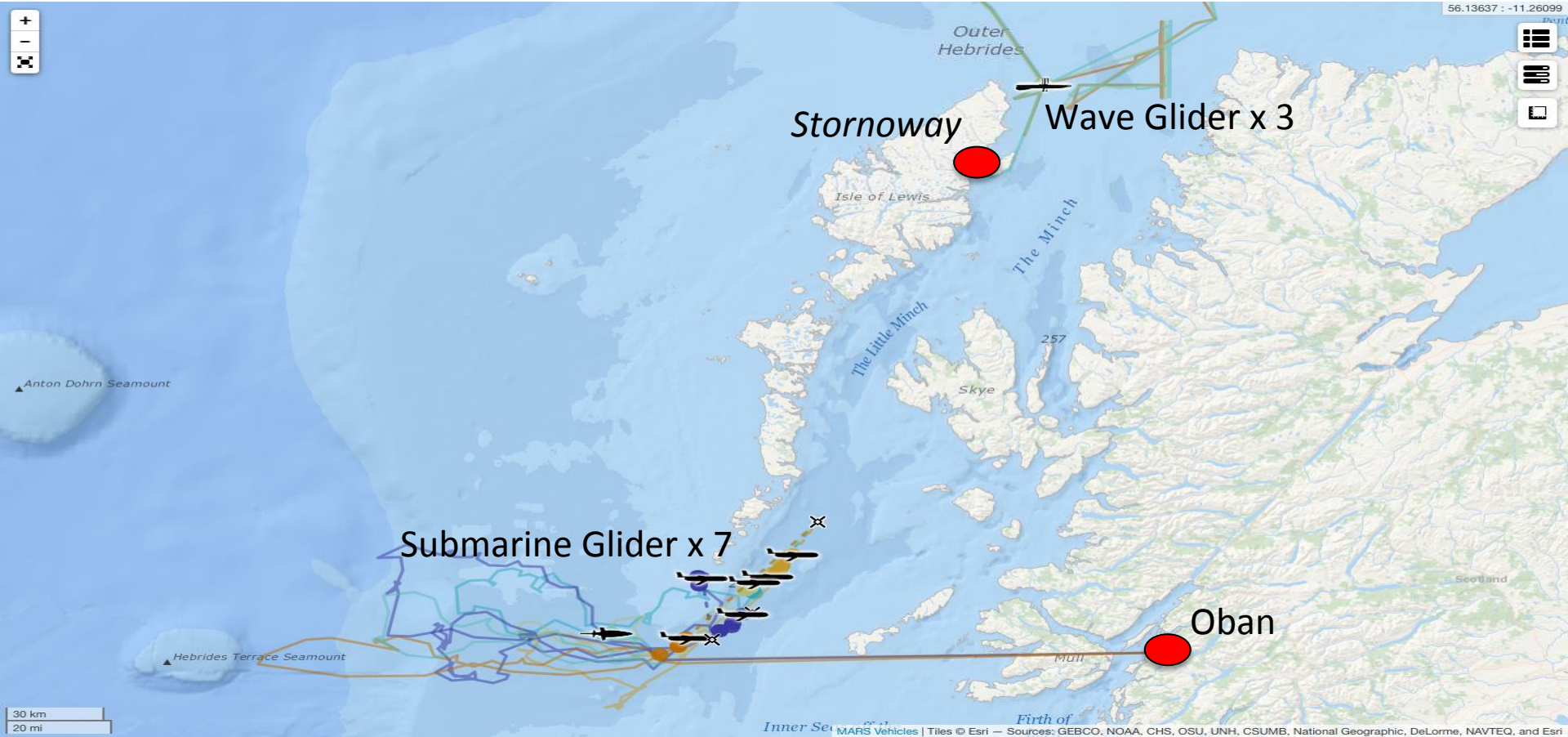
helyx

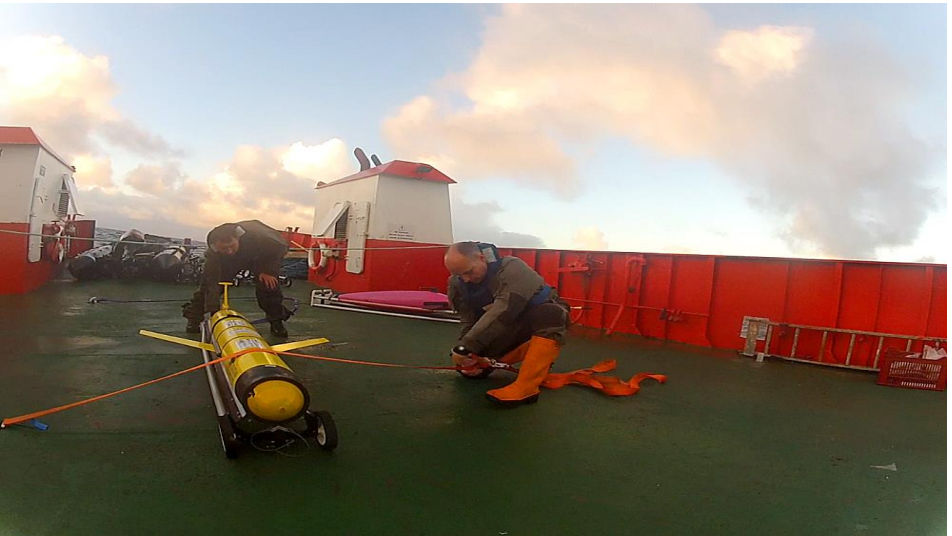
PML Plymouth Marine Laboratory

seebyte

The MASSMO3 fleet at 0820 hrs on 01 Sept 2016

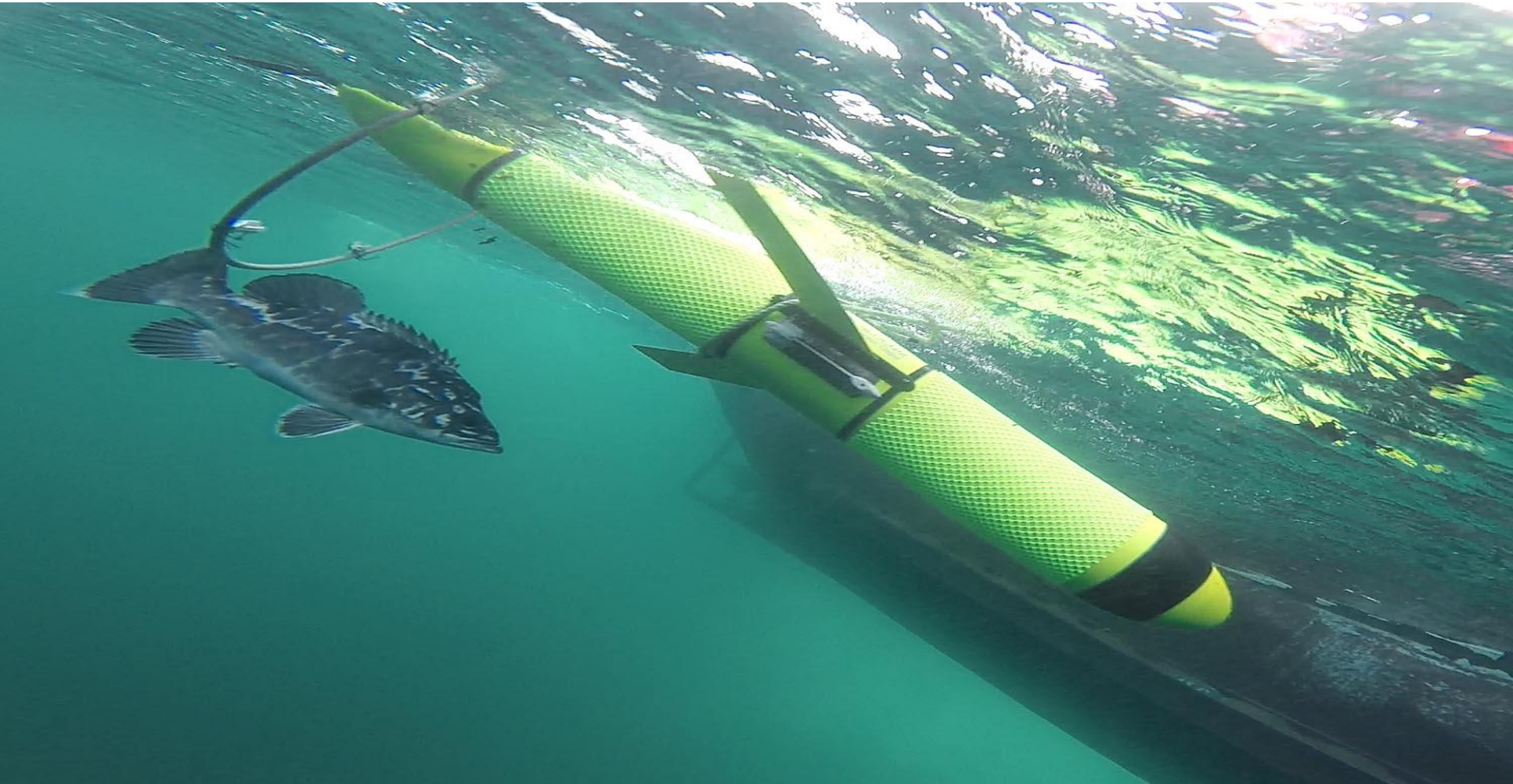
The largest simultaneous deployment of operational MAS in UK waters to date



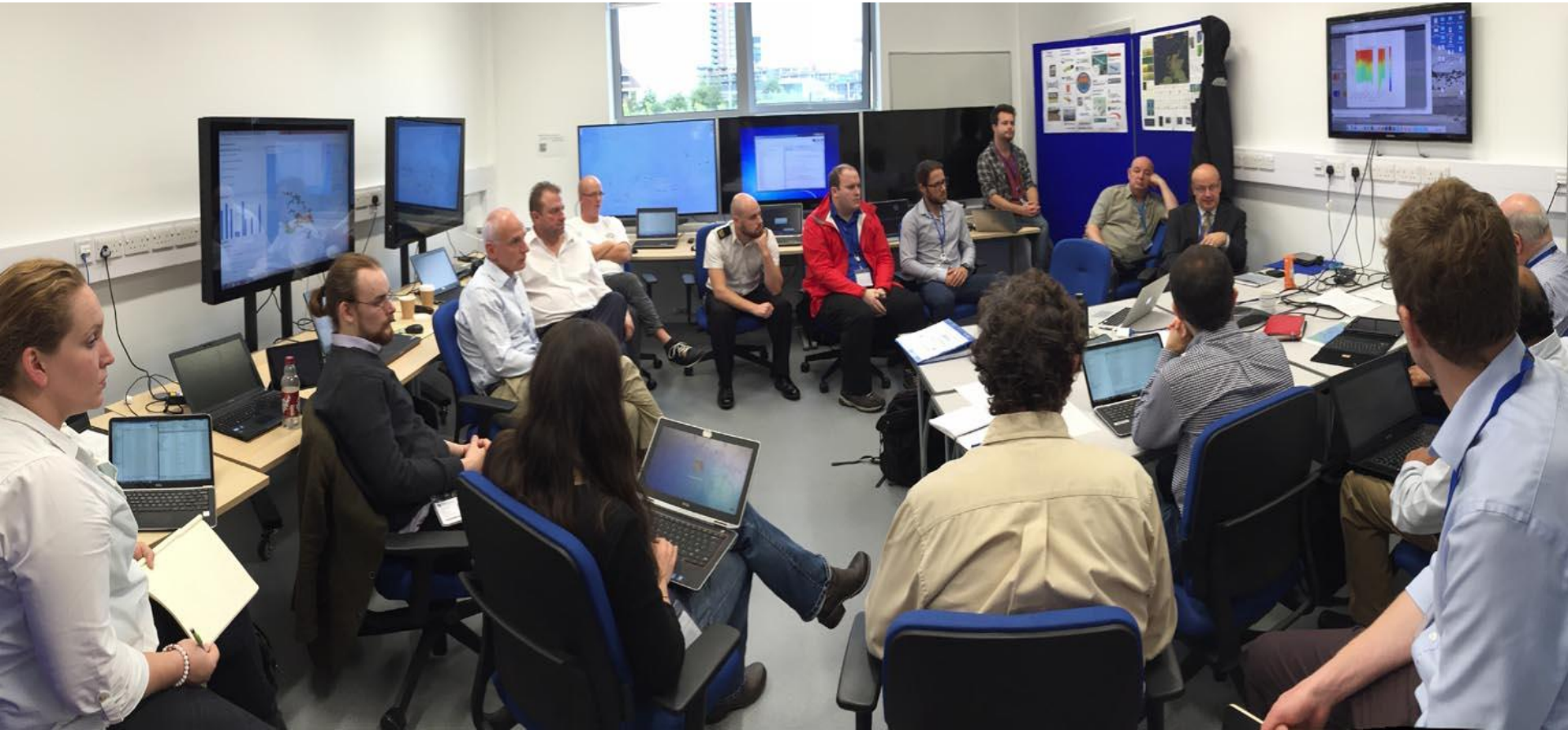


Submarine glider being recovered by RN staff on 01 Oct 2016

Submarine glider prior to recovery (Atlantic Wreckfish in attendance)



MASSMO3 Operations Room at NOC on 29 Sept 2016

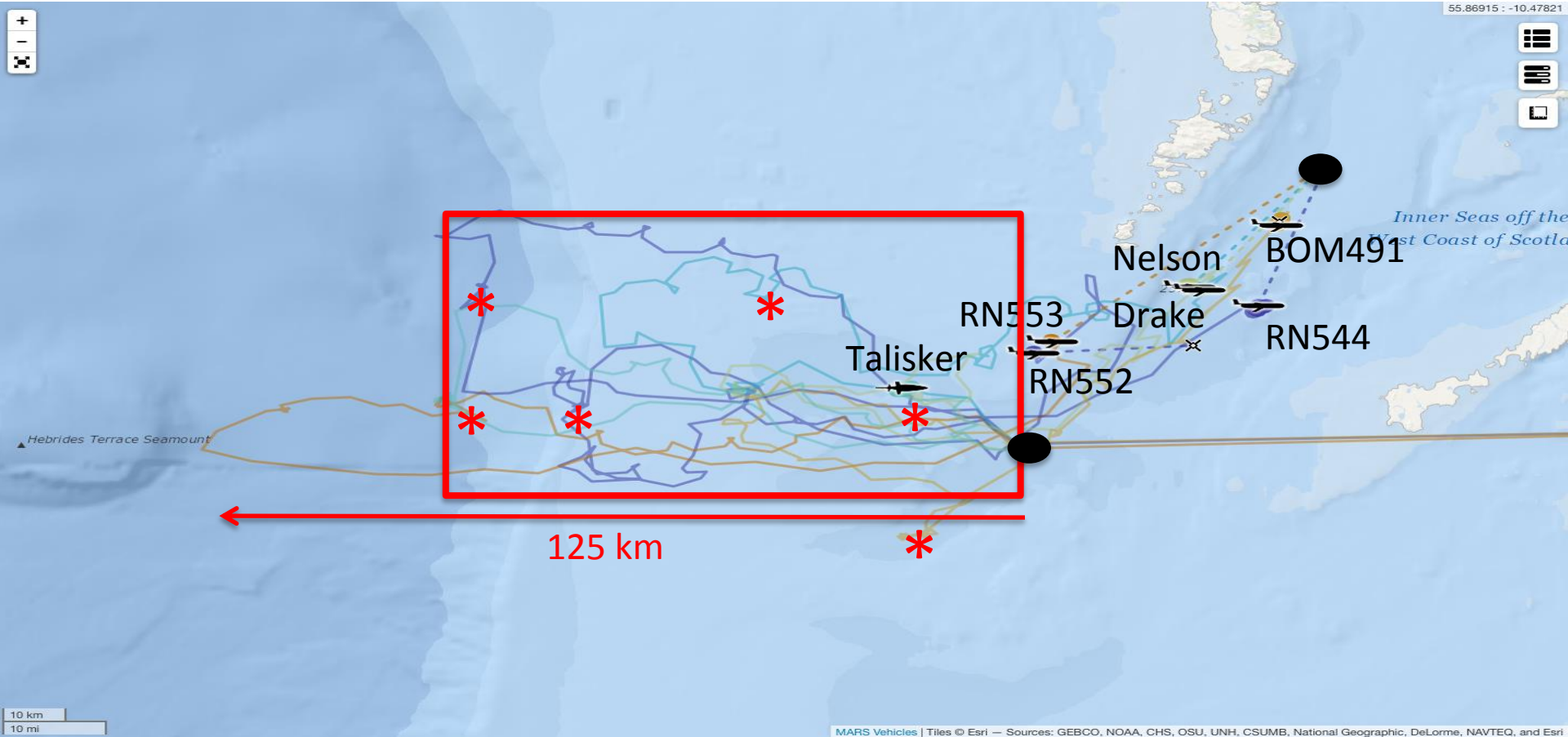


Royal Navy and NOC pilots in the NOC Operations Room

MASSMO3 submarine glider positions on 01 Oct 2016

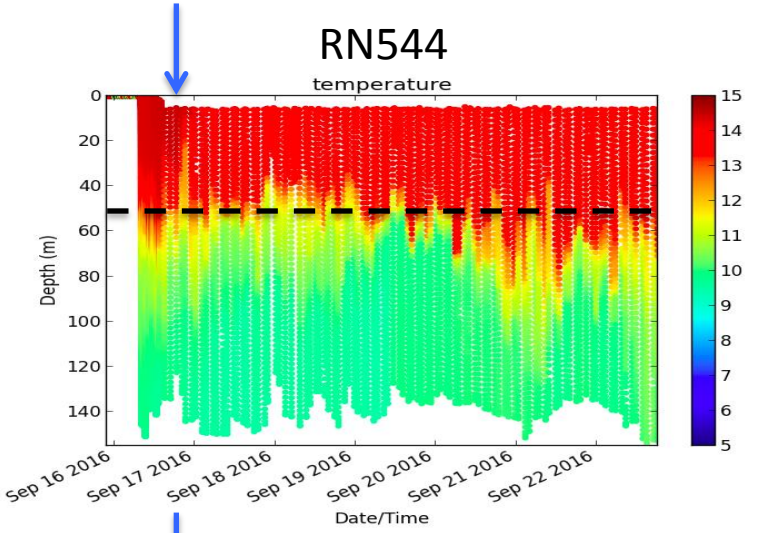
Gliders achieved excellent spatial coverage in two weeks (>1500 NM and >5000 km^2)

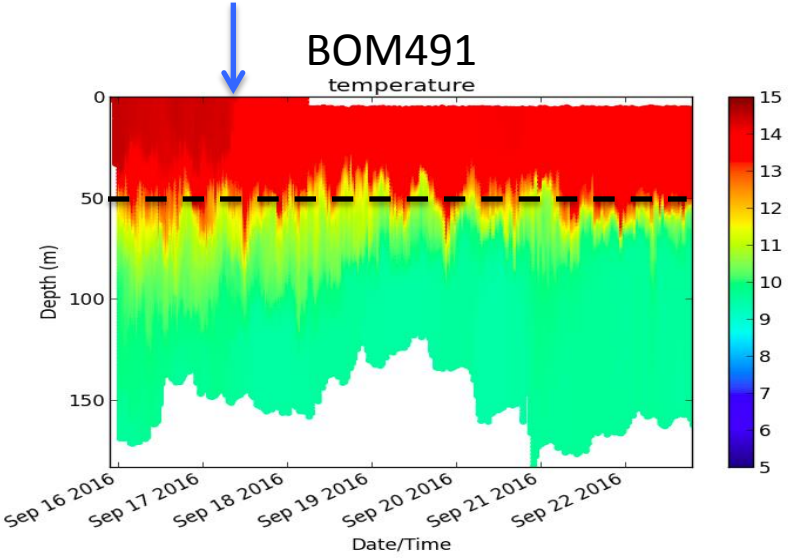
Gliders also undertook a two-day virtual mooring experiment

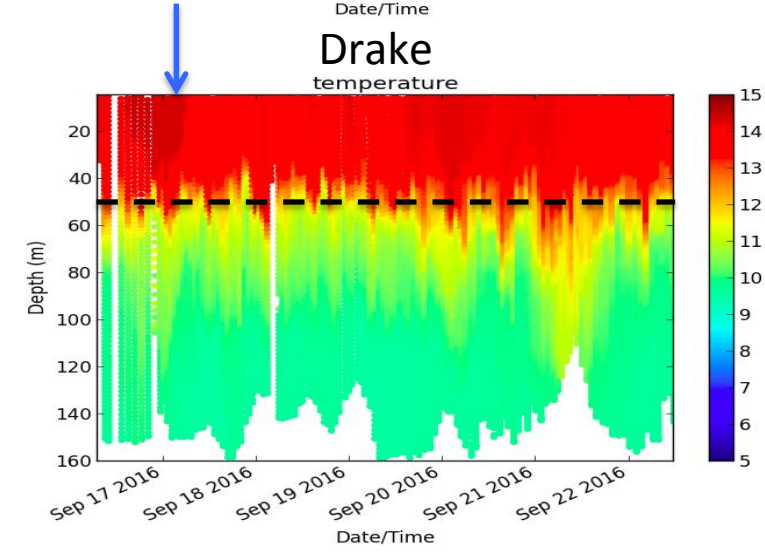


Temperature data from three shallow gliders 16-22 Sept 2016

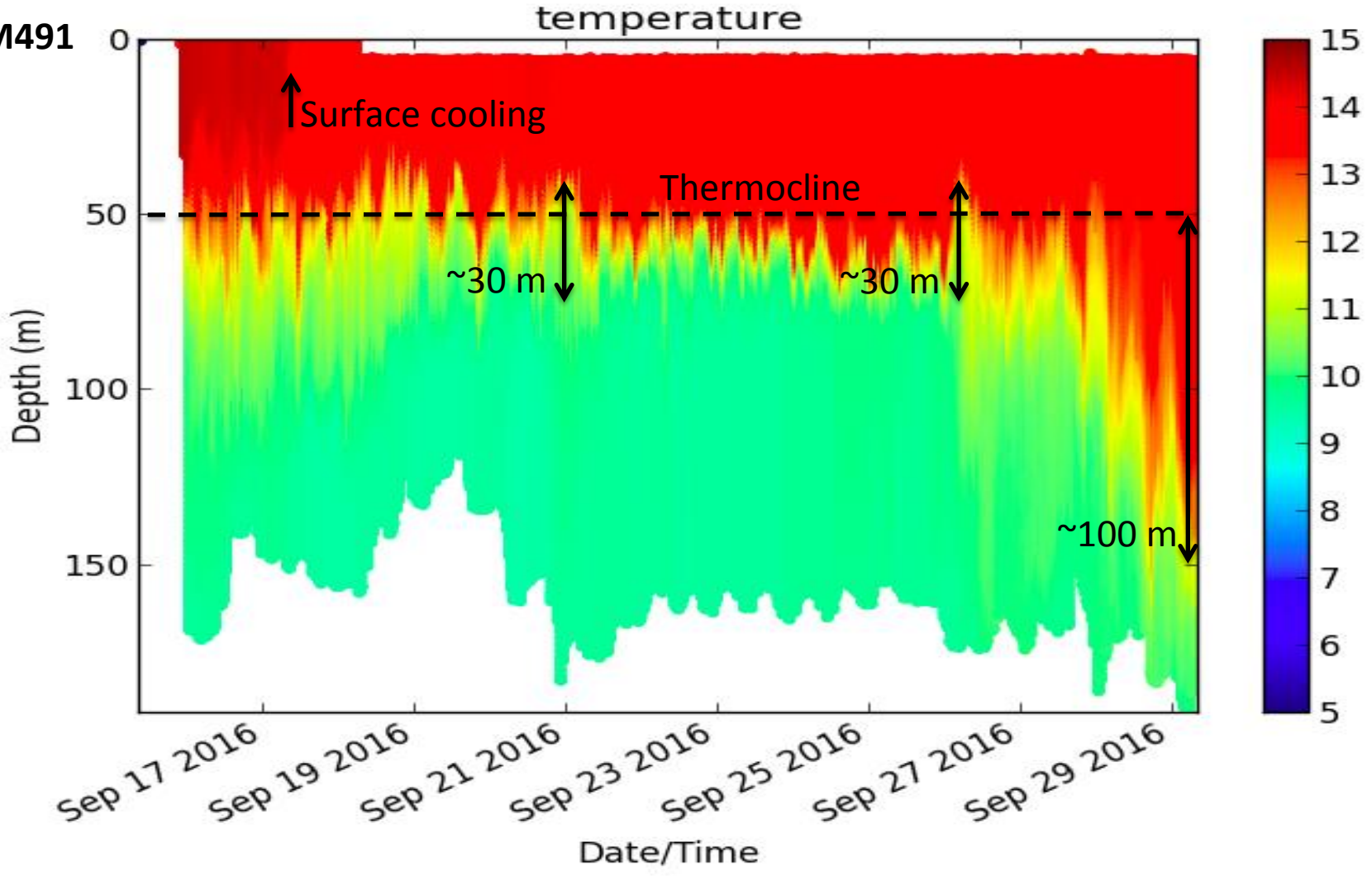
- Note surface temperature decrease on 17 Sept (blue arrows)
- Note consistent thermocline depth at ~50 m (black dashed line)



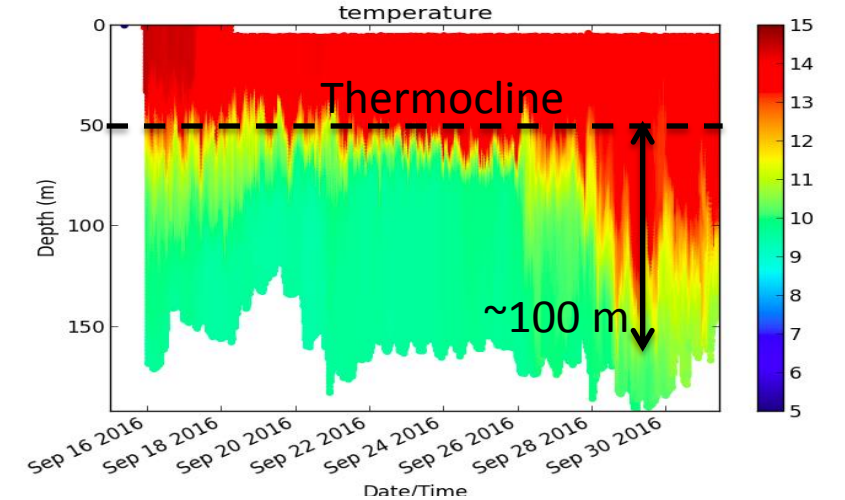


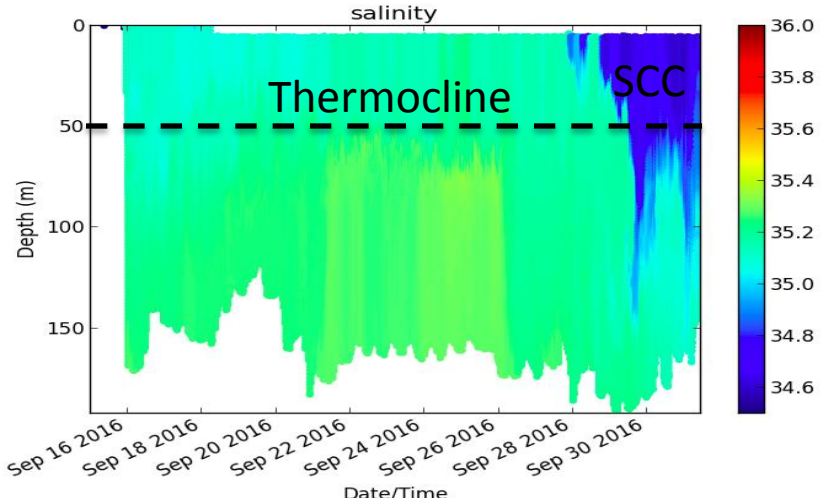


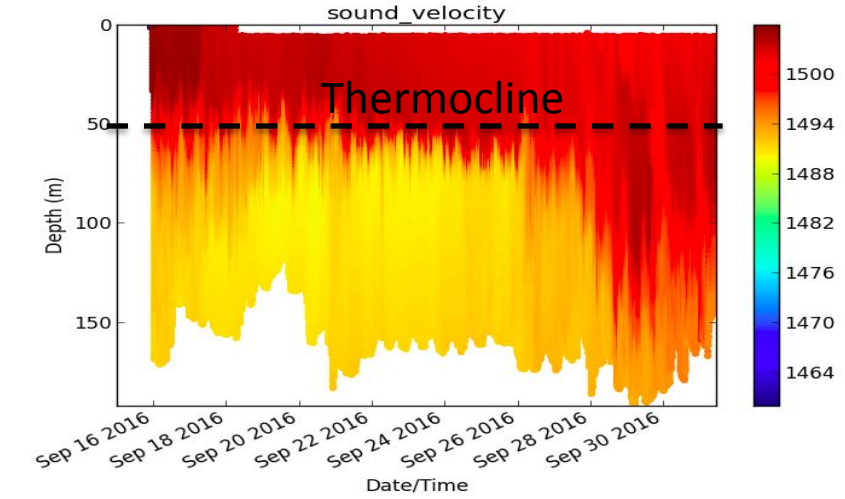
BOM491

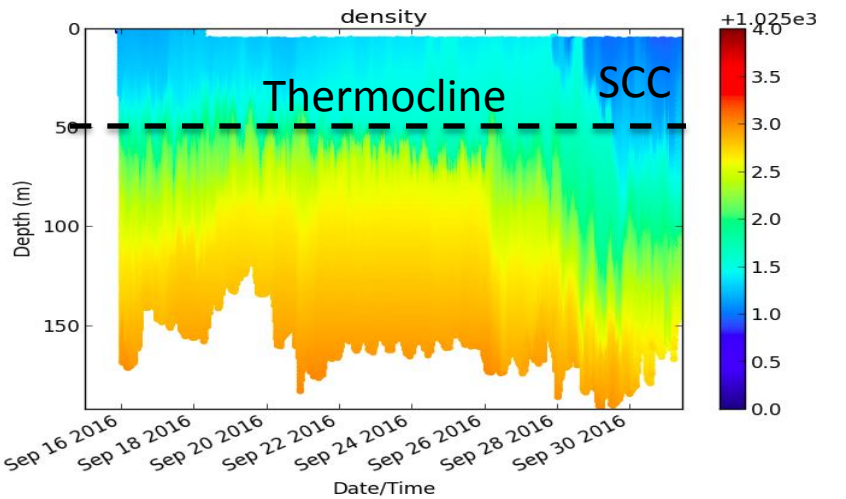

temperature
Surface cooling
Thermocline
~30 m
~30 m
~100 m
Depth (m)
0
50
100
150
Sep 17 2016
Sep 19 2016
Sep 21 2016
Sep 23 2016
Sep 25 2016
Sep 27 2016
Sep 29 2016
Date/Time
15
14
13
12
11
10
9
8
7
6
5

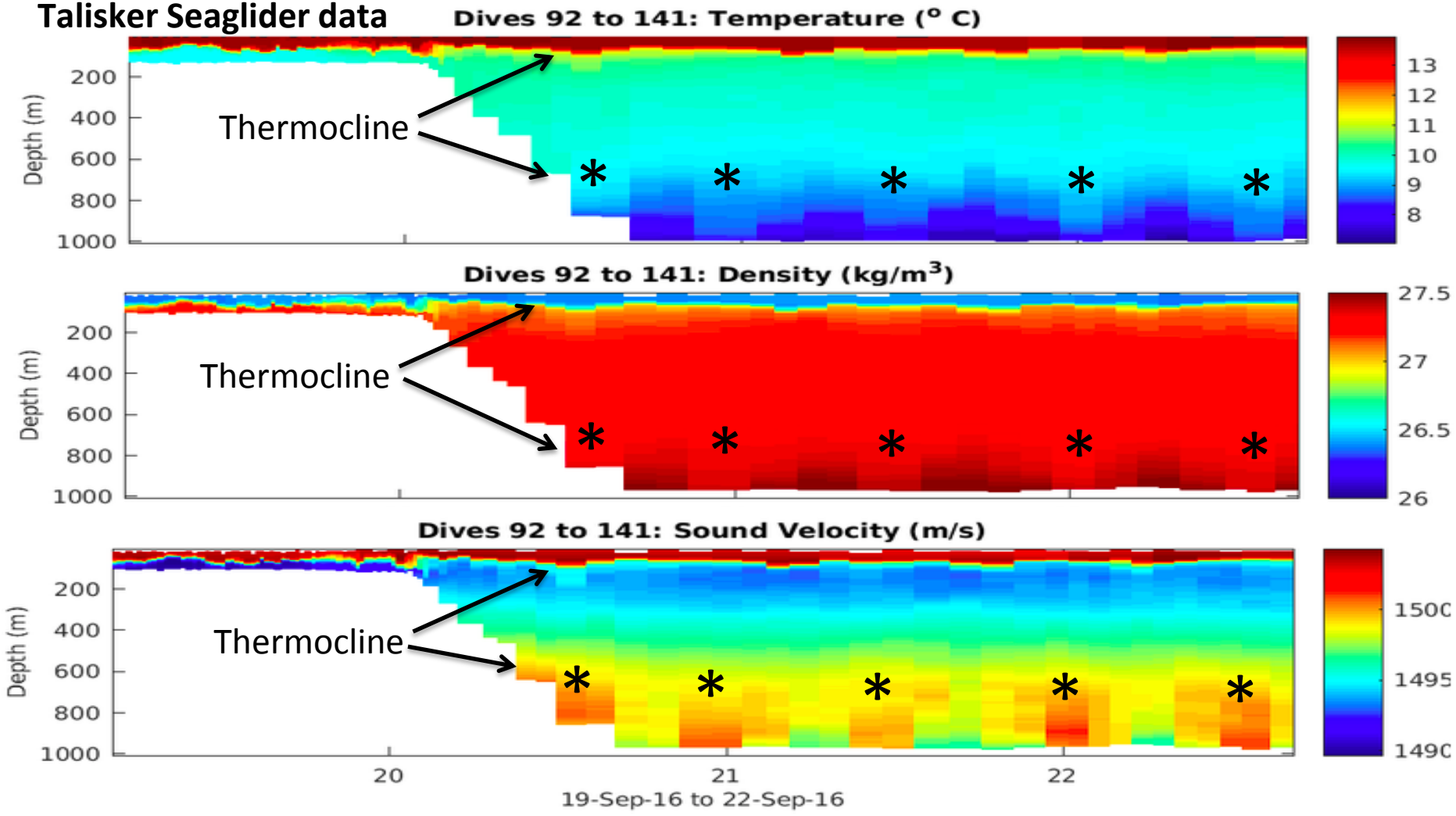
BOM491 data collected during MASSMO3, showing transition into Scottish Coastal Current





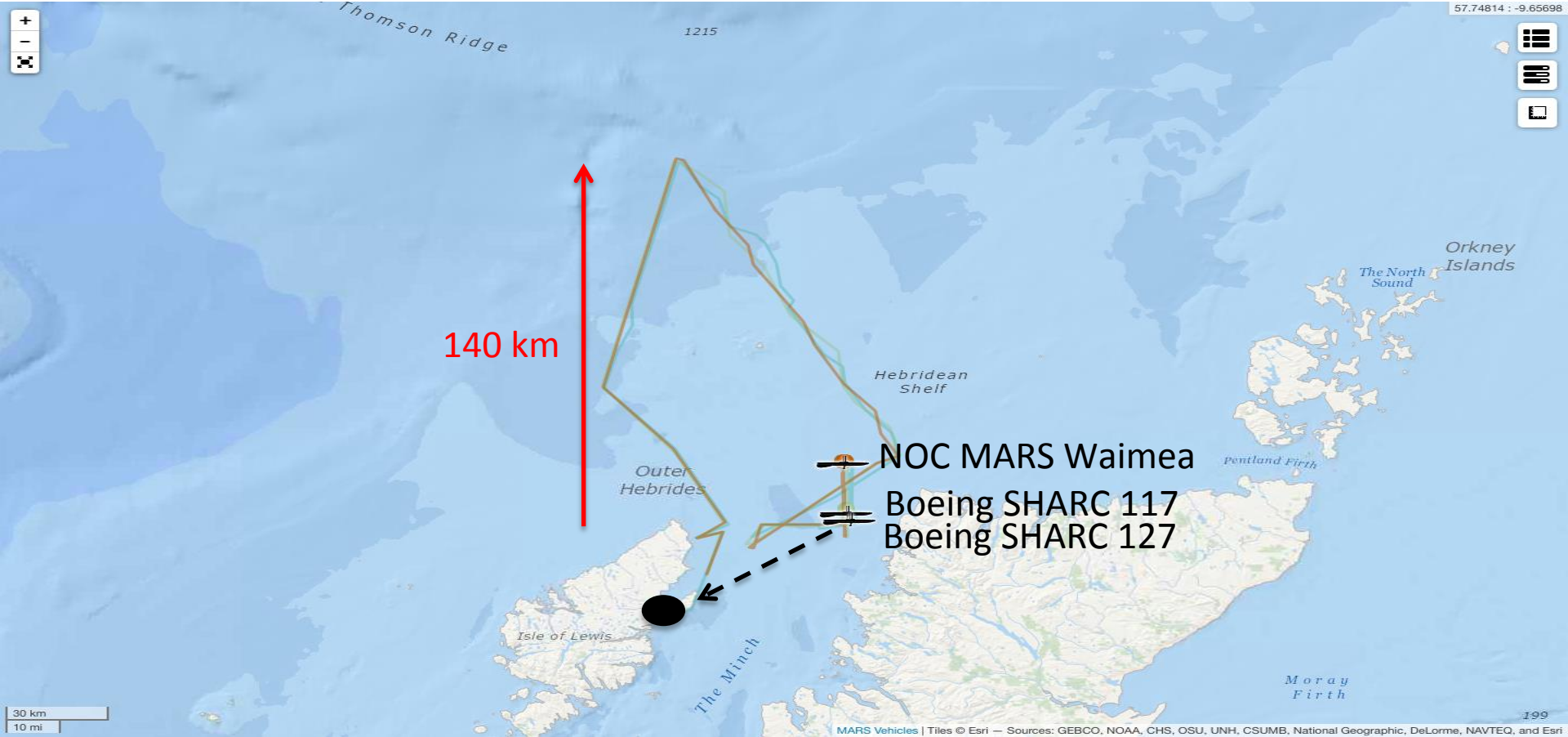




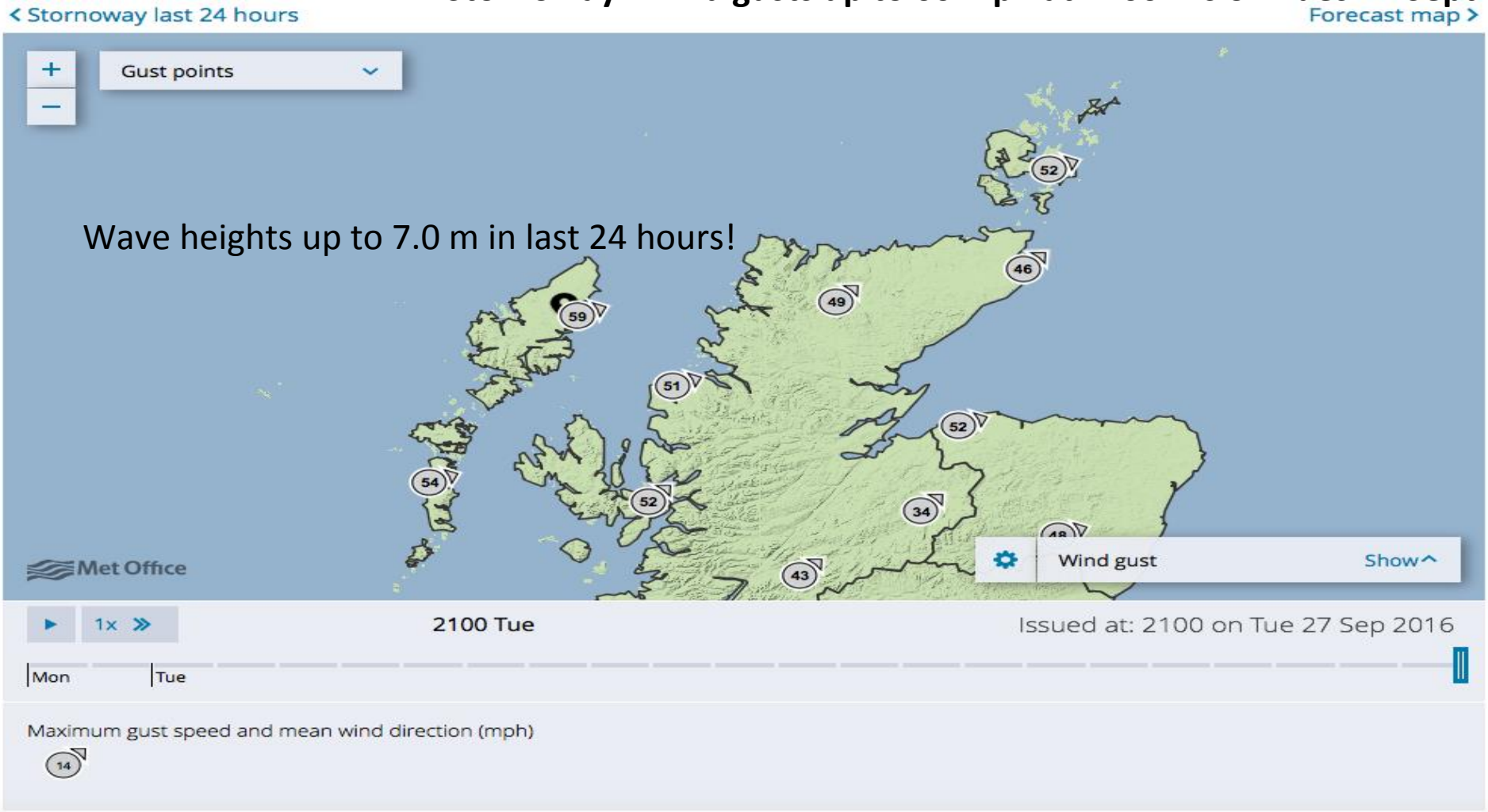

Talisker Seaglider data
Dives 92 to 141: Temperature (° C)
Depth (m)
200
400
600
800
1000
Thermocline
13
12
11
10
9
8
Dives 92 to 141: Density (kg/m3)
Depth (m)
200
400
600
800
1000
Thermocline
27.5
27
26.5
26
Dives 92 to 141: Sound Velocity (m/s)
Depth (m)
200
400
600
800
1000
Thermocline
1500
1495
1490
20
21
22
19-Sep-16 to 22-Sep-16

Wave Glider locations at 1100 hrs on 29 Sept 2016

Wave Gliders have covered >1000 km and reached up to 140 km offshore

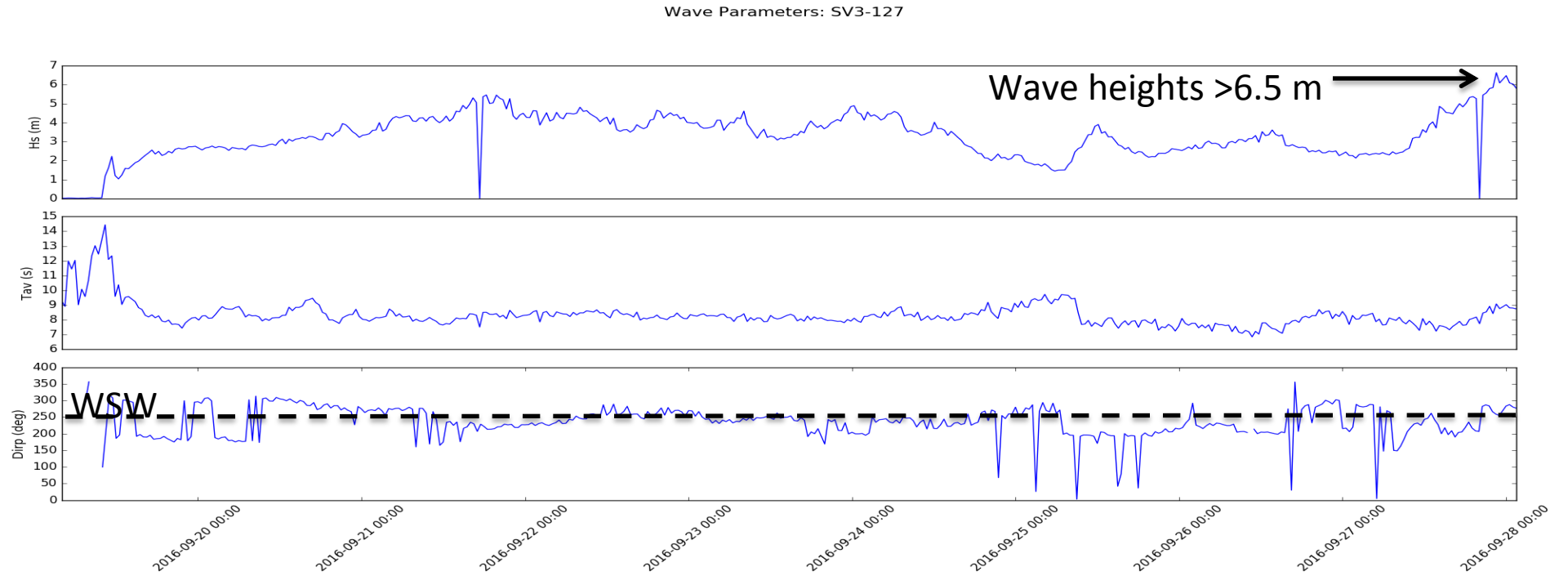


Stornoway - wind gusts up to 60 mph at 2100 hrs on Tues 27 Sept



Wave data from Wave Glider Boeing SHARC 127 from 19-28 Sept 2016

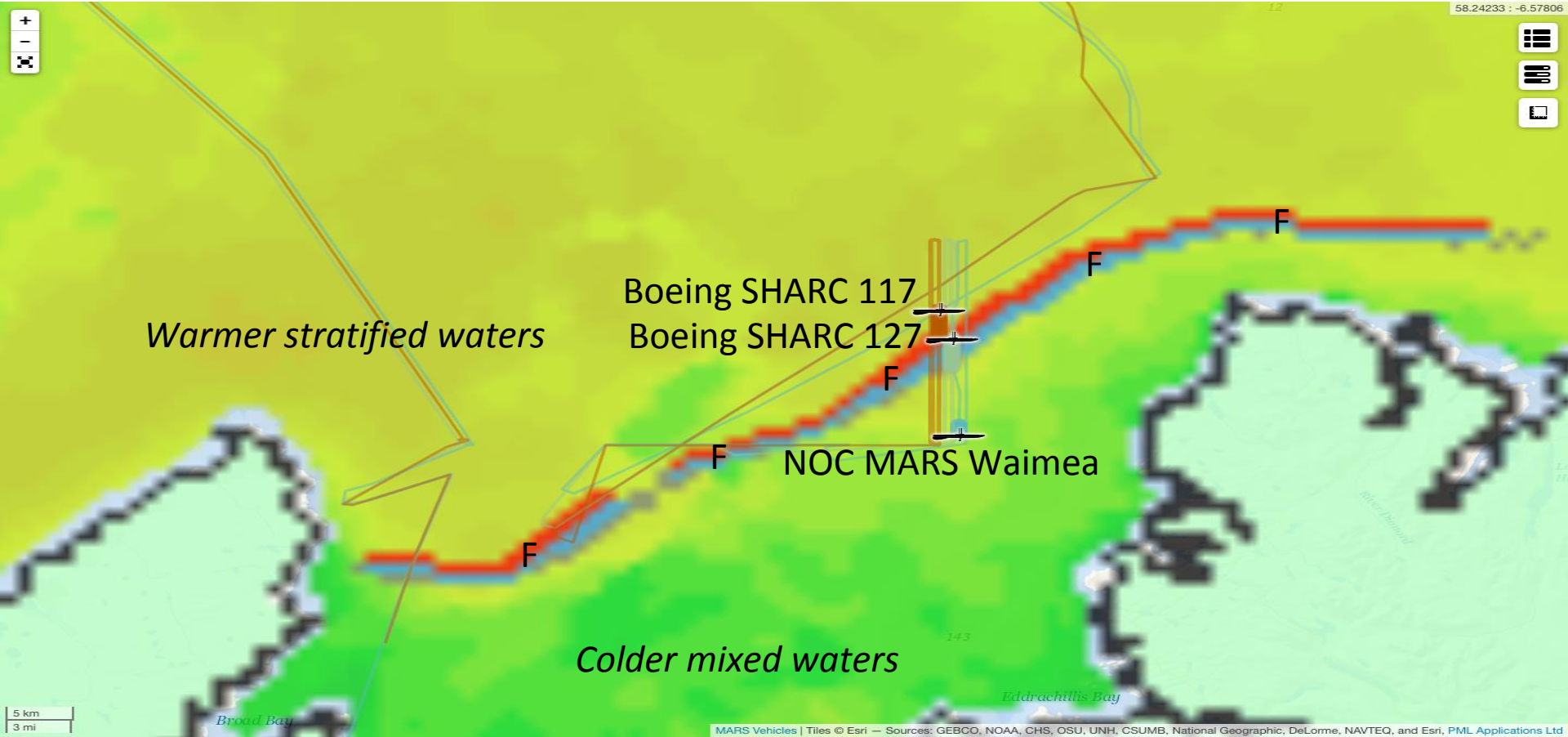
Data show dominance of WSW/SW winds and wave heights >6.5 m!



Wave Glider locations at 0630 hrs on 28 Sept 2016

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

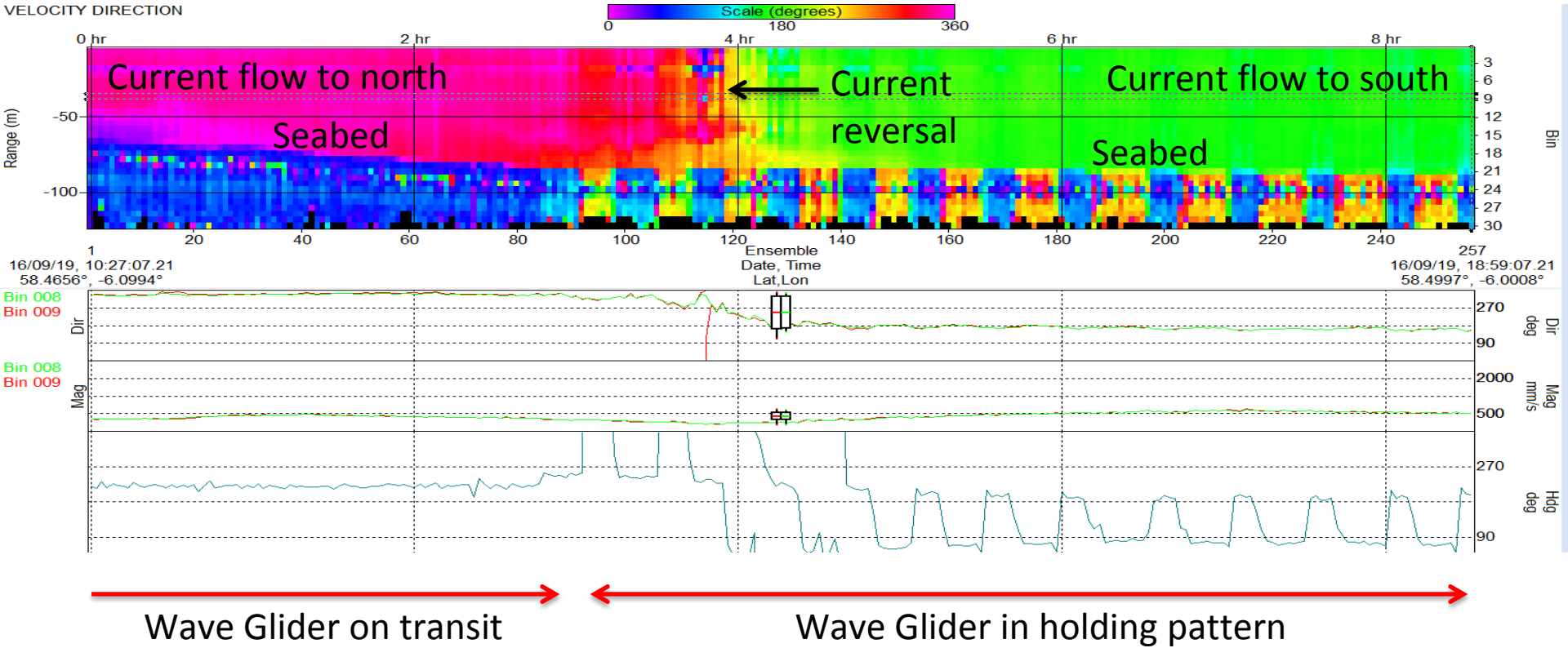
Sea surface temperature map shows colder mixed surface waters south of this front



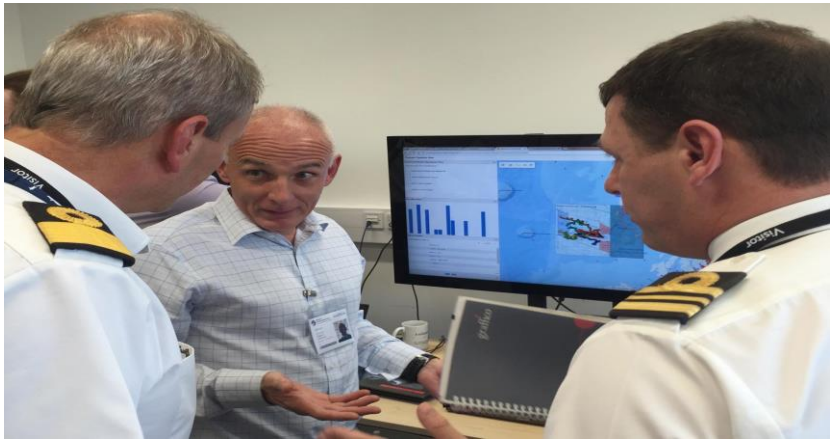
Wave Glider ADCP data from 19 Sept 2016

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



MASSMO3 - VIP visit day to NOC Operations Room



Media coverage of MASSMO3

BBC Sign in | News | Sport | Weather | iPlayer | TV | Ra

NEWS

Home | UK | World | Business | Politics | Tech | Science | Health | Education | Ente

Scotland | Scotland Politics | Scotland Business | Edinburgh, Fife & East | Glasgow & We

Large-scale deployment of robots in sea off Scotland

1 November 2016 | Highlands & Islands

Share

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.

SUBSEA world news

HOME | NEWS BY TOPIC | REGIONAL NEWS | EVENTS | SUBSCRIBE

ABOUT | CONTACT | REPORT YOUR NEWS | ADVERTISING

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."*

Lyndsey Dodds

World Wildlife Fund WWF

WWF-UK, MASSMO2A and the JSR programme

WWF-UK and MASSMO 2

Lyndsey Dodds
Head of Marine Policy,
WWF-UK

18th November 2016

Panda facts

+100

WWF is in over
100 countries, on
5 continents

+5,000

WWF has over
5,000 staff worldwide

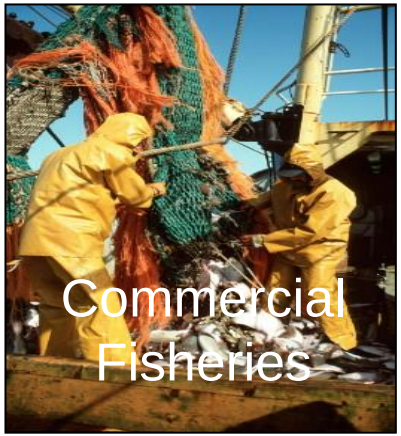
1961

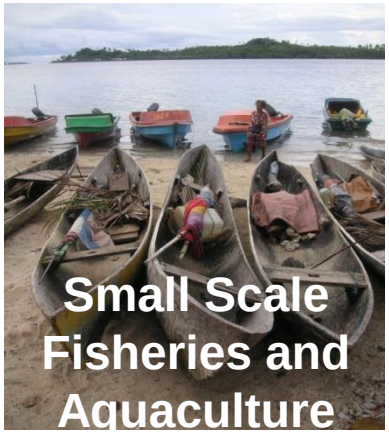
WWF was founded
In 1961

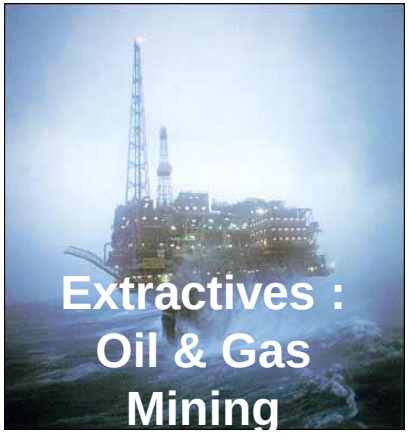
+5M

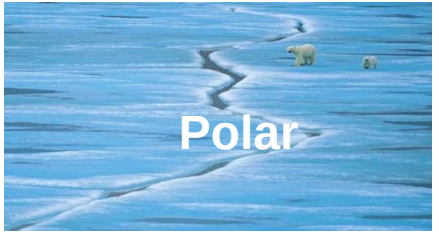
WWF has over
5 million supporters

Global Marine Programme









UK Marine Programme

Marine governance

Marine Protected Areas
Marine planning
Regional management
Stakeholder engagement
Celtic Seas Partnership

Fisheries governance

Improving selectivity
Implementing policy
Driving sustainability

Polar governance

Marine Protected Areas
Fisheries management
Species monitoring
Climate change

Communications

Working in partnership

Science and evidence based

MASSMO2A

Supporting innovative technology that will gather much needed evidence from ocean fronts – areas rich in marine life. The information will be increase understanding and help inform future management of our seas.

Robots to capture image

k/news/uk-wales-south-west-wale

Home | UK | World

Wales | Wales Politics

Robots to
Pembrokes

20 August 2015 | South

A pair of pioneering
the ocean life off the

The project, described
the National Oceanogr

Robots Unlocking Secret

/story/robots-unlocking-secrets-of-th

sky NEWS

Home UK World Bus

Robots Unl

Robots covered in a rang
us more about the botto

Swipe: Robots Take To The Sea

By Angela Barnes,

as the marine engi

t.com/article/2089165-thomas-the-marine-engine-set-to-explore-uk-ocean-fronts/

New Scientist

HOME NEWS TECHNOLOGY SPACE PHYSICS HEALTH EARTH HUMANS LIFE TOPICS EVENTS JOBS

Home | News | Life | Technology

36

DAILY NEWS 20 May 2016

Thomas the marine engine set to explore UK ocean fronts

12 December 2016

Joint Strategic Response

Overarching objective: to accelerate the use of autonomous measurements and combined observational-model outputs in meeting long-term science need and statutory policy requirements

- Monitoring status of marine ecosystems
- Inform management of MPAs
- Inform policy implementation

Wider interests

- Exportability
  - Overseas territories
  - Developing countries
  - Polar regions

Thank you

Dr Lyndsey Dodds – ldodds@wwf.org.uk

www.wwf.org.uk


BLUE THUNDER

Caroline Sloane

Royal Navy

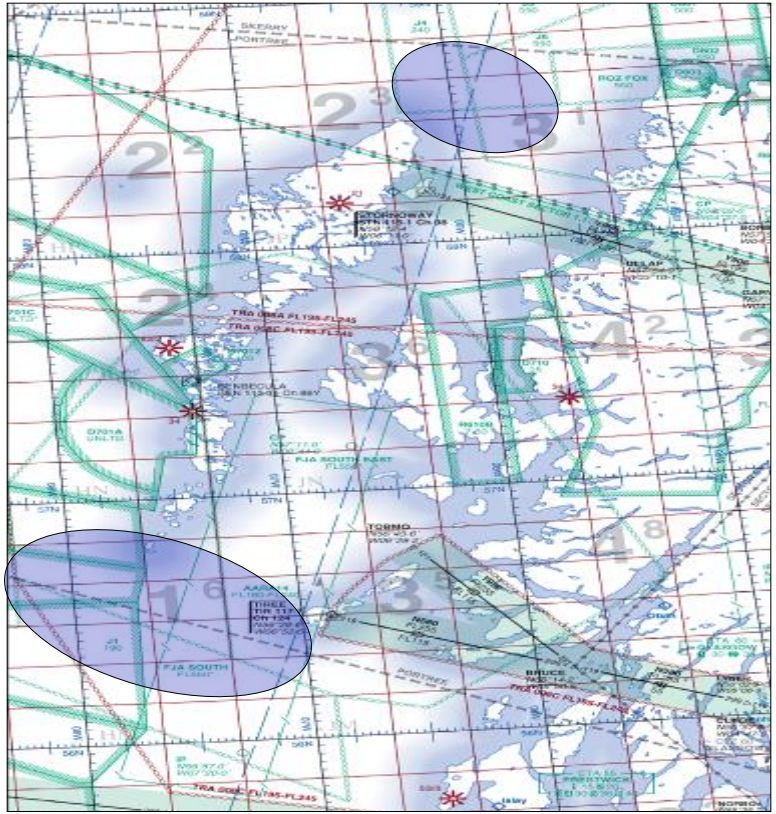
MASSMO3 contribution to Unmanned Warrior

EXERCISE UNMANNED WARRIOR 16 (UW16)
GEOINT THEME

Caroline Sloan
Fleet Environmental Information Officer, NCHQ
MoD Theme Lead – UW16 GEOINT

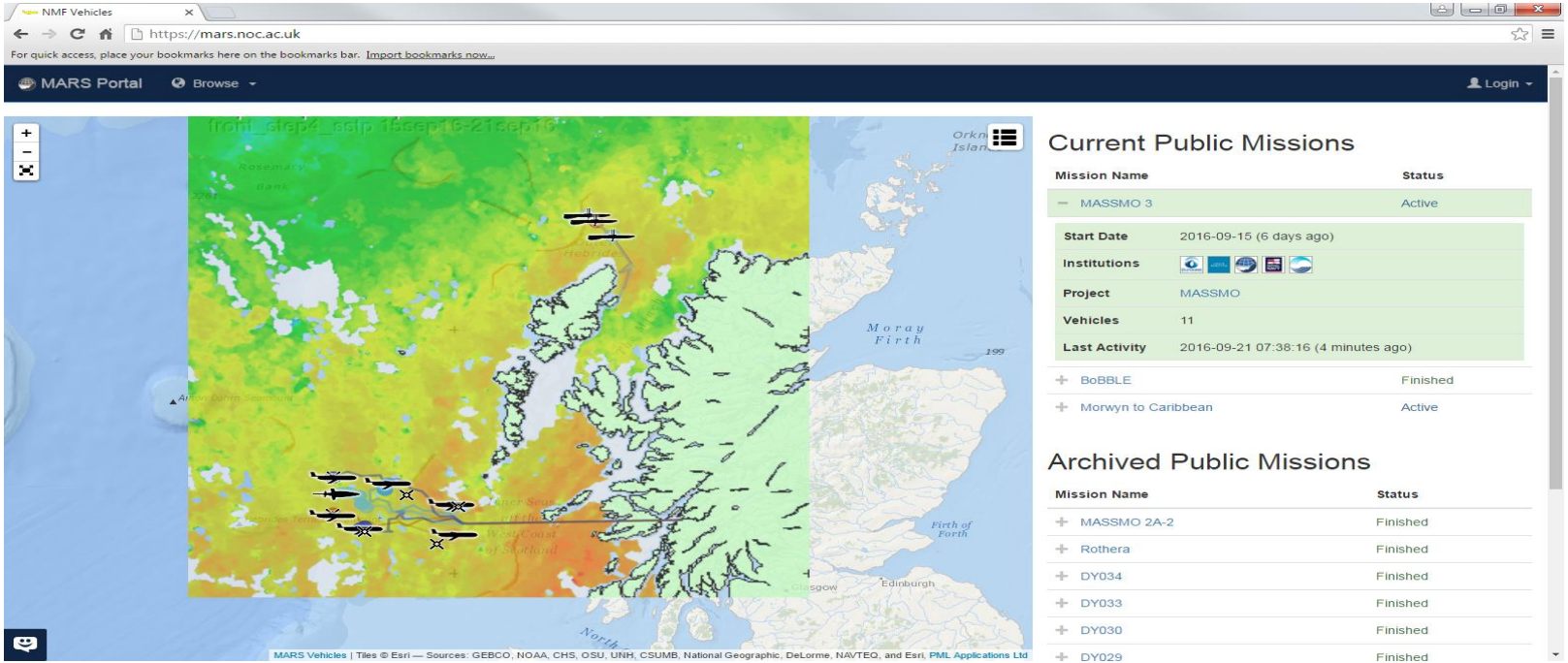
“Through collaborative Maritime Autonomous Systems (MAS) Enterprise behaviours, collective effort and clear leadership; to demonstrate, trial and experiment with the tactical employment of unmanned and autonomous systems in the maritime and littoral environments in order to mature credible capability choices for the mainstream utility of MAS; develop concepts and doctrine for their employment and Command and Control; prove the enabling technologies required for their successful operation; and engender a broader understanding of their potential across the Royal Navy, our sister Services and our Allies.”

First Sea Lord



GEOINT

GEOINT - Oceanography



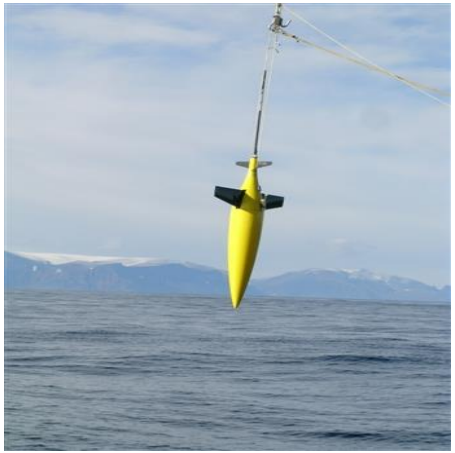
UUVs / USVs

Unmanned Underwater Vehicles

ROYAL NAVY

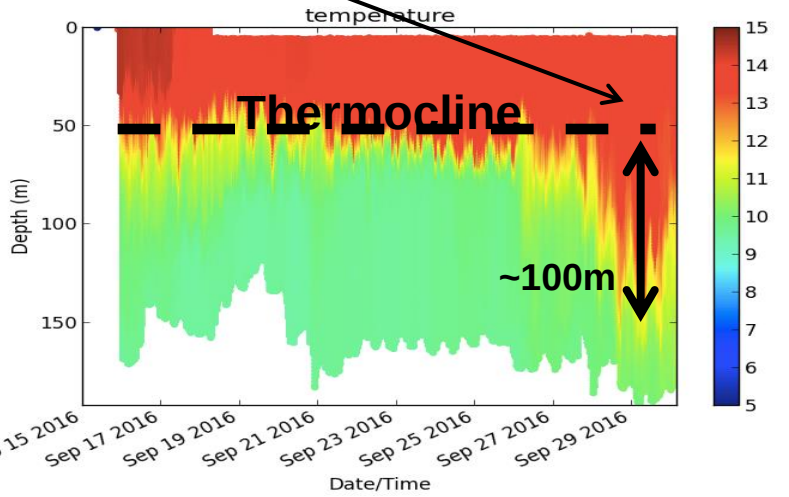
Slocum Glider – (Teledyne Webb)

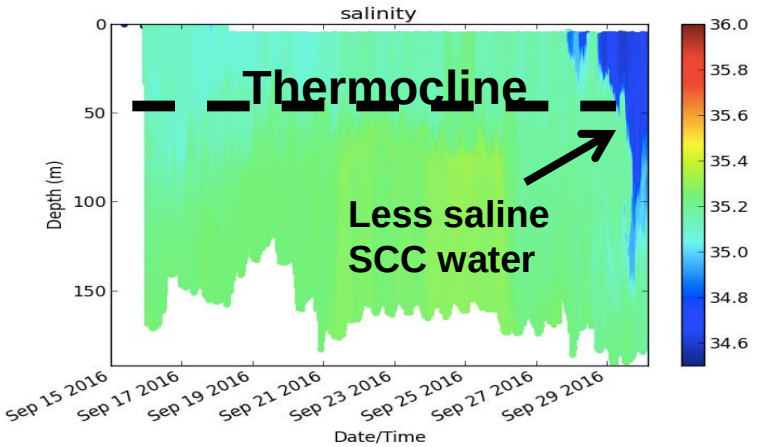
Unmanned Underwater Vehicles



SeaGlider – (Kongsberg)

Frontal area with warmer mixed waters down to ~150m



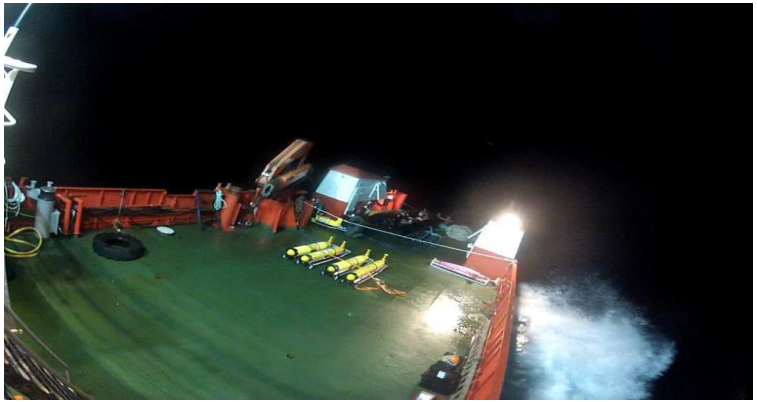


Salinity data indicates presence of less saline waters from Scottish Coastal Current (SCC)

Unmanned Surface Vehicles

WAVE GLIDER – (Liquid Robotics / Boeing SHARC)

Launch



Recovery

Overview

GEOINT interim observations:

•If UXVs (and the associated software) have a future use in the HM branch then it will be necessary to place return of service requirements on the SQEP individuals and for firm strategic direction and guidance to be implemented by senior HM members and the RN as a whole to provide the justification for training and support.

•UXV technology is proven and the assets are useable and functional; however, the data output and processing is problematic. The clear requirement is the end state/output from these systems as there has been a lack of development by manufacturers in providing a user friendly or tactical end product. The RN does not have enough SQEP personnel available to interpret the data and provide informative outputs to non-technical end users.

•It is apparent that UXVs are still manpower heavy and for the GEOINT theme in particular, unmanned vehicles are proven force multipliers and valuable enablers; but are not replacements for traditional full spectrum military data gathering.

•Further work is required on the GEOINT UXVs to determine the cost of having them encrypted for use in operational areas and to ascertain if they can be hardened against electronic attack.

Questions?

Adrian Baker

DSTL

MASSMO3 data products

Information from submarine gliders

Dr A.C.Baker
Dstl Fellow
acbaker@dstl.gov.uk

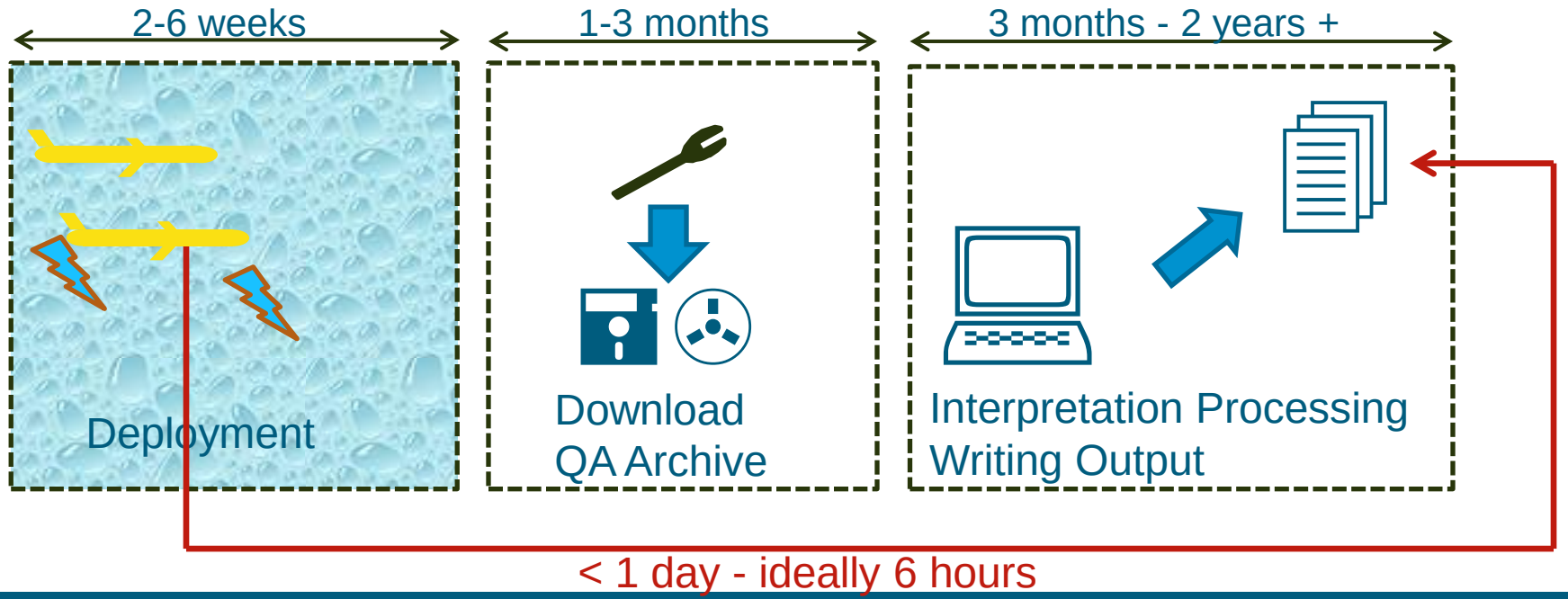
Overview

- What Dstl/ MOD want from the MASSMO trials
- Getting information from a submarine glider
- Issues with real-time data
- Information product ideas
- Where next?

Why are Dstl/ RN supporting MASSMO trials?

- Potential for improved operational effectiveness
- But ….
  - How much effort is it to use submarine gliders?
  - How robust and reliable are they?
  - What (useful) information can they generate?
  - What concepts of operation should be employed?
  - How do we transmit, process and present information to aid operational decision making?

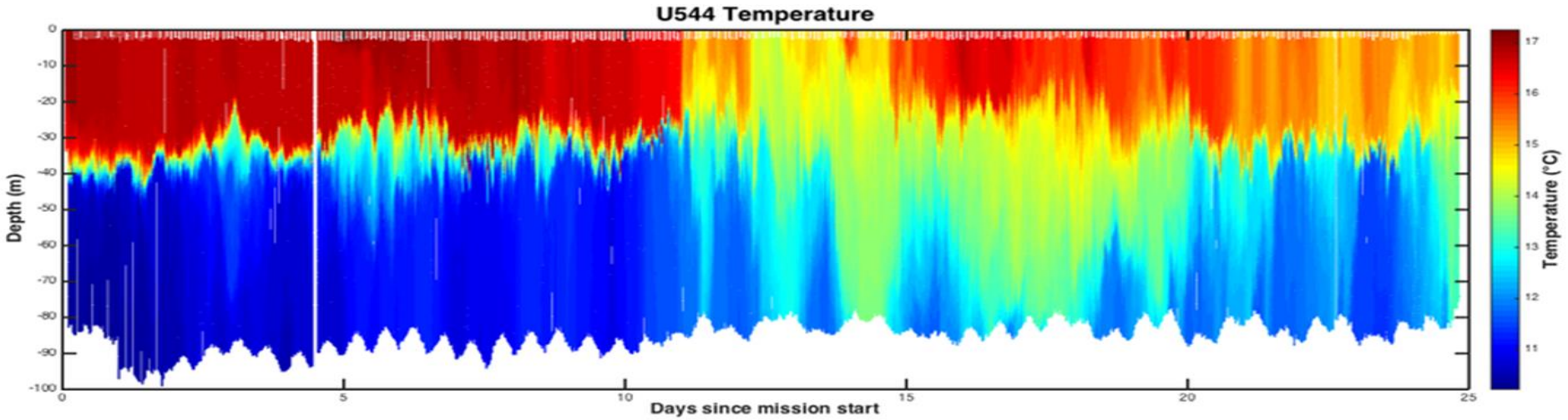
Management and processing of glider data



Issues for glider information management

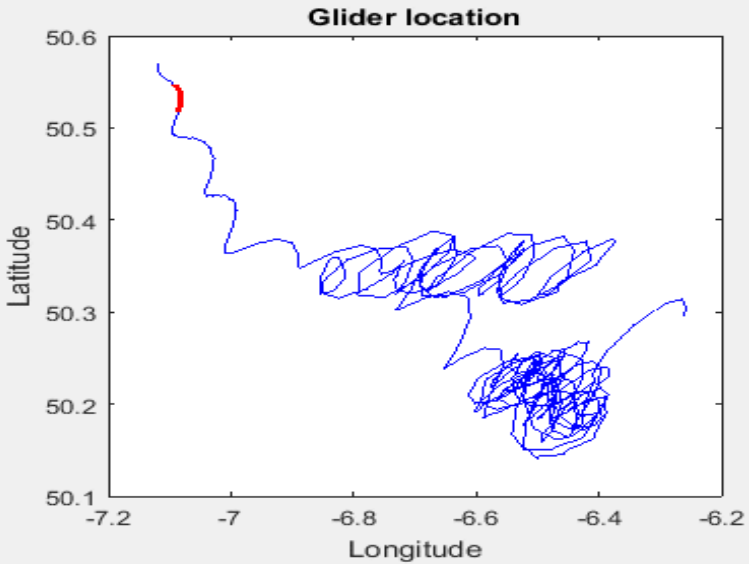
- What is important?
- Concepts of operation
- Decimation
- Real-time data processing (without human intervention)
- Dealing with complexity – 4-dimensional data
- Getting the right information to the right person
- Presentation to aid decision making

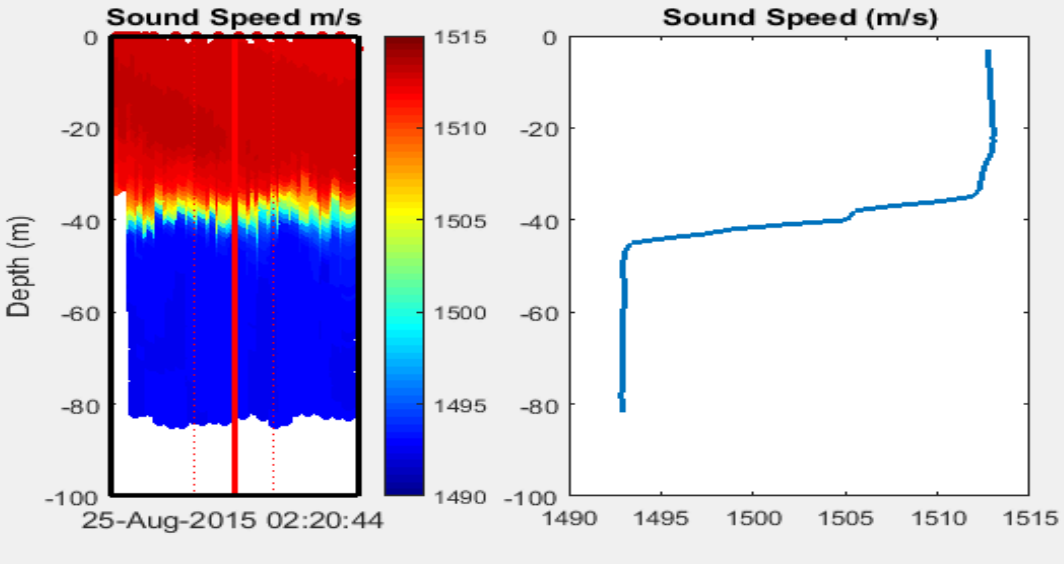
MASSMO2 – common output

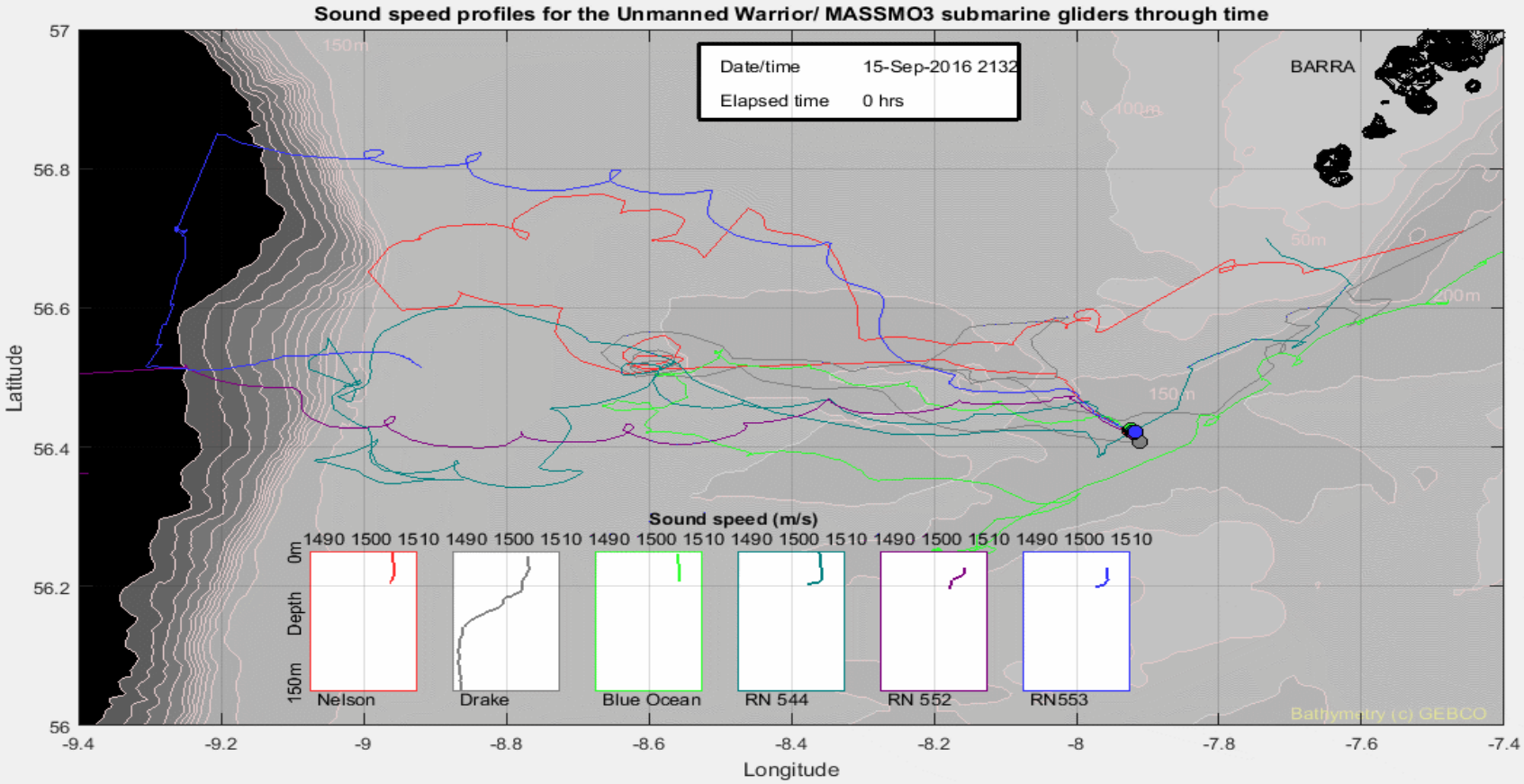


- Position in space cannot be determined

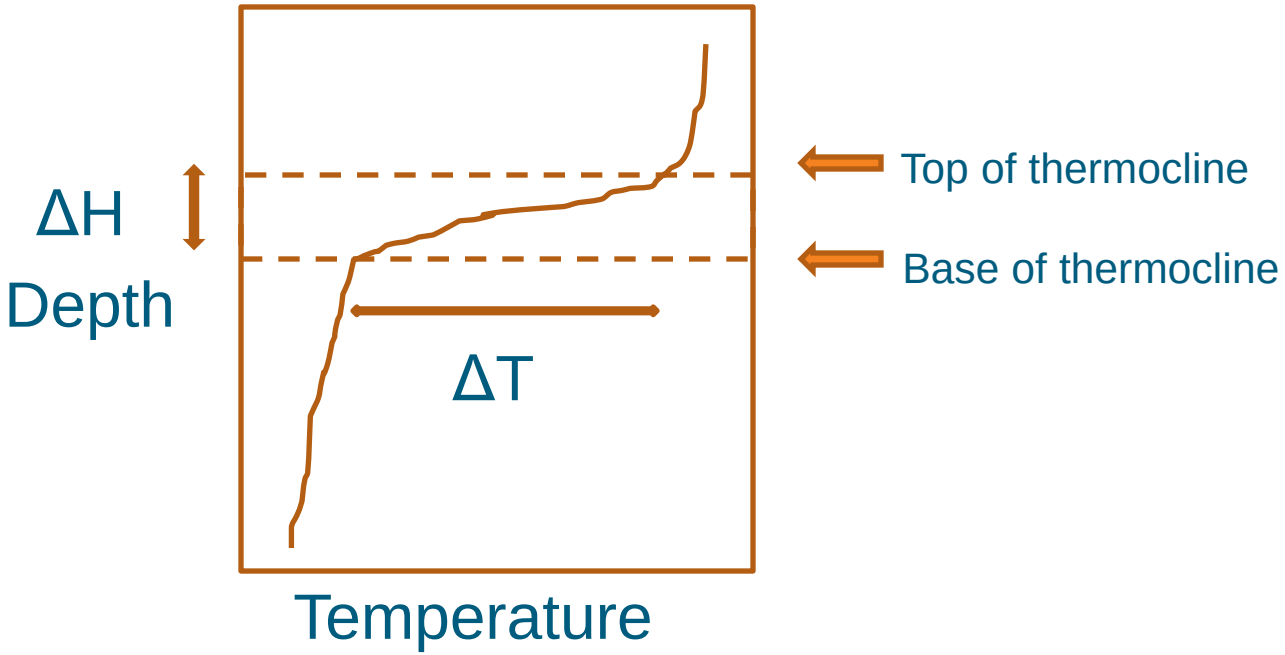
MASSMO2 - Representing 4-D data



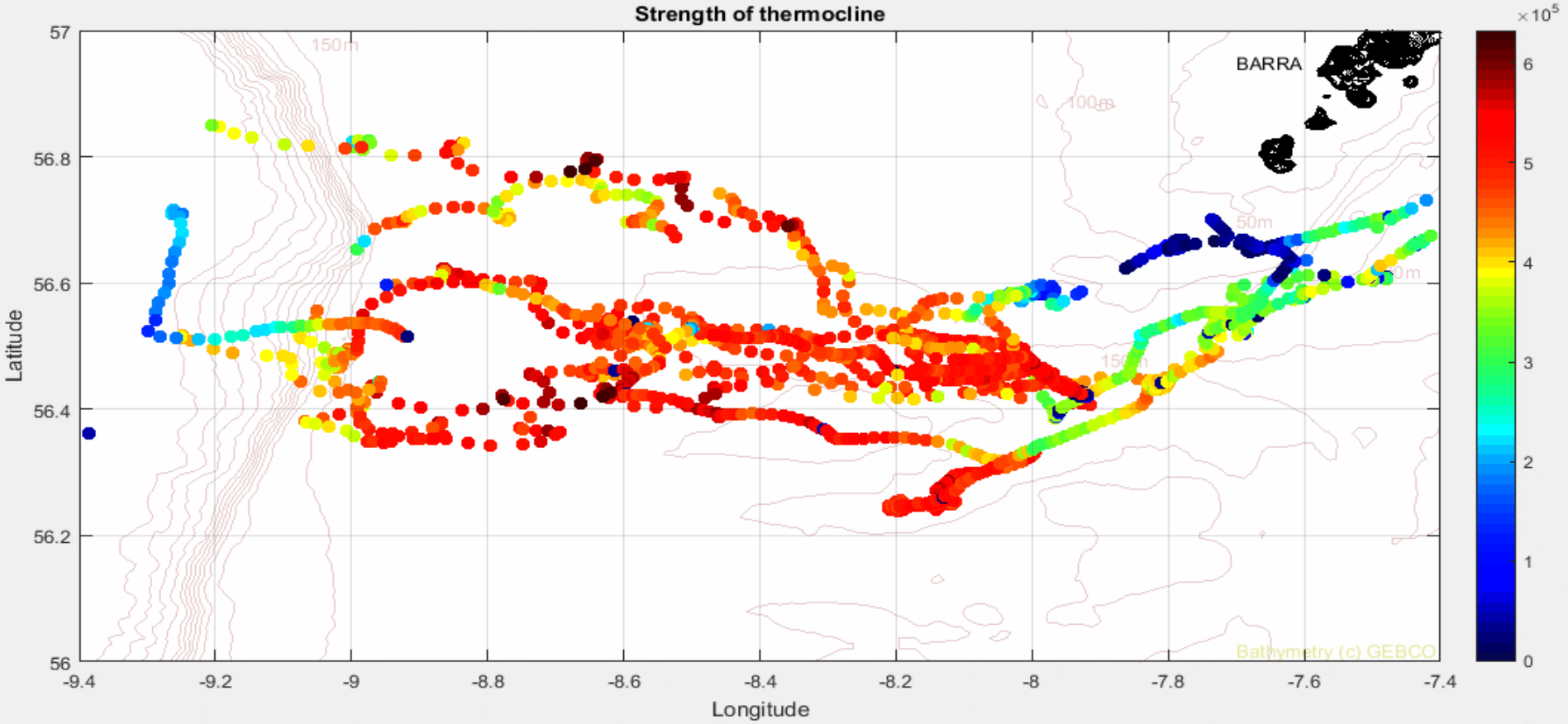




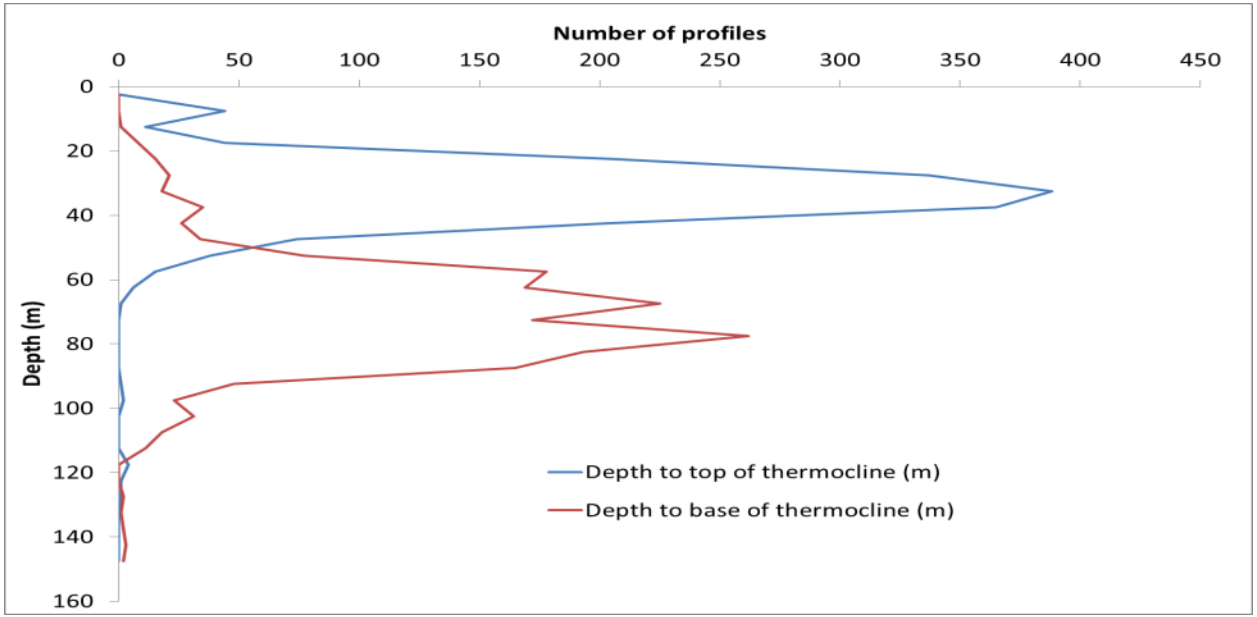
Create new spatial parameters to simplify dimensions

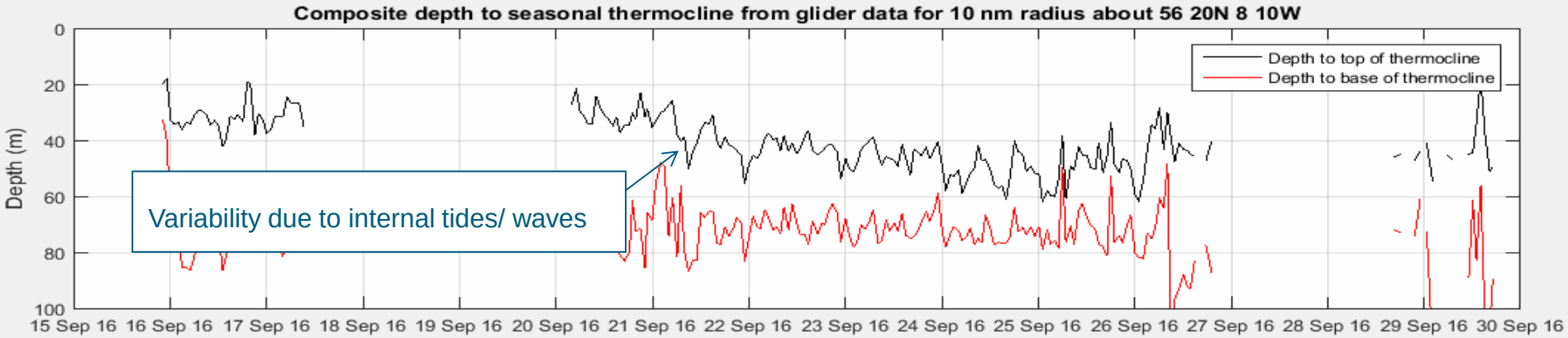


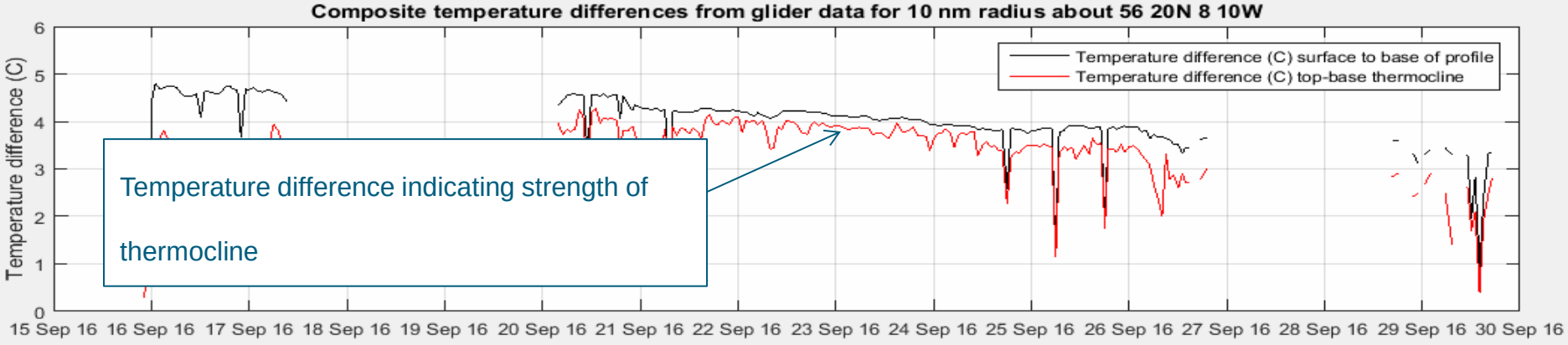
$\Delta T^2/\Delta H$ = strength of thermocline?



Summary data for MASSMO3 region







Where next?

- A better understanding of where gliders can help MOD operations
- An increased focus on concepts of operation
- Better data products and methods of communicating data
- Other sensors


[dstl]

Roly Rogers

Adviser Marine Law And Policy

MASSMO3 OPERATIONS

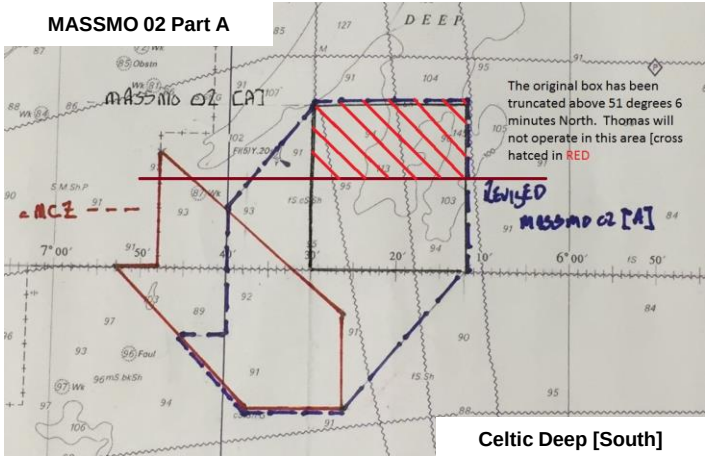
MASSMO – An Operations Management Model

Roland Rogers MASSMO Operations Manager

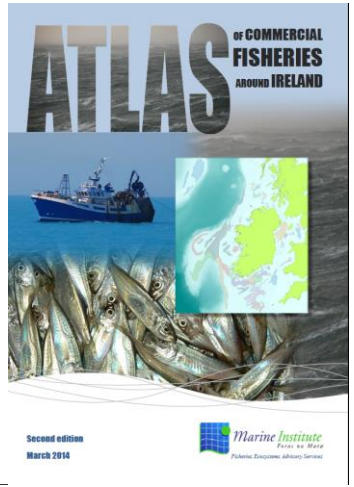
rxr@noc.ac.uk

MASSMO – Operations Management

MASSMO 02 Part A



Celtic Deep [South]



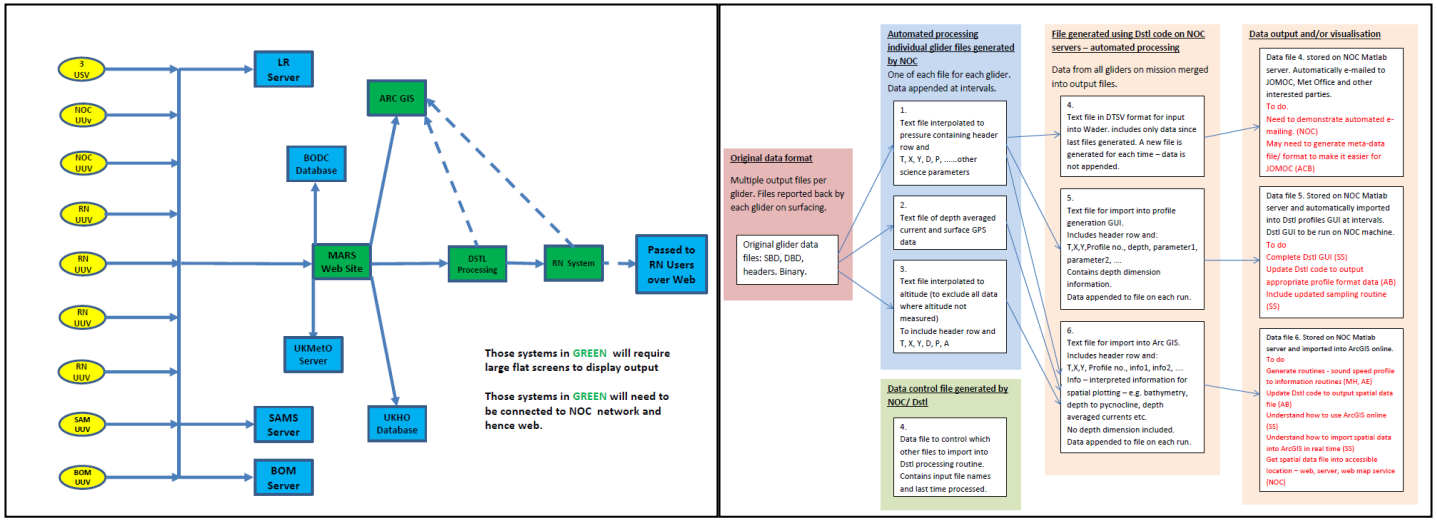
Pre Operational Planning Intelligence
MASSMO 02

MASSMO – Operations Management

Event	Responsible Party			Funding Source	Notes
	LRI	RS Aqua	NOCS		
SV3 Updates & System Preparation	☑	☑		Warranty (LRI) In-kind (RS Aqua)	RS Aqua may need to support software/firmware updates to NOC SV3, as well as any hardware updates/recalls
Refresher Training at NOC (Southampton, England)		☑		In-kind (RS Aqua)	Support Vessel TBD, NOC had previously asked for RSA to directly charter.
Shipment to MASSMO3 Staging area (Oban, Scotland)			☑	NOCS/3rd Party	
Mission Planning	☑			In-kind (LRI)	LRI Standard Mission Planning. Separate op area from Boeing SHARCS.
Deployment Operations	?		☑	NOCS/3rd Party	Piggyback with UW16 GEOINT vessel(s), NOC will have primary responsibility. TBD whether LRI personnel could support (Field Ops or SEs)
On-mission Piloting	☑			In-kind (LRI)	1X SV3, ~23 days
On-mission Data & Direct NOC Support			☑	NOCS/3rd Party	Iridium data and NOC personnel costs
Recovery Operations	?		☑	NOCS/3rd Party	Piggyback with UW16 GEOINT vessel(s), NOC will have primary responsibility. TBD whether LRI personnel could support (Field Ops or SEs)
Emergency Response/Recovery	?	?	☑	NOCS/3rd Party	Vessel of Opportunity may be required. NOCS would have primary responsibility, but RSA or LRI may attempt to assist depending on circumstances.

Example of Complex Operational Relationship Model Experienced During MASSMO03 [source LRI/RS Aqua]

Operational Dataflow Plan and Formats
MASSMO 03



MASSMO – Operations Management

PROTECT - COMMERCIAL ASV Ltd

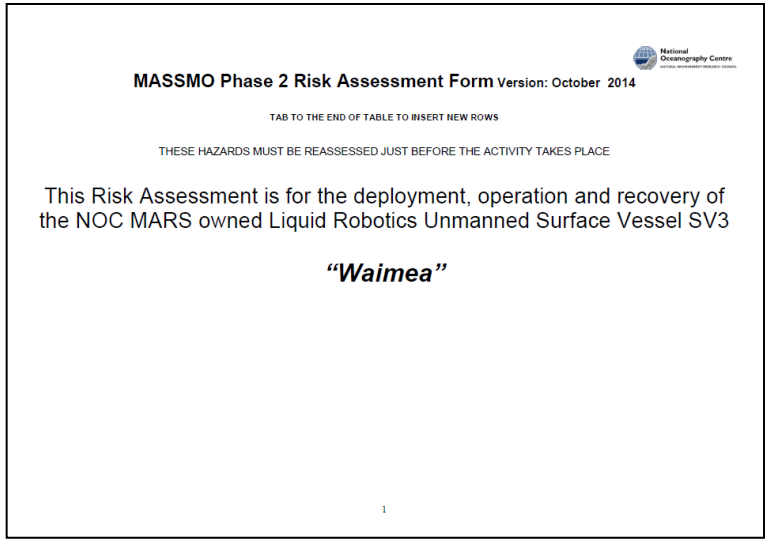
ASV unmanned marine systems

C-ENDURO SAFETY ASSESSMENT MASSMO TRIAL – PHASE 2

Document Number:	ASV-010-D-088
Issue:	A
Date:	15th October 2014

	Name	Date
Originator Head of Project Delivery	Steve Davenport	15th October 2014
Authorised C-Enduro Product Manager	James Cowles	15th October 2014

DISTRIBUTION		
Name	Establishment	Copy Number
File copy	ASV	1
Roland Rogers	NOC	2



National Oceanography Centre

MASSMO Phase 2 Risk Assessment Form Version: October 2014

TAB TO THE END OF TABLE TO INSERT NEW ROWS

THESE HAZARDS MUST BE REASSESSED JUST BEFORE THE ACTIVITY TAKES PLACE

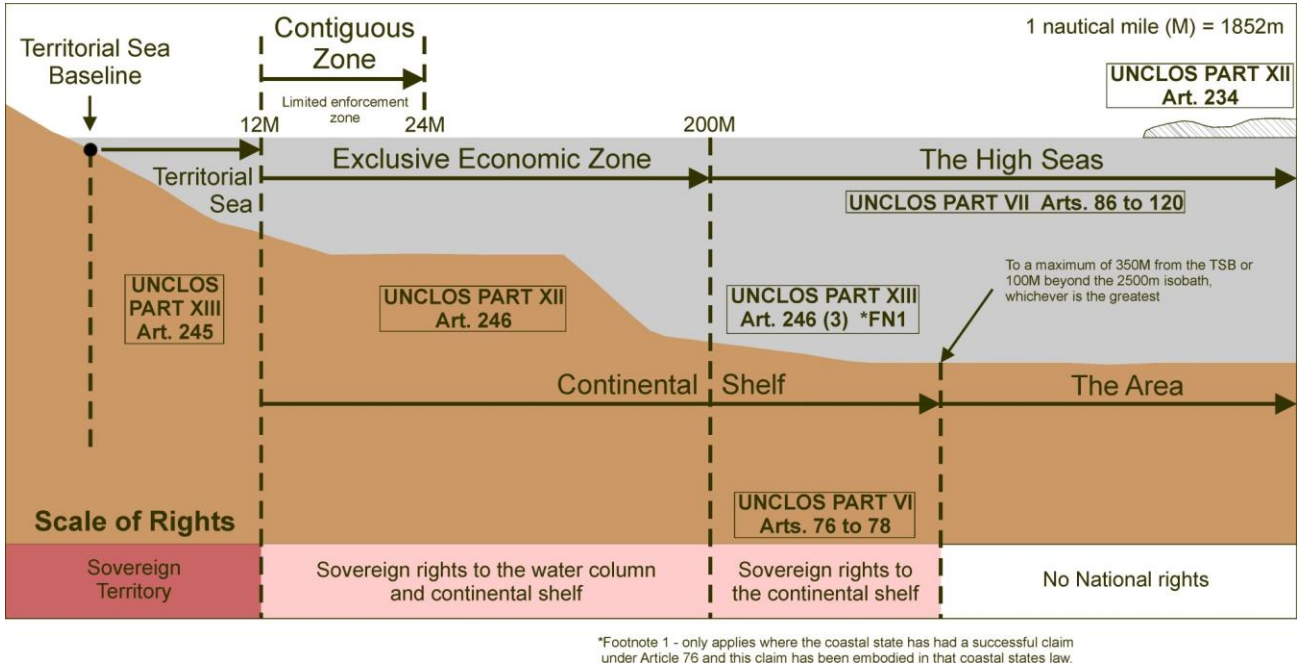
This Risk Assessment is for the deployment, operation and recovery of the NOC MARS owned Liquid Robotics Unmanned Surface Vessel SV3

"Waimea"

1

MAS RISK ASSESSMENTS – MAASMO 01 Phase 2

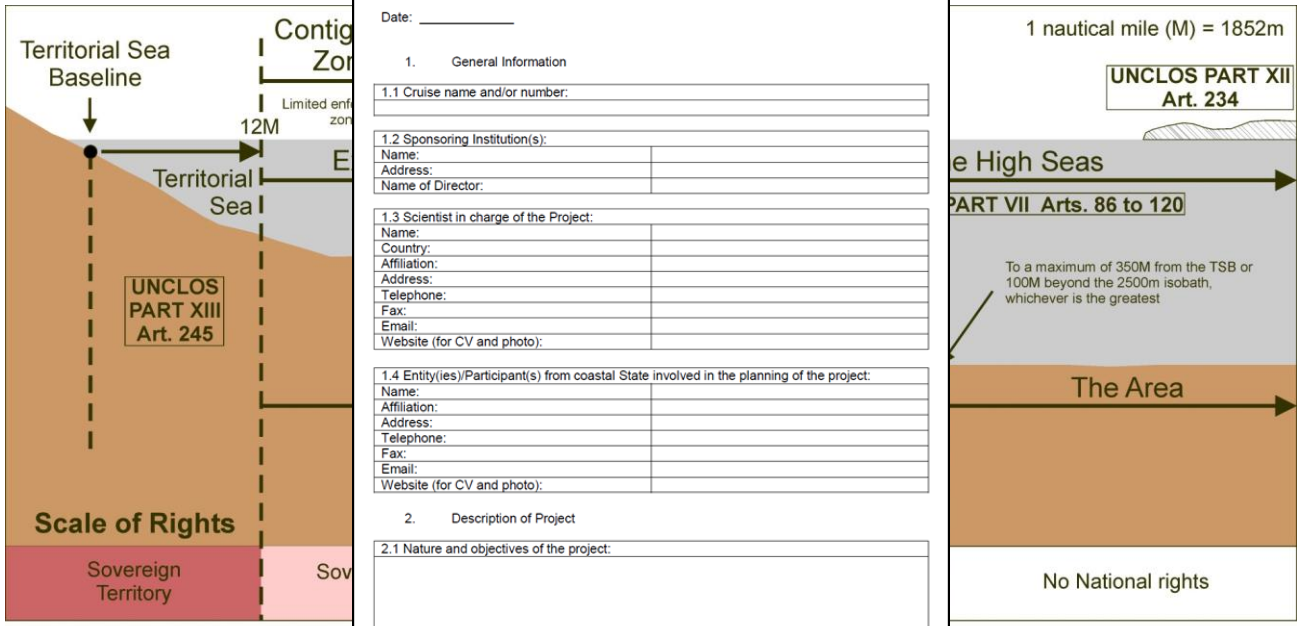
MASSMO – Operations Management



*Footnote 1 - only applies where the coastal state has had a successful claim under Article 76 and this claim has been embodied in that coastal states law.

Diplomatic Clearance – Maritime Zones

MASSMO – Operations Management



Application for Consent to conduct
Marine Scientific Research

Date: _____

1. General Information

1.1 Cruise name and/or number:

1.2 Sponsoring Institution(s):	
Name:	
Address:	
Name of Director:	

1.3 Scientist in charge of the Project:	
Name:	
Country:	
Affiliation:	
Address:	
Telephone:	
Fax:	
Email:	
Website (for CV and photo):	

1.4 Entity(ies)/Participant(s) from coastal State involved in the planning of the project:	
Name:	
Affiliation:	
Address:	
Telephone:	
Fax:	
Email:	
Website (for CV and photo):	

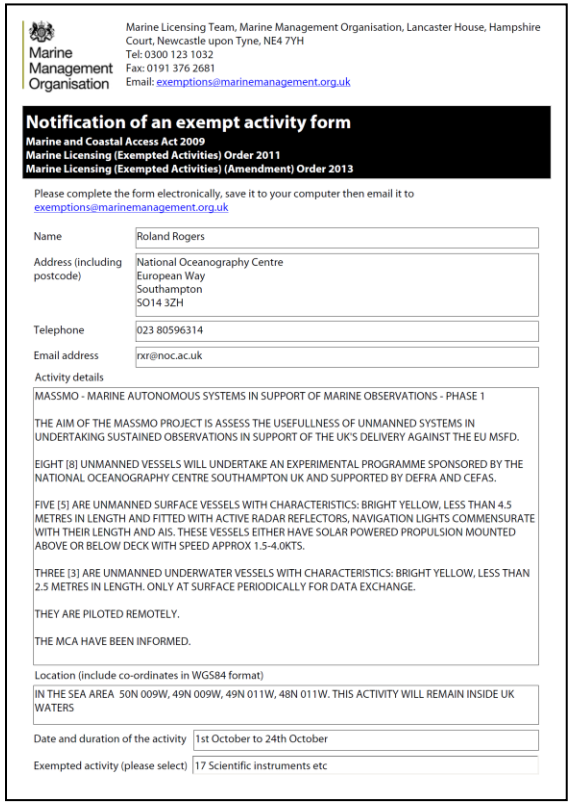
2. Description of Project

2.1 Nature and objectives of the project:

2.3 Relevant previous or future research projects:

Diplomatic Clearance – Maritime Zones – Form A

MASSMO – Operations Management



Marine Management Organisation

Marine Licensing Team, Marine Management Organisation, Lancaster House, Hampshire Court, Newcastle upon Tyne, NE4 7YH
Tel: 0300 123 1032
Fax: 0191 376 2681
Email: exemptions@marinemanagement.org.uk

Notification of an exempt activity form

Marine and Coastal Access Act 2009
Marine Licensing (Exempted Activities) Order 2011
Marine Licensing (Exempted Activities) (Amendment) Order 2013

Please complete the form electronically, save it to your computer then email it to exemptions@marinemanagement.org.uk

Name	Roland Rogers
Address (including postcode)	National Oceanography Centre European Way Southampton SO14 3ZH
Telephone	023 80596314
Email address	rxr@noc.ac.uk

Activity details

MASSMO - MARINE AUTONOMOUS SYSTEMS IN SUPPORT OF MARINE OBSERVATIONS - PHASE 1

THE AIM OF THE MASSMO PROJECT IS ASSESS THE USEFULLNESS OF UNMANNED SYSTEMS IN UNDERTAKING SUSTAINED OBSERVATIONS IN SUPPORT OF THE UK'S DELIVERY AGAINST THE EU MSFD.

EIGHT [8] UNMANNED VESSELS WILL UNDERTAKE AN EXPERIMENTAL PROGRAMME SPONSORED BY THE NATIONAL OCEANOGRAPHY CENTRE SOUTHAMPTON UK AND SUPPORTED BY DEFRA AND CEFAS.

FIVE [5] ARE UNMANNED SURFACE VESSELS WITH CHARACTERISTICS: BRIGHT YELLOW, LESS THAN 4.5 METRES IN LENGTH AND FITTED WITH ACTIVE RADAR REFLECTORS, NAVIGATION LIGHTS COMMENSURATE WITH THEIR LENGTH AND AIS. THESE VESSELS EITHER HAVE SOLAR POWERED PROPULSION MOUNTED ABOVE OR BELOW DECK WITH SPEED APPROX 1.5-4.0KTS.

THREE [3] ARE UNMANNED UNDERWATER VESSELS WITH CHARACTERISTICS: BRIGHT YELLOW, LESS THAN 2.5 METRES IN LENGTH. ONLY AT SURFACE PERIODICALLY FOR DATA EXCHANGE.

THEY ARE PILOTED REMOTELY.

THE MCA HAVE BEEN INFORMED.

Location (include co-ordinates in WGS84 format)

IN THE SEA AREA 50N 009W, 49N 009W, 49N 011W, 48N 011W. THIS ACTIVITY WILL REMAIN INSIDE UK WATERS

Date and duration of the activity	1st October to 24th October
Exempted activity (please select)	17 Scientific instruments etc

Marine Management Organisation [MMO]

Marine Scientific Research [MSR] comes under the MMO purview.

Types of MSR that requires permission and possible Environmental Impact Assessment:

- **Active Sonar Transmission**
- **Use of chemicals in water**
- **Sampling the sea bed**

All other forms of MSR usually exempted.

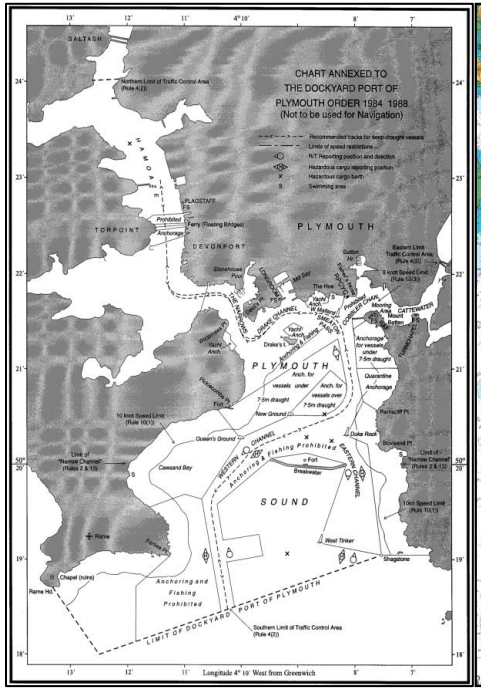
MMO's are regional can be some variations in application of the marine and Coastal Access Act.

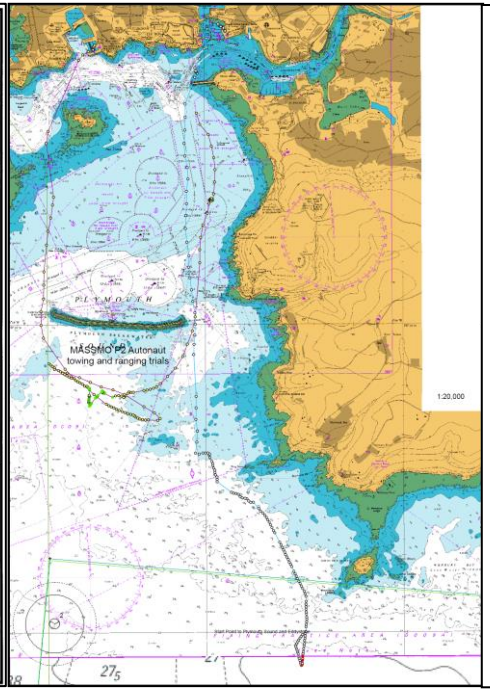
Need to register to make application

MASSMO 01 Part A MMO Exemption Form

MASSMO – Operations Management

Compliance with local Port Orders via Harbour Master





QHM

Plymouth Local Notices to Mariners (PLNTM)

Plymouth Local Notice to Mariners are issued by the Queen's Harbour Master Plymouth pursuant to the Dockyard Port of Plymouth Order 1999, Schedule 1 Regulation 1, Regulation 11 and Regulation 29. These Notices are numbered consecutively starting at the beginning of each year. They contain information fundamental to the safety of mariners.

QUEEN'S HARBOUR MASTER PLYMOUTH

LOCAL NOTICE TO MARINERS

No 40/14

PLYMOUTH SOUND - UNMANNED SURFACE RESEARCH VEHICLES

1. This notice is issued for information by the Queen's Harbour Master Plymouth pursuant to the Dockyard Port of Plymouth Order 1999.

2. Three unmanned surface vehicles up to 4m in length will be launched from Queen Anne Battery and will transit to outside the port limits to commence trials between 3 Nov and 14 Nov. Each vessel is fitted with AIS and navigation lights.

3. Whilst in port limits the unmanned surface vehicles will be towed and/or escorted by a controlling vessel until the craft are 1nm clear of the port limits.

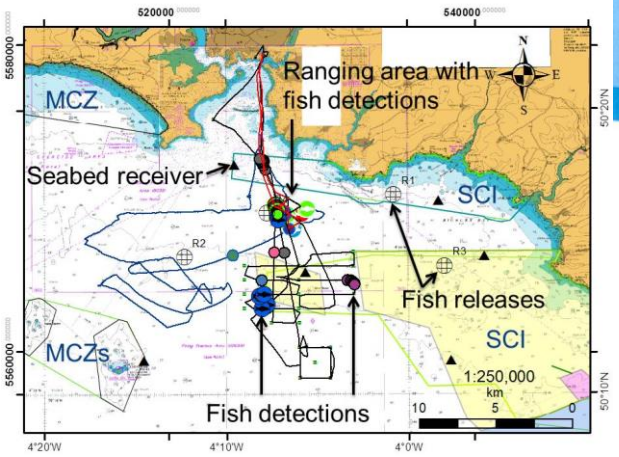
4. Once clear of the port limits the vessels will conduct scientific data gathering. During this phase the vehicles will be autonomous, unmanned and remote operated within an area to the south of the port, approximately bounded by:

   50 21.5 N 4 20.00 W

   50 05.00 N 4 20.00 W

Example MASSMO 01 PART 1 A

MASSMO – Operations Management



MASSMO 01 Part B

Sea Bed Mounted Sensors and USV
Voluntary Notification
Free

marinescotland

Kingfisher Fortnightly Bulletin

SEAFISH
THE KINGFISHER INFORMATION SERVICE

Oil and Gas | Oil and Gas | Oil and Gas

Area 4 — 23 October 2014 | Issue 22

For 'live' Kingfisher updates of offshore activities, visit www.fishsafe.eu and follow @Kingfisherinfo onTwitter

Seabed Activity — First Published: 23 October 2014 | Latest Update: 23 October 2014

Plymouth – Deployment Operations

Fish Tracking Instruments deployed without topmarks at the following locations

50°11.160'N 004°14.520'W
50°18.060'N 004°09.540'W
50°14.280'N 004°05.640'W
50°16.800'N 003°58.320'W
50°14.820'N 003°55.800'W
50°11.160'N 003°57.660'W

Deployment Date: 13th October 2014 – Ongoing

For further information: Dr Stephen Cotterell, MBA UK, Tel: +44(0)1752 633207 email: stette@MBA.ac.uk
http://www.mba.ac.uk/simsleb/research/

Seabed Activity — First Published: 23 October 2014 | Latest Update: 23 October 2014

Plymouth – Deployment Operations

Passive Acoustic Fish Tracking by unmanned Surface Vessels

50°21.680'N 004°20.000'W (near The Brawn, West of Portwrinkle)
50°05.000'N 004°20.000'W (at sea)
50°05.000'N 003°50.000'W (at Sea)
50°13.320'N 003°50.000'W (near Soar Mill Cove (beach)).

Deployment Date: 20th October 2014 to 14th November

The USVs are between 2.5 and 4.5 meters in length, are painted bright yellow and piloted remotely. They are fitted with cameras, navigational lights, radar reflectors and AIS. They can operate up to a maximum of 4kts.

The National Oceanography Centre working together with the MBA would be grateful if shipping would keep clear of these marine scientific research vessels.

For further information: Dr Stephen Cotterell, MBA UK, Tel: +44(0)1752 633207 email: stette@MBA.ac.uk Roland Rogers,NOC, Tel: 07525770526 email: rxr@noc.ac.uk http://projects.noc.ac.uk/exploring-ocean-fronts/

MASSMO – Operations Management

Examples of Operational Warnings – MASSMO02 and MASSMO03

MASSMO03 NAV WARNINGS MESSAGE

WZ 1089

SCOTLAND, NORTH-WEST COAST. Butt of Lewis and Cape Wrath Northward.

1. Survey operations in progress by 3 unmanned, remotely controlled surface vessels in area bounded by: 60-00N 007-00W, 58-00N 007-00W, 60-00N 004-00W and 58-00N 004-00W.

Vessels are 3.5 metres long, yellow or grey in colour and fitted with a fixed white light, radar reflector and AIS. Wide berth requested.

2. Cancel this message 080059 UTC Oct 16.

WZ 1090

SCOTLAND, WEST COAST. Western approaches to the North Channel and Sea of Hebrides.

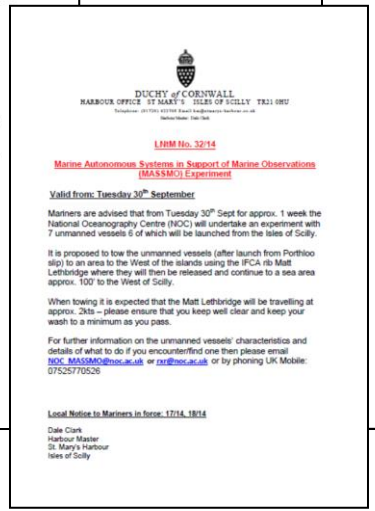
1. Survey operations in progress by 8 unmanned, remotely controlled underwater vessels in area bounded by: 56-00N 007-00W, 57-00N 007-00W, 56-00N 010-00W and 57-00N 010-00W.

Vessels are 2.5 metres long, yellow and purple in colour and fitted with a fixed white light, radar reflector and AIS.

Wide berth requested.

2. Cancel this message 080059 UTC Oct 16.

NNNN



DUCHY of CORNWALL
HARBOUR OFFICE ST MARY'S ISLES OF SCILLY TR21 0HU

LNM No. 32/14

Marine Autonomous Systems in Support of Marine Observations (MASSMO) Experiment

Valid from: Tuesday 30th September

Mariners are advised that from Tuesday 30th Sept for approx. 1 week the National Oceanography Centre (NOC) will undertake an experiment with 7 unmanned vessels 6 of which will be launched from the Isles of Scilly.

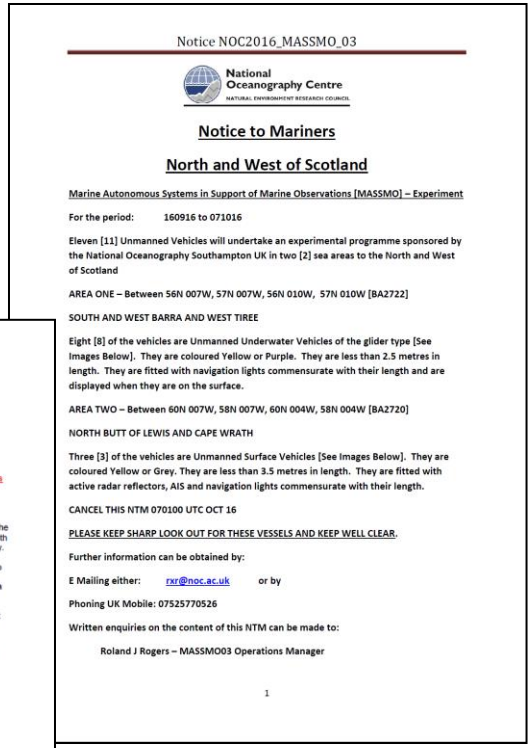
It is proposed to tow the unmanned vessels (after launch from Porthloo slip) to an area to the West of the islands using the IFCA rib Matt Lethbridge where they will then be released and continue to a sea area approx. 100' to the West of Scilly.

When towing it is expected that the Matt Lethbridge will be travelling at approx. 2kts – please ensure that you keep well clear and keep your wash to a minimum as you pass.

For further information on the unmanned vessels' characteristics and details of what to do if you encounter/find one then please email NOC_MASSMO@noc.ac.uk or rxr@noc.ac.uk or by phoning UK Mobile: 07525770526

Local Notice to Mariners in force: 17/14, 18/14

Dale Clark
Harbour Master
St. Mary's Harbour
Isles of Scilly



Notice NOC2016_MASSMO_03

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Notice to Mariners

North and West of Scotland

Marine Autonomous Systems in Support of Marine Observations [MASSMO] – Experiment

For the period: 160916 to 071016

Eleven [11] Unmanned Vehicles will undertake an experimental programme sponsored by the National Oceanography Southampton UK in two [2] sea areas to the North and West of Scotland

AREA ONE – Between 56N 007W, 57N 007W, 56N 010W, 57N 010W [BA2722]

SOUTH AND WEST BARRA AND WEST TIREE

Eight [8] of the vehicles are Unmanned Underwater Vehicles of the glider type [See Images Below]. They are coloured Yellow or Purple. They are less than 2.5 metres in length. They are fitted with navigation lights commensurate with their length and are displayed when they are on the surface.

AREA TWO – Between 60N 007W, 58N 007W, 60N 004W, 58N 004W [BA2720]

NORTH BUTT OF LEWIS AND CAPE WRATH

Three [3] of the vehicles are Unmanned Surface Vehicles [See Images Below]. They are coloured Yellow or Grey. They are less than 3.5 metres in length. They are fitted with active radar reflectors, AIS and navigation lights commensurate with their length.

CANCEL THIS NTM 070100 UTC OCT 16

PLEASE KEEP SHARP LOOK OUT FOR THESE VESSELS AND KEEP WELL CLEAR.

Further information can be obtained by:

E Mailing either: rxr@noc.ac.uk or by

Phoning UK Mobile: 07525770526

Written enquiries on the content of this NTM can be made to:

Roland J Rogers – MASSMO03 Operations Manager

1

MASSMO – Operations Management

Operational Routines

MASSMO 03 - DAILY ROUTINE [19th September to 7th October 2016]

WORKING DAY 0900 – 1600

OUT OF HOURS 1600 – 0900

MONDAY TO FRIDAY

SATURDAY TO SUNDAY OUT OF HOURS ROUTINE

[1]	0900	START OF WORKING DAY
[2]	0900 - 1000	PREPARATIONS FOR DAILY BRIEF
[3]	0900 – 1600	PILOTING OF MASSMO VEHICLES
[4]	1000 – 1100	DAILY BRIEF
[5]	1500 – 1600	OPERATIONS ROOMS REVIEW
[6]	1600	CLOSE OF WORKING DAY
[7]	1600 – 0900	OUT OF HOURS ROUTINE VEHICLES PILOTED FROM DISTRIBUTED LOCATIONS [SEE PILOT CONTACT DETAILS IN MASSMO FOLDERS]

MASSMO DAILY BRIEF

1000 HOURS

[1]	INTRODUCTIONS	PS/OM
[2]	REVIEW OF PREVIOUS DAY	
	• SCIENCE	PS
	• OPERATIONS/LOGISTICS	OM
	• DSTL/RN Objectives	DSTL/RN
[3]	VEHICLE/SENSORS UPDATE	
	• USV	LIQUID ROBOTICS/BOEING
	• UUV	NOC/SAMS/BLUEOCEAN
[4]	FORECAST CONDITIONS FOR NEXT 24 HRS	OM
[5]	AGREE PLAN FOR THE NEXT 24 HOURS	ALL
[6]	COMMUNICATIONS	COMMS
[7]	AOB	ALL

Conference Dial In: Freefone 0800 7836753, Direct 0203 651 8923, Participants Pass Code 97499805 then #

PS = Principal Scientist, OM =Operations Manager

MASSMO – Operations Management

Recovery Procedures

Liquid Robotics® Operations

Wave Glider® SV3 Launch and Recovery Guide

Doc #06135 Rev A

COMMERCIAL IN CONFIDENCE

MASSMO PHASE 1 & 2

AUTONAUT - RECOVERY AT SEA BY NON-SPECIALIST VESSEL

INTRODUCTION

If it is necessary to recover AutoNaut at sea the operator and crew should familiarise themselves with the following in order to maintain their safety and minimise damage to the AutoNaut unmanned surface vessel (USV), and the recovery vessel.

BE AWARE:

- AutoNaut is 3.5m long and painted yellow
- Weight about 120 kg (unless flooded)
- Has a 1.5m mast carrying a single all round white light visible 2 miles, AirMar weather station, and two cameras.

Recovery of Slocum glider

The gliders move at about 0.5kt so repositioning a glider is less efficient than repositioning the ship. Only the tail section is above the waterline, as the glider floats horizontally in recovery mode.

1) The ship calls the pilot to confirm that recovery is going ahead, and gives an ETA and position. Positions for the gliders can be obtained independently from the internet page http://www.noc.soton.ac.uk/omf/projects/glider/data.php Note that the estimated surface times are projected from the previous dive length, which the pilot will shorten as the ship approaches.
2) For net recovery, a cargo net should be rigged as per the photographs prior to recovery.
3) When the ship is less than 3 hours away, the pilot will put the glider into "recovery mode" on the surface, calling in every 10 minutes or so but drifting with the sea. Unless there is a strong wind, the glider will only drift very slowly and the ggs positions on the webpage will show drifts of less than a cable between updates.
4) The ship may be able to spot the glider at a range of ¼ mile. Once seen, you should inform the pilot as soon as convenient; the ship then goes into the recovery procedure.
5) For a nose recovery (preferred): once the pilot has been told the ship is in position the nose release can be fired. This can take 20 minutes before the command is acknowledged. The yellow nose then separates from the glider body, linked by a 5-metre Dyneema lifting line.
   a. The line is grappled, either by throwing line or by a long pole and snap-hook.
   b. The line is brought aboard and the lifting line tied or shackled into it, and the glider can be lifted by the nose line. A crane or auxiliary winch is preferred, gliders weigh between 50kg and 70kg and are not ideally slid up the side of the ship.
6) For a net recovery: lower the net to the surface of the water from the crane and use it to scoop up the glider. The long poles are useful to prod the glider into position.
7) For a small boat recovery: take the trolley and a cross-head screwdriver in the boat and use it to pull the glider out of the water as per the Recovery Procedure section of the laminated notes. If there is no trolley or if it is a rough sea the glider can be pulled out of the water by its tail and laid on the floor of the RIB. Undo the locking screws on the wing roots and unclip the wings.
8) Once on deck, whatever method is used, put the glider onto a launch trolley or other support such as a car tyre and hose down with fresh water, especially the CTD tube under the port wing. Remove the wings, if not done already, by unscrewing the small central screw on the wing root and sliding the clip on the trailing edge backwards. Leave the glider out in the open until it is powered down.

ASV unmanned marine systems

C-ENDURO LARGE VESSEL RECOVERY

Document Number:	ASV-276-4-006
Issue:	C
Date:	31st October 2014

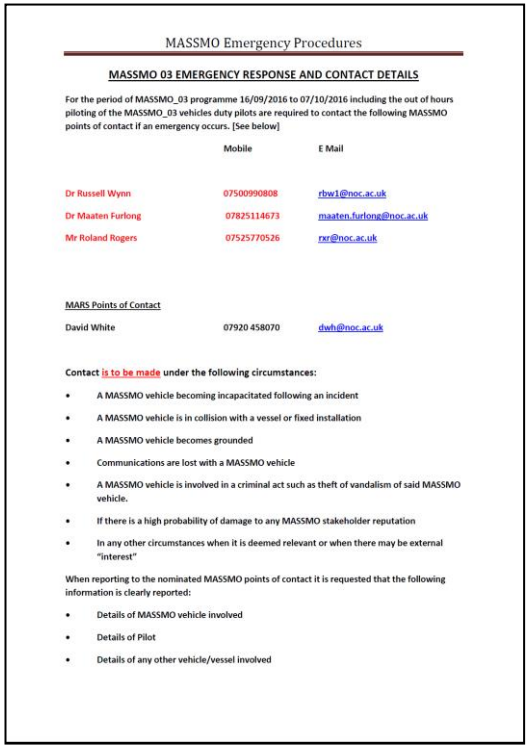
	Name	Date
Originator	Chris Chase	1st October 2014
Authorised Head Of Vehicle Operations	Phil Clark	1st October 2014

DISTRIBUTION

Name	Establishment	Copy Number
Project File	ASV Ltd.	1
Roland J Rogers	National Oceanography Centre	2

MASSMO – Operations Management

Operational Emergency Procedures – MASSMO 03



MASSMO Emergency Procedures

MASSMO 03 EMERGENCY RESPONSE AND CONTACT DETAILS

For the period of MASSMO_03 programme 16/09/2016 to 07/10/2016 including the out of hours piloting of the MASSMO_03 vehicles duty pilots are required to contact the following MASSMO points of contact if an emergency occurs. [See below]

	Mobile	E Mail
Dr Russell Wynn	07500990808	rbw1@noc.ac.uk
Dr Maaten Furlong	07825114673	maaten.furlong@noc.ac.uk
Mr Roland Rogers	07525770526	rxr@noc.ac.uk

MARS Points of Contact

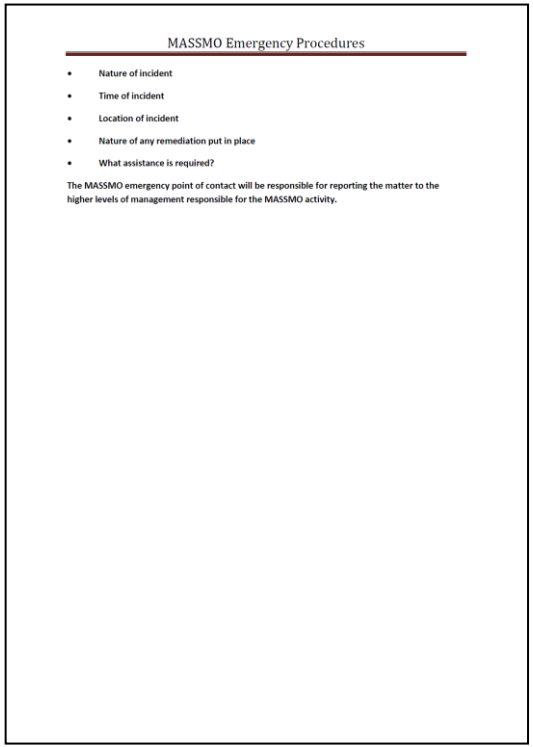
David White	07920 458070	dwh@noc.ac.uk

Contact is to be made under the following circumstances:

- A MASSMO vehicle becoming incapacitated following an incident
- A MASSMO vehicle is in collision with a vessel or fixed installation
- A MASSMO vehicle becomes grounded
- Communications are lost with a MASSMO vehicle
- A MASSMO vehicle is involved in a criminal act such as theft of vandalism of said MASSMO vehicle.
- If there is a high probability of damage to any MASSMO stakeholder reputation
- In any other circumstances when it is deemed relevant or when there may be external "interest"

When reporting to the nominated MASSMO points of contact it is requested that the following information is clearly reported:

- Details of MASSMO vehicle involved
- Details of Pilot
- Details of any other vehicle/vessel involved



MASSMO Emergency Procedures

- Nature of incident
- Time of incident
- Location of incident
- Nature of any remediation put in place
- What assistance is required?

The MASSMO emergency point of contact will be responsible for reporting the matter to the higher levels of management responsible for the MASSMO activity.

MASSMO – Operations Management

MAS OPERATIONAL MODEL

MASSMO – Operations Management

MAS Operations Model (s)

Customer

Platform and Piloting Manager

Principal Scientist

Operations Manager

NOC Master

NOC Pilot/Engineer

ASV unmanned marine systems

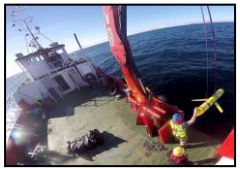
Third Party Pilot UK

liquid robotics

Third Party Pilot Abroad

ROYAL NAVY

Third Party Pilot Customer



Mid Morning Refreshments

20 Minute Break

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Alvaro Lorenzo

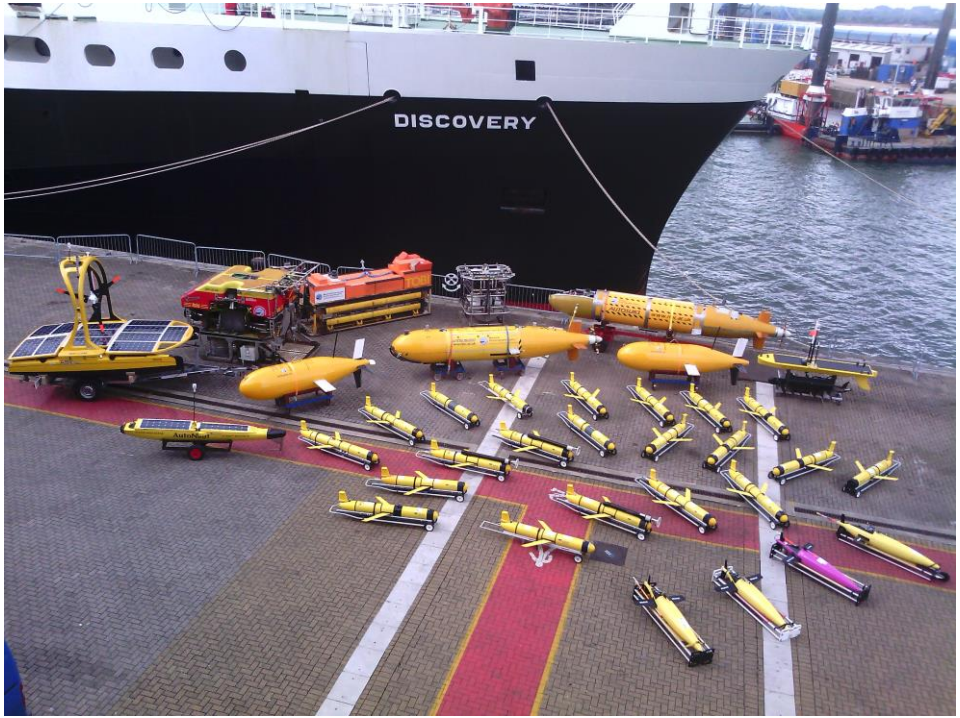
NOC

MARS command-and-control developments

MASSMO 3 – Command and Control Developments

ALVARO LORENZO

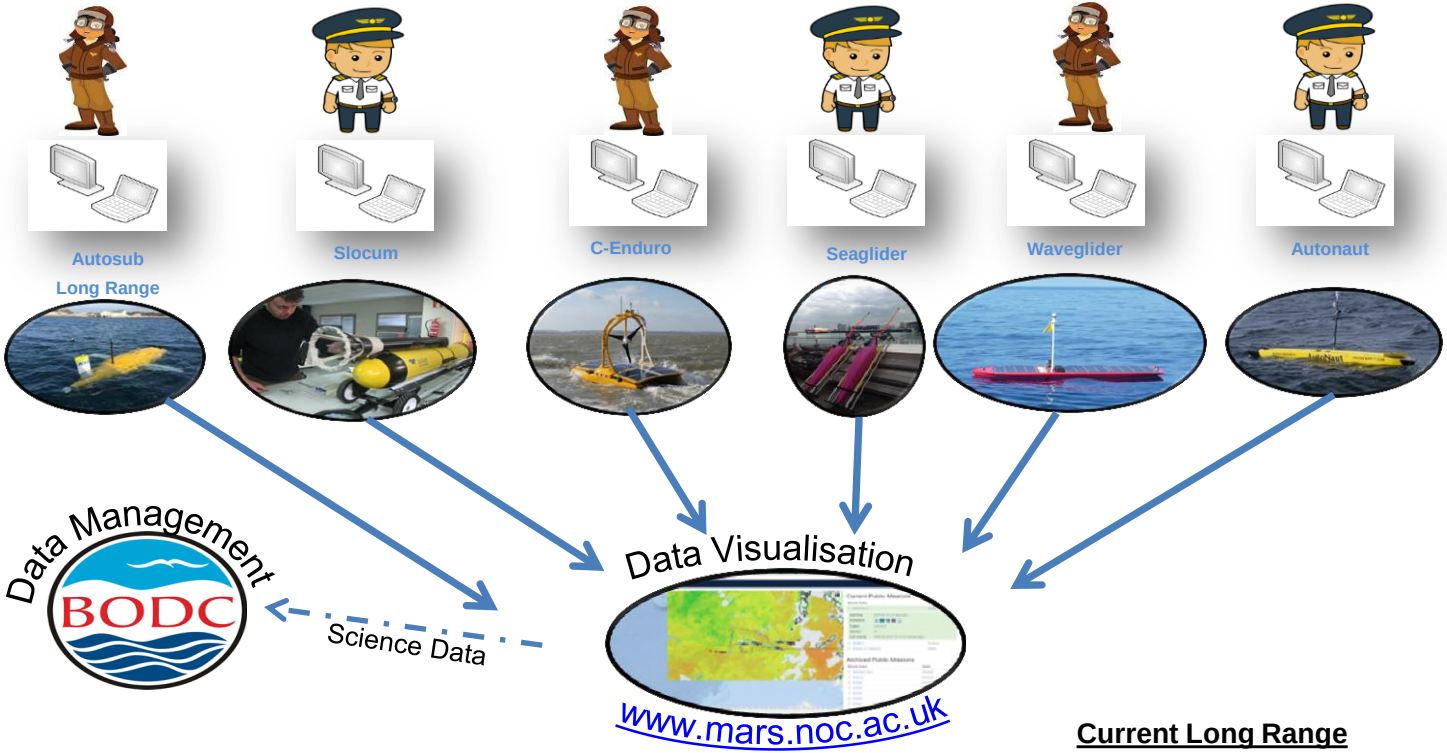
The Fleet



The Long Range Fleet

Challenges Operating The Long Range Fleet

- Assets from different manufacturers:
    - Different control interfaces
- Assets from different partners (NOC, Royal Navy, SAMS, Blue Ocean Monitoring):
    - Different Servers
- Environmental Awareness
    - Multiple streams of data from various providers
- Mission Planning:
    - Need to share it with other pilots and partners

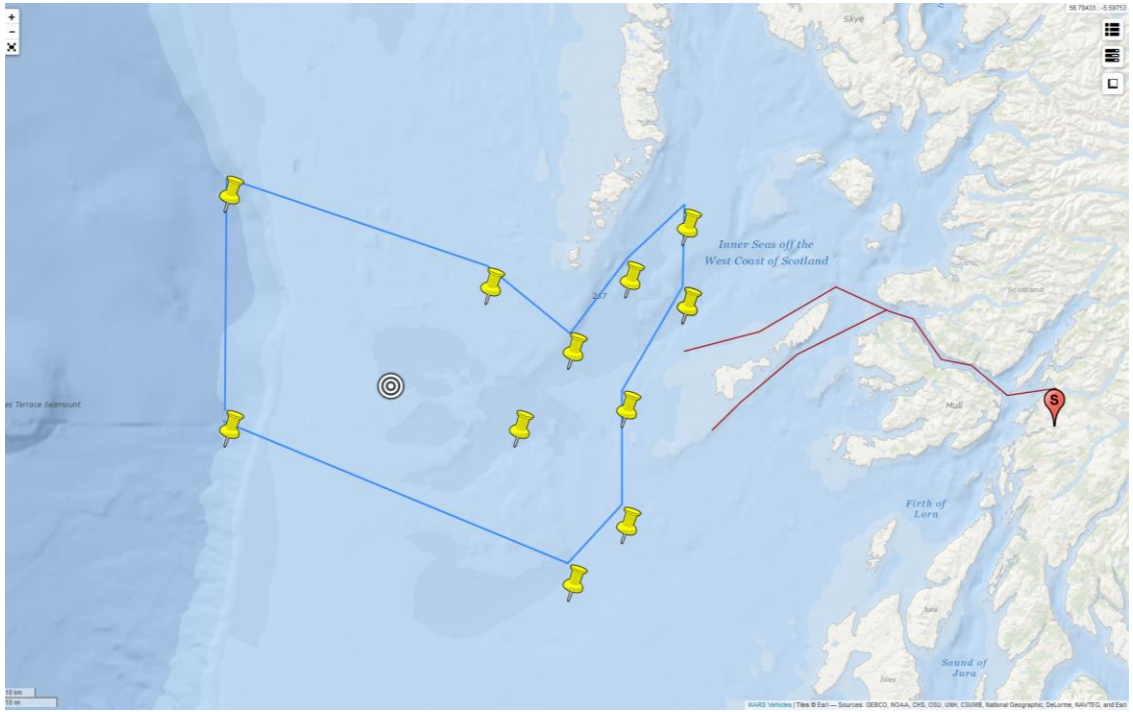


Current Long Range Operations

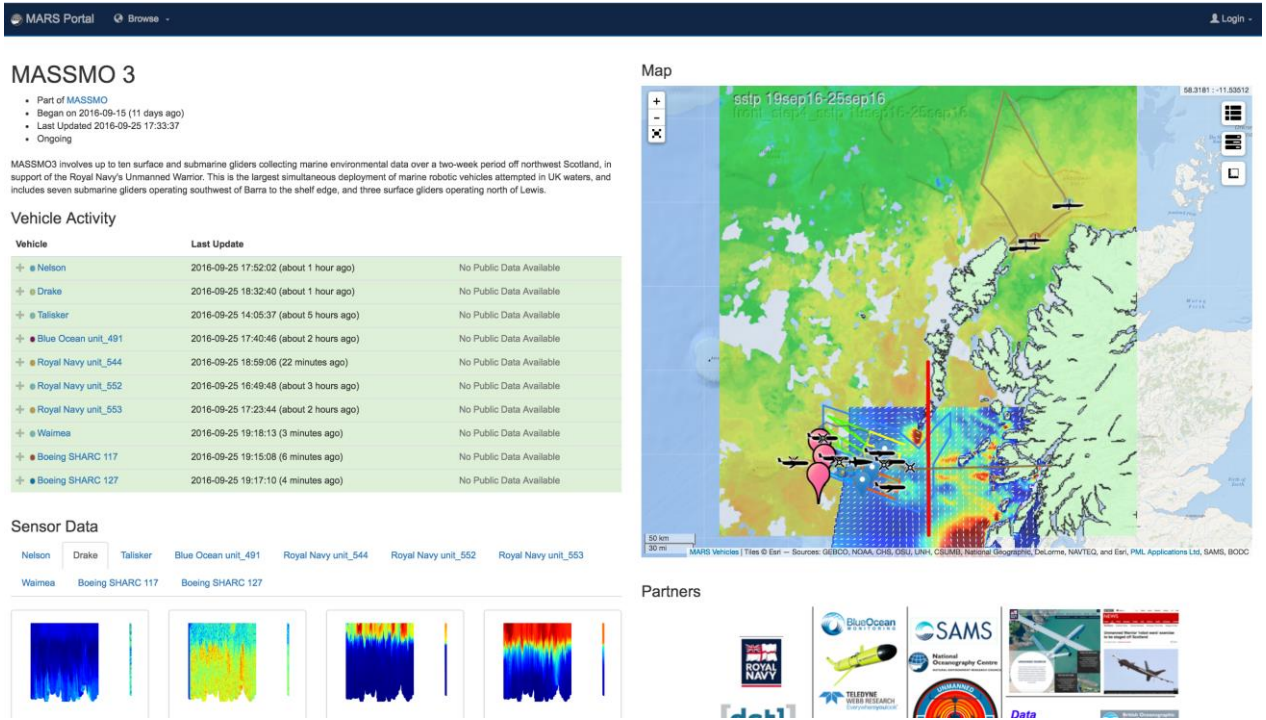
https://mars.noc.ac.uk

SINGLE CENTRALIZED TOOL

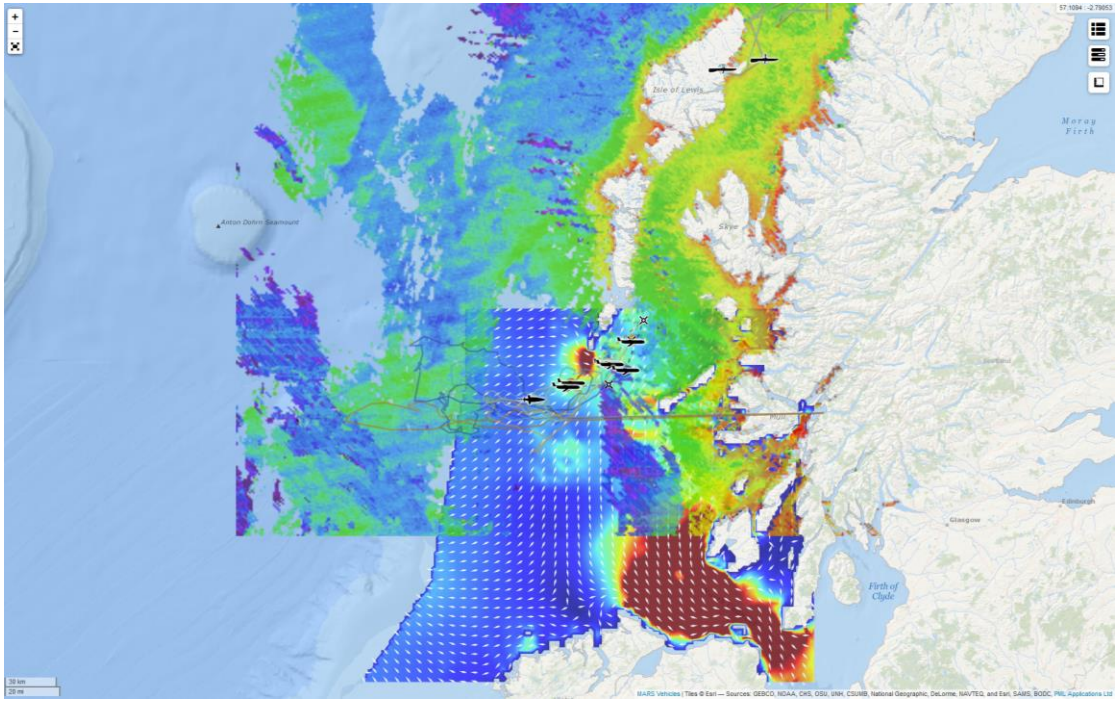
Mission Planning



Operational Dashboard



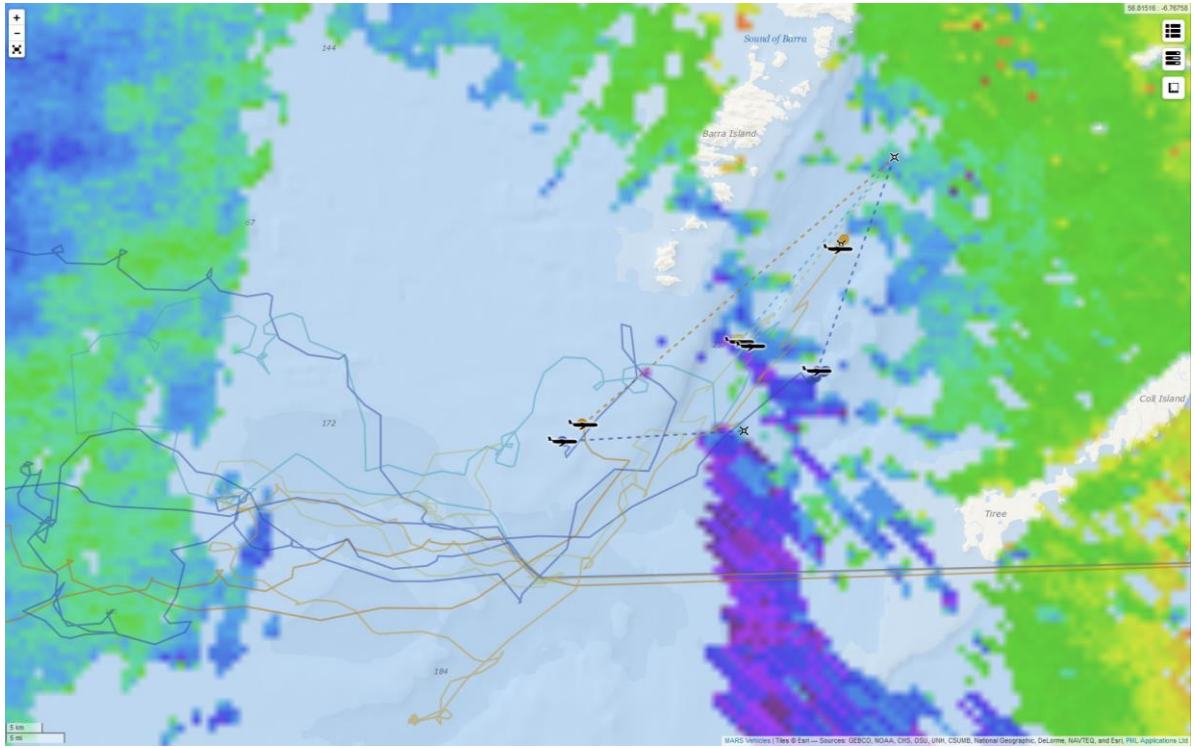
Environmental Information



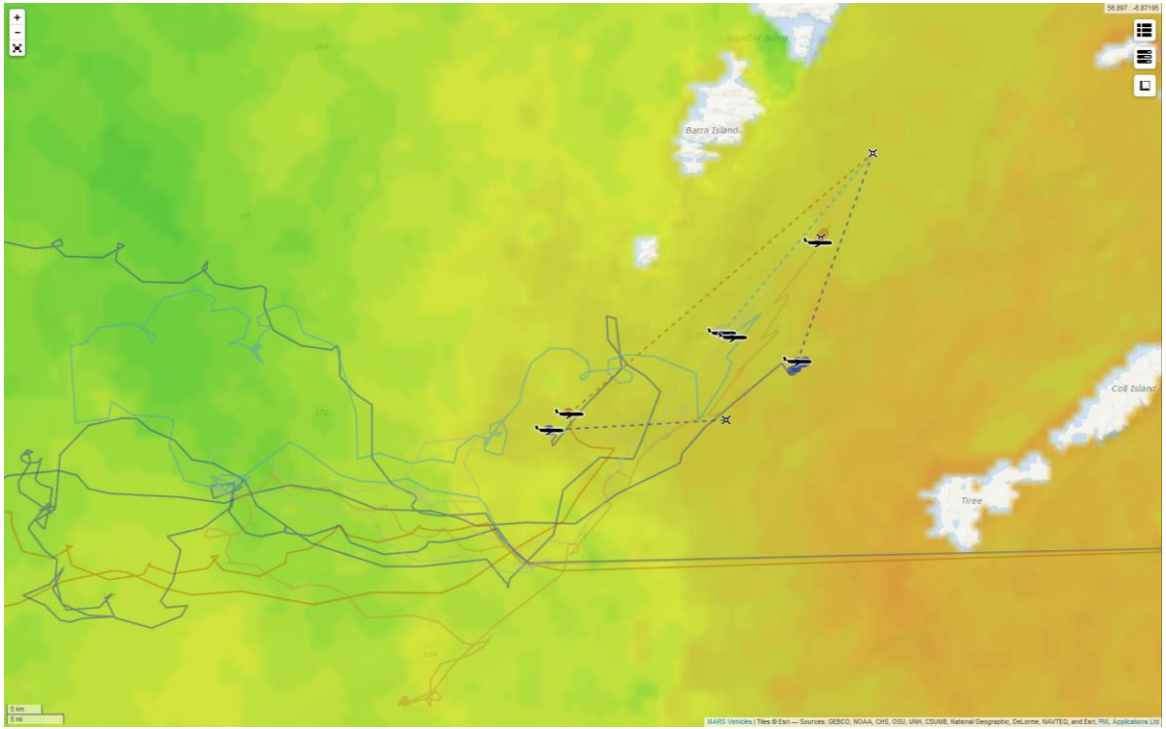
Product Providers

- PML-NEODASS
  - Chlorophyll
  - SST
  - Fronts
- NOCL & BRUNCIN
  - Tides

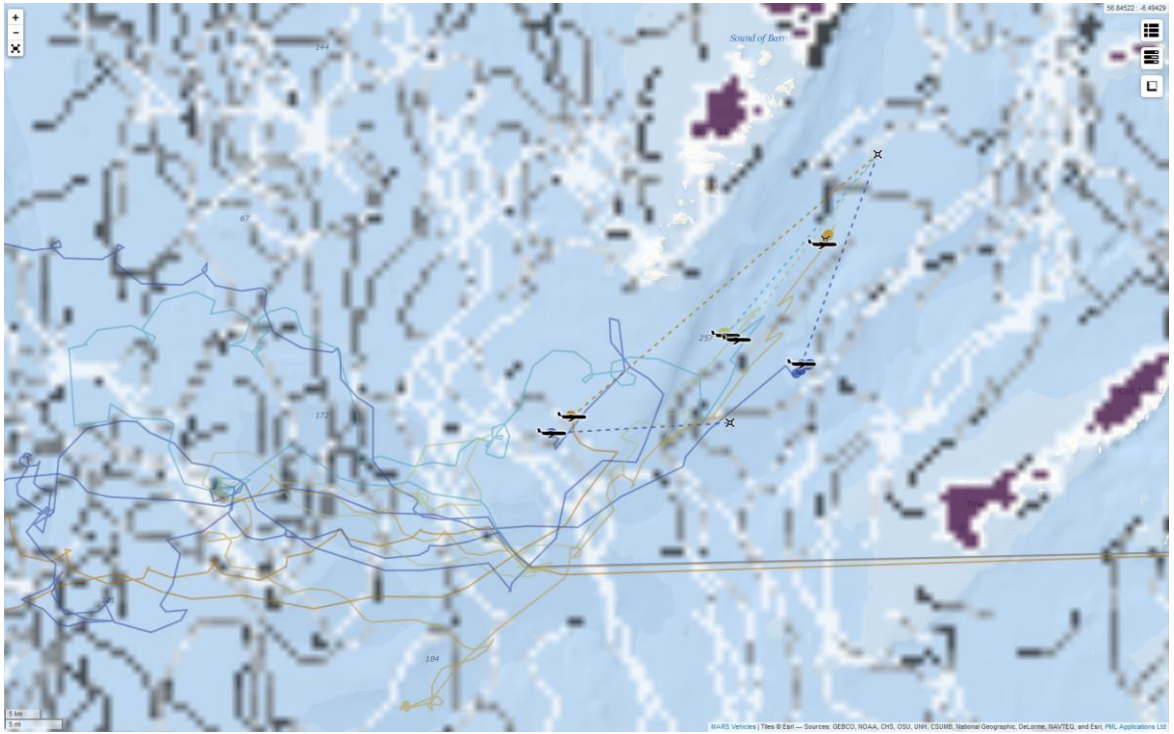
Chlorophyll (NEODASS)



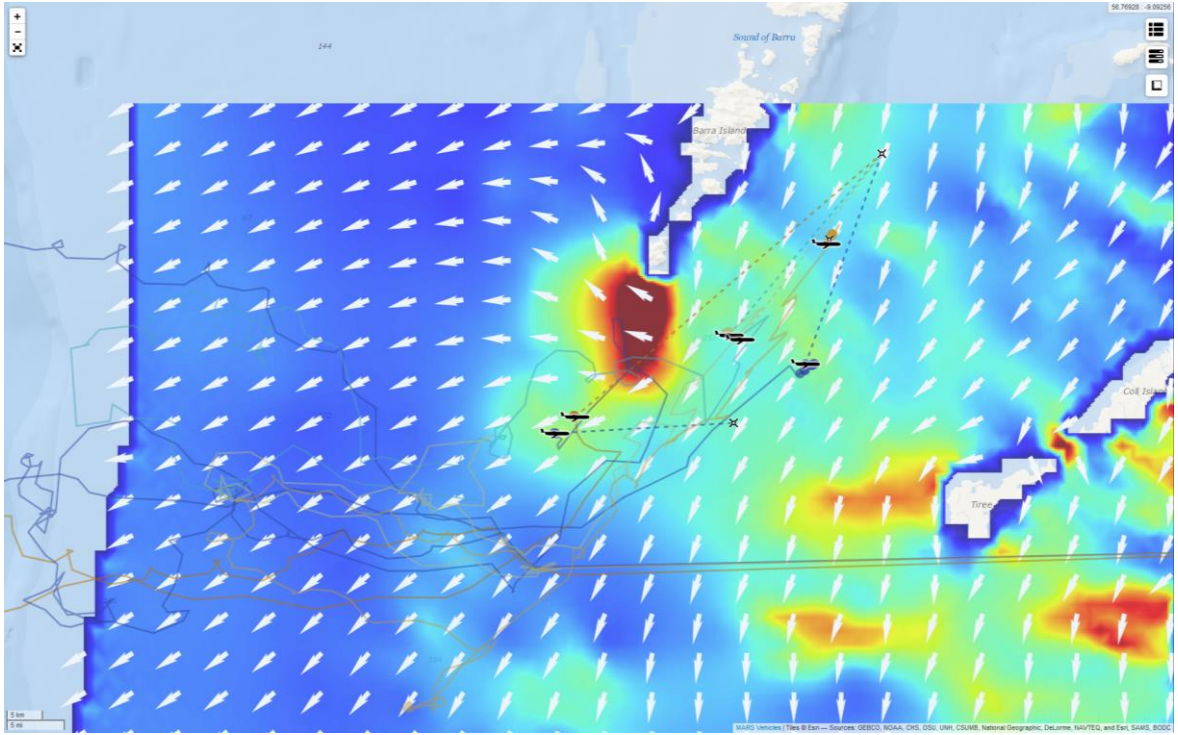
SST (NEODASS)



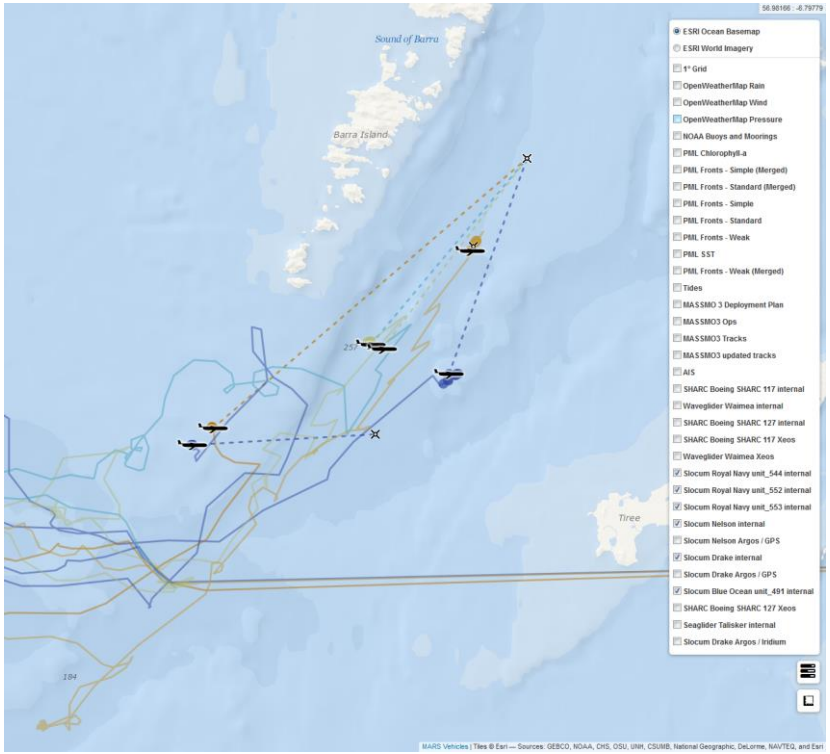
Ocean Fronts (NEODASS)



Tides (NOCL)



Configurable Layers



Fleet Status

MASSMO 3

Edit | Delete

- Inactive
- Part of MASSMO
- Began on 2016-09-15 (2 months ago)
- Last Updated 2016-11-01 12:14:04
- Finished on 2016-10-02 (a month ago)

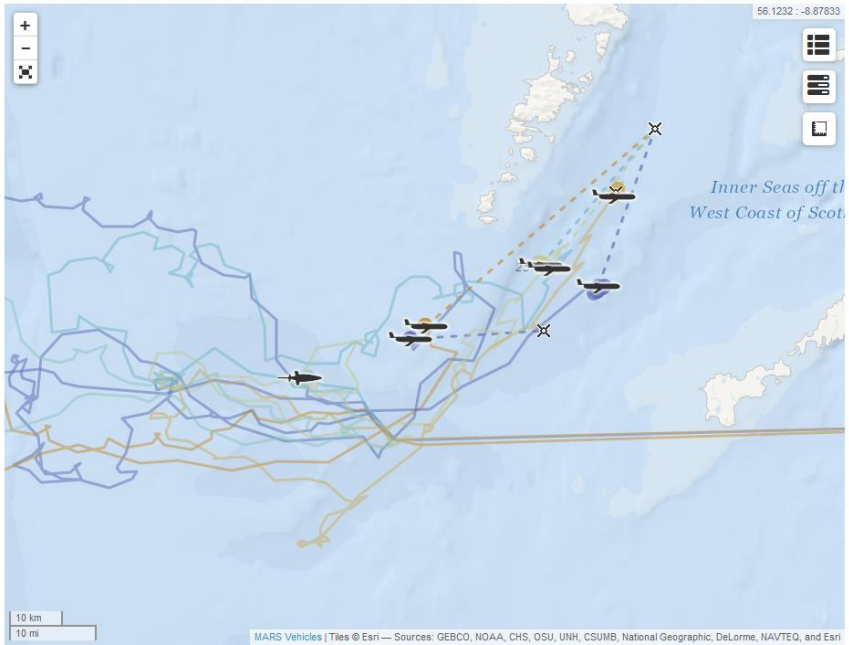
MASSMO3 involves up to ten surface and submarine gliders collecting marine environmental data over a two-week period off northwest Scotland, in support of the Royal Navy's Unmanned Warrior. This is the largest simultaneous deployment of marine robotic vehicles attempted in UK waters, and includes seven submarine gliders operating southwest of Barra to the shelf edge, and three surface gliders operating north of Lewis.

Vehicle Activity

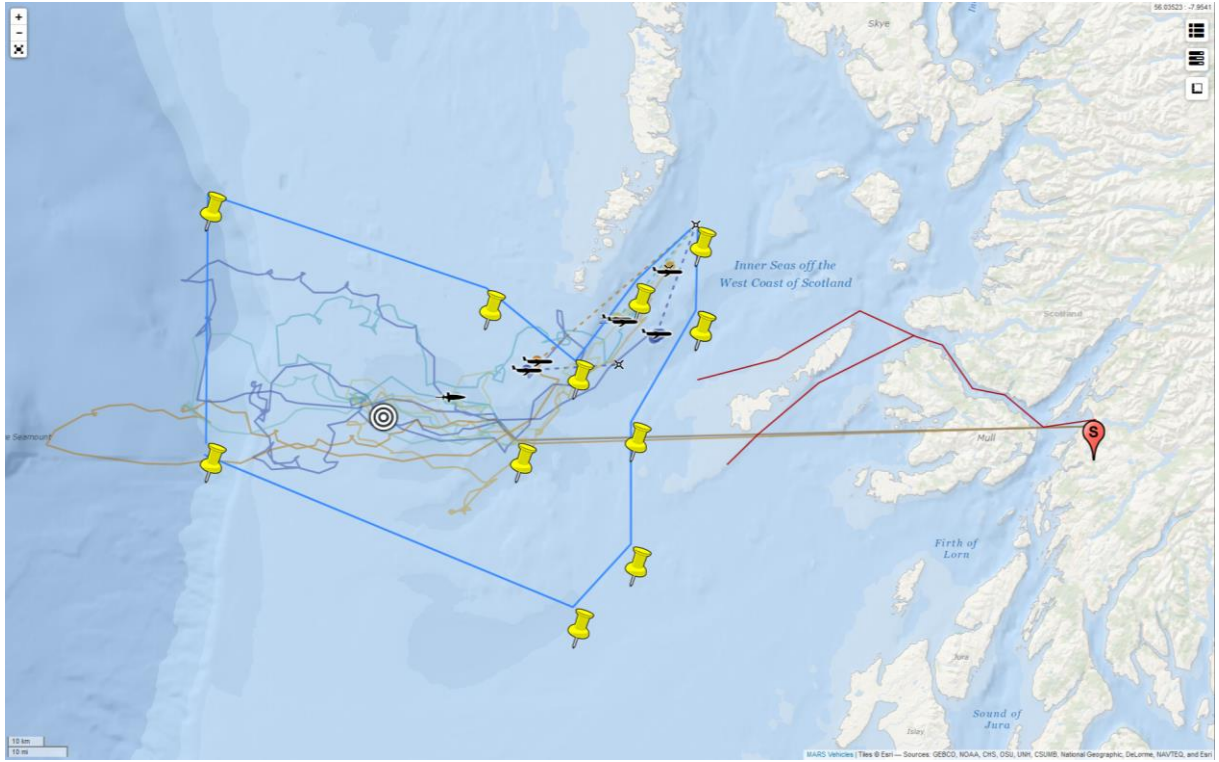
Assign

Vehicle	Last Update	Distance (N. Mi.)
Nelson	2016-10-01 14:39:05 (a month ago)	179.22
Drake	2016-10-01 14:21:15 (a month ago)	167.98
Talisker	2016-09-30 14:22:28 (2 months ago)	157.51
Blue Ocean unit_491	2016-10-01 12:10:19 (a month ago)	233.27
Royal Navy unit_544	2016-10-01 18:06:10 (a month ago)	200.40
Royal Navy unit_552	2016-10-01 17:50:58 (a month ago)	269.87
Royal Navy unit_553	2016-10-01 15:16:37 (a month ago)	266.59
Waimea	2016-10-02 23:58:06 (a month ago)	406.83
Boeing SHARC 117	2016-10-03 00:00:00 (a month ago)	458.31
Boeing SHARC 127	2016-10-02 23:55:36 (a month ago)	472.53

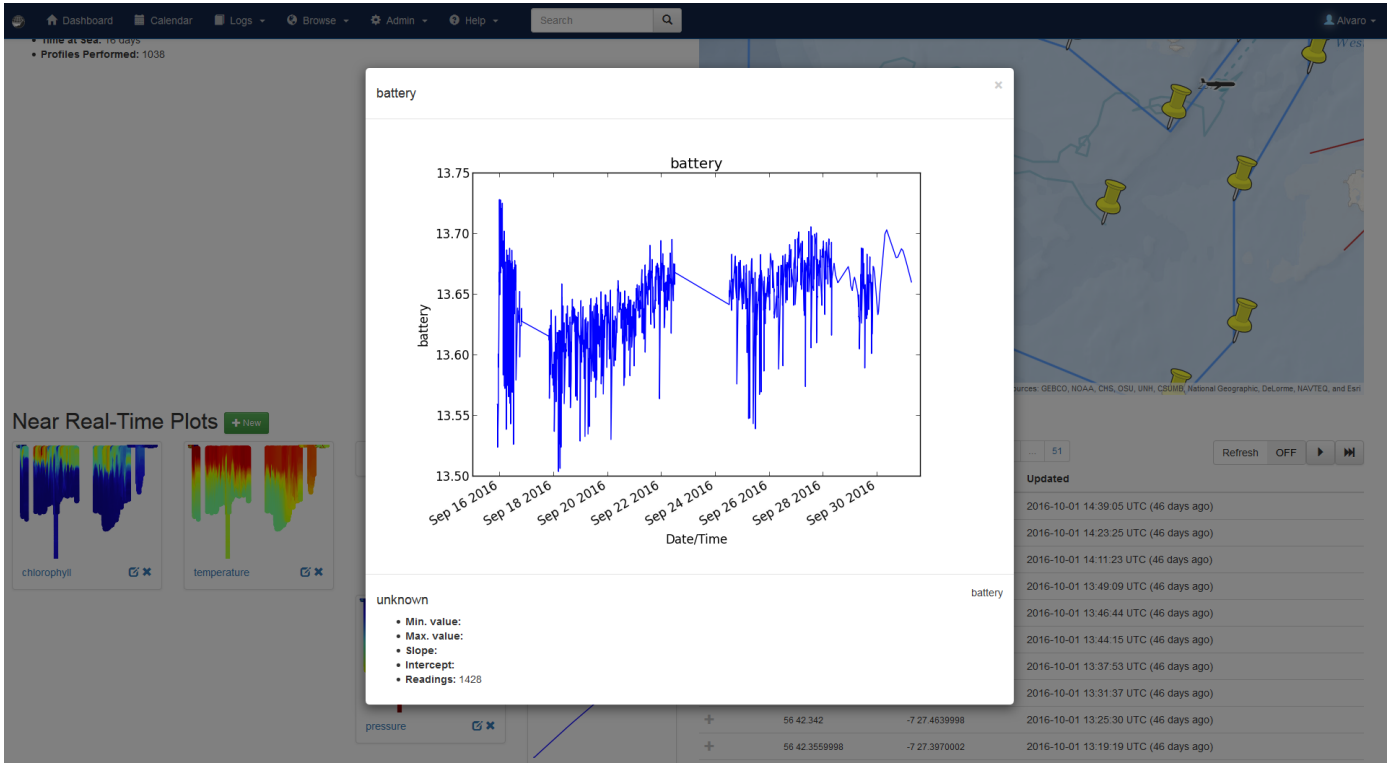
Map



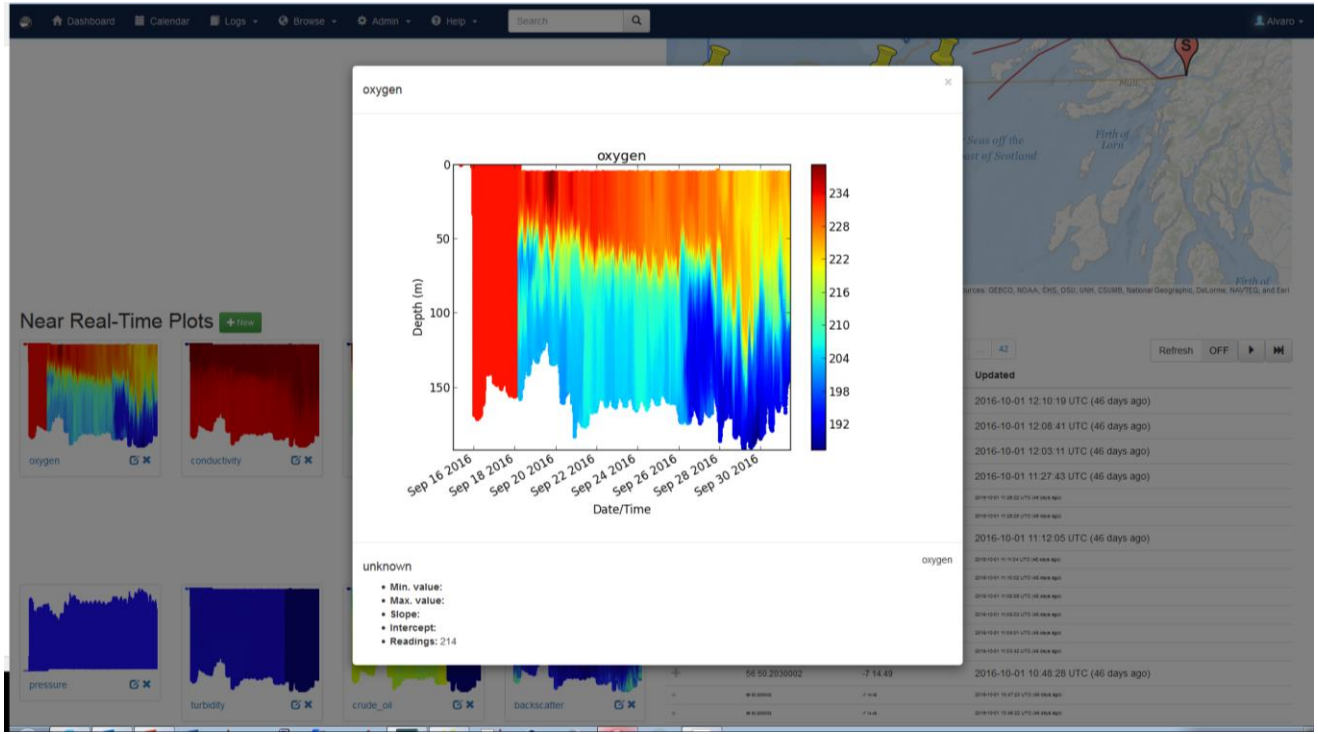
Fleet Status



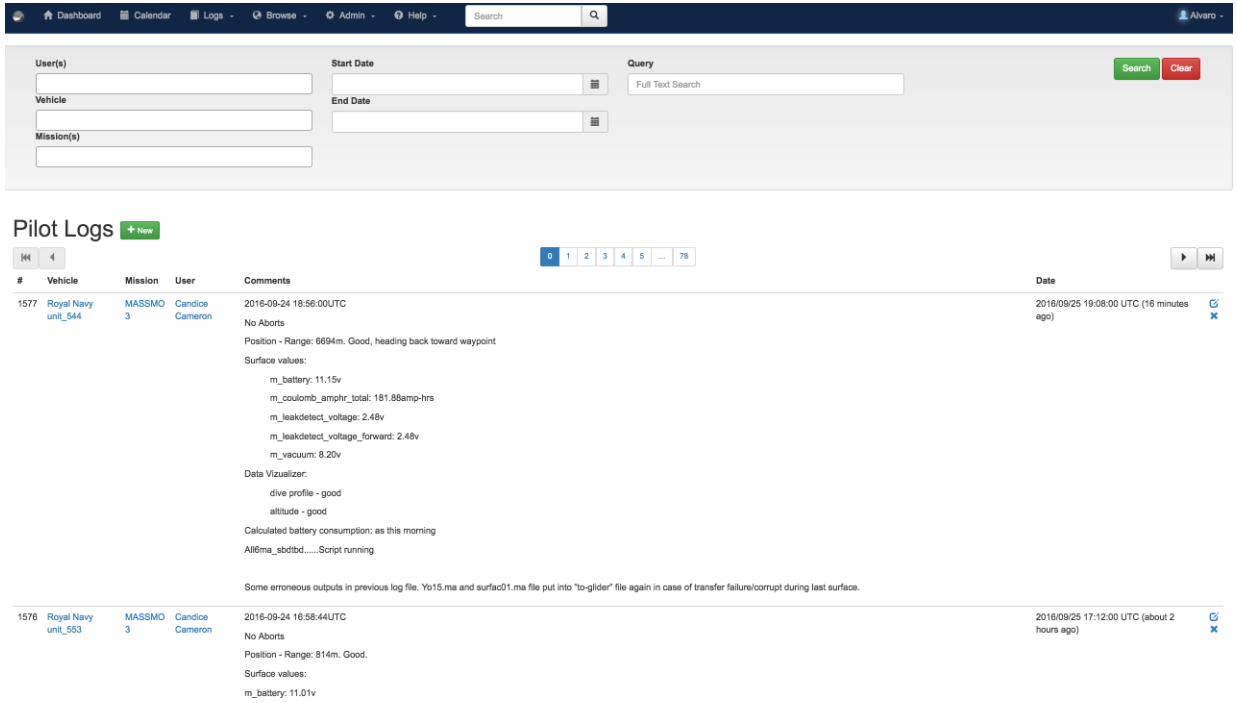
Vehicle Performance



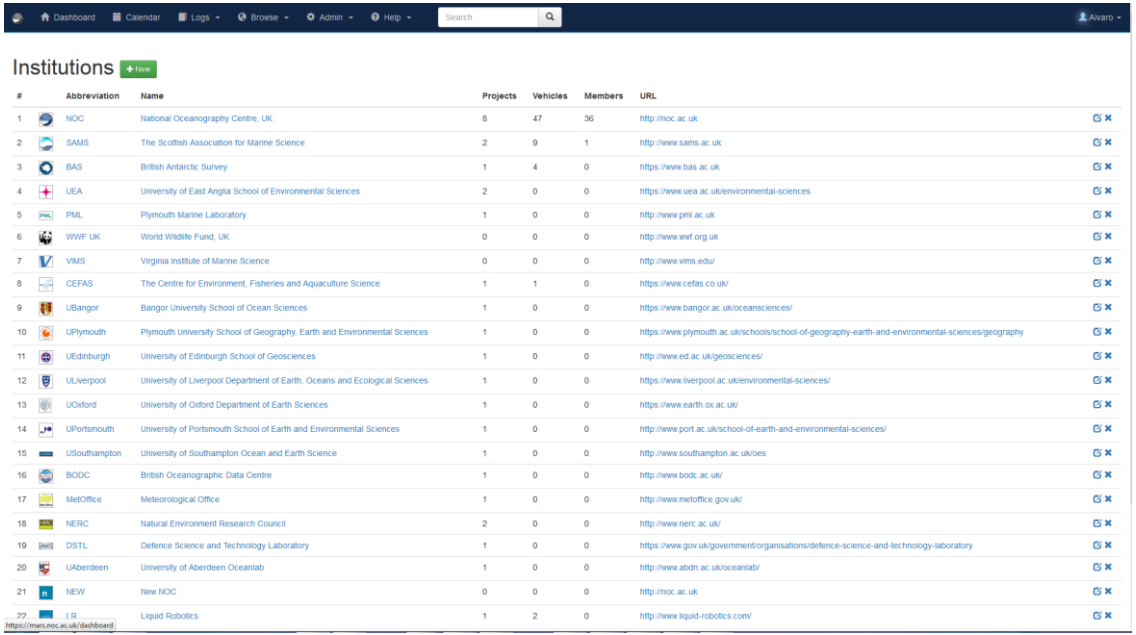
Data Display



Operations Log



A platform for the Community



#		Abbreviation	Name	Projects	Vehicles	Members	URL
1		NOC	National Oceanography Centre, UK	8	47	36	http://noc.ac.uk
2		SAMS	The Scottish Association for Marine Science	2	9	1	http://www.sams.ac.uk
3		BAS	British Antarctic Survey	1	4	0	https://www.bas.ac.uk
4		UEA	University of East Anglia School of Environmental Sciences	2	0	0	https://www.uea.ac.uk/environmental-sciences
5		PML	Plymouth Marine Laboratory	1	0	0	http://www.pml.ac.uk
6		WWF UK	World Wildlife Fund, UK	0	0	0	http://www.wwf.org.uk
7		VIMS	Virginia Institute of Marine Science	0	0	0	http://www.vims.edu/
8		CEFAS	The Centre for Environment, Fisheries and Aquaculture Science	1	1	0	https://www.cefas.co.uk/
9		UBangor	Bangor University School of Ocean Sciences	1	0	0	https://www.bangor.ac.uk/oceansciences/
10		UPlymouth	Plymouth University School of Geography, Earth and Environmental Sciences	1	0	0	https://www.plymouth.ac.uk/schools/school-of-geography-earth-and-environmental-sciences/geography
11		UEdinburgh	University of Edinburgh School of Geosciences	1	0	0	http://www.ed.ac.uk/geosciences/
12		ULiverpool	University of Liverpool Department of Earth, Oceans and Ecological Sciences	1	0	0	https://www.liverpool.ac.uk/environmental-sciences/
13		UOxford	University of Oxford Department of Earth Sciences	1	0	0	https://www.earth.ox.ac.uk/
14		UPortsmouth	University of Portsmouth School of Earth and Environmental Sciences	1	0	0	http://www.port.ac.uk/school-of-earth-and-environmental-sciences/
15		USouthampton	University of Southampton Ocean and Earth Science	1	0	0	http://www.southampton.ac.uk/oes
16		BODC	British Oceanographic Data Centre	1	0	0	http://www.bodc.ac.uk/
17		MetOffice	Meteorological Office	1	0	0	http://www.metoffice.gov.uk/
18		NERC	Natural Environment Research Council	2	0	0	http://www.nerc.ac.uk/
19		DSTL	Defence Science and Technology Laboratory	1	0	0	https://www.gov.uk/government/organisations/defence-science-and-technology-laboratory
20		UAberdeen	University of Aberdeen Oceanlab	1	0	0	http://www.abdn.ac.uk/oceanlab/
21		NEW	New NOC	0	0	0	http://noc.ac.uk
22		I R	Liquid Robotics	1	2	0	http://www.liquid-robotics.com/

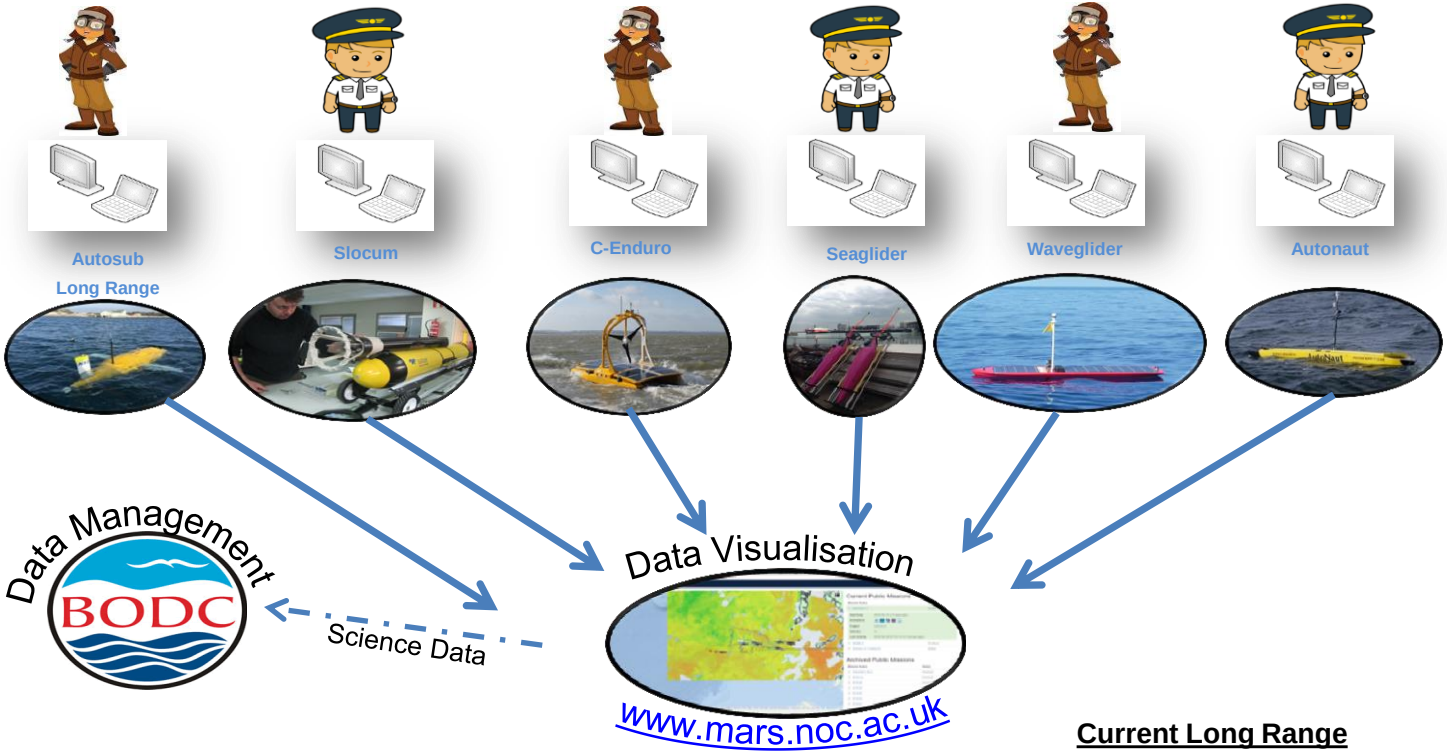
Lessons Learnt

- Having a web based tool makes thing easier:
    - Accessible everywhere
    - People are familiar with web technologies
- It is a good platform to absorb quick changes.
- Works well for outreach.
- Lot of things to be done yet:
    - Centralize comms through the site. Emails are undesirable.
    - We can do better in terms of visualization: more reliable and interactive

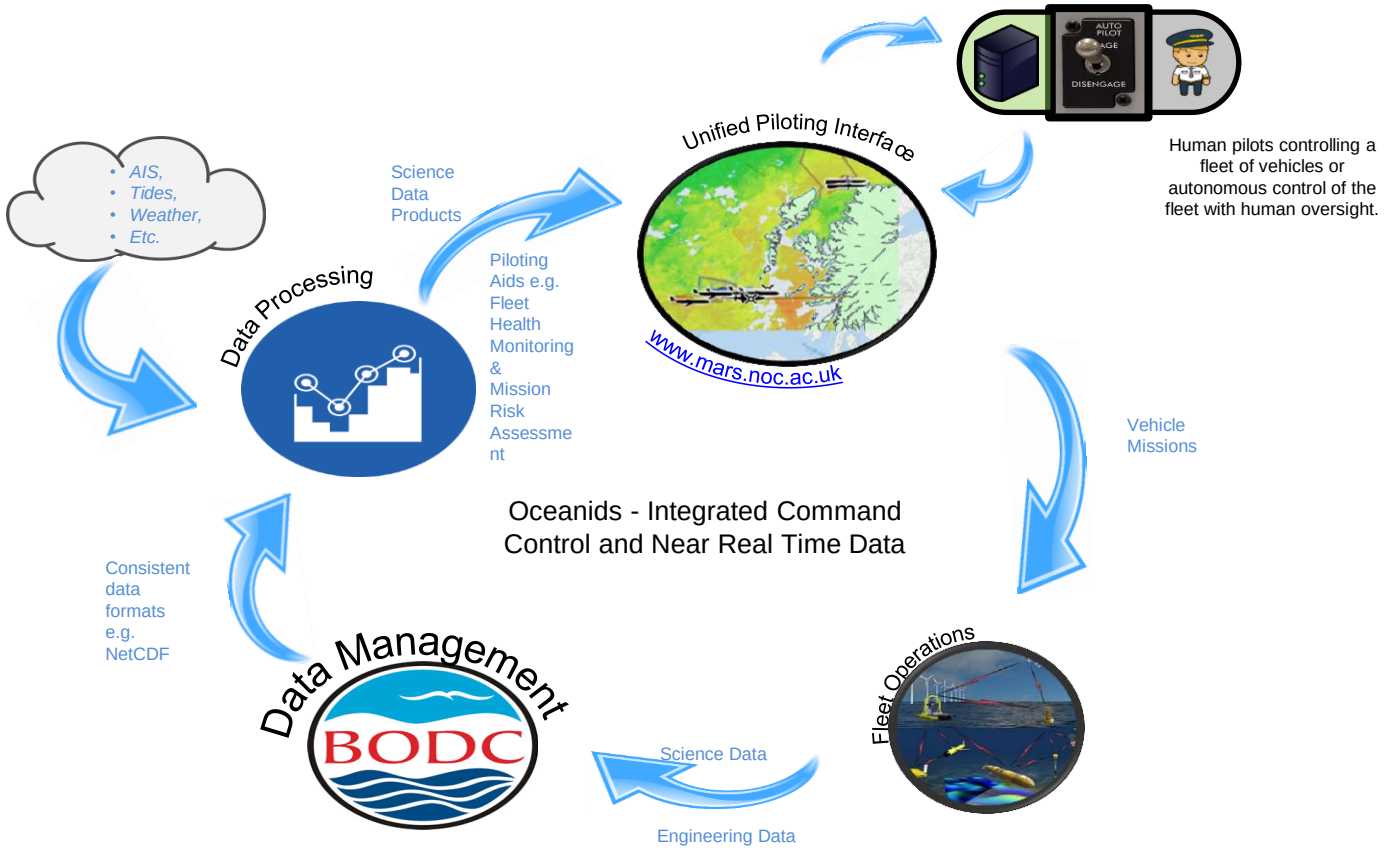
Just a visualization tool (yet)

The Future

- Full integration of all fleet platforms
- Integration of the UK community needs
- Host other institutions
- Connect with more Datacentres
- Help on Data Delivery
- Improve visualization
- Better human interfaces
- More clever “stuff” everywhere



Current Long Range Operations


AUTO PILOT
DISENGAGE
Unified Piloting Interface
Human pilots controlling a fleet of vehicles or autonomous control of the fleet with human oversight.
• AIS,
• Tides,
• Weather,
• Etc.
Science Data Products
Piloting Aids e.g. Fleet Health Monitoring & Mission Risk Assessment
Data Processing
www.mars.noc.ac.uk
Vehicle Missions
Oceanids - Integrated Command Control and Near Real Time Data
Consistent data formats e.g. NetCDF
Data Management
BODC
Fleet Operations
Science Data
Engineering Data


Happy Scientist
Data Management
BODC
Science Data
Unified Piloting & Visualization
www.mars.noc.ac.uk

OCEANIDS C&C

- Part of a group of NERC funded projects (15M)
- Objectives:
  - Develop a national C&C infrastructure, open to all the UK Oceanographic Community.
  - Offer a unified piloting experience across platforms.
  - Improve the data delivery, making the process transparent to the end users (scientists).
  - Create a infrastructure able to cope with future challenges:
    - Advance Autonomy (AI)
    - Big Data
    - Resilient System
    - Advance Products – Data Fusion

People

Please Contact Us

Alvaro Lorenzo
OCEANIDS C2 Technical Leader

allore@noc.ac.uk

Alexander Phillips
OCEANIDS C2 Project Manager

abp@noc.ac.uk

https://mars.noc.ac.uk

Peter Miller

Plymouth Marine Laboratory PML

Satellite imaging in support of MAS operations

PML | Applications Ltd

Marine Matters

Satellite imaging in support of marine autonomous system operations

Peter Miller

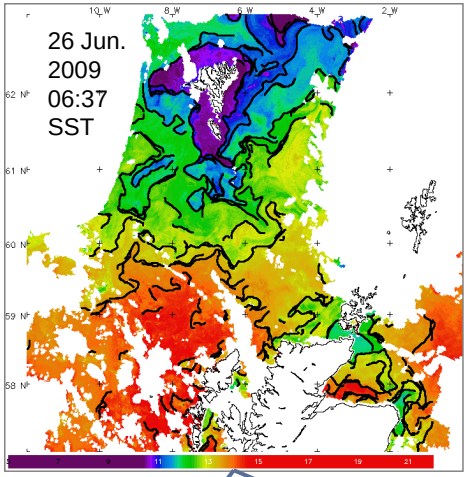
MASSMO 2/3 Workshop
NOC, 18 Nov. 2016

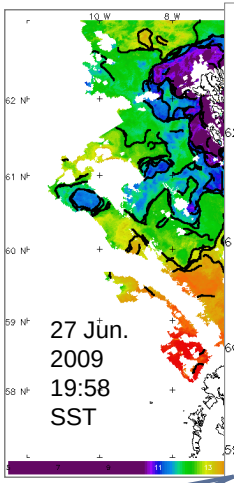
PML | Applications Ltd

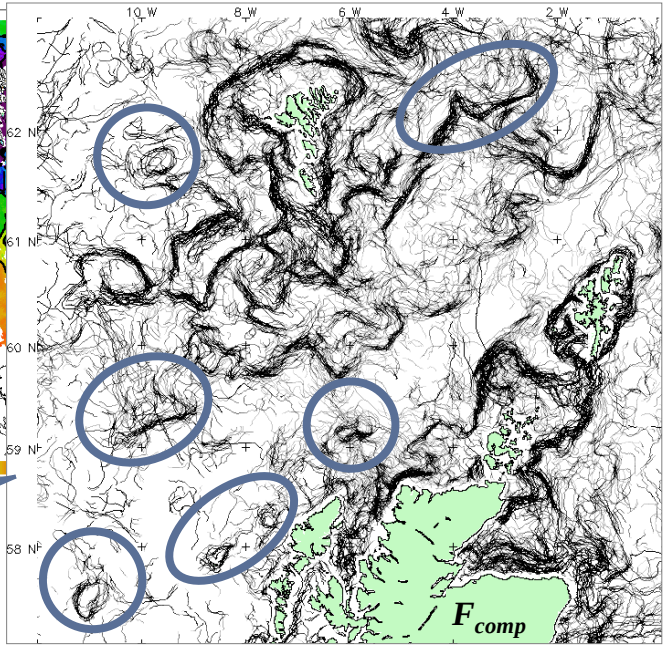
Satellite imaging for MAS operations

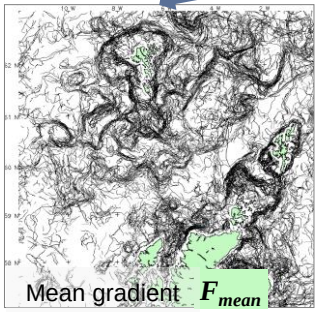
- Oceanic fronts overview
- Satellite data integration into MASSMO GIS
- Key satellite images for MASSMO-3 operations
- Next steps

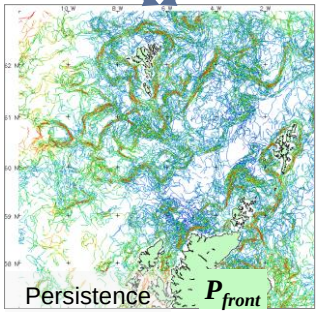
Oceanic fronts overview

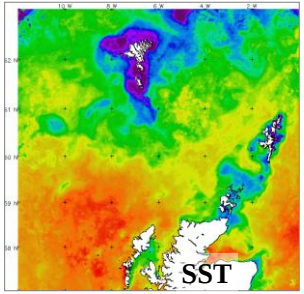




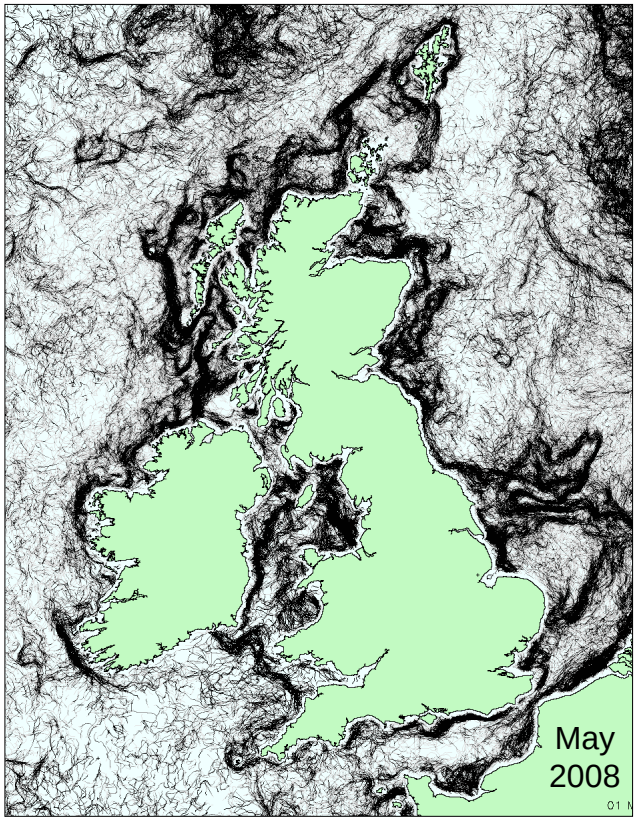


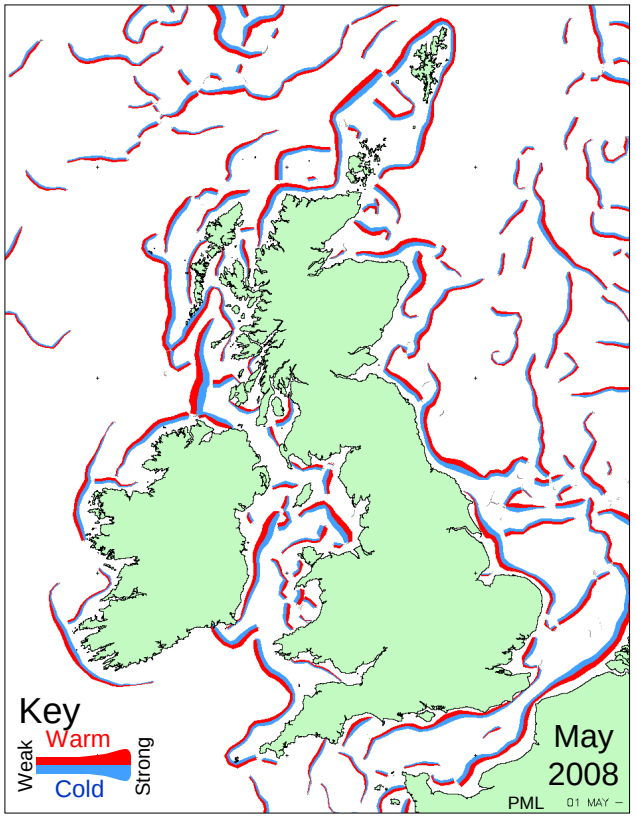




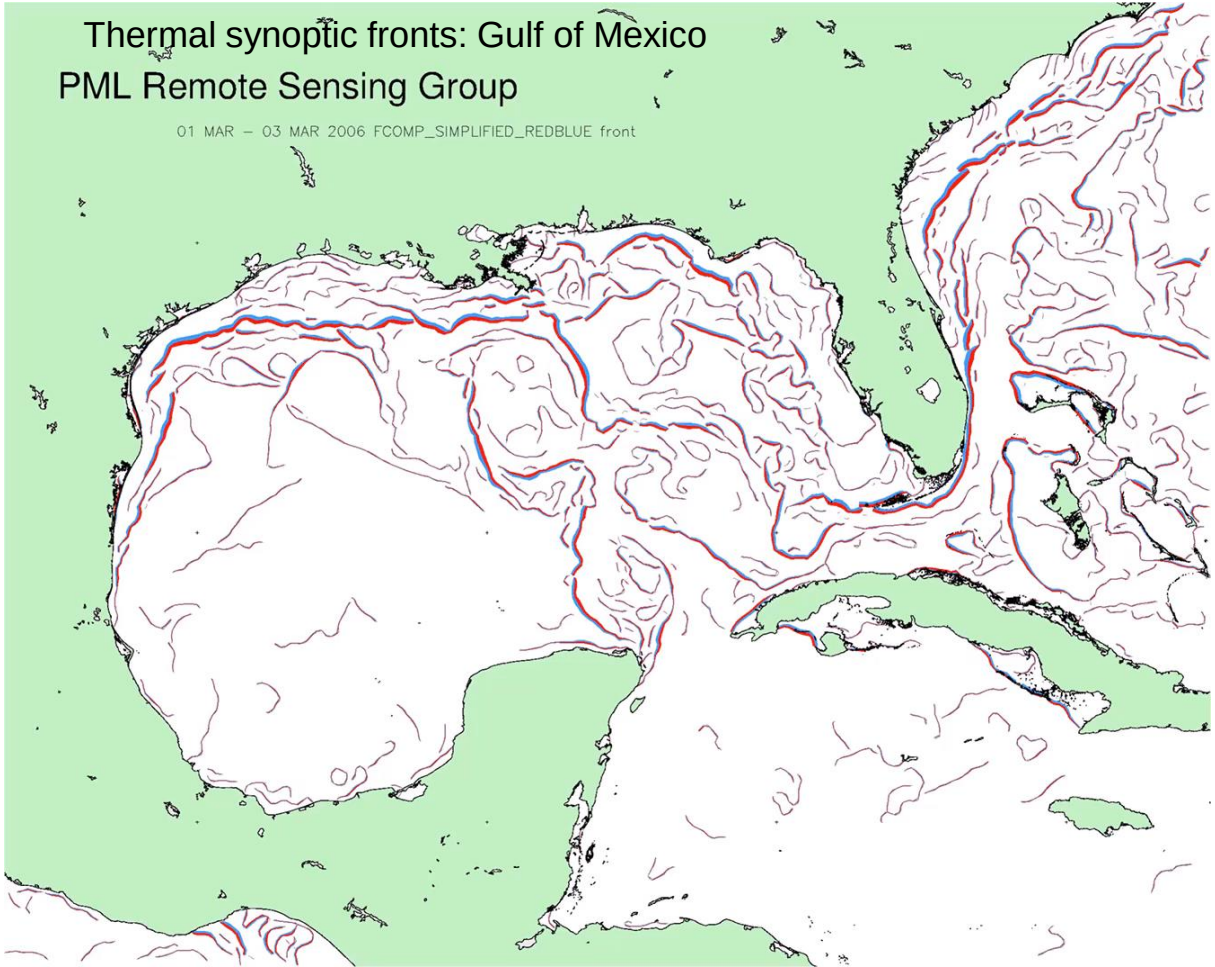


From spaghetti to synoptic front map





Visualising dynamic and transient features



Daily 1km resolution SST;

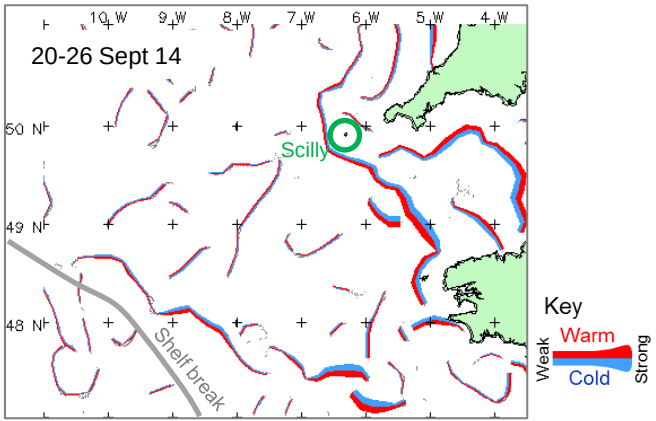
3-day front map; reduced smoothing

01 Mar–31 May 2006

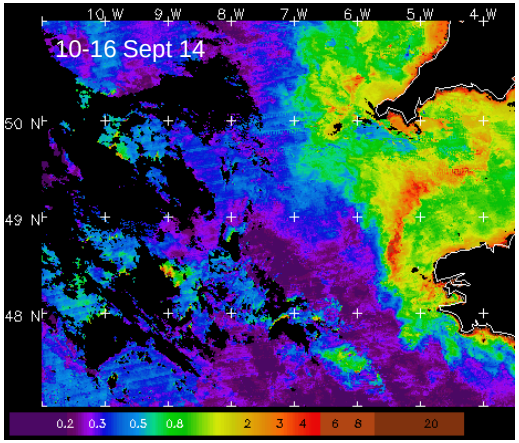
Experience from MASSMO 1

MASSMO Project, Sep. 2014

Marine Autonomous Systems in Support of Marine Observations

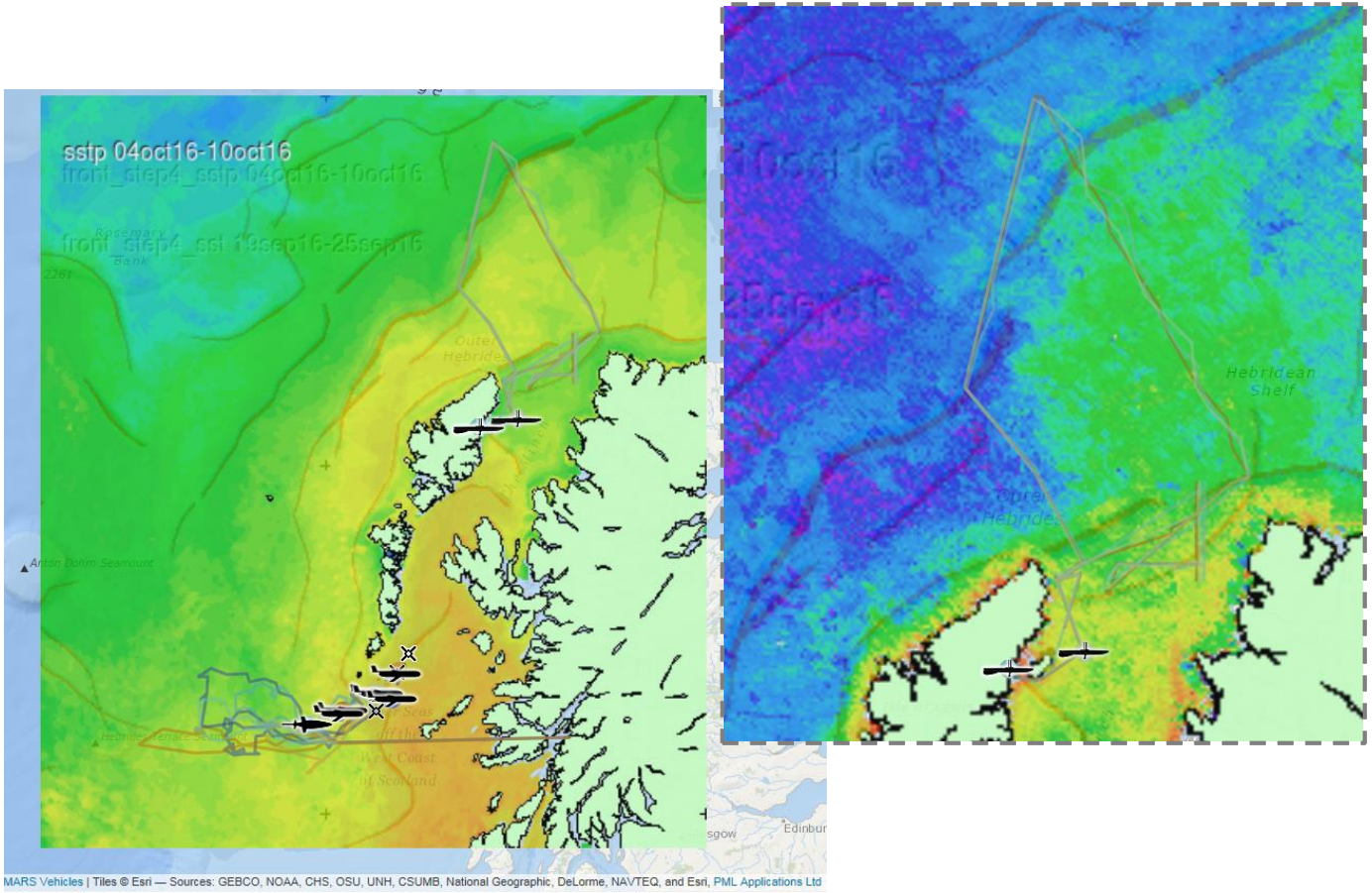


7-day thermal synoptic front map



7-day median chlorophyll-a map

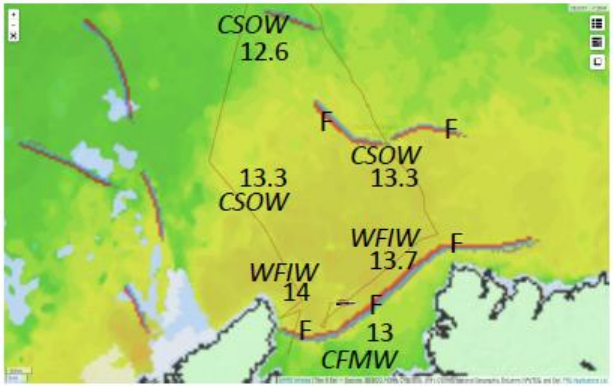
Satellite image integration using WebGIS



Key satellite images for MASSMO 3

25 Sep. 2016

SST map supplied by PML
Fronts marked as F (red = warmer side)
Green shading denotes SST <13°C
Thin brown line = Boeing SHARC 117 track

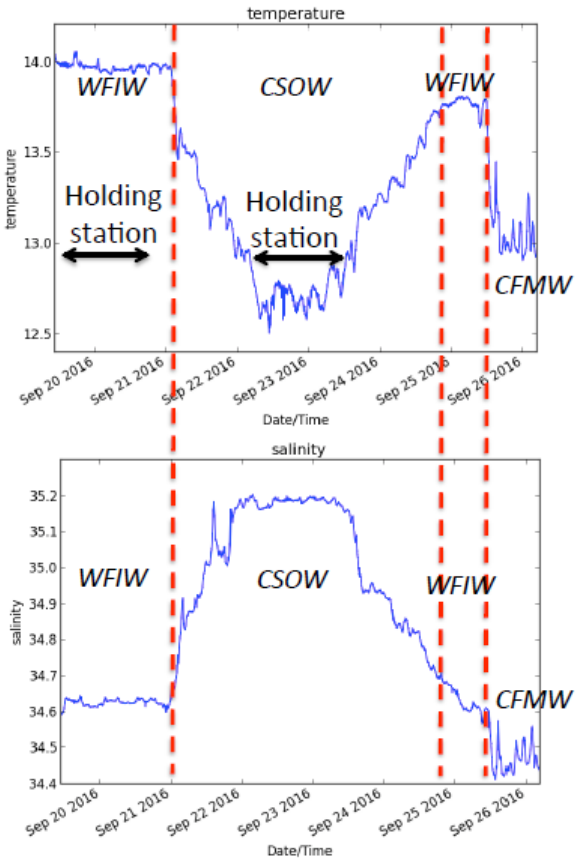


WFIW = Warmer, Fresher, Inshore Water
(14°C reducing to 13.7°C due to wind-driven mixing)

CSOW = Colder, Saltier, Offshore Water
(reducing offshore to a minimum of 12.6°C)

CFMW = Colder, Fresher, Mixed Water
(variable but averaging ~13°C)

Boeing SHARC 117 SST data

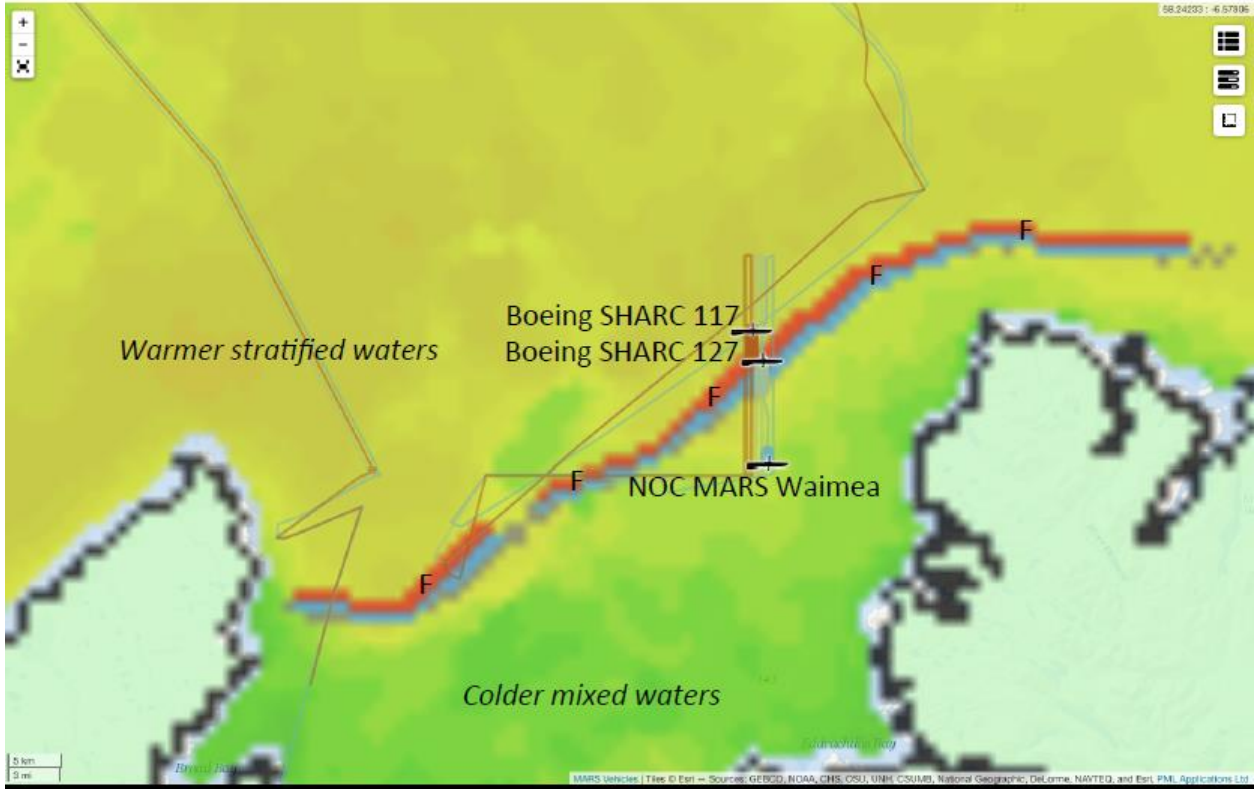


Key satellite images for MASSMO 3

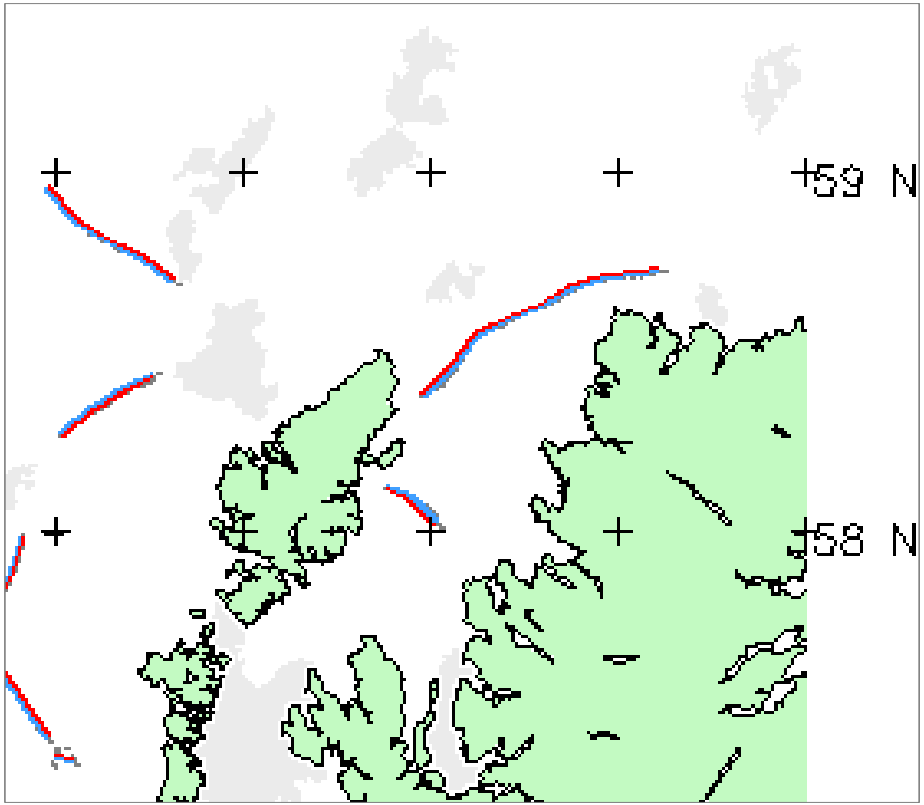
Wave Glider locations at 0630 hrs on 28 Sept 2016

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

The SST map shows colder mixed surface waters south of this front



Dynamic tidal mixing front



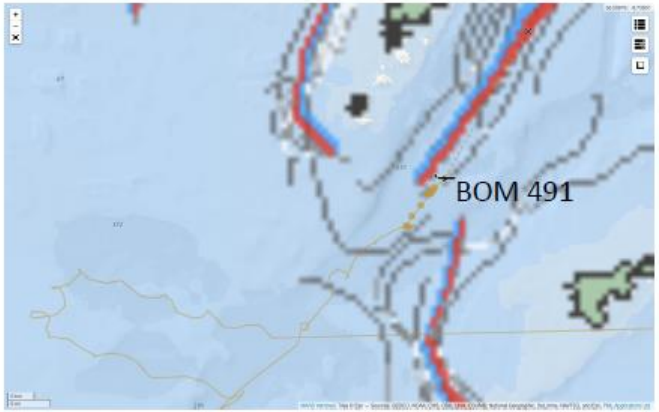
30 Sep. 2016

Key satellite images for MASSMO 3

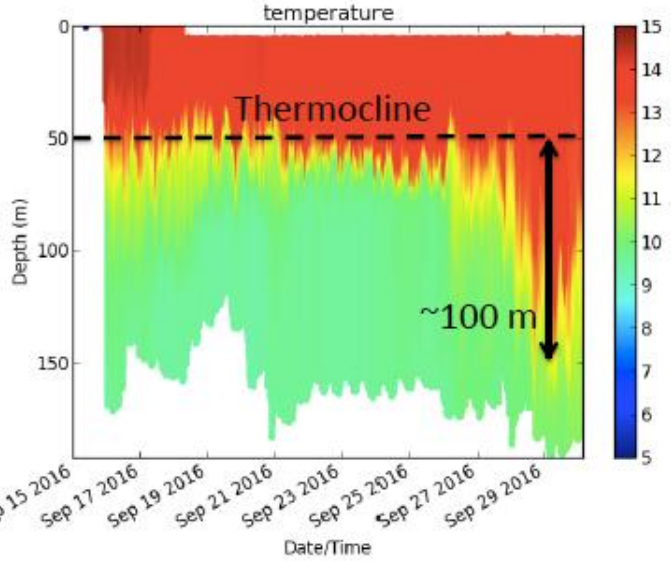
29 Sep. 2016

BOM491 temperature and salinity data

- BOM491 has recently crossed a frontal area with warmer mixed waters down to ~150 m
- Salinity data indicate presence of less saline waters of the Scottish Coastal Current (SCC)



Satellite front data from PML



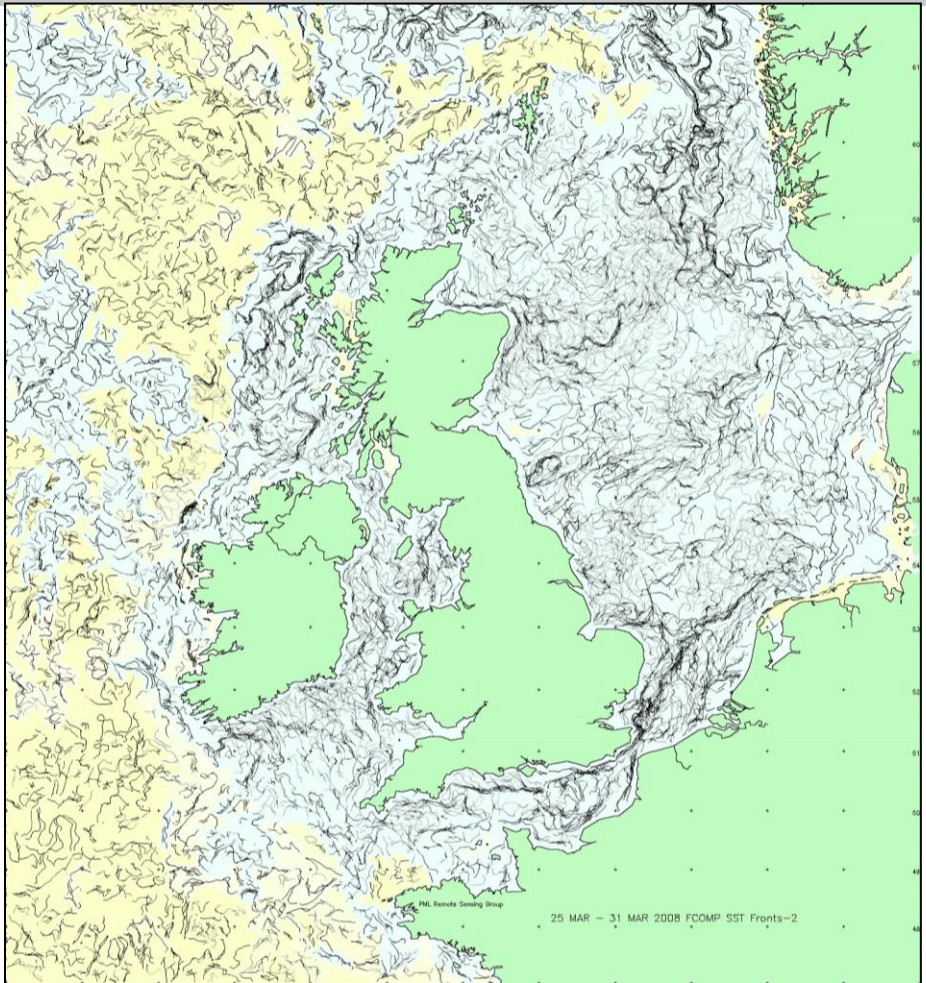
Communication with Navy and Dstl

MASSMO3 VIP Day, NOC, 29 Sep. 2016

Next stage: satellite vs. glider data

- Compare SST & fronts with glider transects
- Transient fronts (with Tim Clarke, Dstl)
- Timing of stratification
- Data visualisation using PML Web GIS

Revealing the timing of stratification



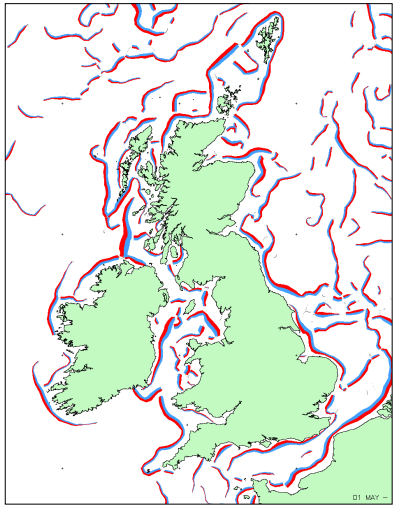
- Thermal composite front map animation.
- Daily-rolling 7-day maps.
- Apr-May 2008.

Revealing the timing of stratification

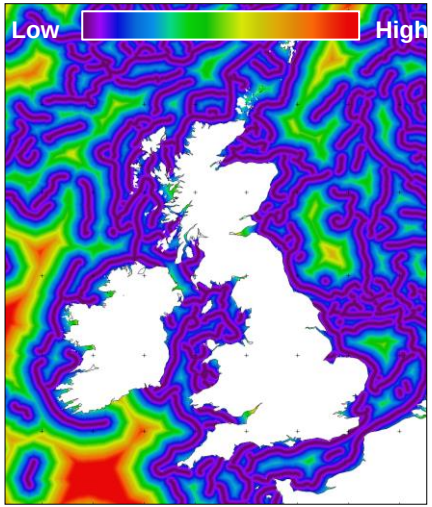
Sea-surface relationship:

Ignoring buoyancy frequency,
Richardson number, T profile, etc..

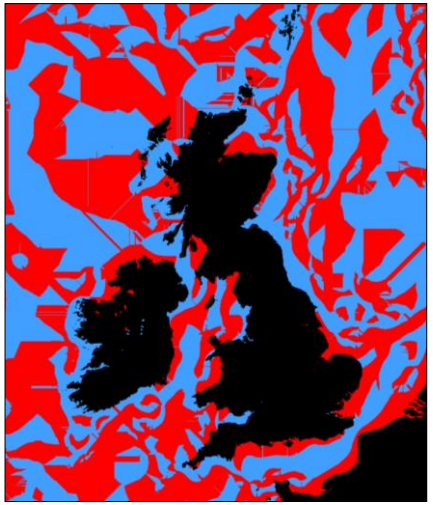
$$\Delta\, stratification = f(strength, distance, side, \ldots.)$$



Simplified front map



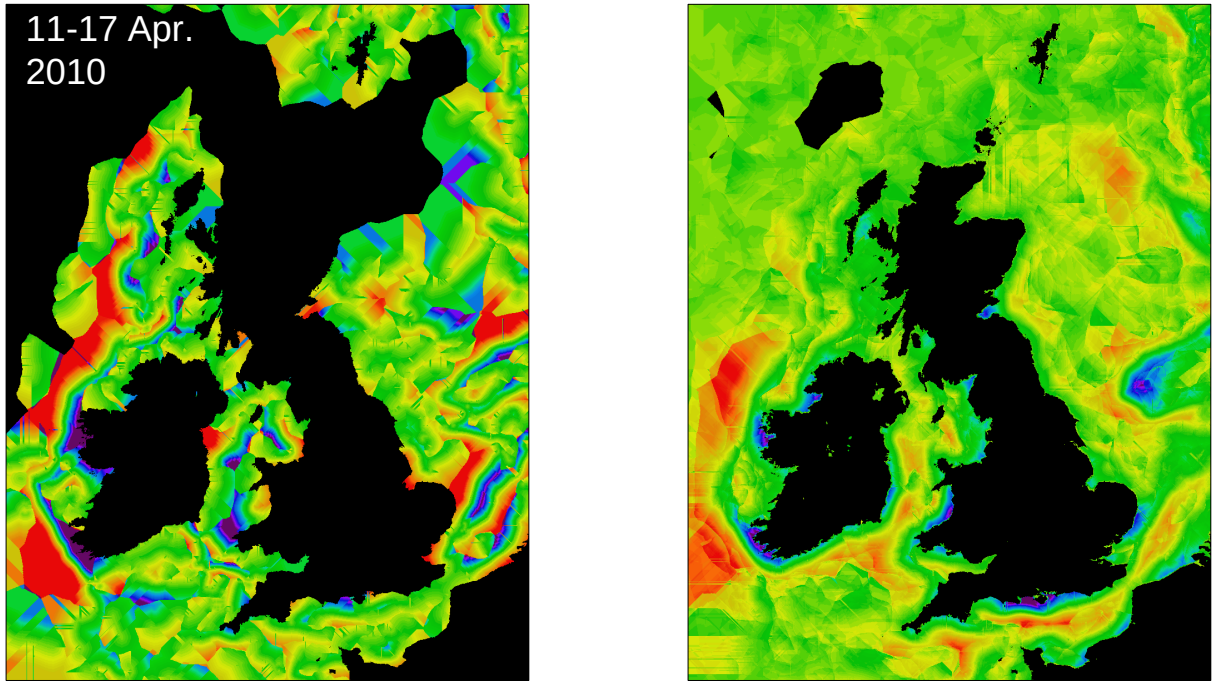
Nearest front distance



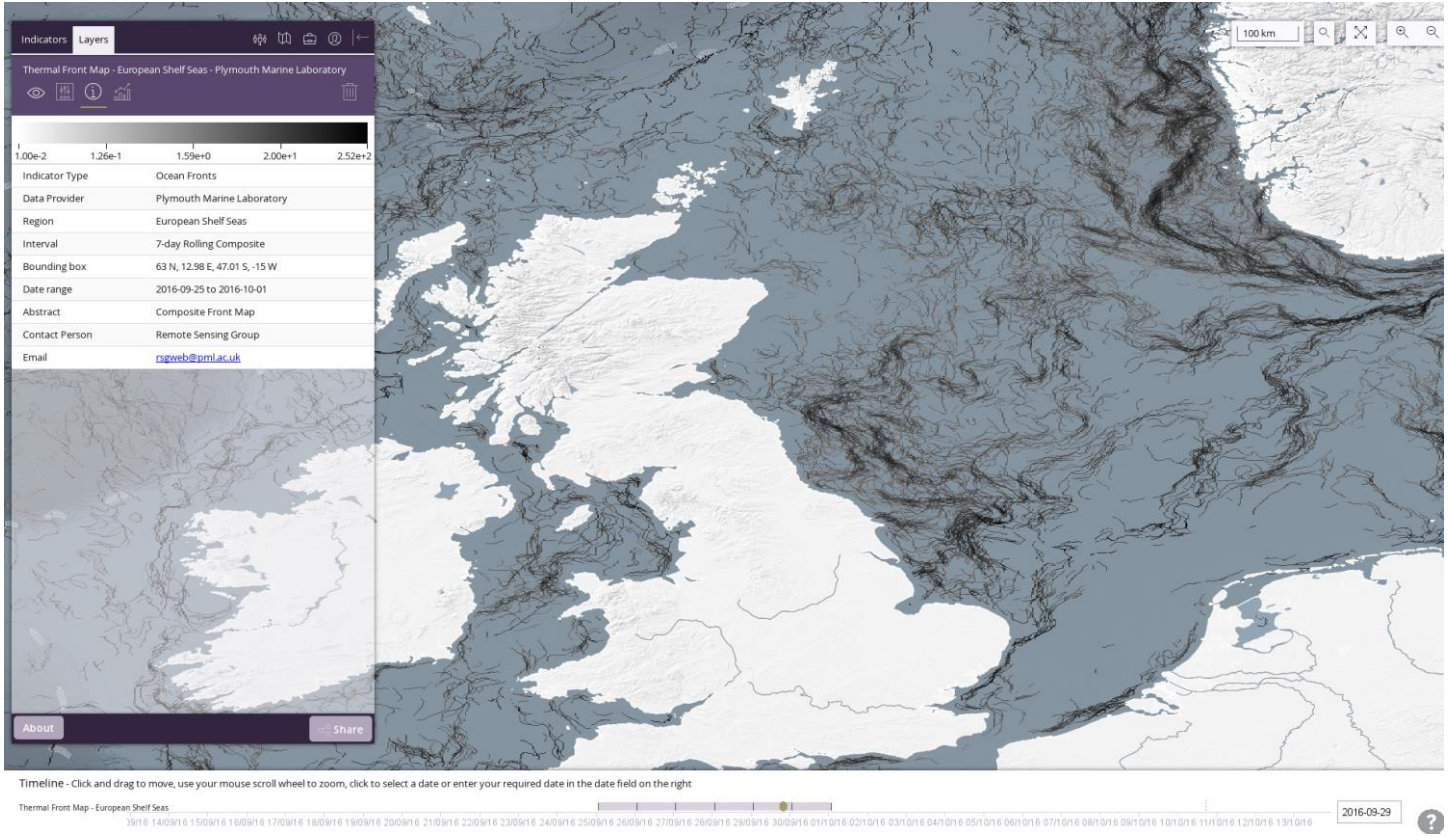
Nearest front side

‘Stratification’ map from remote sensing

$$\Delta\, stratification \qquad stratification_t \cong \sum_{i=0}^{t} \Delta stratification_i$$

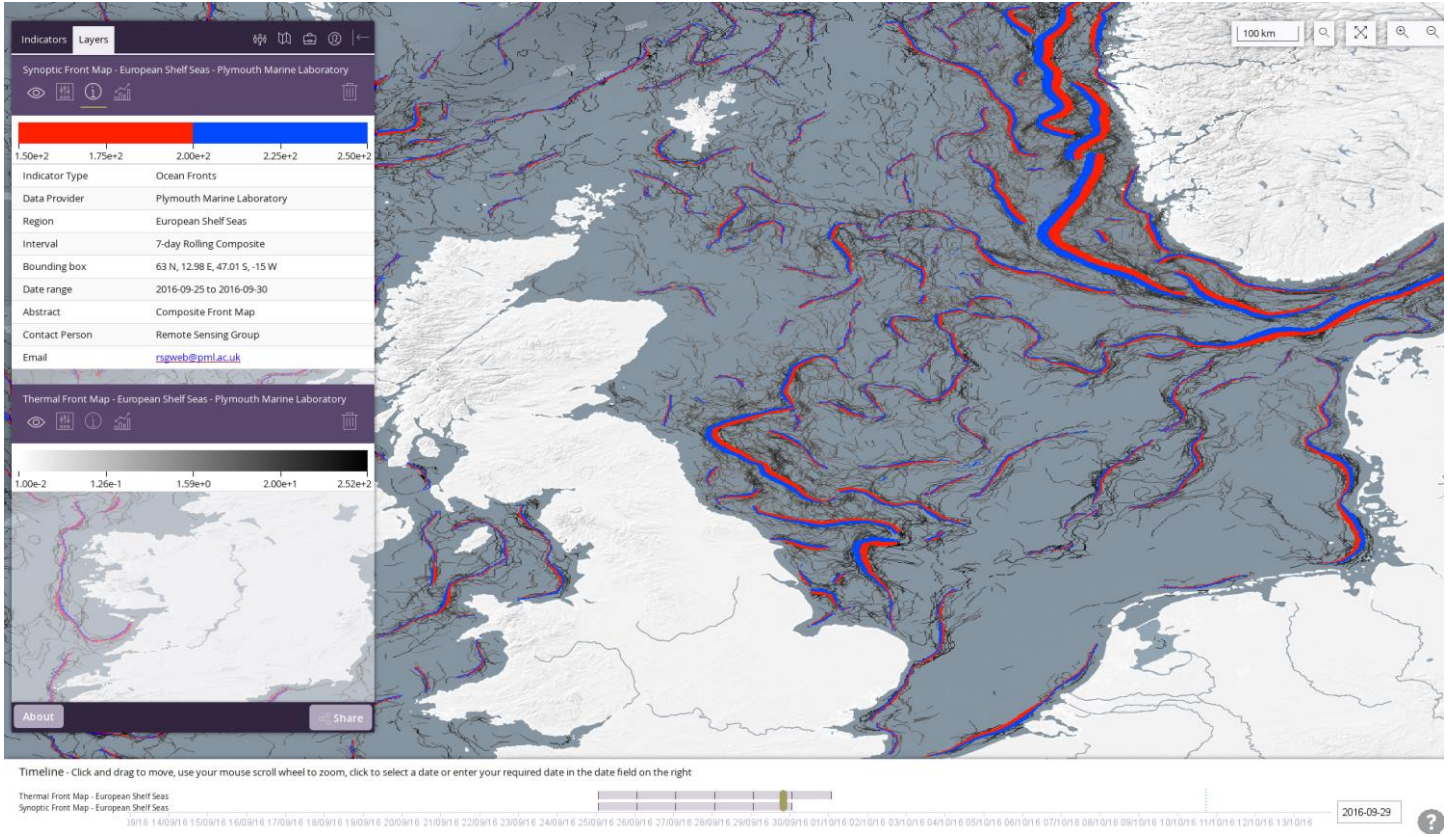


Fronts visualised in PML Data Portal



Thermal front map, 7-day analysis up to 30 Sep. 2016

Fronts visualised in PML Data Portal



Combining two layers: synoptic and thermal front map

PML | Applications Ltd

Satellite imaging for MAS operations

- Oceanic fronts overview
- Satellite data integration into MASSMO GIS
- Key satellite images for MASSMO-3 operations
- Next steps

More info about PML fronts: tinyurl.com/pmlfronts

pim@pml.ac.uk

Dr Justin Buck

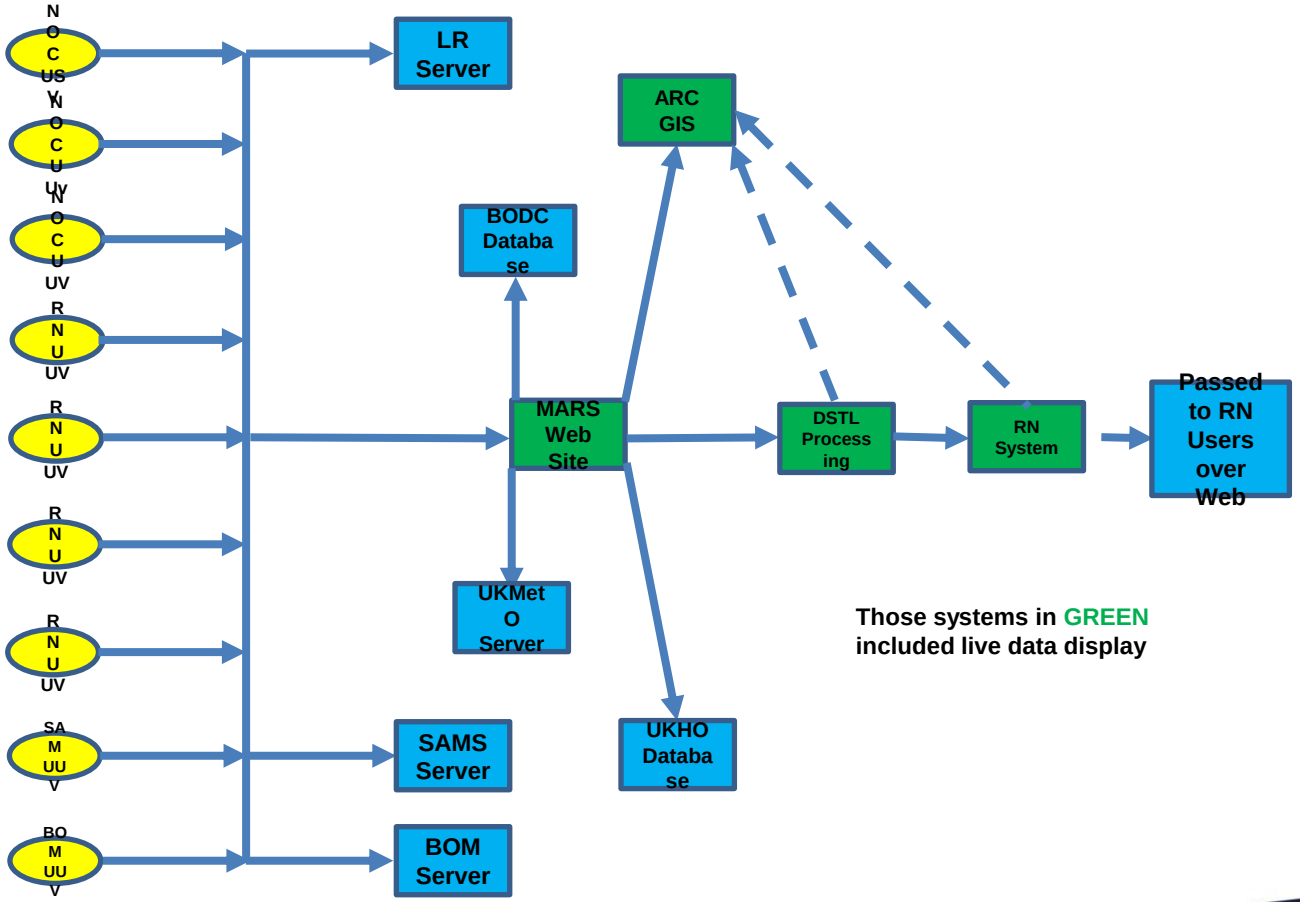
British Oceanographic Data Centre BODC

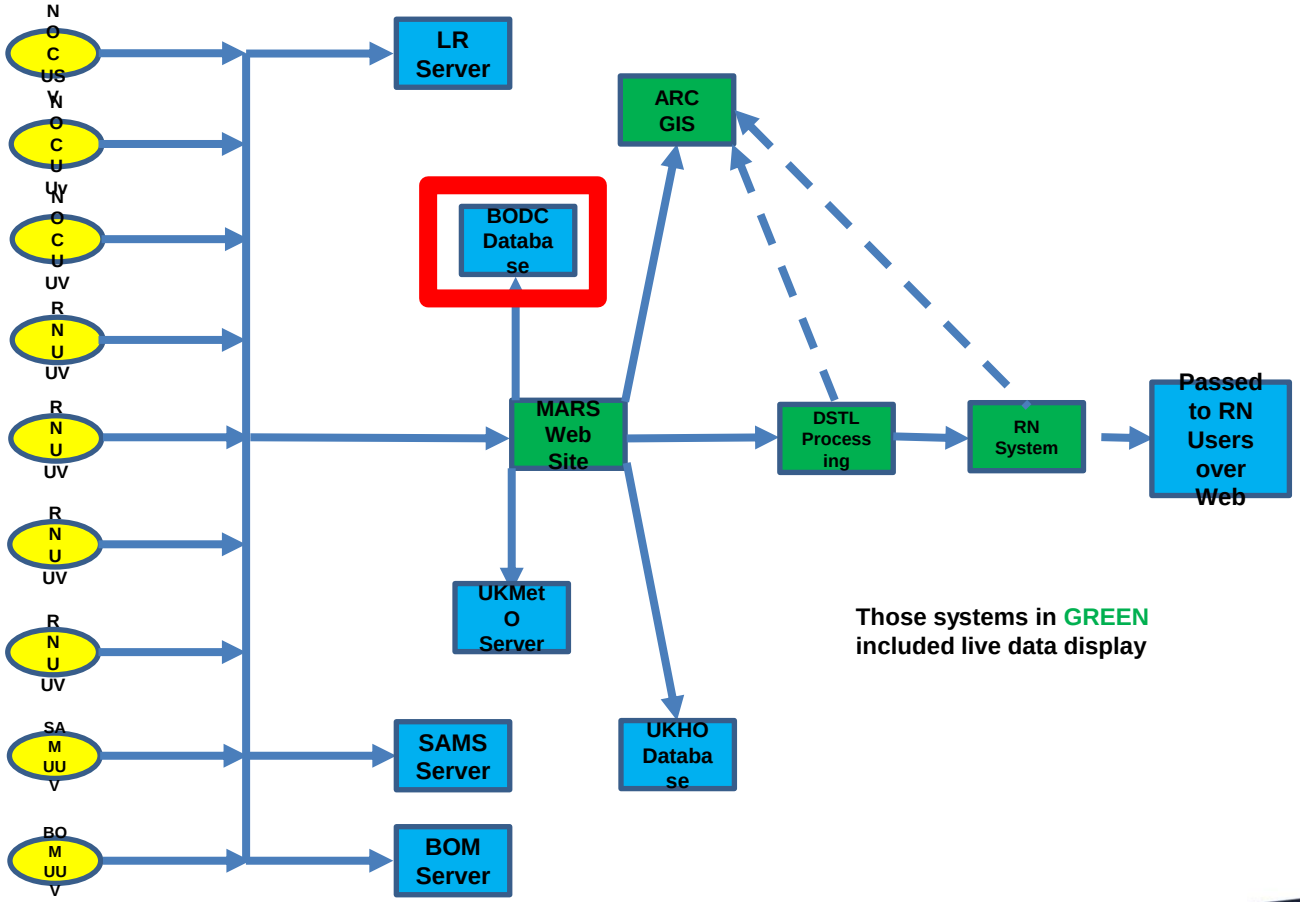
MAS data management and real-time data provision

MASSMO03 data processing and an introduction to Oceanids/C2 data flow

JUSTIN BUCK

MASSMO03 data processing


LR Server
ARC GIS
BODC Database
MARS Web Site
DSTL Processing
RN System
Passed to RN Users over Web
UKMet O Server
UKHO Database
SAMS Server
BOM Server
Those systems in GREEN included live data display


LR Server
ARC GIS
BODC Database
MARS Web Site
DSTL Processing
RN System
Passed to RN Users over Web
UKMet O Server
UKHO Database
SAMS Server
BOM Server
Those systems in GREEN included live data display

MASSMO data management plan

Pilot base station

Secure archive

Reformatting and QC

Data dissemination

Collect data from providers in real time

- Long term archive data in triplicate

Collect data from providers after recovery

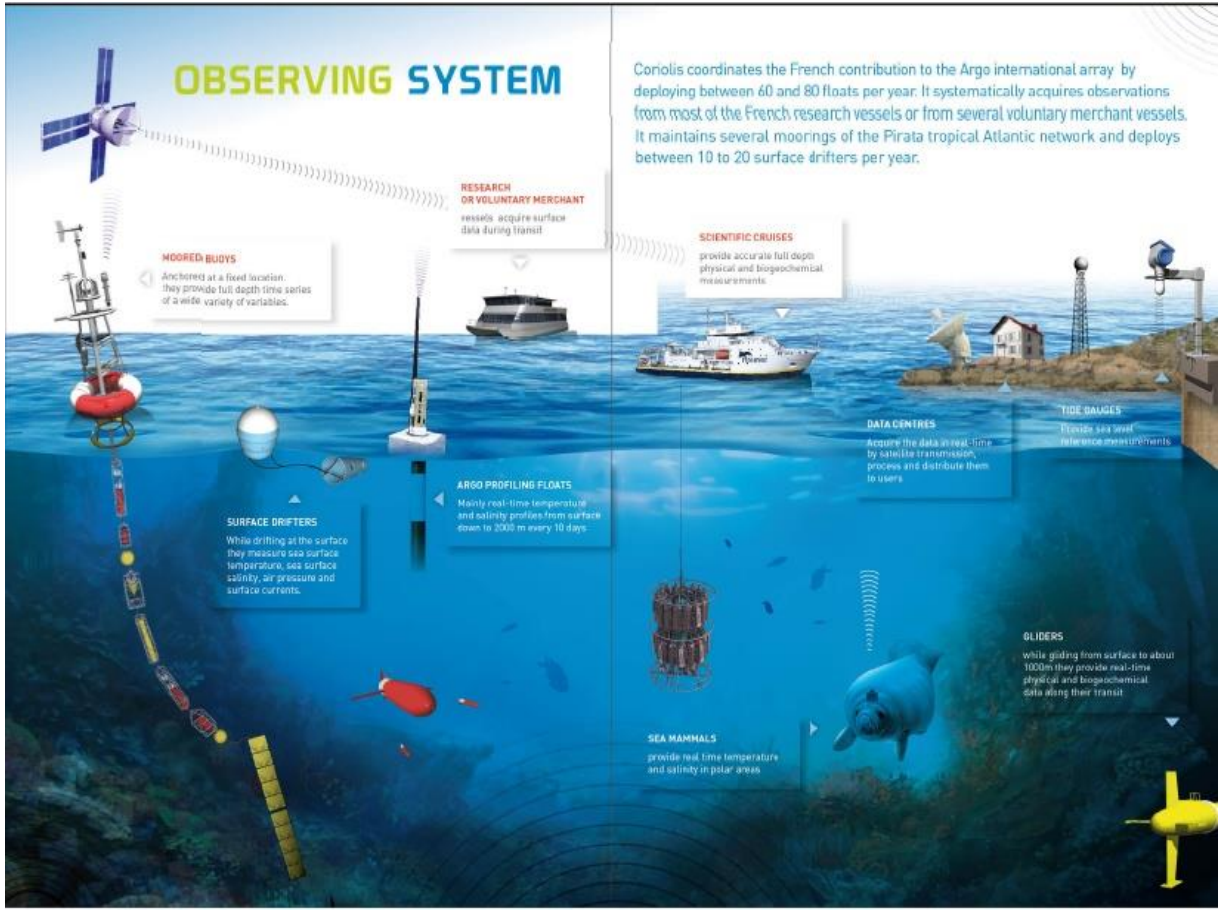
- Long term archive data in triplicate

Convert data to EGO format

Forward data to:

- MASSMO project partners
- UK Met Office
- EGO GDAC (once data access restrictions passed)

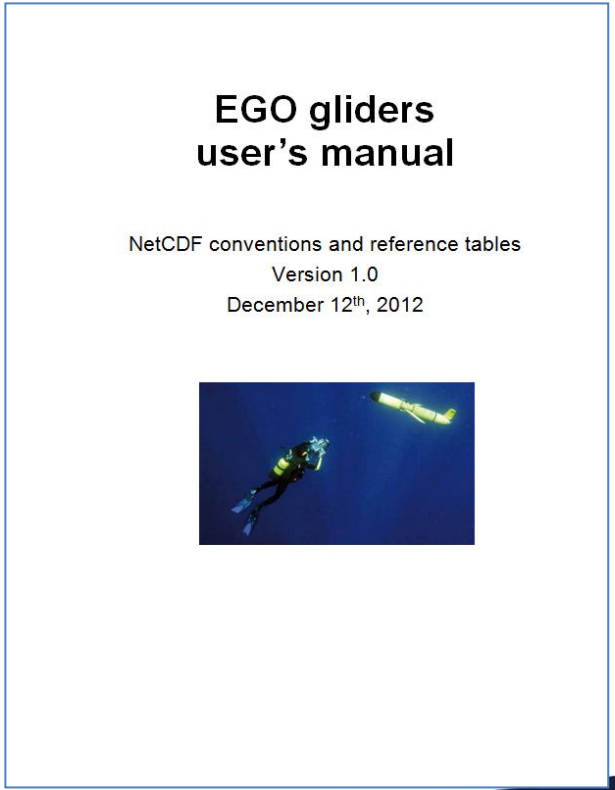
Everyone's Glider Observatories (EGO) – glider data in the context of the global ocean observing system



EGO format - A common data exchange format

EGO glider data format established by the GROOM community (October 2012):

- Climate and Forecast (CF) and SeaDataNet compliant NetCDF.
- Moving towards alignment with data standards being developed internationally (e.g. IMOS in Australia and IOOS in the U.S).
- Standard quality control protocols for both near real-time and ‘delayed-mode’ glider datasets (utilising Argo).
- Ensures that glider data, metadata and technical information are stored and distributed in a consistent manner.



MASSMO data management status

Pilot base station

Secure archive

Reformatting and QC

Data dissemination

Secure archive

- On-going, recovery data currently being synchronised from SAMS

Convert data to EGO format

- Conversion to start week commencing 21st November

How to share with project partners

- Is secure FTP acceptable?

Forward of data to EGO GDAC

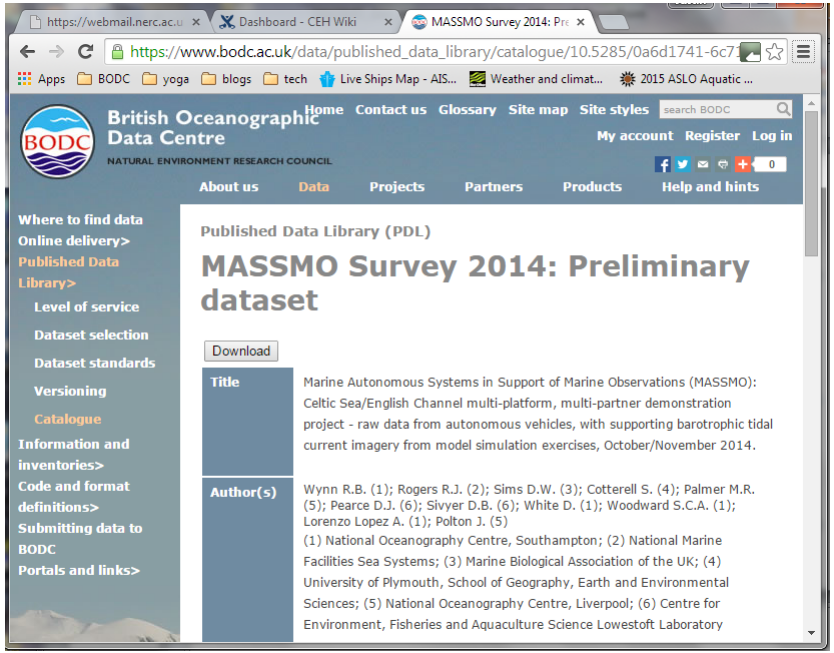
- Need to confirm when data can be made public

Assign a DOI to the dataset?

Is a DOI needed for the dataset of raw data (with ASCII conversions) and EGO version of the data?

Example from MASSMO01:

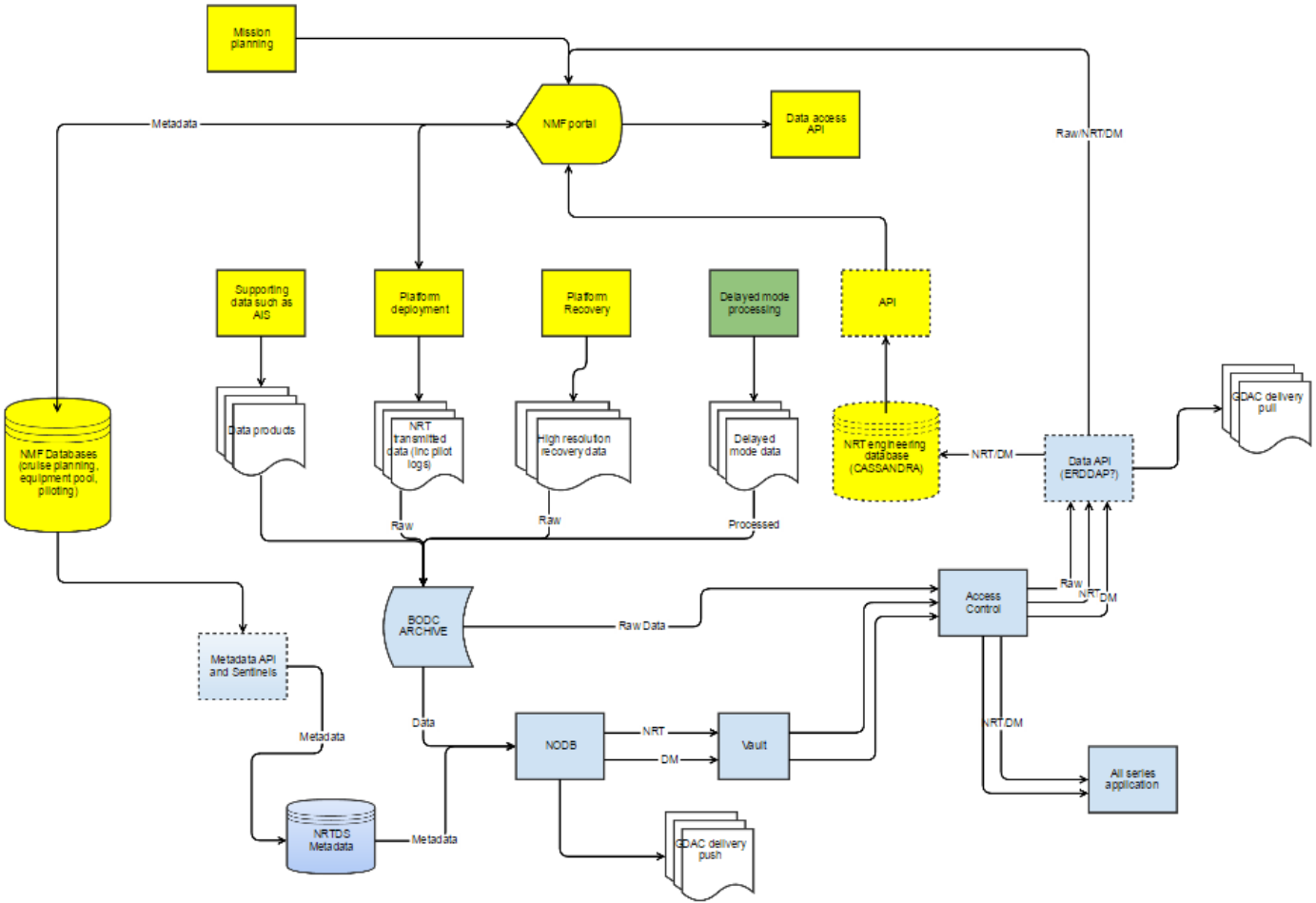
https://www.bodc.ac.uk/data/published_data_library/catalogue/10.5285/0a6d1741-6c71-248b-e053-6c86abc0175d/



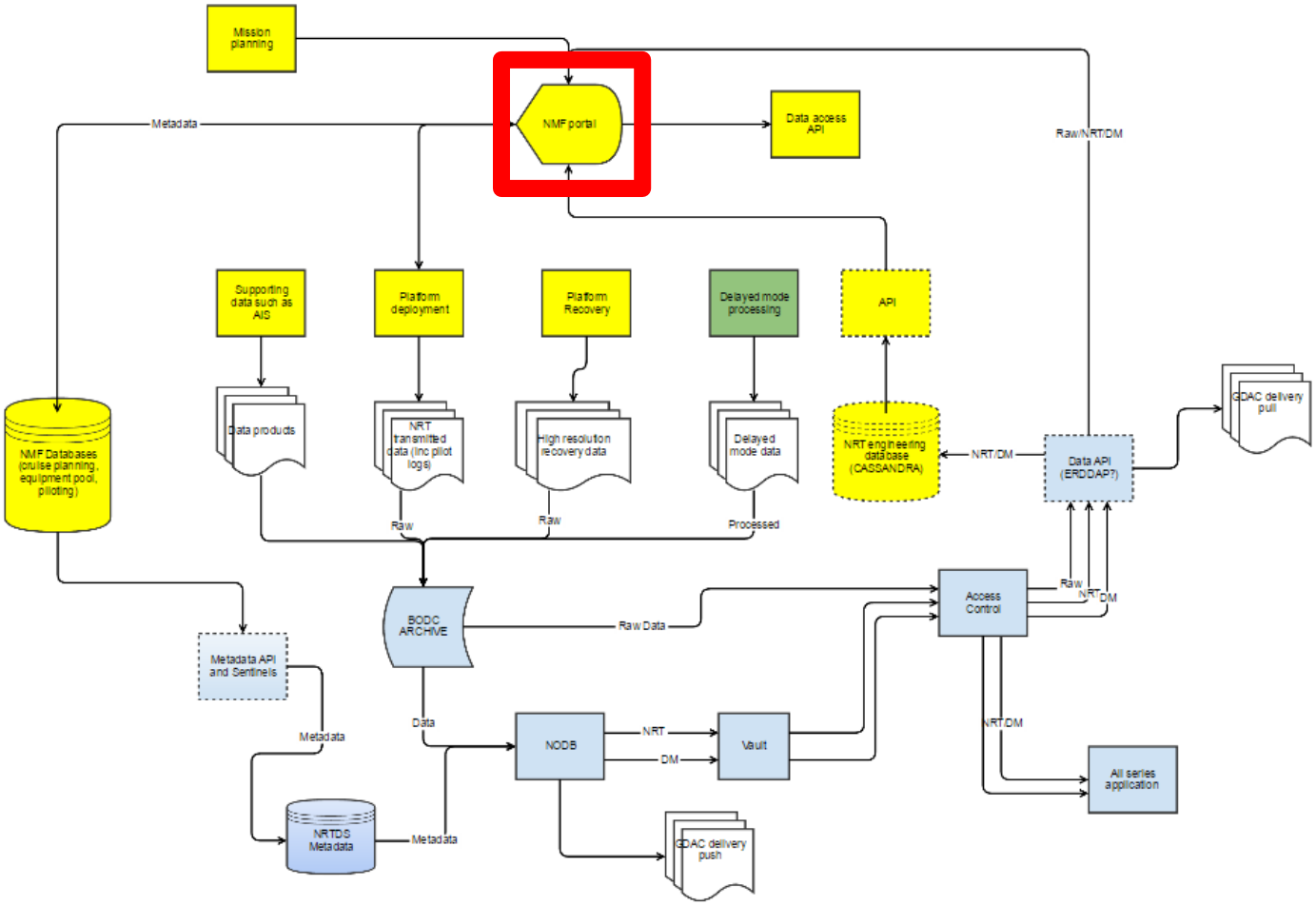
Introduction to Oceanids/Command and Control (C2) data flow

C2 data flow will cover mission planning, data processing, data exposure and forwarding.

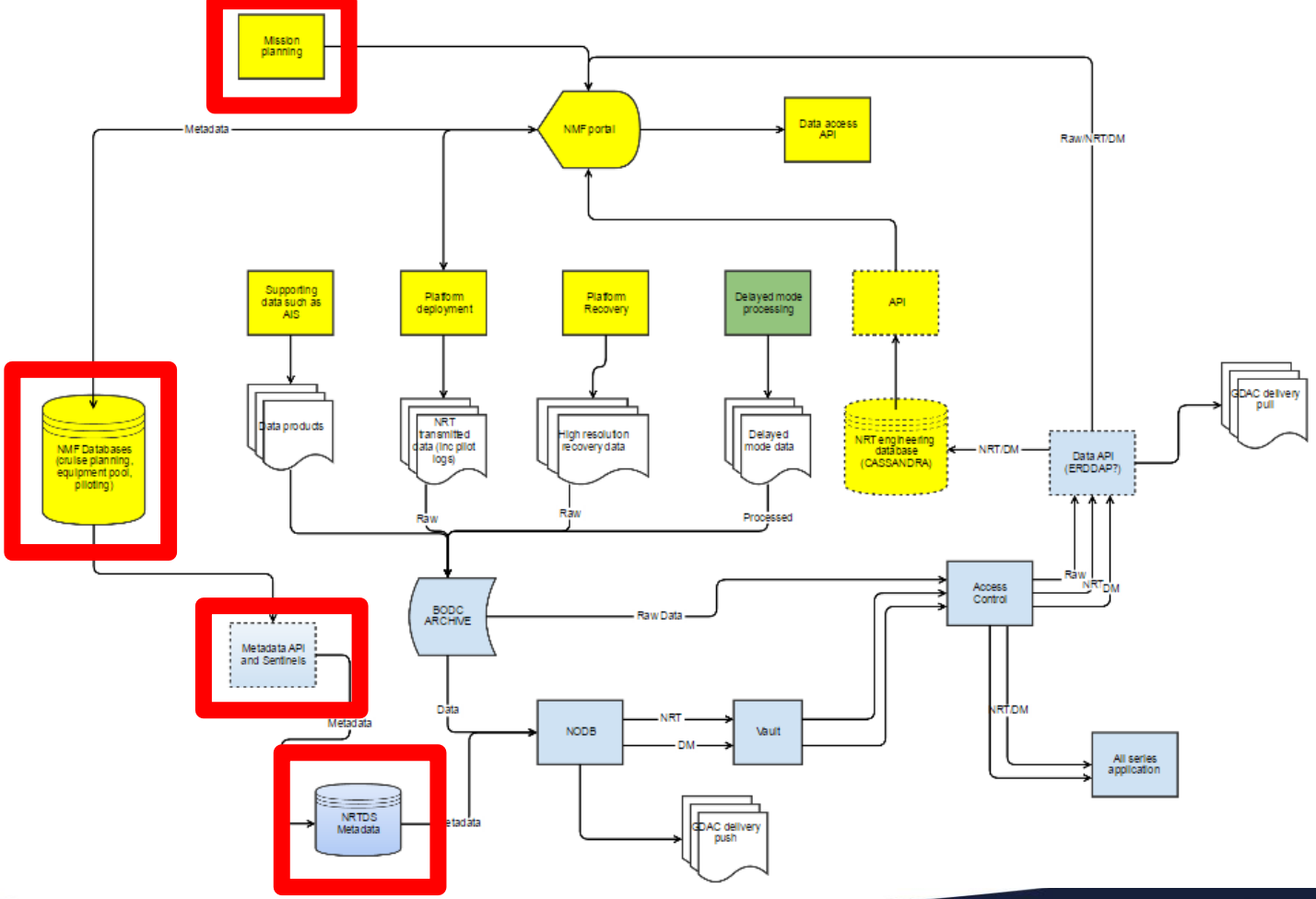
An integrated data system spanning MARS, Sea Systems and BODC.



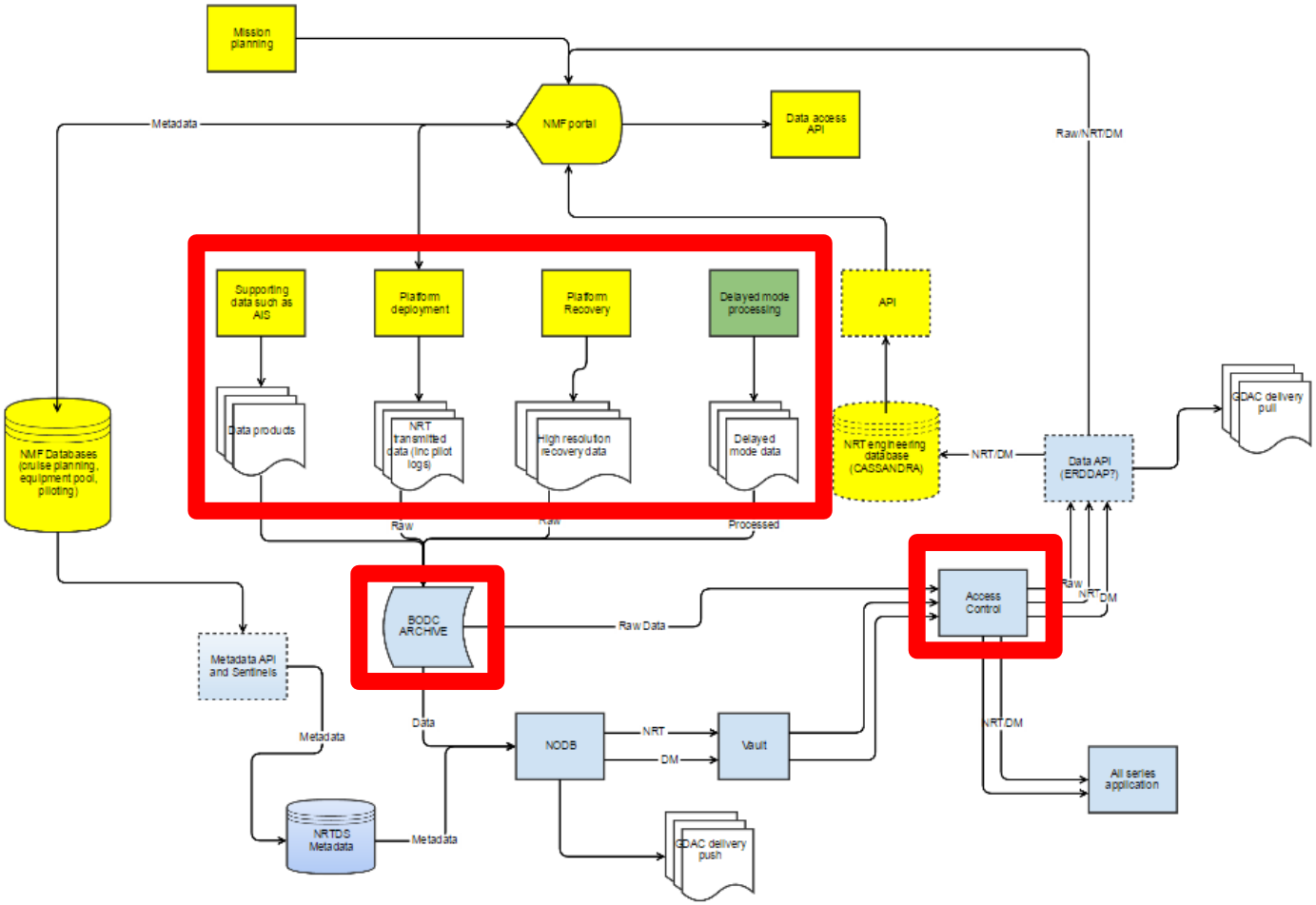
NMF data portal will be central point for user to access services



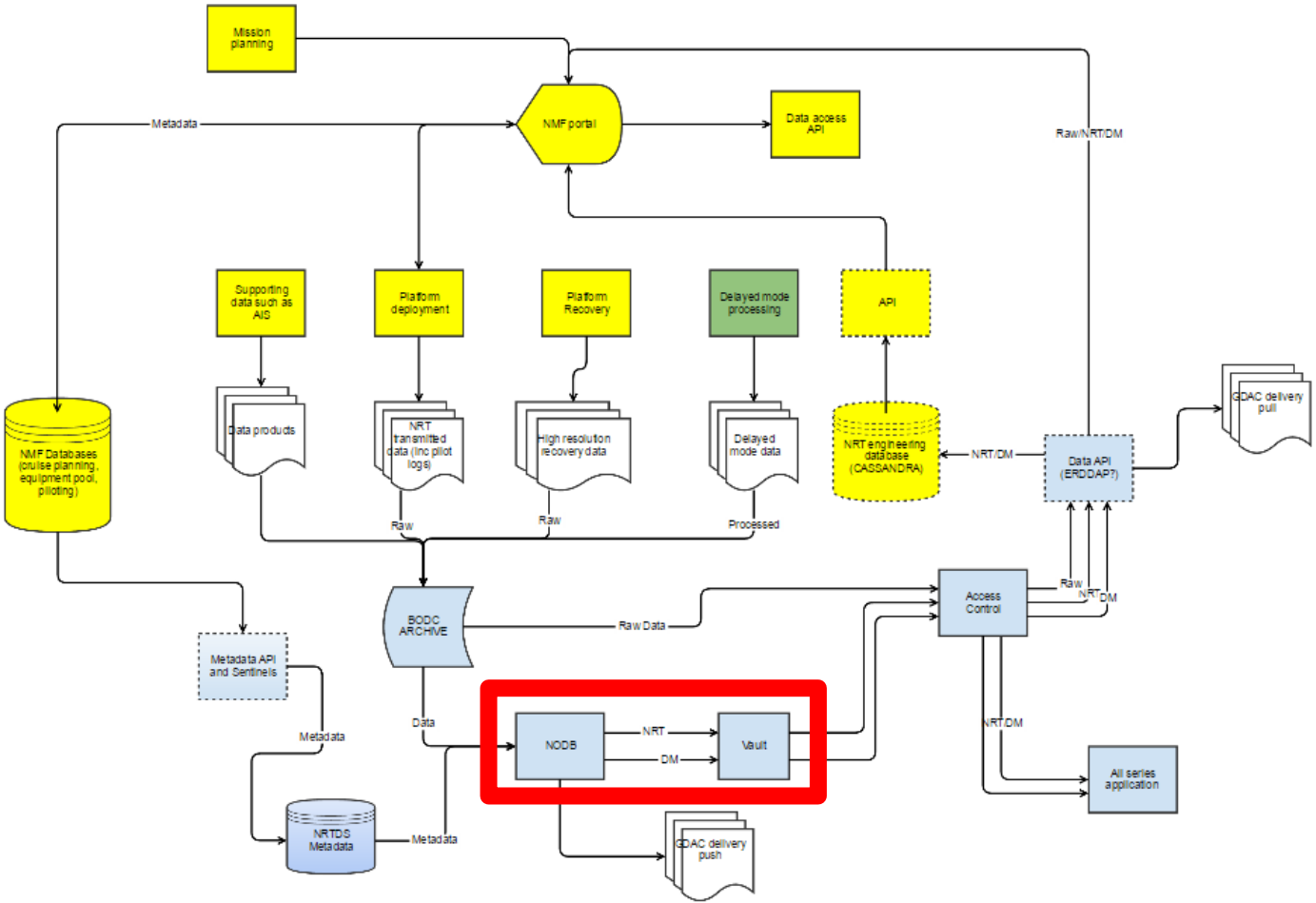
Metadata collation and Job creation



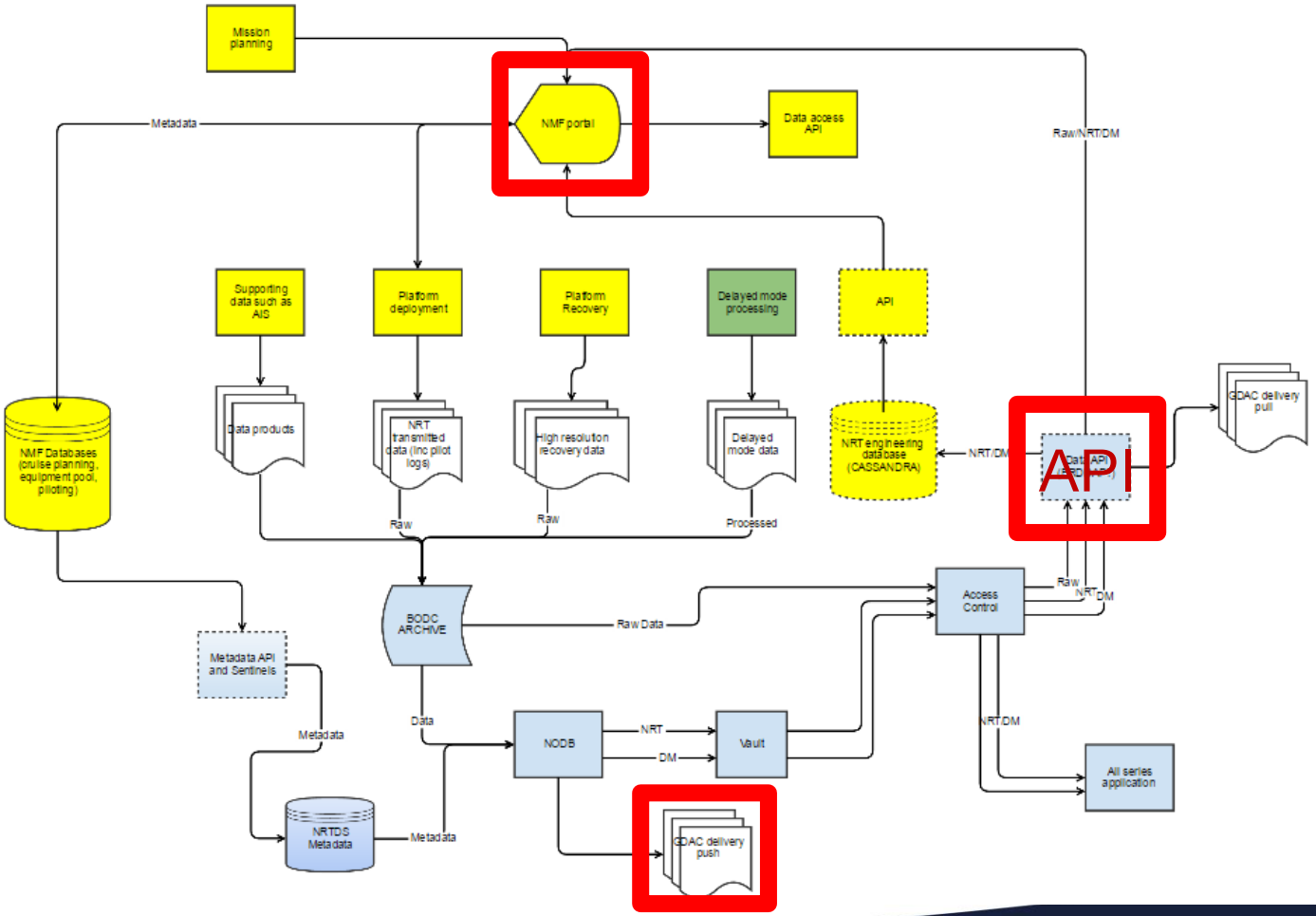
Archive and access control



Near Real Time data conversion



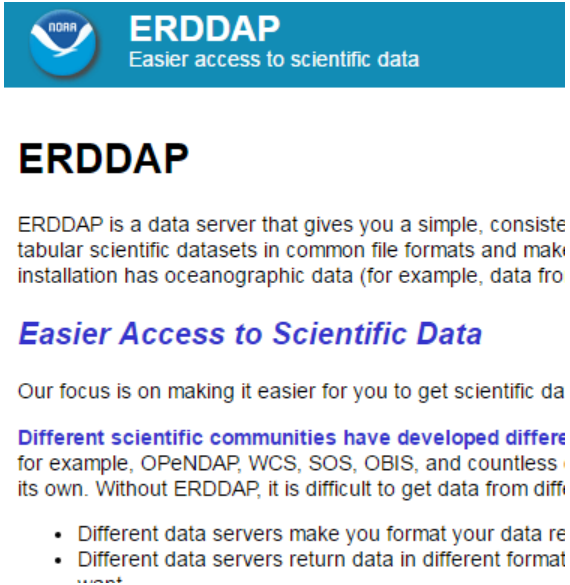
Data discovery and delivery



Why use an Application Programming Interface?

ERDDAP is an option being investigated:

- Open source, NOAA are primary authors
- Integration with access control needed
- Addition of OGC SWE standards delivery module possible (enabling a future link to automated EMODNet data ingestion & ISO19115 compliance)
- Enables users to subset data
- Select different output formats i.e. exposure in text based formats in addition to EGO, new formats can potentially be added
- Built in data plotting routines
- RESTful queries to data/metadata/plots



System wide components

Workflow management

- Move from a schedule based system to an event driven system to reduce delays and manage load i.e. ensure processing of large recovery datasets does not impact on NRT data

timely
/ˈtʌɪmli/

adjective

done or occurring at a favourable or useful time; opportune.
"a timely warning"
synonyms: opportune, well timed, at the right time, prompt, p
suitable, apt, fitting, expedient, felicitous; *archaic*
"a timely warning"

resilient
/rɪˈzɪlɪənt/

adjective

1. (of a substance or object) able to recoil or spring back into shape after bending, being compressed.
"a shoe with resilient cushioning"
synonyms: flexible, pliable, pliant, supple, plastic, elastic, springy, rubbery; Mc
2. (of a person or animal) able to withstand or recover quickly from difficult conditi
"babies are generally far more resilient than new parents realize"
synonyms: strong, tough, hardy; More

Software System Resilience

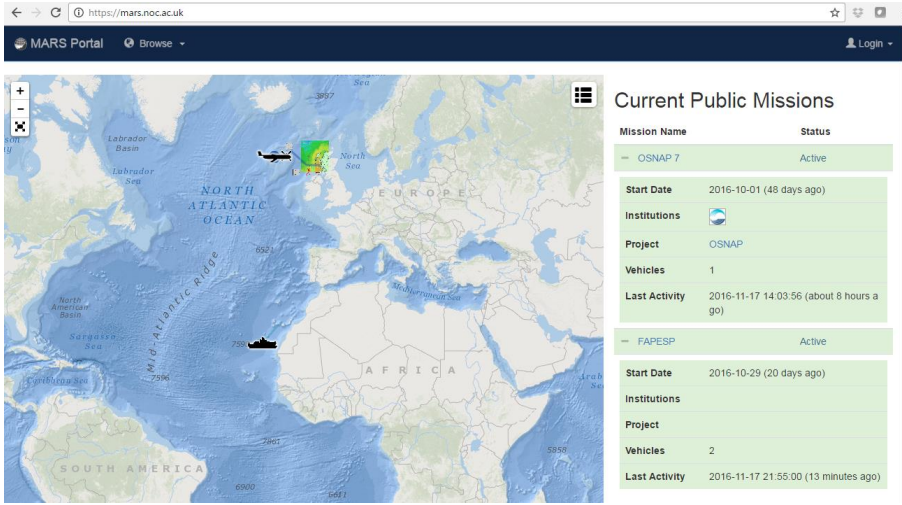
- Introduction of systems failover that will make system resilient to single site IT interruptions
- Necessary to function as a real time data assembly centre

End-to-end sensor-to-desktop data service

To be available to the UK marine community; making data an integral component of marine autonomous systems services.

Web portal will enable users/technicians/pilots to:

- Setup sensor and platform metadata
- Setup glider deployments
- Assign access control policies
- Rapid access to data (raw, recovery, converted to exchange formats, delayed mode)



Data system will support:

- Standardised metadata and data (incoming and outgoing)
- API based data access

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Prof Russ Wynn

Chief Scientist Marine Autonomous and Robotic Systems MARS NOC

Initial plans for MASSMO4 and 5

Initial plans for MASSMO4 and 5

- MASSMO4 (May-June 2017) - oceanography and PAM in NE Atlantic
- Platform focus = combined USV and submarine glider fleet
- Hopefully undertaken in partnership with NATO-CMRE CWIX 2017
- Dstl aiming to provide funding for co-ordination and operations at NOC
- NOC will work with partners to deliver data, analysis, management
- MASSMO5 (TBC 2018) - oceanography and PAM in Arctic, under ice
- Platform focus = Ausosub Long Range……possibly other platforms
- Likely to be undertaken in partnership with NERC, RN, US Navy
- Industry partners invited - support platform, sensor and C2 development

Project funding

ROYAL NAVY

[dstl]

NERC SCIENCE OF THE ENVIRONMENT

Promoting innovation

BlueOcean MONITORING

TELEDYNE WEBB RESEARCH Everywhereyoulook

KONGSBERG

LIQUID ROBOTICS

RS AQUA

BOEING

Joint operations

SAMS

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

UNMANNED 2016 WARRIOR

ROYAL NAVY

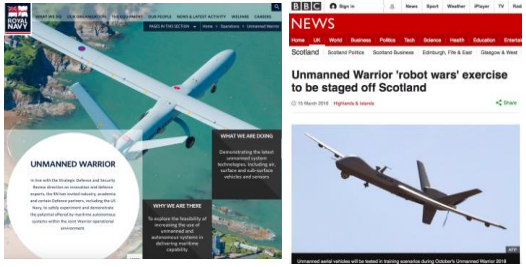
[dstl]

Ministry of Defence

QinetiQ

MASSMO3
Autumn 2016

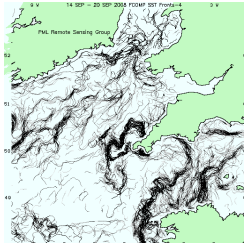
Public engagement



Data management

BODC British Oceanographic Data Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Operational products



United Kingdom Hydrographic Office

Met Office

esri UK

PML Plymouth Marine Laboratory

helyx

seebyte

Networking Lunch